Development Services

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APPEAL SUMMARY

Status: Mixed Decision. Item 1: Decision Rendered. Item 2: Hold for Additional Information

Appeal ID: 22229	**Project Address:** 151 SW 1st Ave
Hearing Date: 12/18/19	**Appellant Name:** Tom Jaleski
Case No.: B-003	**Appellant Phone:** (503) 488-5651
Appeal Type: Building	**Plans Examiner/Inspector:** John Cooley, Corey Stanley
Project Type: commercial	**Stories:** 5 **Occupancy:** B, M, S-1 **Construction Type:** III-A
Building/Business Name:	**Fire Sprinklers:** Yes - Throughout
Appeal Involves: Erection of a new structure	**LUR or Permit Application No.:** 19-185198-CO
Plan Submitted Option: pdf [File 1] [File 2]	**Proposed use:** Office, Retail

APPEAL INFORMATION SHEET

Appeal item 1

Code Section	§703.3, §704.3
Requires	703.3 Alternative methods for determining fire resistance. The application of any of the alternative methods listed in this section shall be based on the fire exposure and acceptance criteria specified in ASTM E 119 or UL 263. The required fire resistance of a building element, component or assembly shall be permitted to be established by any of the following methods or procedures: Engineering analysis based on a comparison of building element, component or assemblies designs having fire-resistance ratings as determined by the test procedures set forth in ASTM E 119 or UL 263. 704.3 Protection of the primary structural frame other than columns. Members of the primary structural frame other than columns that are required to have protection to achieve a fire-resistance rating and support more than two floors or one floor and roof, or support a load-bearing wall or a nonload-bearing wall more than two stories high, shall be provided individual encasement protection by protecting them on all sides for the full length, including connections to other structural members, with materials having the required fire-resistance rating. Exception: Individual encasement protection on all sides shall be permitted on all exposed sides provided the extent of protection is in accordance with the required fire-resistance rating, as determined in Section 703.
Proposed Design	Continuous fire rating must be maintained for primary structural frame members, including attachments and fasteners. The steel floor supports, and steel fasteners are a weak link in wood structures as steel fails quickly once heated to critical temperatures. The protection outlined in the review below will meet the concerns from the FLS Review: Comments

	Item #1 (Appeal Item#1) RE: BDS comment 175 (Summary of comment): The City FLS review: lag screw heads are not protected from above. Item #1. To ensure the steel bolt attachments are protected for 1-hour, intumescent paint will be added to the top surface bolt heads. 2" concrete topping will provide less than 1 hour of protection from heat, while the additional coating will provide a full 1 hour of protection. (Fig.1) Note: This is a conservative protection measure. ASTM: E119 does not perform tests with a fire located above the member as convective heat rises and radiative heat transfer is a smaller contributing component in the overall failure of an assembly.
Reason for alternative	As documented above, the steel assemblies will be protected through tested protection measures to meet the minimum fire rating requirements per the OSSC. The proposed fire proofing application uses an analysis from an Oregon registered Fire Protection Engineer to provide equivalent life safety and fire protection for the requirements of the OSSC. After Reviewing the EJ, we urge you to grant this appeal.

Appeal item 2

Code Section	§703.3, §704.3
Requires	703.3 Alternative methods for determining fire resistance. The application of any of the alternative methods listed in this section shall be based on the fire exposure and acceptance criteria specified in ASTM E 119 or UL 263. The required fire resistance of a building element, component or assembly shall be permitted to be established by any of the following methods or procedures: Engineering analysis based on a comparison of building element, component or assemblies designs having fire-resistance ratings as determined by the test procedures set forth in ASTM E 119 or UL 263. 704.3 Protection of the primary structural frame other than columns. Members of the primary structural frame other than columns that are required to have protection to achieve a fire-resistance rating and support more than two floors or one floor and roof, or support a load-bearing wall or a nonload-bearing wall more than two stories high, shall be provided individual encasement protection by protecting them on all sides for the full length, including connections to other structural members, with materials having the required fire-resistance rating. Exception: Individual encasement protection on all sides shall be permitted on all exposed sides provided the extent of protection is in accordance with the required fire-resistance rating, as determined in Section 703.
Proposed Design	Continuous fire rating must be maintained for primary structural frame members, including attachments and fasteners. The steel floor supports, and steel fasteners are a weak link in wood structures as steel fails quickly once heated to critical temperatures. The protection outlined in the review below will meet the concerns from the FLS Review: Comments Item #1 (Appeal Item#1) RE: BDS comment 175 (Summary of comment): The City FLS review: lag screw heads are not protected from above. Item #1. To ensure the steel bolt attachments are protected for 1-hour, intumescent paint will be added to the top surface bolt heads. 2" concrete topping will provide less than 1 hour of protection from heat, while the additional coating will provide a full 1 hour of protection. (Fig.1) Note: This is a conservative protection measure. ASTM: E119 does not perform tests with a fire

located above the member as convective heat rises and radiative heat transfer is a smaller contributing component in the overall failure of an assembly.

Reason for alternative As documented above, the steel assemblies will be protected through tested protection measures to meet the minimum fire rating requirements per the OSSC.

The proposed fire proofing application uses an analysis from an Oregon registered Fire Protection Engineer to provide equivalent life safety and fire protection for the requirements of the OSSC. After Reviewing the EJ, we urge you to grant this appeal.

APPEAL DECISION

1. Alternate method of providing 1 hour fire protection to fastener heads: Granted as proposed.

2. Alternate method of providing 1 hour fire protection to fastener heads: Hold for additional information. Appellant may contact John Butler (503 823-7339) with questions.

For Item1: The Administrative Appeal Board finds with the conditions noted, that the information submitted by the appellant demonstrates that the approved modifications or alternate methods are consistent with the intent of the code; do not lessen health, safety, accessibility, life, fire safety or structural requirements; and that special conditions unique to this project make strict application of those code sections impractical.

Pursuant to City Code Chapter 24.10, you may appeal this decision to the Building Code Board of Appeal within 90 calendar days of the date this decision is published. For information on the appeals process, go to www.portlandoregon.gov/bds/appealsinfo, call (503) 823-7300 or come in to the Development Services Center.

For Item 2: Additional information is submitted as a no fee reconsideration, following the same submittal process and using the same appeals form as the original appeal. Indicate at the beginning of the appeal form that you are filing a reconsideration and include the original assigned Appeal ID number. The reconsideration will receive a new appeal number.
Include the original attachments and appeal language. Provide new text with only that information that is specific to the reconsideration in a separate paragraph(s) clearly identified as "Reconsideration Text" with any new attachments also referenced. No additional fee is required.

Softwood Lumber Board

Glulam Connection Fire Test

Summary Report

Issue | June 5, 2017

Job number 246190

Arup USA, Inc
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Washington DC 20036
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ARUP

Contents

Appendices

1 Introduction

The Softwood Lumber Board, Arup, MyTiCon and DR Johnson have partnered to complete three full-scale fire tests for glulam beam to column connectors. The fire tests have been completed for “off-the-shelf” connectors for glulam beams, testing the connector to meet a minimum of a 1hr fire resistance rating (FRR).

2 Background

Buildings of Type IV Heavy Timber construction, as defined by the International Building Code (IBC), can be constructed up to 85ft and are required to have member sizes that meet a prescriptive minimum dimension, to provide a FRR. Mass timber buildings, using engineered timber products such as glulam and cross laminated timber (CLT), are normally designated as Type IV construction. Where glulam beams and columns intersect, the connectors need to achieve a FRR and how this is achieved is not well-detailed within the IBC or referenced guides. Typically, a FRR of 1hr is requested for Type IV connections, for building permit.

The lack of an “off-the-shelf” fire rated solution for glulam beam to column connectors achieving a 1 hr FRR is a barrier to medium-rise mass timber construction (4 to 8 stories, below 85ft). The most widely accepted method for proving a building element achieves a FRR is through a fire test, to meet the requirements of Chapter 7 of the IBC.

To assist the construction industry, three different configurations of glulam beam to column connections were fire tested at an approved fire testing facility. The fire tests were carried out to meet ASTM E119-16a “*Standard Test Methods for Fire Tests of Building Construction and Materials*”, hence meeting Chapter 7 of the IBC.

The completed fire tests and supporting reports allow engineers and architects to specify these tested connection assemblies and satisfy the requirements of the IBC. Approval by an authority having jurisdiction (AHJ) will therefore be easier for future building projects.

3 Methodology

The fire tests were carried out in an upright furnace, with the glulam beam to column connection located within a specialized loading frame. The loading frame sits within the upright furnace that is programmed to deliver a standard time-temperature curve to meet ASTM E119.

The specimen is made up of a glulam beam, connected directly to a glulam column, with concealed end-grain connectors. A CLT floor is screw-fixed to the glulam beam (see Figure 1 and Figure 2). The tested connection was loaded to

represent actual building conditions. A jack on the frame applies the load direct to the CLT floor, located over the beam end connection. The CLT floor also acts as the lid of the furnace. The applied load was determined from calculations carried out by Arup, based on an assumed structural grid for a typical office building.

All glulam timber dimensions were chosen based on typical commodity glulam stock, so that the timber was economical to source.

Figure 1 – Test specimen being assembled, before CLT floor is installed

Figure 2 – Test specimen in loading frame with CLT floor attached to beam, within upright furnace

4 Beam to Column Connection Set Up

4.1 Connectors Used

The connectors used for the fire testing were:

- Ricon S steel connector:
  - Test 1 – Ricon S VS 290x80
  - Test 2 – Staggered double Ricon S VS 200x80
- Knapp Megant aluminum connector:
  - Test 3 - Megant 430 x 150

Connectors were installed as per specifications supplied by MyTiCon.

Figure 3 – Overview of a typical Ricon connector (image from MyTiCon)

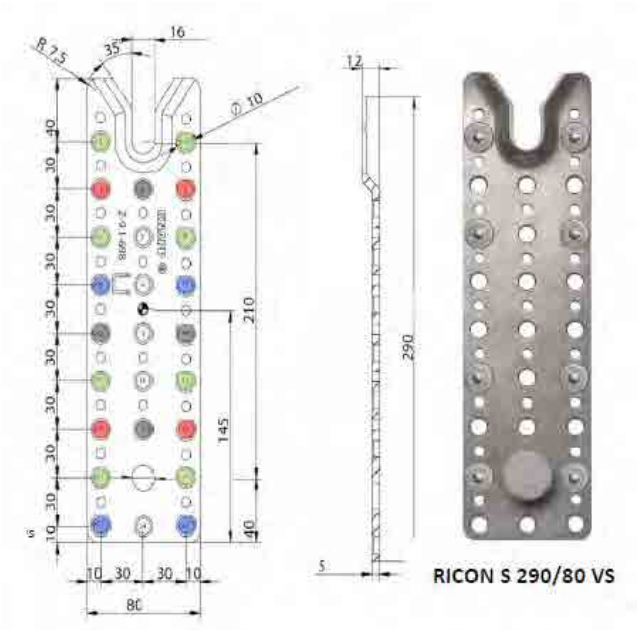

Figure 4 – Ricon S VS 290x80 connector used in Test 1 (image from MyTiCon)

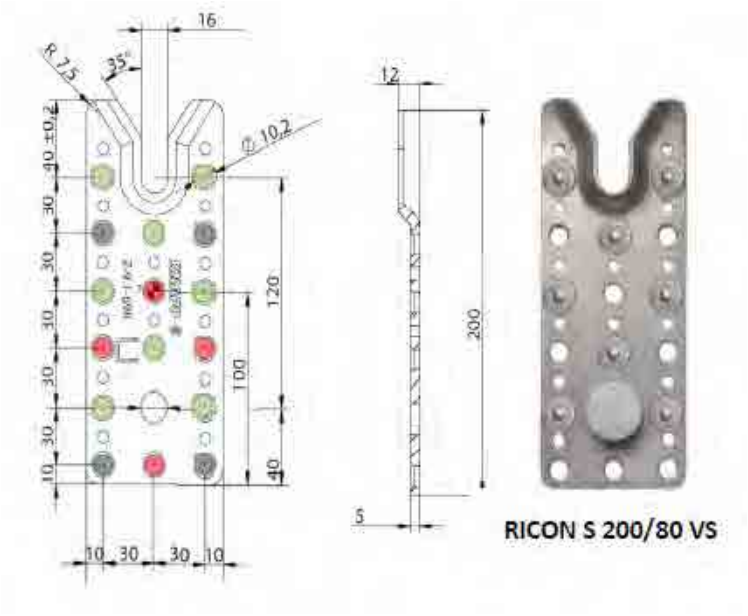

Figure 5 – Ricon S VS 200x80 for Test 2 (double connector used) (image from MyTiCon)

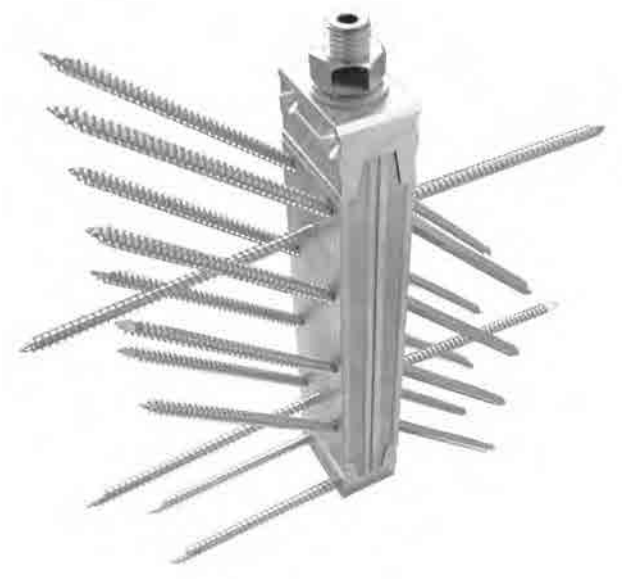

Figure 6 – Typical Megant connector (image from MyTiCon)

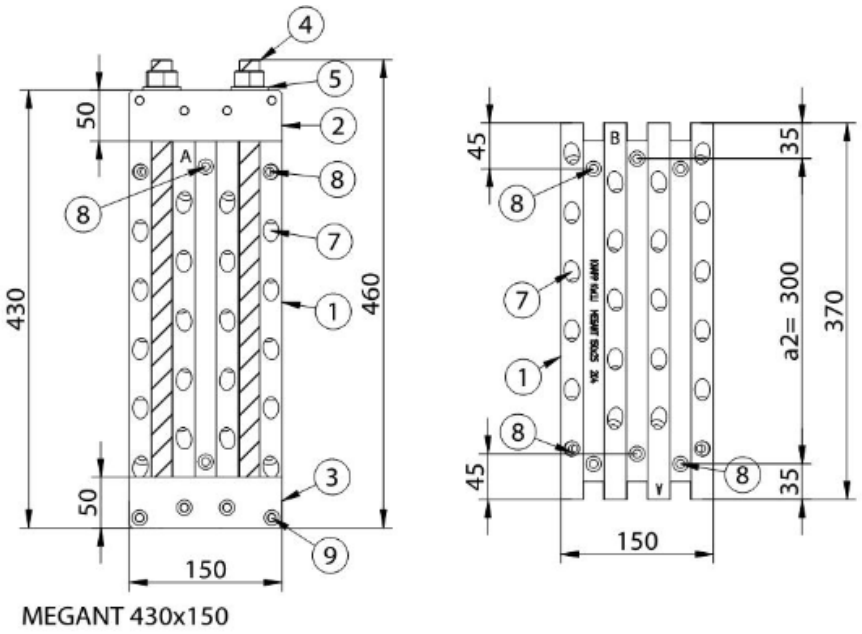

Figure 7 – Megant 430 x 150 connector used in Test 3 (image from MyTiCon)

4.2 Fire Stop Sealant

Fire stop sealant (also called fire caulk) was applied at the following locations:

- A ½" bead of fire stop sealant was applied on the column face, such that it was located 1.5" from the beam edge. The sealant was applied prior to connection of the beam. Excess sealant was then cleaned away once the beam was fitted (see Figure 8). This was to ensure the gap between beam and column was effectively fire sealed.
- A ½" bead of fire sealant was applied to the top of the beam for Test 1 and two beads of sealant were placed on the beam, for Tests 2 and 3, prior to the CLT floor being screwed into place. The line of sealant was central to the beam for Test 1 and 1.5" away from the beam edges, for Tests 2 and 3. Excess sealant was cleaned away.

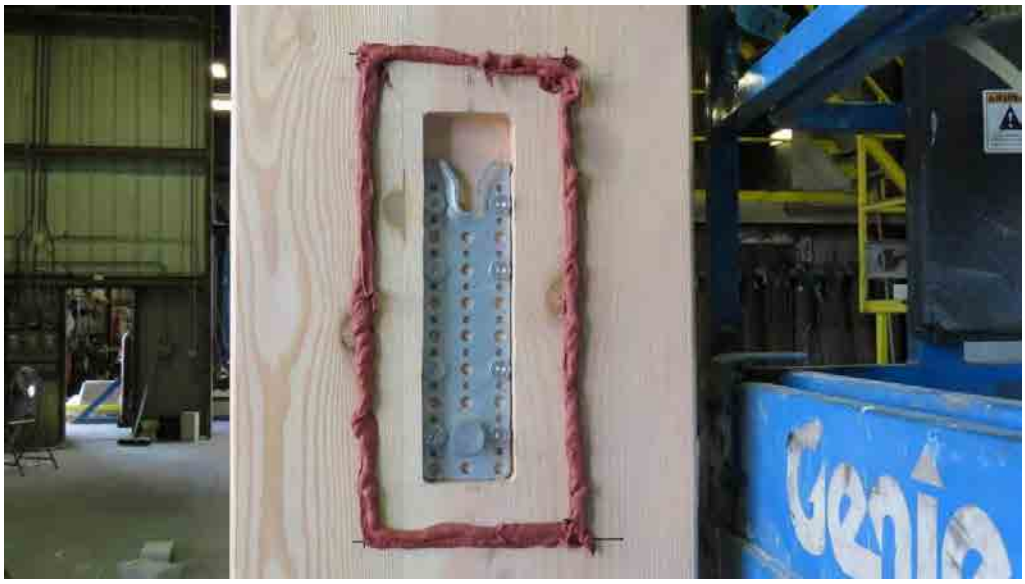

Figure 8 – Test 1 fire sealant in place prior to connection of beam

5 Fire Tests Undertaken

5.1 Test 1 – Small Beam with Single Ricon

The assumption for this beam to column connection is a secondary beam and hence a relative lighter applied load:

- Column: 16.5” (419mm) x 14.25” (362mm), beam located on 14.25” side
- Beam: 8.75” (222mm) x 18” (457mm) (width x height)
- Applied load at connector: 3,905lbs (17.4kN)
- Connector type: Single Ricon S VS 290x80 (this connector was not at capacity)
- Fire resistance rating achieved was 1hr

The results of the test are documented within test Report 22532.01.001, dated May 26th, 2017 (see Appendix A).

Figure 9 - Test 1 at 1hr and being removed from furnace

5.2 Test 2 – Large Beam with Double Ricon

The assumption for this beam to column connection is a primary beam and hence a higher applied load.

- Column: 16.5” (419mm) x 14.25” (362mm), beam located on 14.25” side
- Beam: 10.75” (273mm) x 24” (610mm) (width x height)
- Applied load at connector: 16,620lbs (73.9kN)
- Connector type: Staggered double Ricon S VS 200x80
- Fire resistance rating achieved was 1.5 hr

The results of the test are documented within test Report 22532.01.003, dated May 26th, 2017 (see Appendix B).

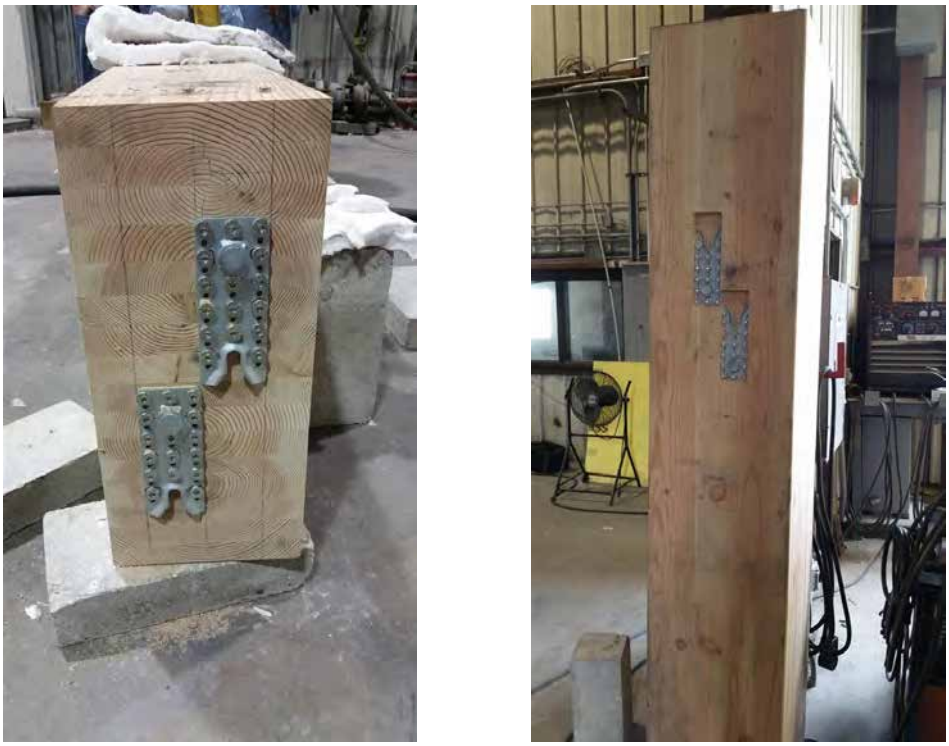

Figure 10 – Test 2 set-up, prior to test

Figure 11 – Test 2 during test and post-test (beam and columns cut for inspection)

5.3 Test 3 – Large Beam with Megant

The assumption for this beam to column connection is a primary beam and hence a higher applied load.

- Column: 16.5” (419mm) x 14.25” (362mm), beam located on 14.25” side
- Beam: 10.75” (273mm) x 24” (610mm) (width x height)
- Applied load at connector: 16,620lbs (73.9kN)
- Connector type: 1 Knapp Megant 430 x 150
- Fire resistance rating achieved was 1.5 hr

The results of the test are documented within test Report 22532.01.002, dated May 26th, 2017 (see Appendix C).

Figure 12 – Test 3 connector before and after test (beam cut for inspection after test)

Figure 13 - Test 3 at end of test

6 Fire Test Results

The test results were:

Test	Beam	Connector	Applied Load	FRR
1	8.75” x 18” (222mm x 457mm)	1 x Ricon S VS 290x80	3,905lbs (17.4kN)	1hr
2	10.75” x 24” (273mm x 610mm)	Staggered double Ricon S VS 200x80	16,620lbs (73.9kN)	1.5hrs
3	10.75” x 24” (273mm x 610mm)	1 x Megant 430	16,620lbs (73.9kN)	1.5hrs

All connectors passed and achieved at least 1hr FRR.

Contact Details

For questions related to this report, please contact:

David Barber,

Arup, Washington DC

+1 202 729 8216

david.barber@arup.com

Appendix A

Fire Test 1 Report (22532.01.001)

SOUTHWEST RESEARCH INSTITUTE

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CHEMISTRY AND CHEMICAL ENGINEERING DIVISION

FIRE TECHNOLOGY DEPARTMENT
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FAX (210) 522-3377

FIRE PERFORMANCE EVALUATION OF A LOAD BEARING GLULAM BEAM TO COLUMN CONNECTION, INCLUDING A CLT PANEL, TESTED IN GENERAL ACCORDANCE WITH ASTM E119-16a, *STANDARD TEST METHODS FOR FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS*

FINAL REPORT
Consisting of 32 Pages

SwRI® Project No. 01.22532.01.001
Test Date: March 6, 2017
Report Date: May 26, 2017

Prepared for:

Softwood Lumber Board
1101 K Street N.W., Suite 700
Washington, DC 20005

Submitted by:

Bill B. Bendele
Principal Engineering Technologist
Fire Resistance Section

Approved by:

Karen C. Carpenter, M.S., P.E.
Manager
Fire Resistance Section

1.0 OBJECTIVE

The objective of the test described in this report was to determine the fire endurance rating of a load bearing glulam beam to column connection, including a CLT panel, when exposed to the time/temperature conditions of ASTM E119-16a, *Standard Test Methods for Fire Tests of Building Construction and Materials* with a 4,500-lb load applied to the assembly in a localized area. Testing was conducted by Southwest Research Institute's (SwRI) Fire Technology Department, located in San Antonio, Texas, for Softwood Lumber Board, located in Washington, DC.

2.0 TEST METHOD

The ASTM E119 test method is intended to evaluate the duration for which the assembly tested will contain a fire, or retain its structural integrity, or display both properties dependent upon the type of assembly involved, during a predetermined fire exposure time.

ASTM E119 measures the response of the assembly to exposure in terms of the transmission of heat and hot gases through the assembly. This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment, which takes into account all the factors that are pertinent to an assessment of the fire hazard of a particular end use.

This report describes the testing and analysis of the assembly tested and the results obtained. The results presented in this report apply specifically to the material tested, in the manner tested, and not to the entire production of these or similar materials, nor to the performance when used in combination with other materials.

3.0 TEST ASSEMBLY DESCRIPTION AND STEEL SELF-REACTING LOAD FRAME

The column, beam, beam connections and CLT panel were prepared before shipping to SwRI. SwRI assembled the test pieces the week of March 6, 2017. The material used in construction of the assembly is described in Table 1.

Table 1. Material Description.

Product Name/Description	Supplier	Provided By	Received On
CLT Deck Panel/5ply, Industrial Grade	DR Johnson, Riddle Laminators	Client	February 21, 2017
Glulam Beam Industrial Grade	DR Johnson, Riddle Laminators	Client	February 21, 2017
Glulam Column Industrial Grade	DR Johnson, Riddle Laminators	Client	February 21, 2017
Ricon S VS 290 × 80 Connection	MyTiCon	Client	February 21, 2017
Structural Screws	MyTiCon	Client	February 21, 2017
Fire stop	Hilti, Inc.	Client	February 28, 2017

The test assembly consisted of steel connection pieces designed as a single slip and lock hardware, a CLT panel with slots to accommodate the steel self-reacting load frame assembly, beam and column. The assembly components included a column that measured 16.5 × 16.5 in., and a beam that measured 18 in. in depth and 8.75 in. in width. Structural screws, as supplied by MyTiCon, were used to secure the steel connection pieces to the column and beam. With the single slip and lock hardware secured to the beam and to the column, an overhead crane was used to connect the beam to the column. The connected beam and column was then placed in the steel self-reacting frame and the CLT panel was lifted, set on the beam and fasten to the beam with screws.

SwRI designed and fabricated a steel self-reacting load frame that supported the base of the column on one end inside the furnace and the beam on the other end outside of the furnace. The portion of the load frame that was inside the furnace is insulated and water cooled to protect the load frame from the heat exposure. The bending load was applied with a servo controlled hydraulic actuator attached to the upper horizontal beam. A load cell and an MTS control system were used to control the applied force during the test. A string potentiometer was used to measure the extension of the jack during the test.

For application of the load a 5 × 6 × 1-in. steel plate was positioned on the top of the CLT panel and the load was applied to the steel plate. Assembly drawings, pictures, details of the test items and self-reacting load frame can be found in Appendix A.

4.0 INSTRUMENTATION

The Client provided test item thermocouple locations and drilled the holes in the wood members for installation of ⅛-in. Inconel sheathed Type K grounded junction thermocouples. When the thermocouple locations were prepped, SwRI inserted the thermocouple in the drilled hole until it would make contact with the wood or metal temperature measurement location. Nine additional thermocouples were used to record and verify furnace conditions and specimen performance in regards to the ASTM E119 test specification. Five were located on top of the CLT panel and four were probes located to record furnace temperature. The probes were positioned 12 in. from the exposed face of the beam and at the bottom of the beam elevation. A computer based data acquisition system was used to record the applied load, displacement and temperature measurements. The test item thermocouple locations can be found in Appendix B. Instrument calibration information can be found in Appendix C.

5.0 TEST RESULTS

Test Date:	March 6, 2017
Test Witness:	Mr. David Barber, representing Arup USA Inc.
Specimen ID:	Specimen A: Ricon S VS 290 × 80 Connection
Ambient Temperature:	71 °F

Relative Humidity: 73%

Observations: Refer to Table 2.

Rating Obtained: 61 min, based on when the test was terminated

Load: 4890 lb applied to the steel plate on the CLT panel

Results: The acquired data for the test is located in Appendix D in graphical form. Photographic documentation of the test can be found in Appendix E.

Deviation: The test was conducted in general accordance with ASTM E119 since the test was not to evaluate heat transmission. The intent of the test was to provide a rating of the integrity of the load bearing CLT panel fastened to a beam to column connection when exposed to the fire conditions stated in ASTM E119-16a, *Standard Test Methods for Fire Test of Building Construction and Materials.*

Table 2. Fire Resistance Test Visual Observations.

Time (min:s)	Observation
	Pre-test application of the 4,890 lb.
0:00	Start of test, furnace ignited and data acquisition initiated, deflection measurement is zero before the start of the test.
2:00	Wood has ignited.
4:40	Furnace gas is controlled to idle.
15:00	No issues.
30:00	Slight creep in deflection.
42:40	Load signal lost; signal line damaged by furnace exhaust; repaired with no effects on load.
60:00	Beam continues to hold load.
61:00	Test is terminated.

6.0 POST TEST

After the tested assembly was removed from the furnace and steel reaction load frame, a chainsaw was used to cut a cross section in the thinnest area of the column and beam. Table 3 provides the measurements of the locations and pictures can be found in Appendix D.

Table 3. Post Test Measurements.

Test Items	Measurements
Beam original dimension	18.00 × 8.75 in.
Post Test Beam measurement, middle of the beam	15.75 × 6.75 in.
Column original dimension	16.50 × 16.50 in.
Post Test Column measurement	14.50 × 13.00 in.

7.0 CONCLUSION

Based on the test results, the load bearing CLT panel, fastened to a glulam beam to column connection, constructed as described herein, obtained a 61-min fire endurance rating when tested in general accordance with ASTM E119-16a.

APPENDIX A

CONSTRUCTION PICTURES AND CLIENT-PROVIDED ASSEMBLY DRAWINGS

(CONSISTING OF 8 PAGES)

Figure A-1. Unexposed Side of CLT Panel.

Figure A-2. Beam Steel Connection Piece.

Figure A-3. Column Prepped.

Figure A-4. Column and Beam Connection.

Figure A-5. Test Article Installed in Self-Reacting Frame.

Figure A-6. Test Assembly Placed Inside Furnace.

Figure A-7. Load Application Instrumentation.

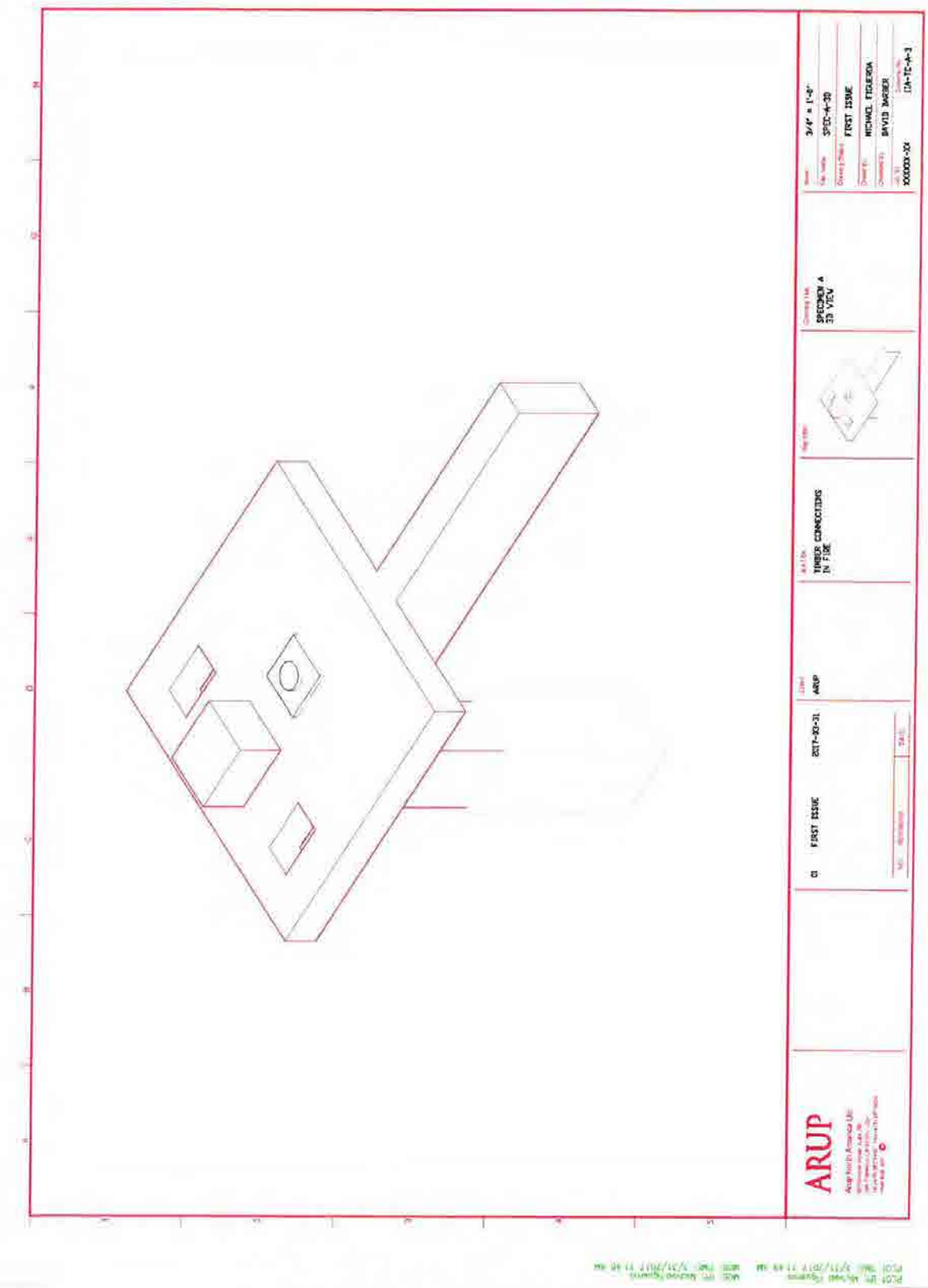

Figure A-8. Client-Provided Drawing.

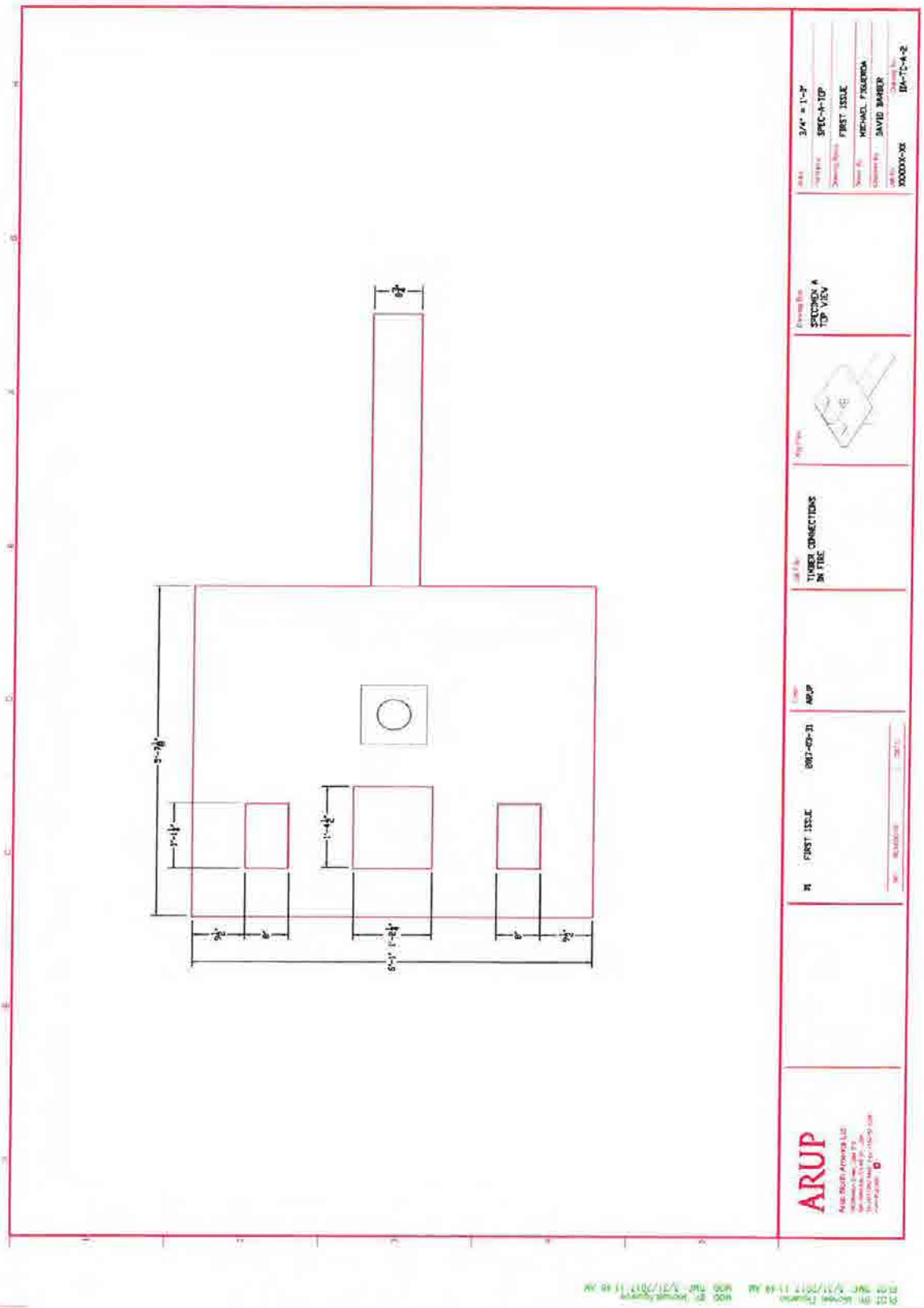

Figure A-9. Client-Provided Drawing.

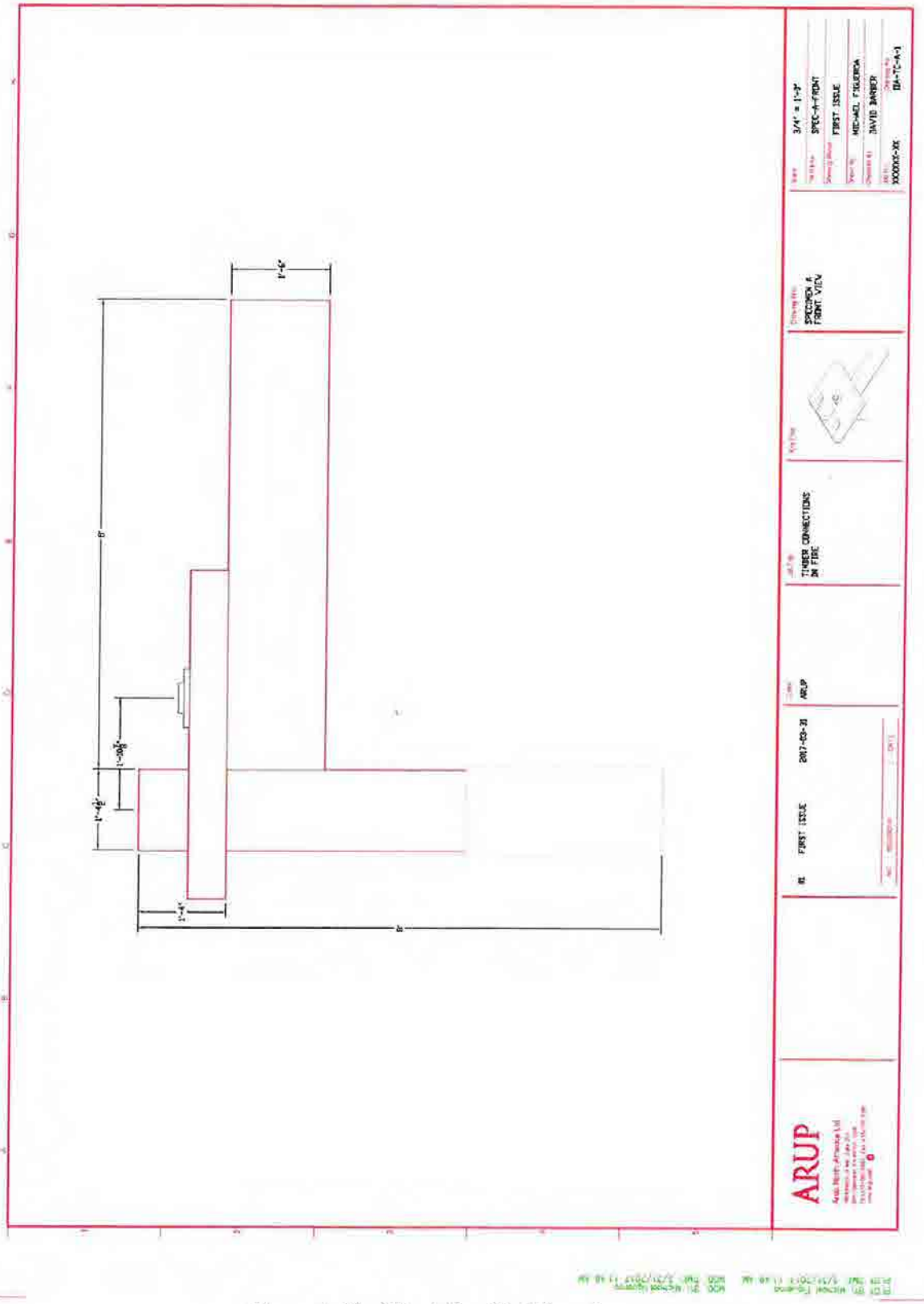

Figure A-10. Client-Provided Drawing.

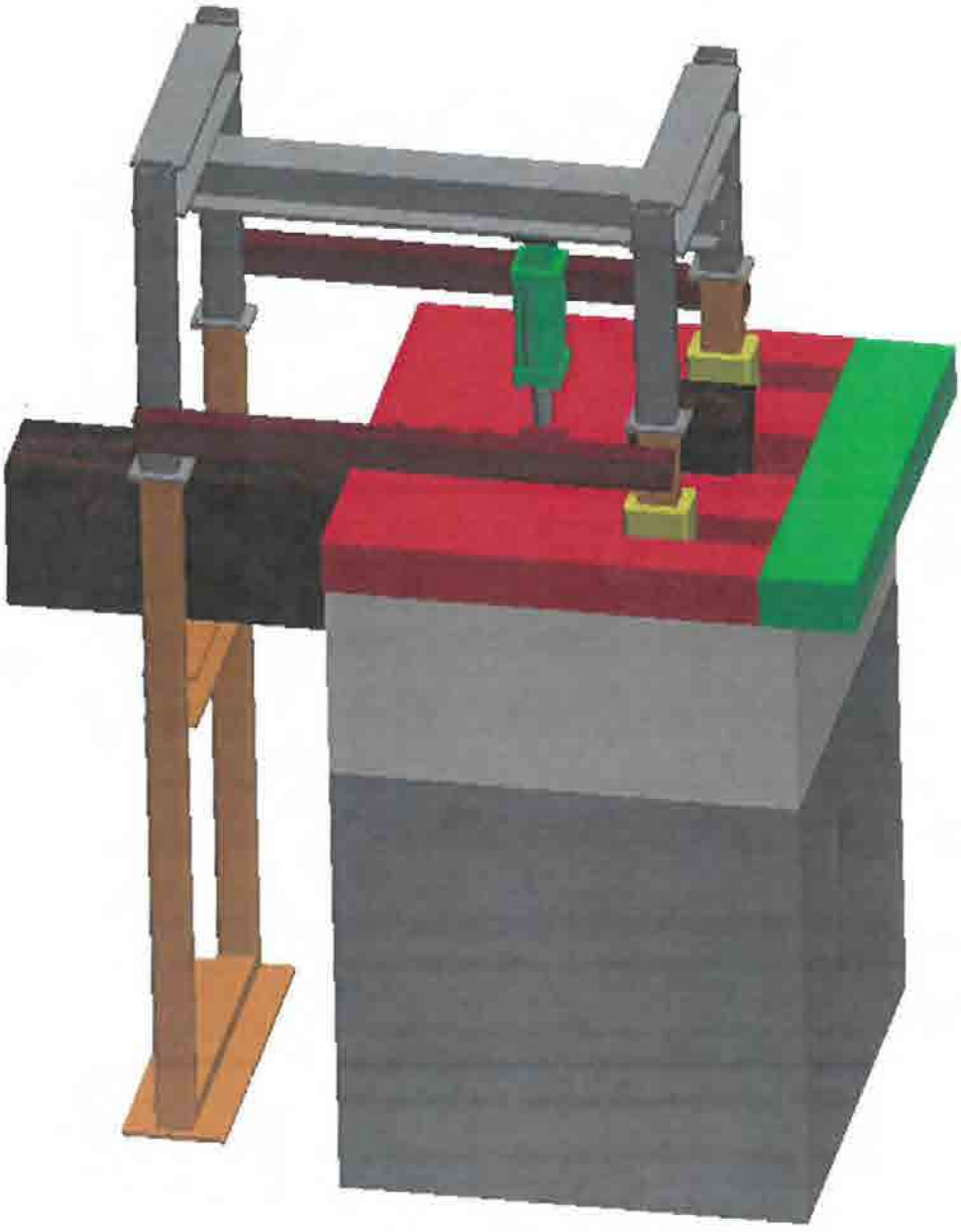

Figure A-11. Load Frame and Furnace Rendering.

APPENDIX B

THERMOCOUPLE LOCATIONS

(CONSISTING OF 5 PAGES)

Table B-1. Thermocouple Locations.

Thermocouple Number	Description
1	Located centrally at the connector.
2	Located centrally at the connector.
3	Located 16 in. from the beam connector (approx.). Hole drilled in from top of beam, to a depth of 4 in. Located 1 in. from right hand side of the beam.
4	Located 18 in. from the beam connector (approx.). Hole drilled in from top of beam, to a depth of 4 in. Located 2 in. from right hand side of the beam.
5	Located 16 in. from beam connector (approx.). Hole drilled in from top of beam, to a depth of 4 in. Located 1 in. from left hand side of the beam.
6	Located 18 in. from beam connector (approx.). Hole drilled in from top of beam, to a depth of 4 in. Located 2 in. from left hand side of the beam.
7	Located 2 ft 2 in. from CLT front edge. Located 1 ft 9 in. from CLT side. Hole drilled in from top of CLT, to a depth of 6 in.
8	Located 2 ft 2 in. from CLT front edge. Located 1 ft 6 in. from CLT side. Hole drilled in from top of CLT, to a depth of 5.5 in.
9	Located 2 ft 2 in. from CLT front edge. Located 1 ft 3 in. from CLT side. Hole drilled in from top of CLT, to a depth of 5 in.
10	Located 2 ft 2 in. from CLT front edge. Located 1 ft from CLT side. Hole drilled in from top of CLT, to a depth of 4.5 in.
11	Located 6 in. from beam connector (approx.). Hole drilled in from top of beam, to a depth of 4 in. Located 2 in. from right hand side of the beam.
12	Located 6 in. from beam connector (approx.). Hole drilled in from top of beam, to a depth of 4 in. Located 2 in. from left hand side of the beam.

Figure B-1. CLT Panel Orientation for Thermocouple Installation.

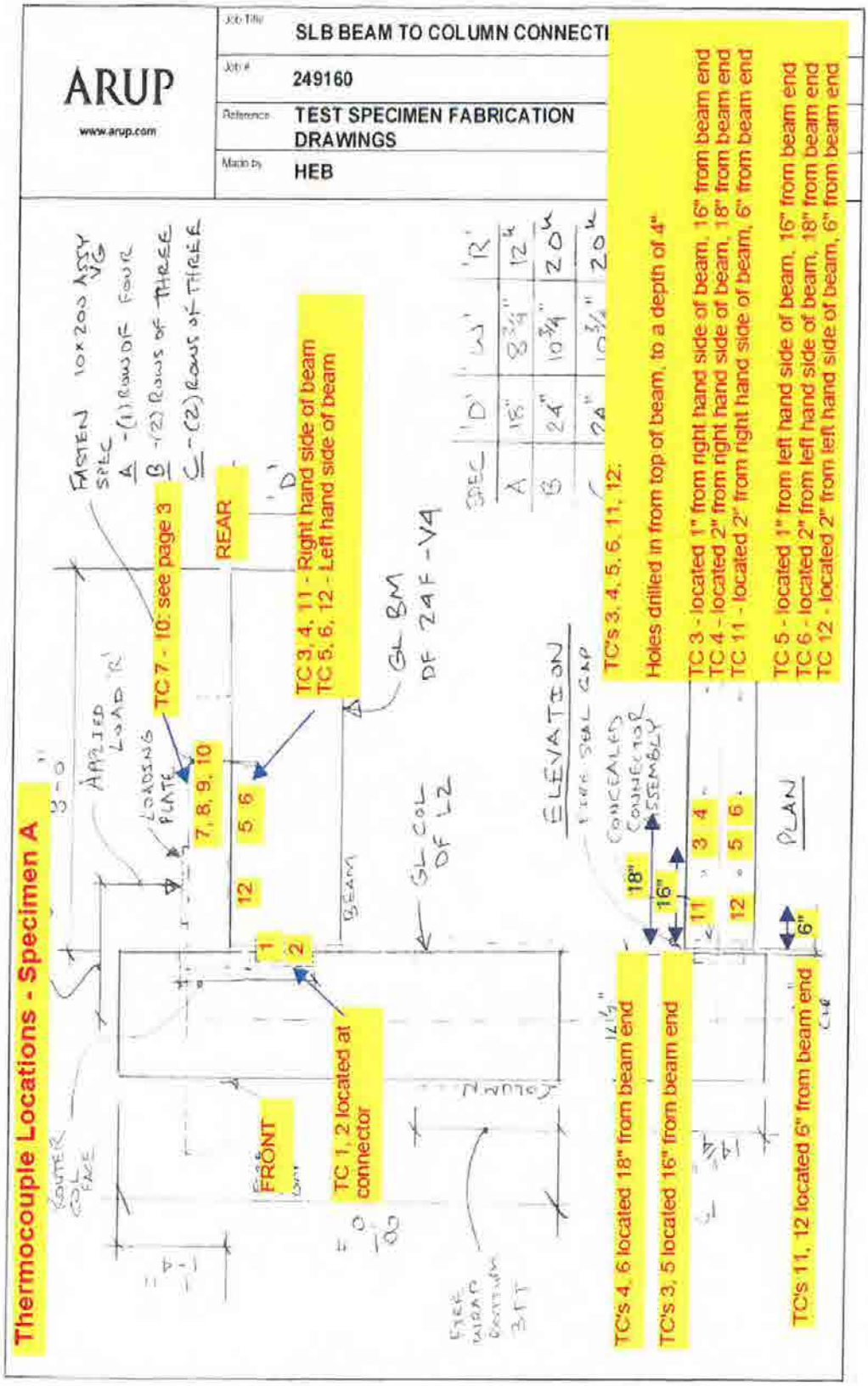

Figure B-2. Thermocouple Locations.

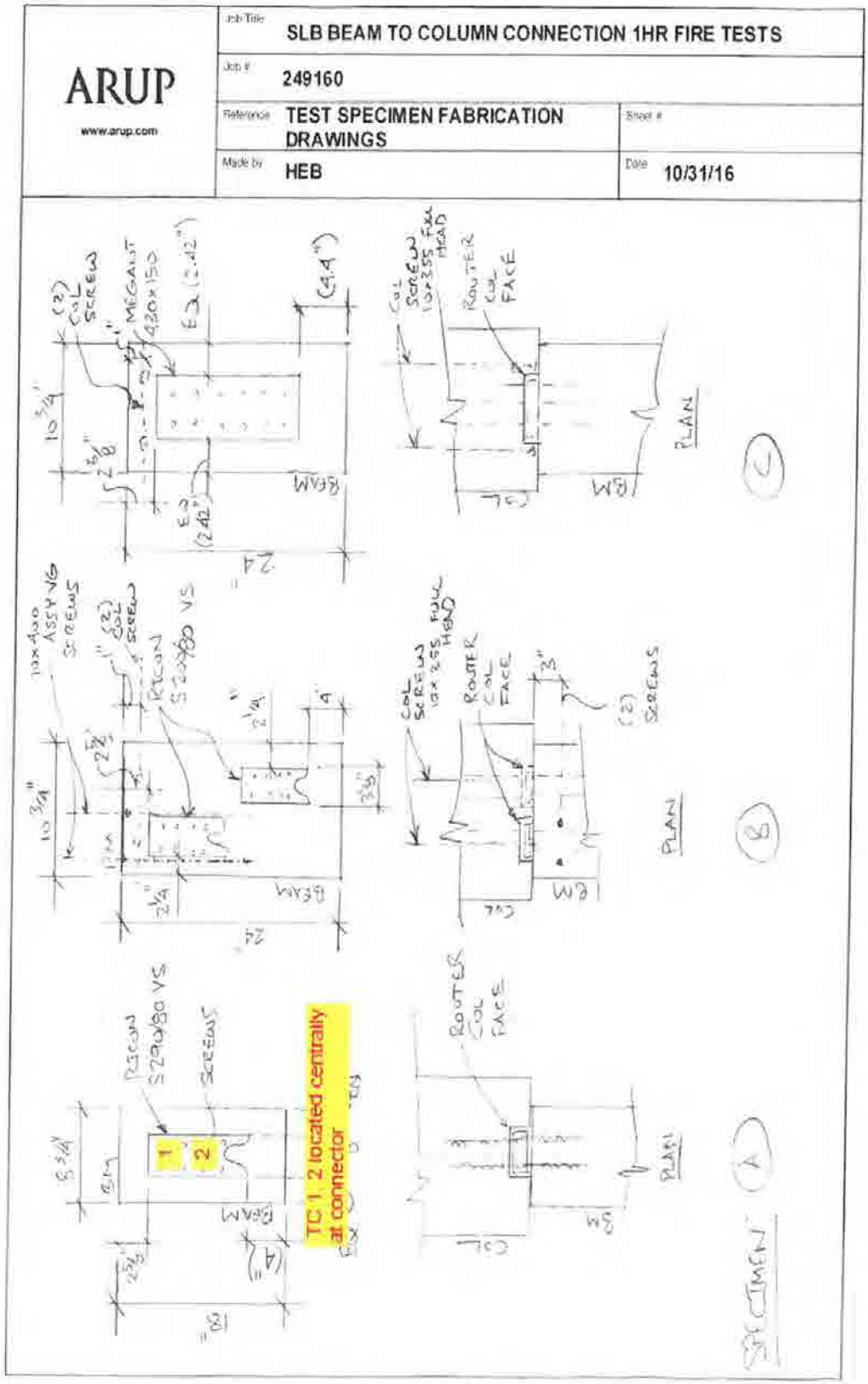

Figure B-3. Thermocouple Locations.

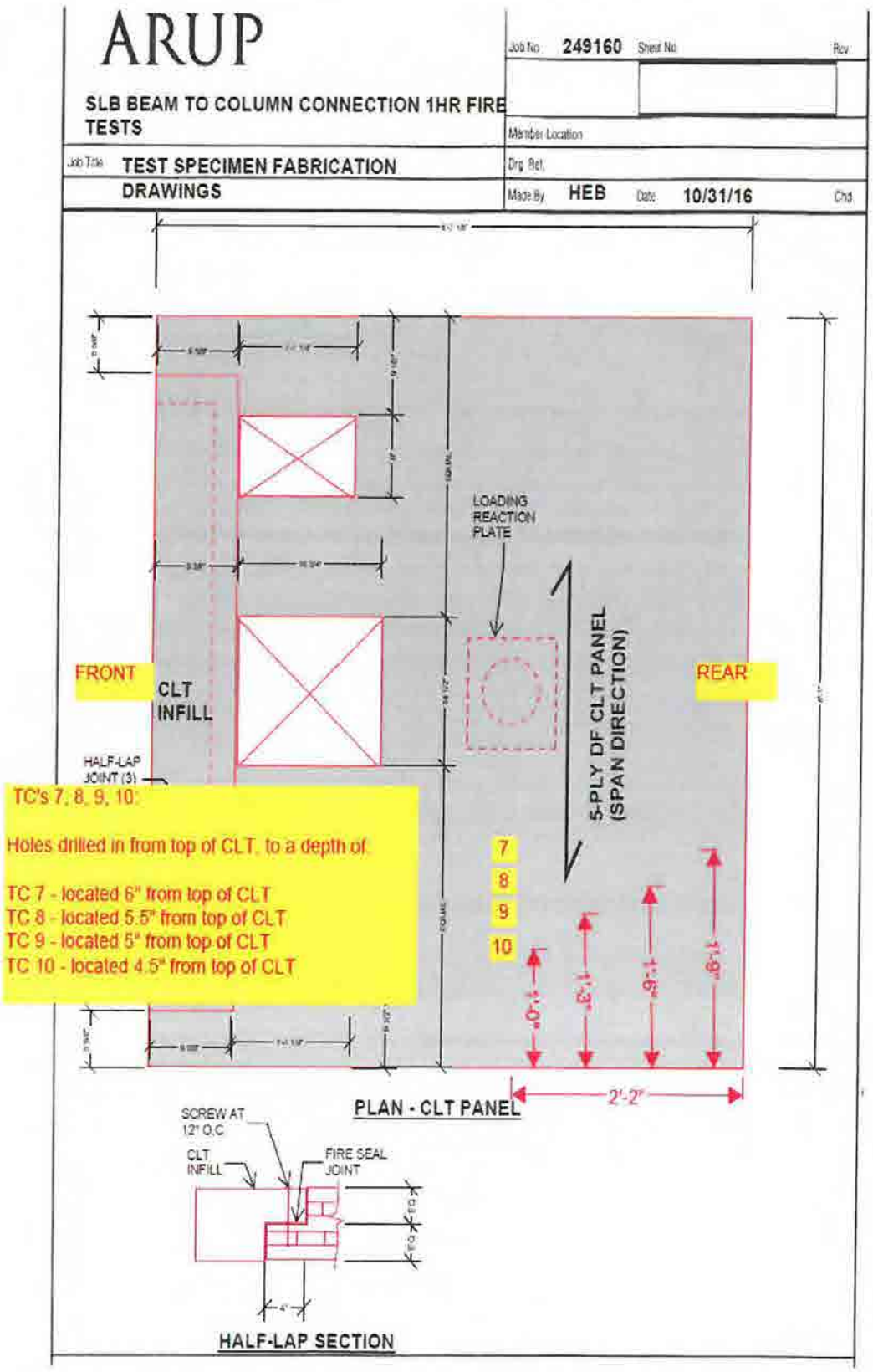

Figure B-4. Thermocouple Locations.

APPENDIX C

EQUIPMENT CALIBRATION DOCUMENTATION

(CONSISTING OF 1 PAGE)

Table C-1. Equipment Calibration Documentation.

Item	Make	Model	Serial No.	Cal Due
Data Acquisition Unit	Yokogawa	DU100-11	91R420032	May 20, 2017
Data Acquisition Unit	Yokogawa	DU100-11	91R420030	May 19, 2017
Data Acquisition Unit	Yokogawa	DU100-11	12VB42119	May 19, 2017
Position Transducer	Celesco	SPD-25-3	L2524245C	January 12, 2018
Furnace Pressure Transducer	Setra	264	2708707	September 11, 2016
Load Cell	Strainsert	SPHC-2XO	Q14372-14	July 26, 2017
Humidity/Temp Indicator	Vaisala	HM 34	W2420016	September 23, 2017

APPENDIX D

GRAPHICAL TEST DATA

(CONSISTING OF 4 PAGES)

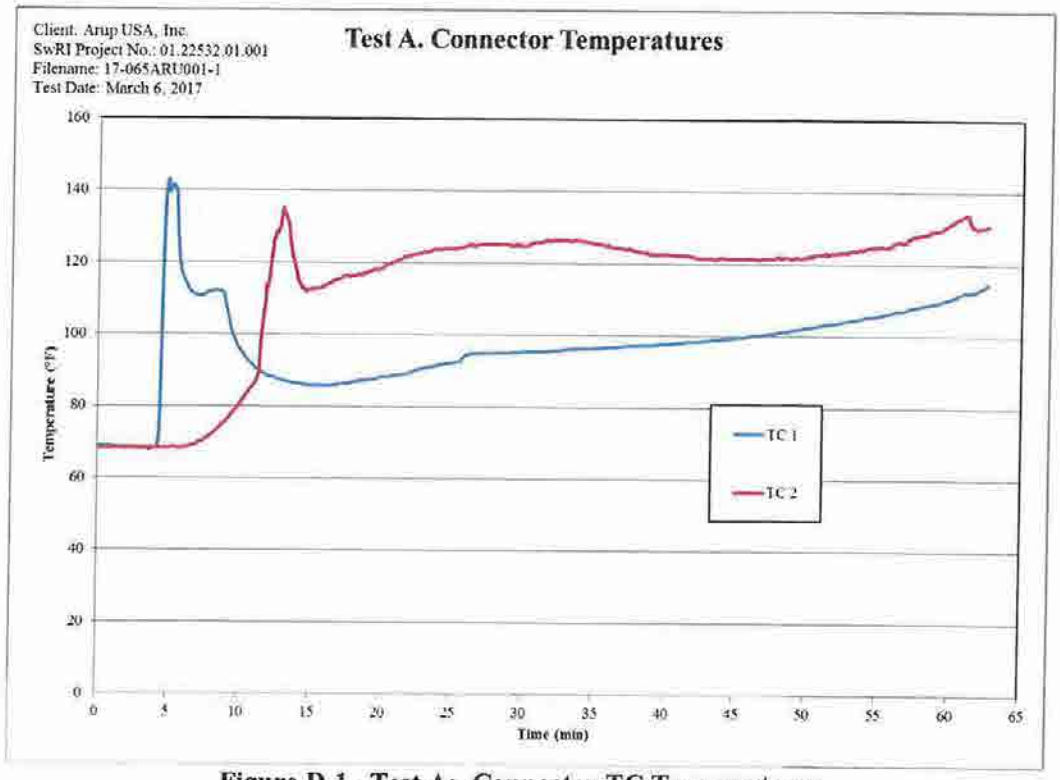

Figure D-1. Test A: Connector TC Temperatures.

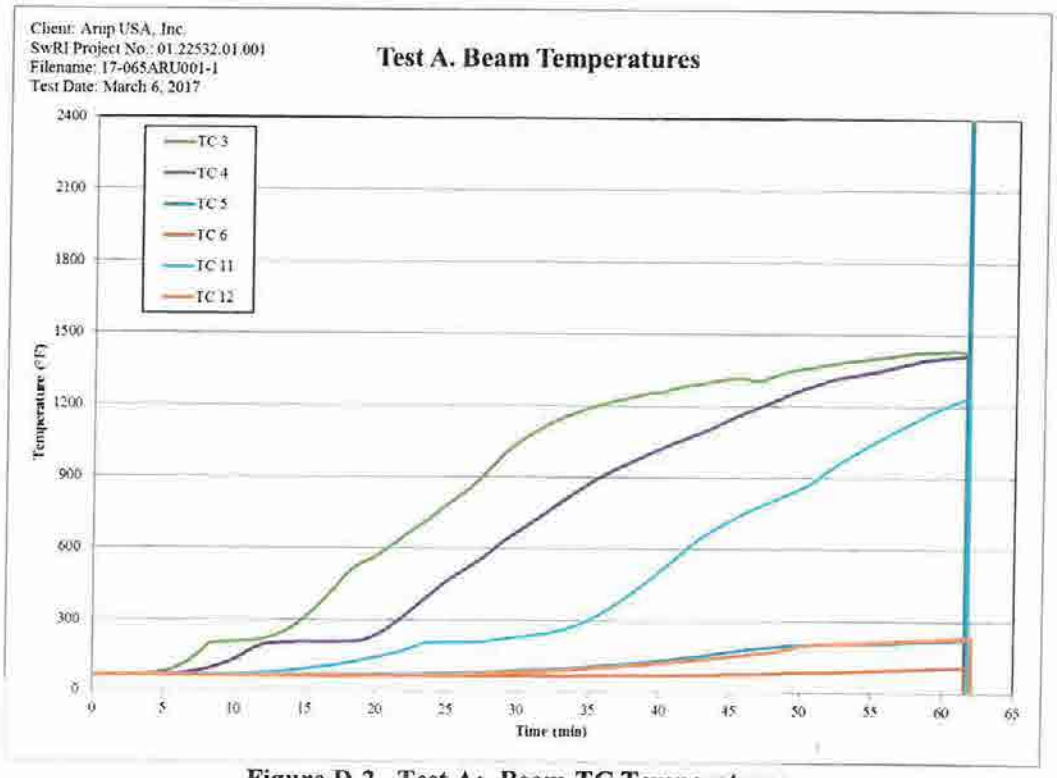

Figure D-2. Test A: Beam TC Temperatures.

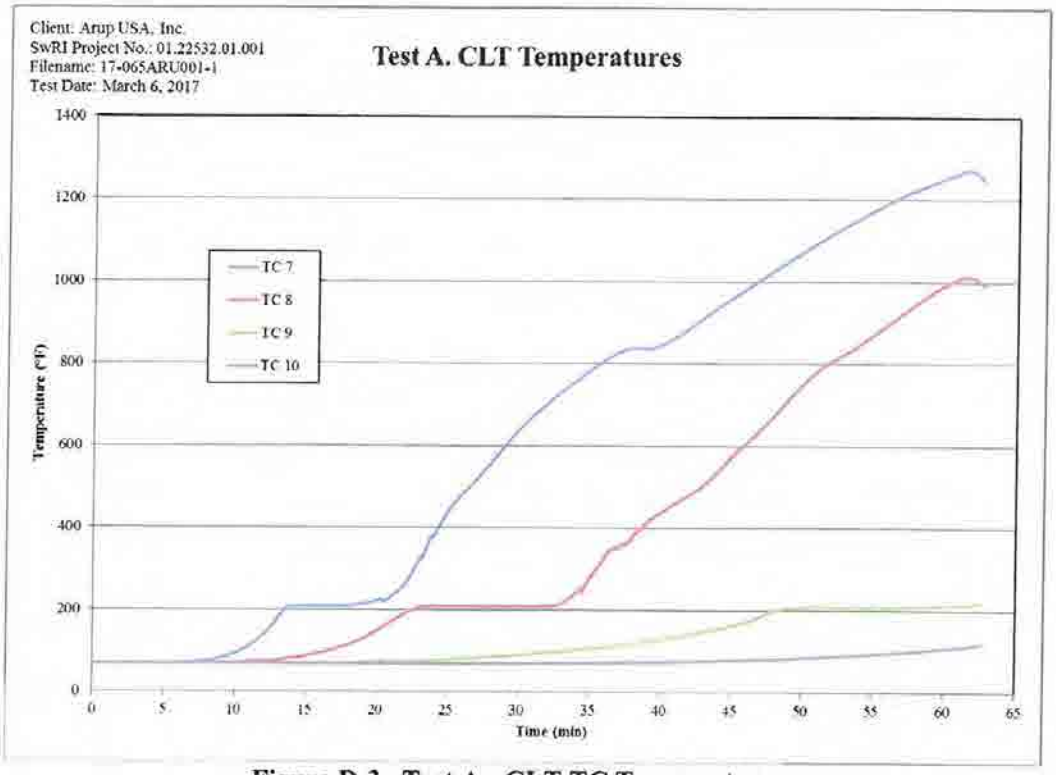

Figure D-3. Test A: CLT TC Temperatures.

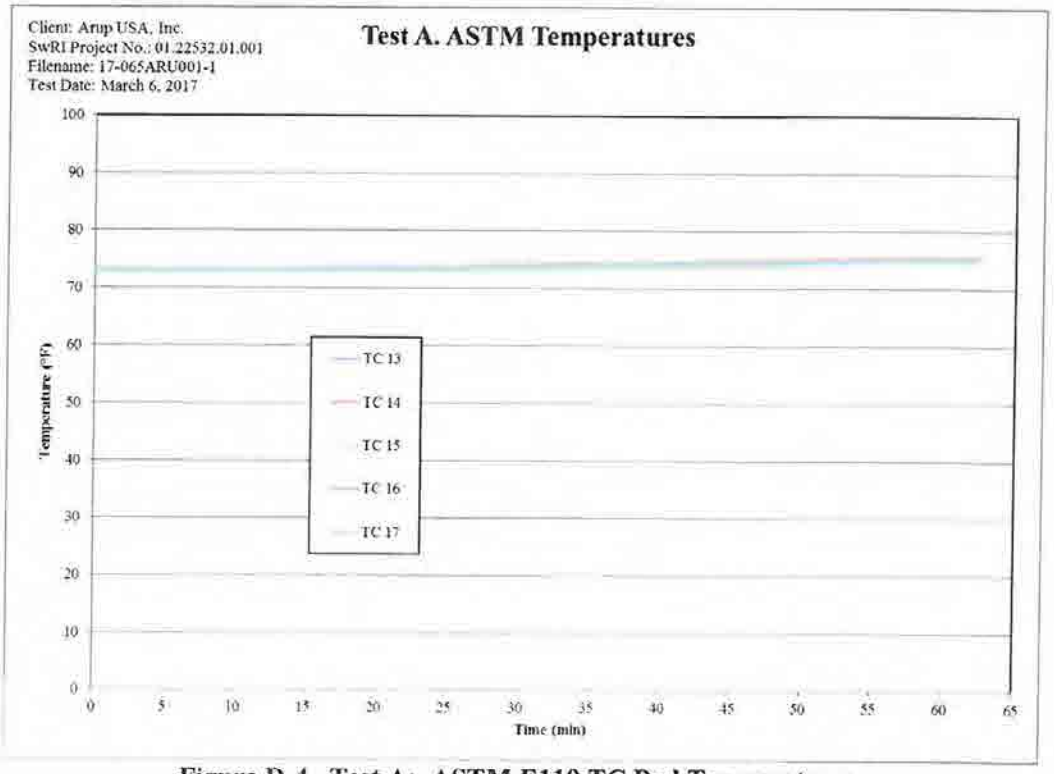

Figure D-4. Test A: ASTM E119 TC Pad Temperatures.

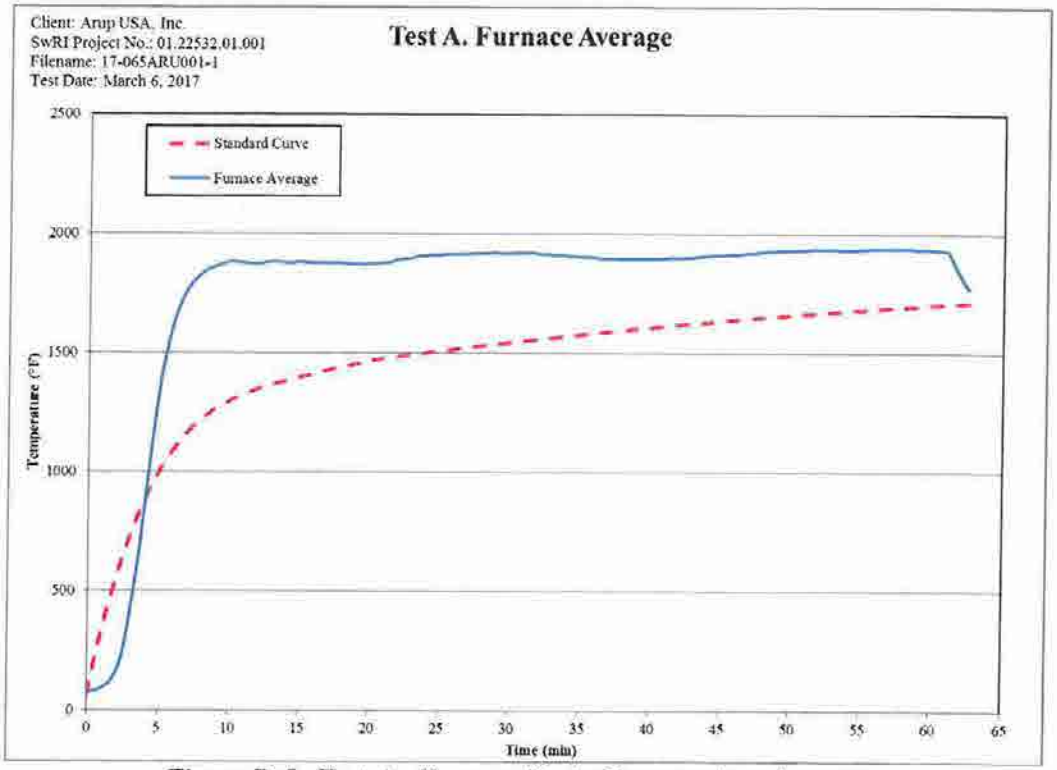

Figure D-5. Test A: Furnace Probe Temperature Average.

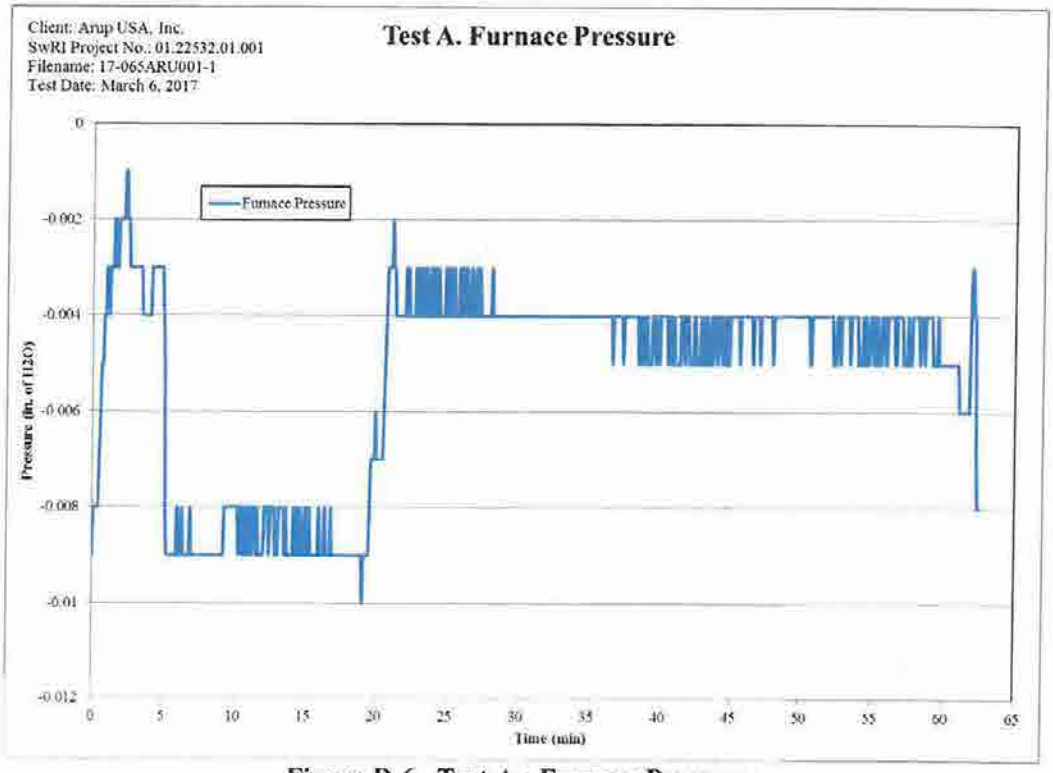

Figure D-6. Test A: Furnace Pressure.

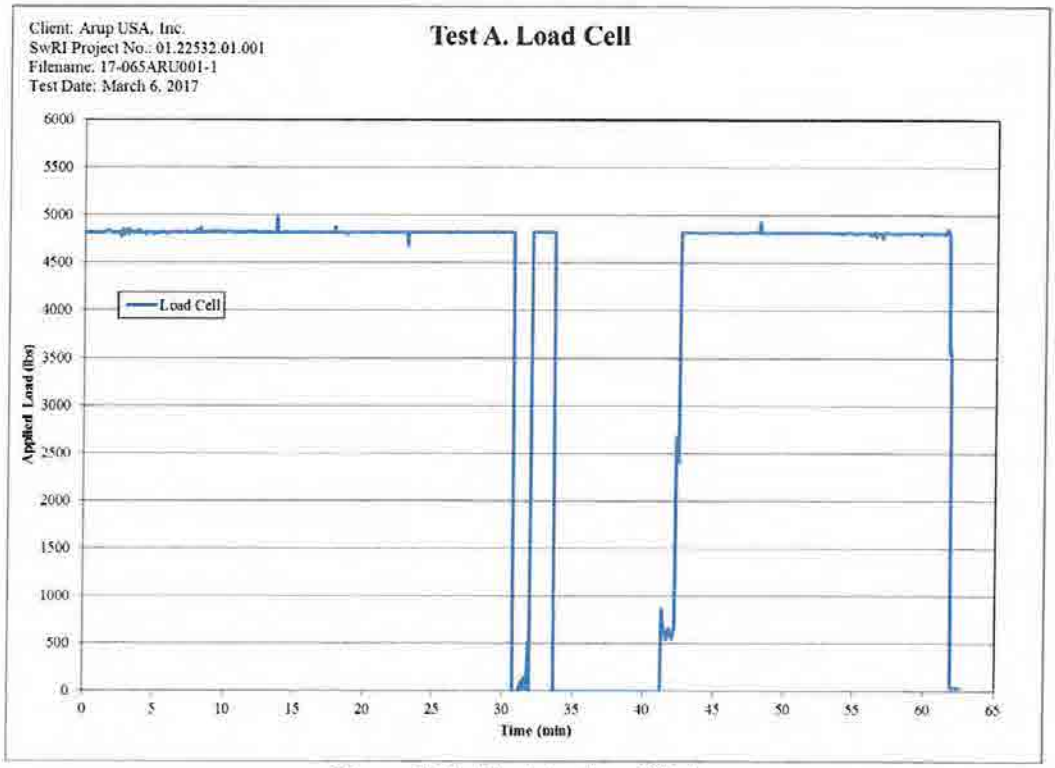

Figure D-7. Test A: Load Data.

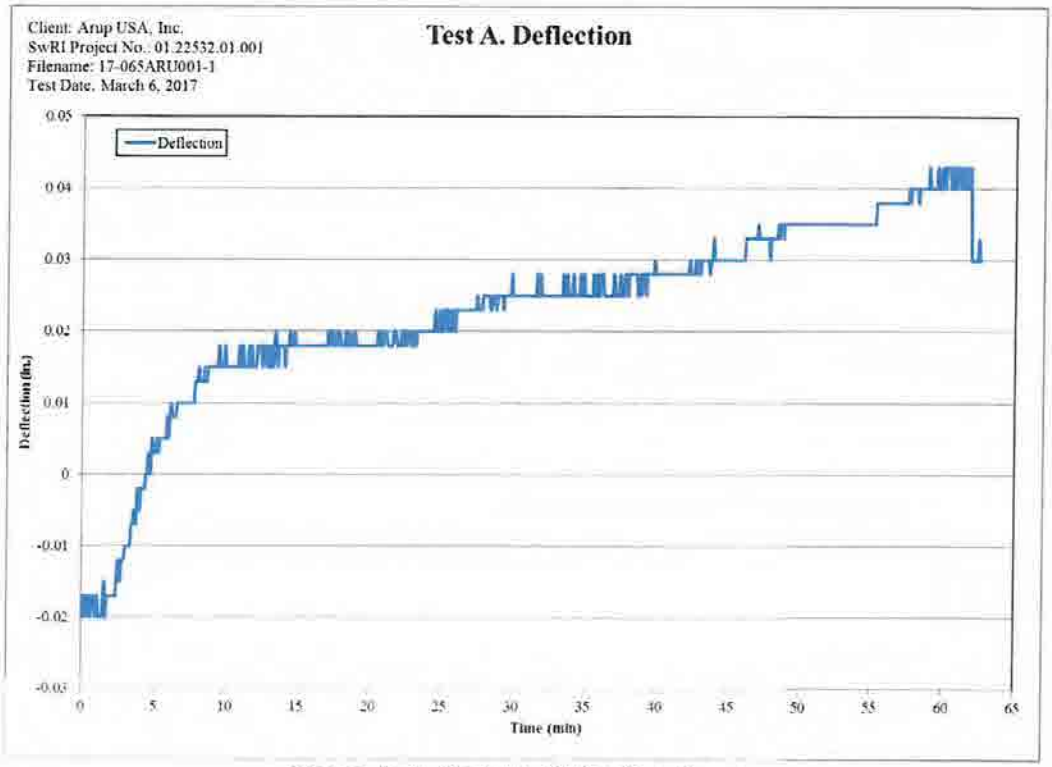

Figure D-8. Test A: Deflection Curve.

APPENDIX E

PHOTOGRAPHIC DOCUMENTATION OF THE TEST AND POST TEST

(CONSISTING OF 4 PAGES)

Figure E-1. View of the Assembly and Applied Load Equipment at 2 min 5 s.

Figure E-2. View of the Test Assembly at 1 h 1 min.

Figure E-3. View of the Assembly immediately after Testing.

Figure E-4. Post Test Pictures of the Beam.

Figure E-5. Post Test Pictures of the Beam.

Figure E-6. Post Test Picture of the Cut Column.

Figure E-7. Post Test Picture of the Cut Column.

Appendix B

Fire Test 2 Report (22532.01.003)

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CHEMISTRY AND CHEMICAL ENGINEERING DIVISION

FIRE TECHNOLOGY DEPARTMENT
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FIRE PERFORMANCE EVALUATION OF A LOAD BEARING GLULAM BEAM TO COLUMN CONNECTION, INCLUDING A CLT PANEL, TESTED IN GENERAL ACCORDANCE WITH ASTM E119-16a, *STANDARD TEST METHODS FOR FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS*

FINAL REPORT
Consisting of 33 Pages

SwRI® Project No. 01.22532.01.002
Test Date: March 7, 2017
Report Date: May 26, 2017

Prepared for:

Softwood Lumber Board
1101 K Street N.W., Suite 700
Washington, DC 20005

Submitted by:

Bill B. Bendele
Principal Engineering Technologist
Fire Resistance Section

Approved by:

Karen C. Carpenter, M.S.
Manager
Fire Resistance Section

1.0 OBJECTIVE

The objective of the test described in this report was to determine the fire endurance rating of a load bearing glulam beam to column connection, including a CLT panel, when exposed to the time/temperature conditions of ASTM E119-16a, *Standard Test Methods for Fire Tests of Building Construction and Materials* with a 20,000-lb load applied to the assembly in a localized area. Testing was conducted by Southwest Research Institute's (SwRI) Fire Technology Department, located in San Antonio, Texas, for Softwood Lumber Board, located in Washington, DC.

2.0 TEST METHOD

The ASTM E119 test method is intended to evaluate the duration for which the assembly tested will contain a fire, or retain its structural integrity, or display both properties dependent upon the type of assembly involved, during a predetermined fire exposure time.

ASTM E119 measures the response of the assembly to exposure in terms of the transmission of heat and hot gases through the assembly. This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment, which takes into account all the factors that are pertinent to an assessment of the fire hazard of a particular end use.

This report describes the testing and analysis of the assembly tested and the results obtained. The results presented in this report apply specifically to the material tested, in the manner tested, and not to the entire production of these or similar materials, nor to the performance when used in combination with other materials.

3.0 TEST ASSEMBLY DESCRIPTION AND STEEL SELF-REACTING LOAD FRAME

The column, beam, beam connections and CLT panel were prepared before shipping to SwRI. SwRI assembled the test pieces the week of March 6, 2017. The material used in construction of the assembly is described in Table 1.

Table 1. Material Description.

Product Name/Description	Supplier	Provided By	Received On
CLT Deck Panel/5ply, Industrial Grade	DR Johnson, Riddle Laminators	Client	February 21, 2017
Glulam Beam Industrial Grade	DR Johnson, Riddle Laminators	Client	February 21, 2017
Glulam Column Industrial Grade	DR Johnson, Riddle Laminators	Client	February 21, 2017
Megant 430 × 150 Connection	MyTiCon	Client	February 21, 2017
Structural Screws	MyTiCon	Client	February 21, 2017
Fire stop	Hilti, Inc.	Client	February 28, 2017

The test assembly consisted of steel connection pieces designed as a slip and tighten hardware, a CLT panel with slots to accommodate the steel self-reacting load frame assembly, beam and column. The assembly components included a column that measured 16.5 × 16.5 in., and a beam that measured 24 in. in depth and 10.75 in. in width. Structural screws, as supplied by MyTiCon, were used to secure the steel connection pieces to the column and beam. With the slip and tighten hardware secured to the beam and to the column, an overhead crane was used to slip the beam hardware into the column hardware and tighten the connection from an access groove in the column above the beam. This access area was then insulated with mineral wool insulation. The connected beam and column was then placed in the steel self-reacting frame and the CLT panel was lifted, set on the beam and fasten to the beam with screws.

SwRI designed and fabricated a steel self-reacting load frame that supported the base of the column on one end inside the furnace and the beam on the other end outside of the furnace. The portion of the load frame that was inside the furnace is insulated and water cooled to protect the load frame from the heat exposure. The bending load was applied with a servo controlled hydraulic actuator attached to the upper horizontal beam. A load cell and an MTS control system was used to control the applied force during the test. A string potentiometer was used to measure the extension of the jack during the test.

For application of the load a 5 × 6 × 1-in. steel plate was positioned on the top of the CLT panel and the load was applied to the steel plate. Assembly drawings, pictures, details of the test items and self-reacting load frame can be found in Appendix A.

4.0 INSTRUMENTATION

The client provided test item thermocouple locations and drilled the holes in the wood members for installation of ⅛-in. Inconel sheathed Type K grounded junction thermocouples. When the thermocouple locations were prepped, SwRI inserted the thermocouple in the drilled hole until it would make contact with the wood or metal temperature measurement location. Nine additional thermocouples were used to record and verify furnace conditions and specimen performance in regards to the ASTM E119 test specification. Five were located on top of the CLT panel and four were probes located to record furnace temperature. The probes were positioned 12 in. from the exposed face of the beam and at the bottom of the beam elevation. A computer based data acquisition system was used to record the applied load, displacement and temperature measurements. The test item thermocouple locations can be found in Appendix B. Instrument calibration information can be found in Appendix C.

5.0 TEST RESULTS

Test Date:	March 7, 2017
Test Witness:	Mr. David Barber, representing Arup USA Inc.
Specimen ID:	Specimen C: Megant 430 × 150 Connection

Ambient Temperature:	78 °F
Relative Humidity:	34%
Observations:	Refer to Table 2.
Rating Obtained:	91 min, based on when the test was terminated
Load:	20,000 lb applied to the steel plate on the CLT panel
Results:	The acquired data for the test is located in Appendix D in graphical form. Photographic documentation of the test can be found in Appendix E.
Deviation:	The test was conducted in general accordance with ASTM E119 since the test was not to evaluate heat transmission. The intent of the test was to provide a rating of the integrity of the load bearing CLT panel fastened to a beam to column connection when exposed to the fire conditions stated in ASTM E119-16a, *Standard Test Methods for Fire Test of Building Construction and Materials.*

Table 2. Fire Resistance Test Visual Observations.

Time (min:s)	Observation
	Pre-test application of the 20,000 lb.
0:00	Start of test, furnace ignited and data acquisition initiated, deflection measurement is zero before the start of the test.
2:10	Wood has ignited.
4:55	Furnace gas is controlled to idle; no visible activity.
20:00	Deflection at 0.072 in.
30:00	Deflection is creeping a small amount.
35:00	Deflection at 0.100 in.; no visible activity.
45:00	Deflection at 0.117 in.; no visible activity.
60:00	Deflection at 0.145 in.; no visible activity.
70:00	Deflection at 0.165 in.; no visible activity.
80:00	Deflection at 0.183 in.
90:00	Deflection at 0.215 in.
91:00	Test terminated.

6.0 POST TEST

After the tested assembly was removed from the furnace and steel reaction load frame, a chainsaw was used to cut a cross section in the thinness area of the column and beam. Table 3 provides the measurements of the locations and pictures can be found in Appendix D.

Table 3. Post Test Measurements.

Test Items	Measurements
Beam original dimension	24.00 × 10.75 in.
Post Test Beam measurement, middle of the beam	No measurement × 5.25 in.
Column original dimension	16.50 × 16.50 in.
Post Test Column measurement	No measurement × 11.5 in.

7.0 CONCLUSION

Based on the test results, the load bearing CLT panel fastened to a glulam beam to column connection, constructed as described herein, obtained a 91-min fire endurance rating when tested in general accordance with ASTM E119-16a.

APPENDIX A

CONSTRUCTION PICTURES AND CLIENT-PROVIDED ASSEMBLY DRAWINGS

(CONSISTING OF 8 PAGES)

Figure A-1. Unexposed Side of CLT Panel.

Figure A-2. Beam Steel Connection Piece.

Figure A-3. Column Steel Connection Piece.

Figure A-4. Beam and Column Connection.

Figure A-5. Test Article Installed in Self-Reacting Frame.

Figure A-6. Test Assembly Instrumented and Placed Inside Furnace.

Figure A-7. Load Application Instrumentation.

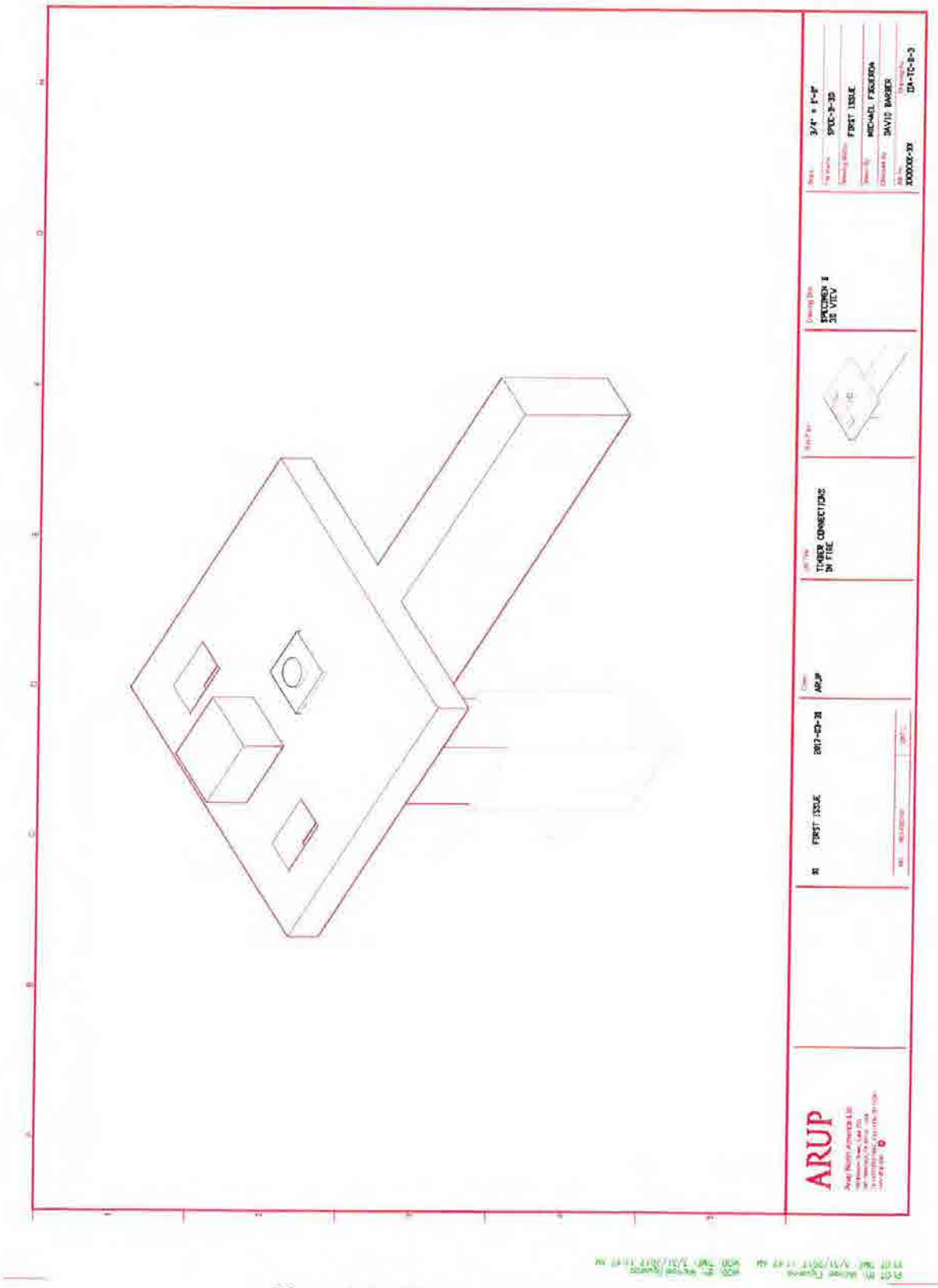

Figure A-8. Client-Provided Drawing.

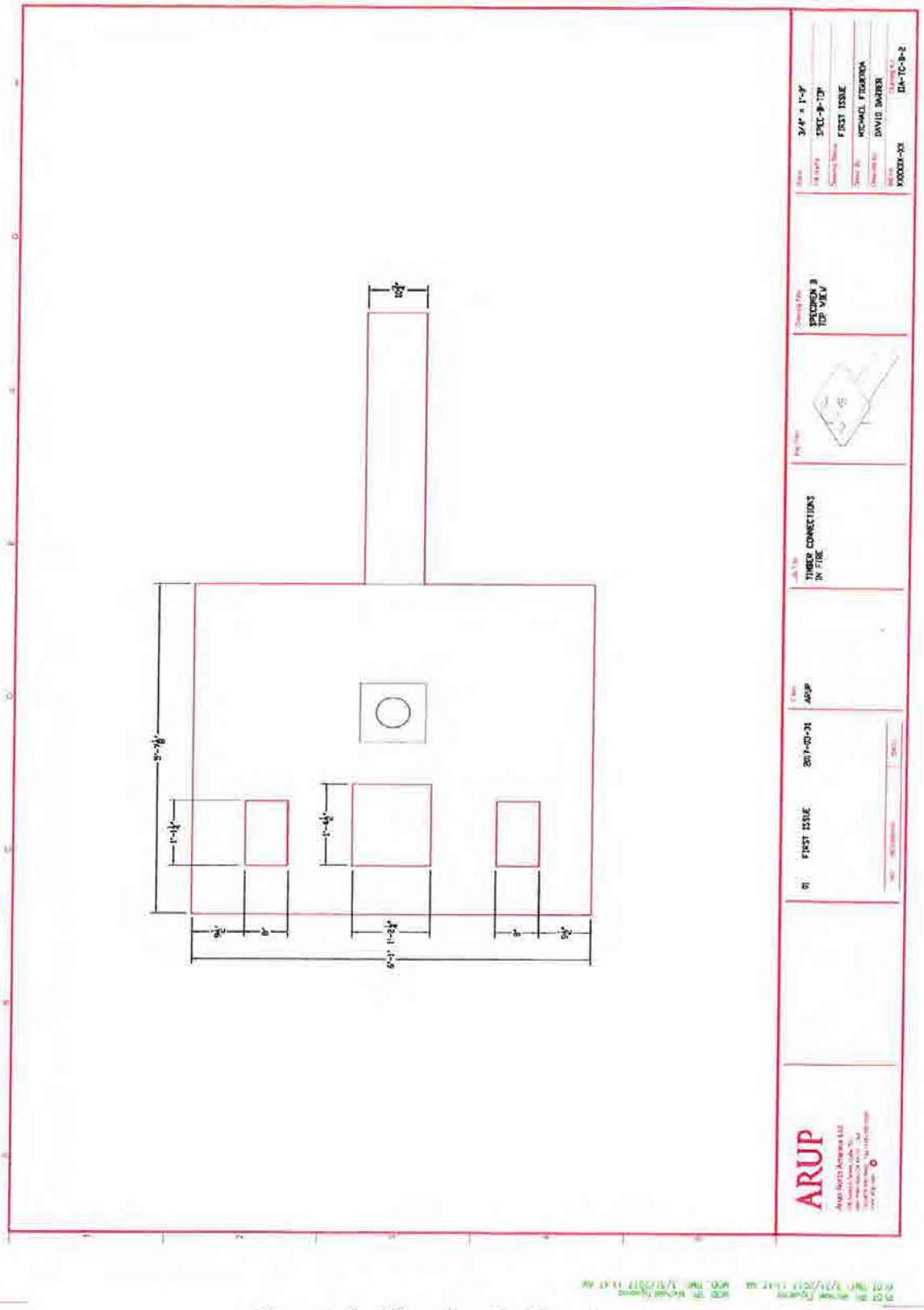

Figure A-9. Client-Provided Drawing.

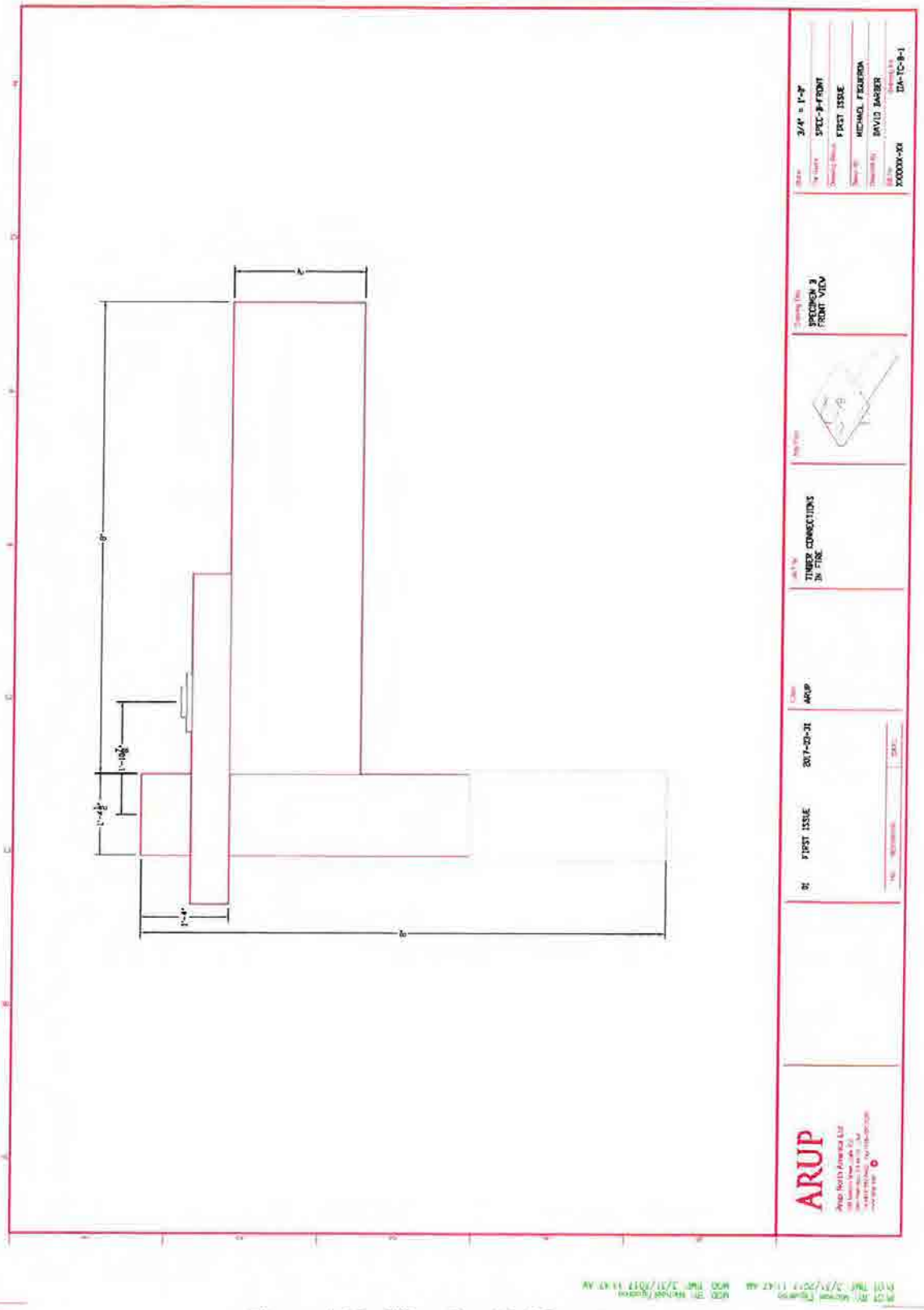

Figure A-10. Client-Provided Drawing.

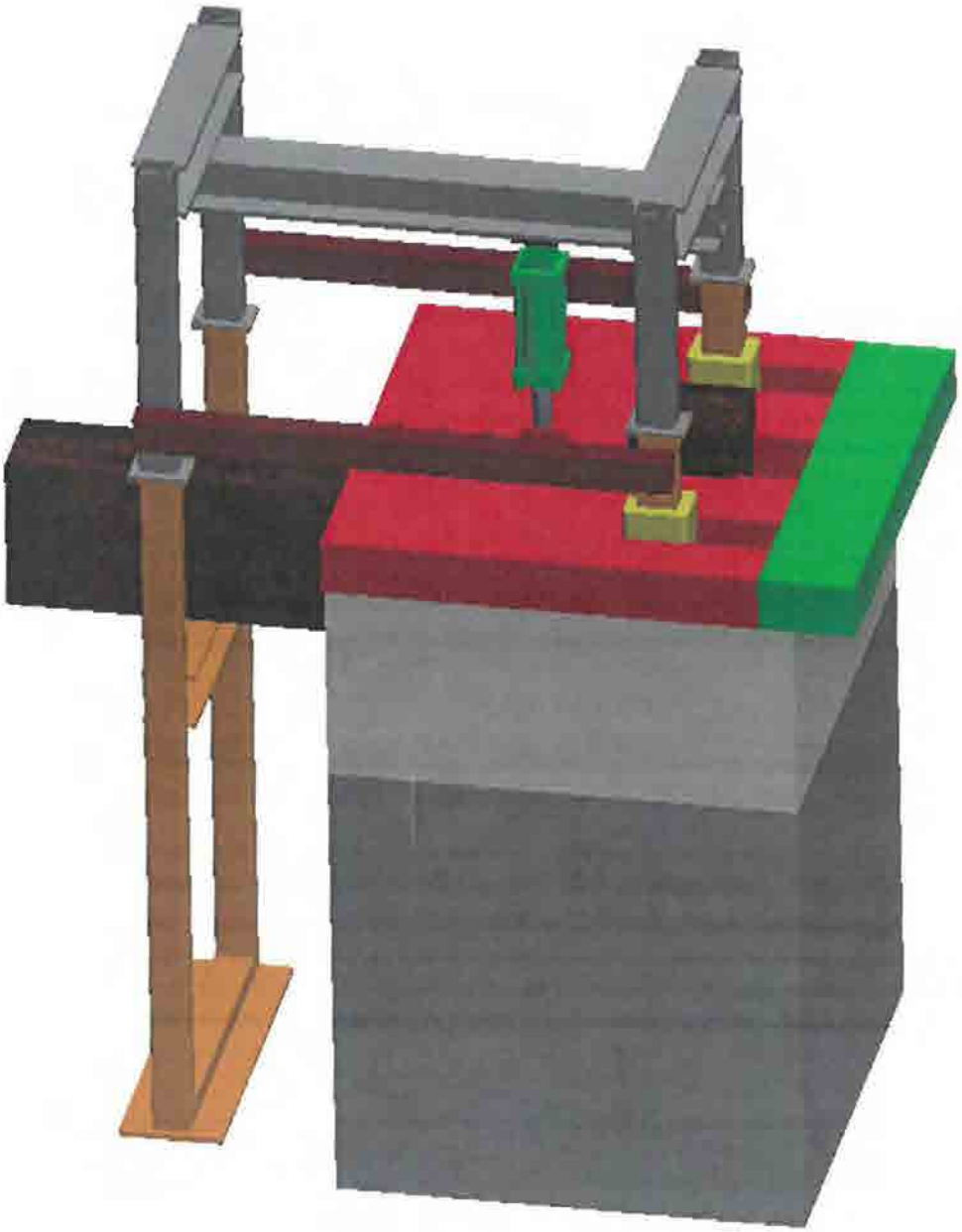

Figure A-9. Load Frame and Furnace Rendering.

APPENDIX B

THERMOCOUPLE LOCATIONS

(CONSISTING OF 5 PAGES)

Table B-1. Thermocouple Locations.

Thermocouple Number	Description
1	Located centrally at the connector.
2	Located centrally at the connector.
3	Located 16 in. from the beam connector (approx.). Hole drilled in from top of beam, to a depth of 4 in. Located 1 in. from right hand side of the beam.
4	Located 18 in. from the beam connector (approx.). Hole drilled in from top of beam, to a depth of 4 in. Located 2 in. from right hand side of the beam.
5	Located 16 in. from beam connector (approx.). Hole drilled in from top of beam, to a depth of 4 in. Located 1 in. from left hand side of the beam.
6	Located 18 in. from beam connector (approx.). Hole drilled in from top of beam, to a depth of 4 in. Located 2 in. from left hand side of the beam.
7	Located 2 ft 2 in. from CLT front edge. Located 1 ft 9 in. from CLT side. Hole drilled in from top of CLT, to a depth of 6 in.
8	Located 2 ft 2 in. from CLT front edge. Located 1 ft 6in. from CLT side. Hole drilled in from top of CLT, to a depth of 5.5 in.
9	Located 2 ft 2 in. from CLT front edge. Located 1 ft 3 in. from CLT side. Hole drilled in from top of CLT, to a depth of 5 in.
10	Located 2 ft 2 in. from CLT front edge. Located 1 ft from CLT side. Hole drilled in from top of CLT, to a depth of 4.5 in.
11	Located centrally at the connector.
12	Located centrally at the connector.

Figure B-1. CLT Panel Orientation for Thermocouple Installation.

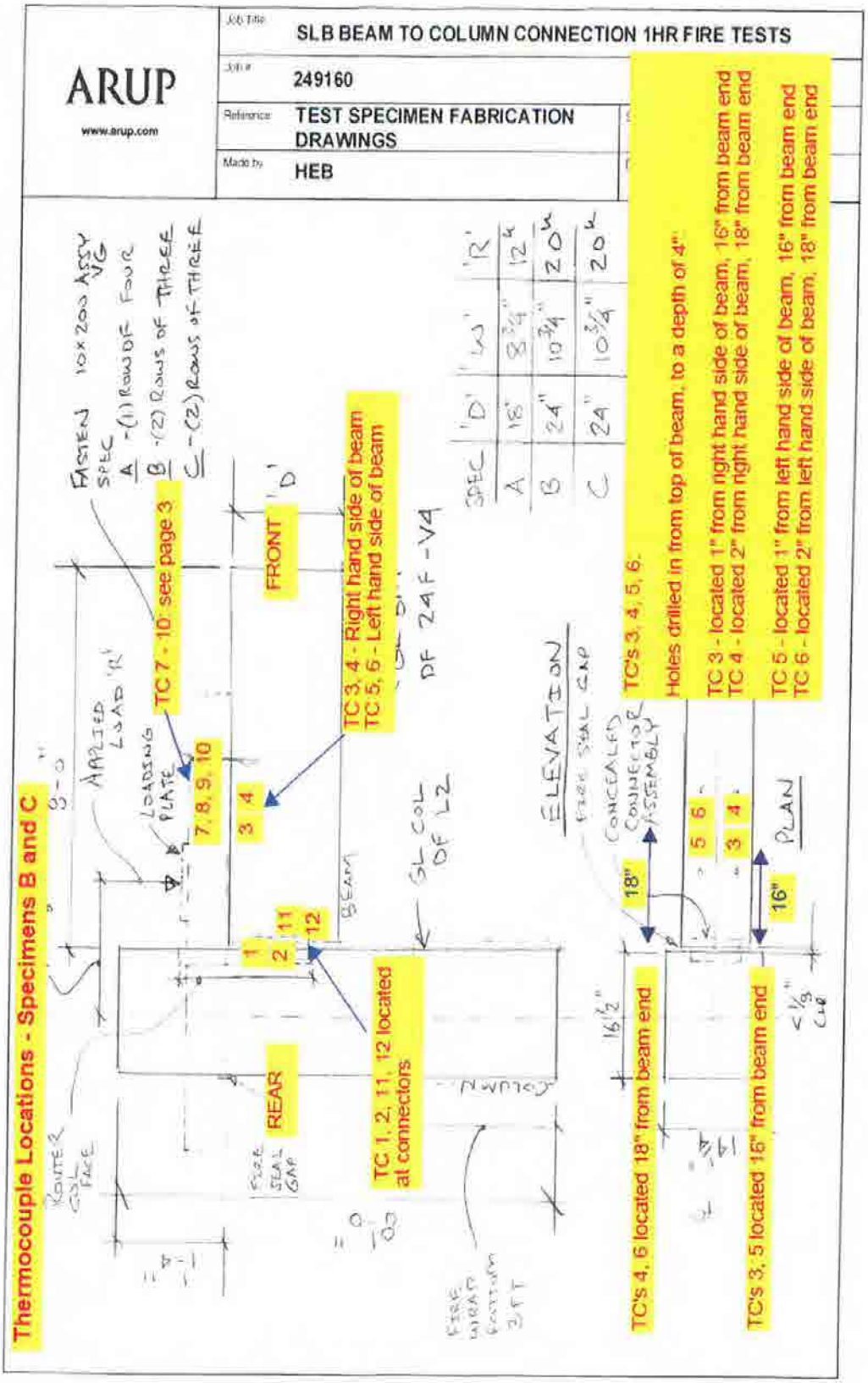

Figure B-2. Thermocouple Locations.

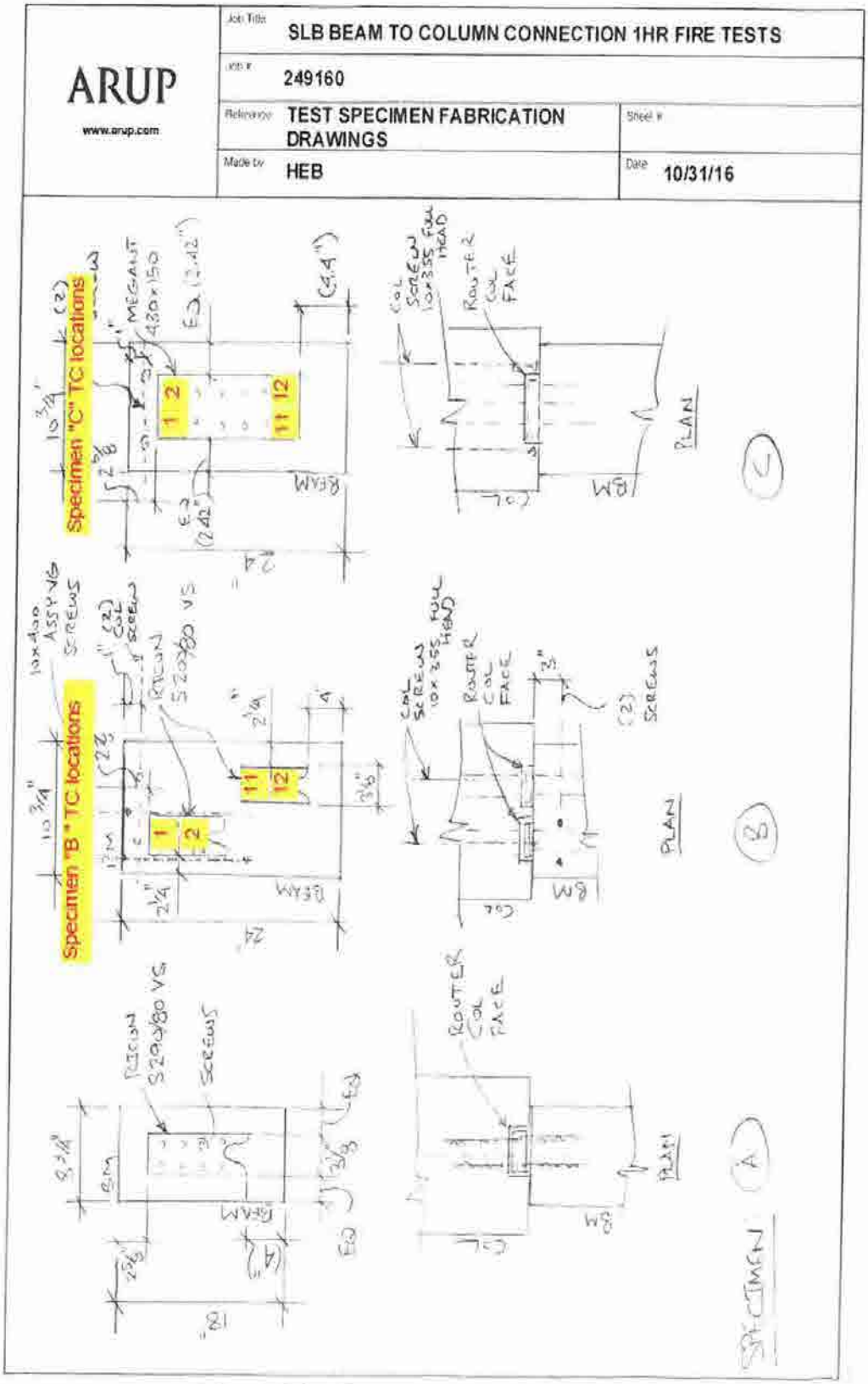

Figure B-3. Thermocouple Locations.

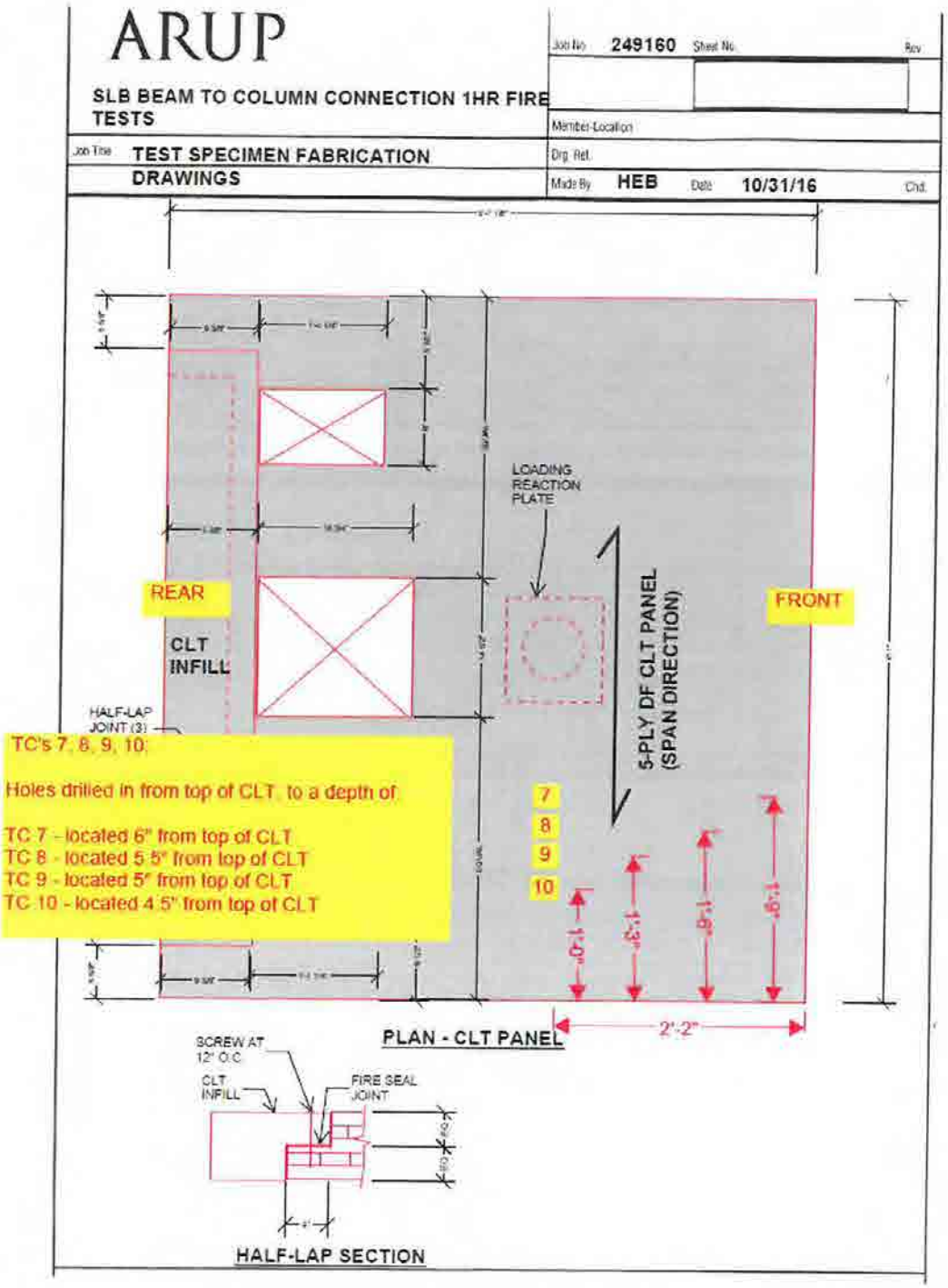

Figure B-4. Thermocouple Locations.

APPENDIX C

EQUIPMENT CALIBRATION DOCUMENTATION

(CONSISTING OF 1 PAGE)

Table C-1. Equipment Calibration Documentation.

Item	Make	Model	Serial No.	Cal Due
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Load Cell	Strainsert	SPHC-2XO	Q14372-14	July 26, 2017
Humidity/Temp Indicator	Vaisala	HM 34	W2420016	September 23, 2017

APPENDIX D

GRAPHICAL TEST DATA

(CONSISTING OF 4 PAGES)

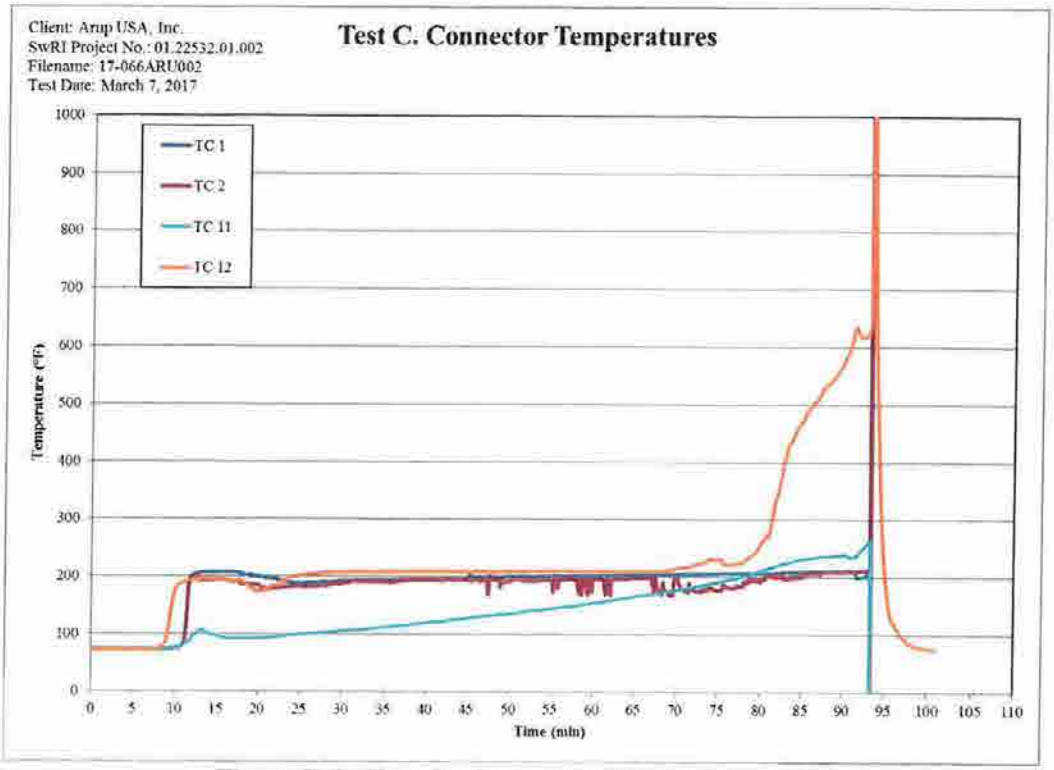

Figure D-1. Test C: Connector TC Temperatures.

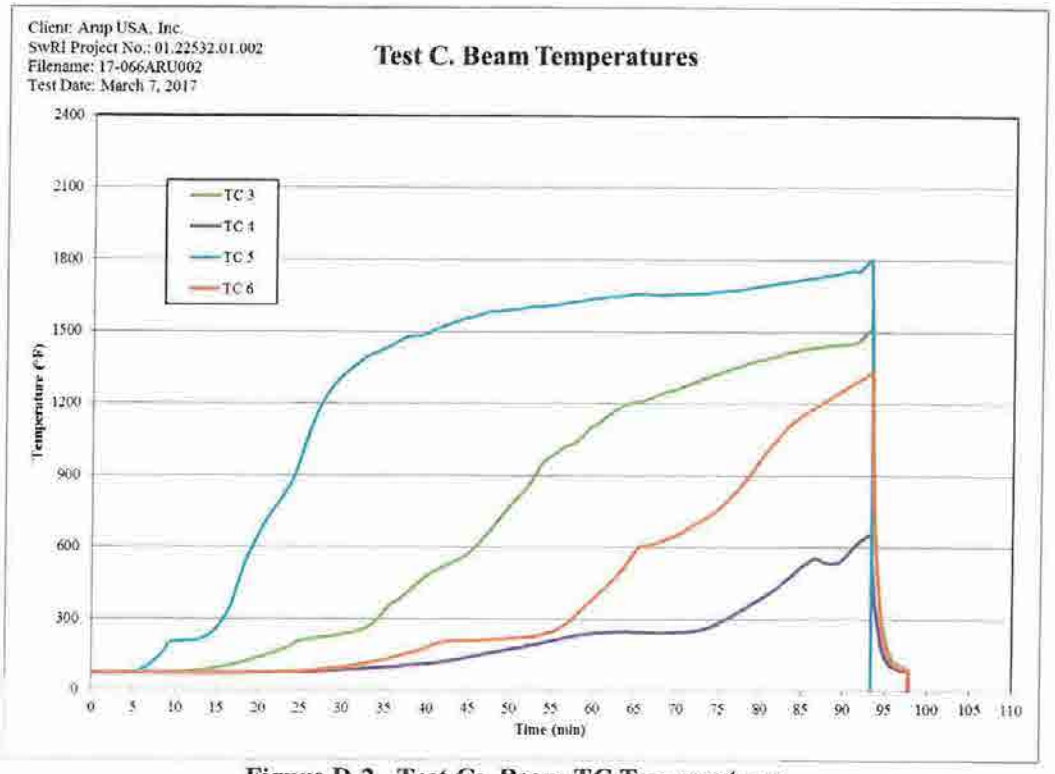

Figure D-2. Test C: Beam TC Temperatures.

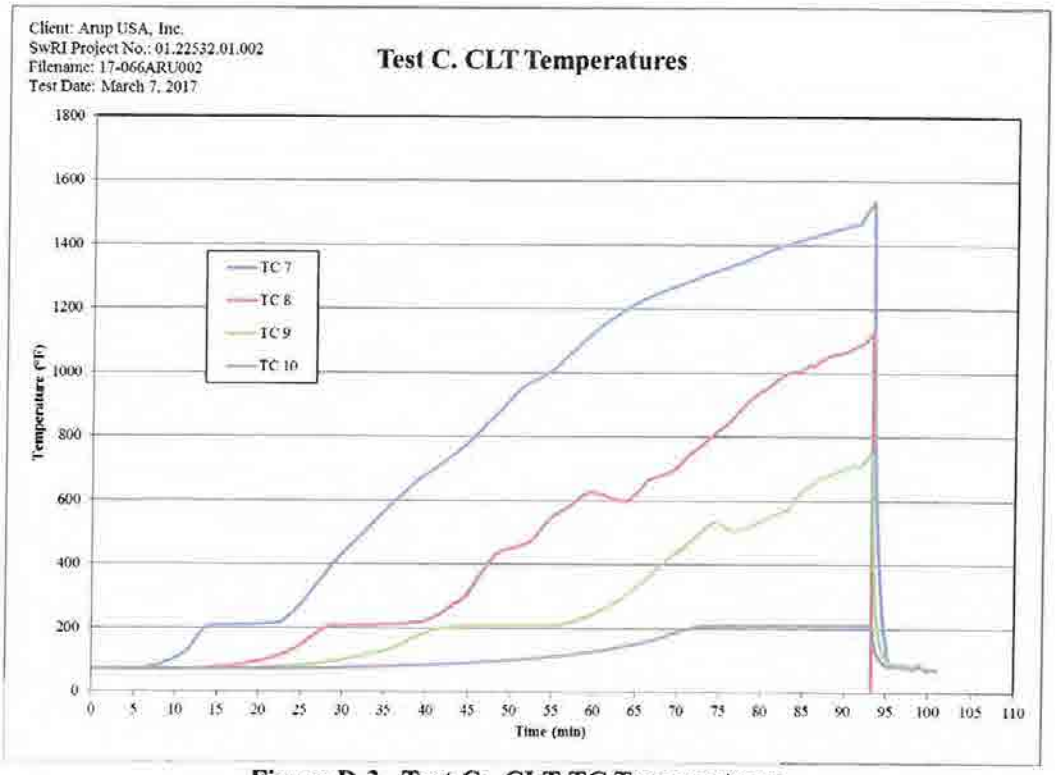

Figure D-3. Test C: CLT TC Temperatures.

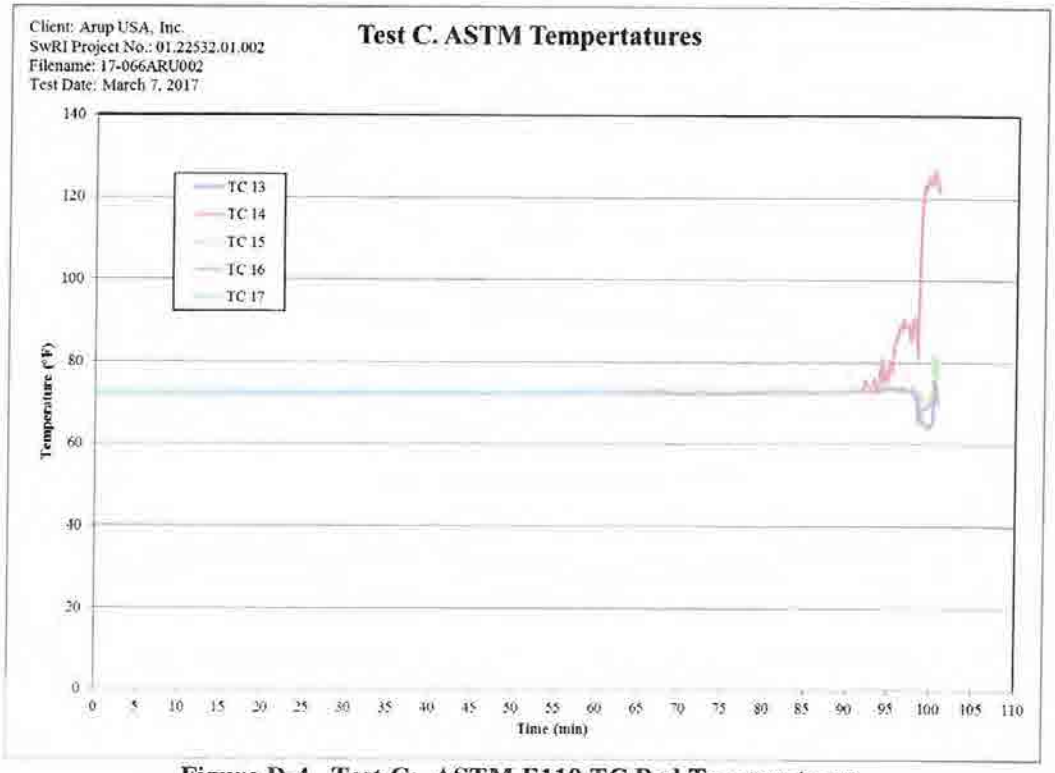

Figure D-4. Test C: ASTM E119 TC Pad Temperatures.

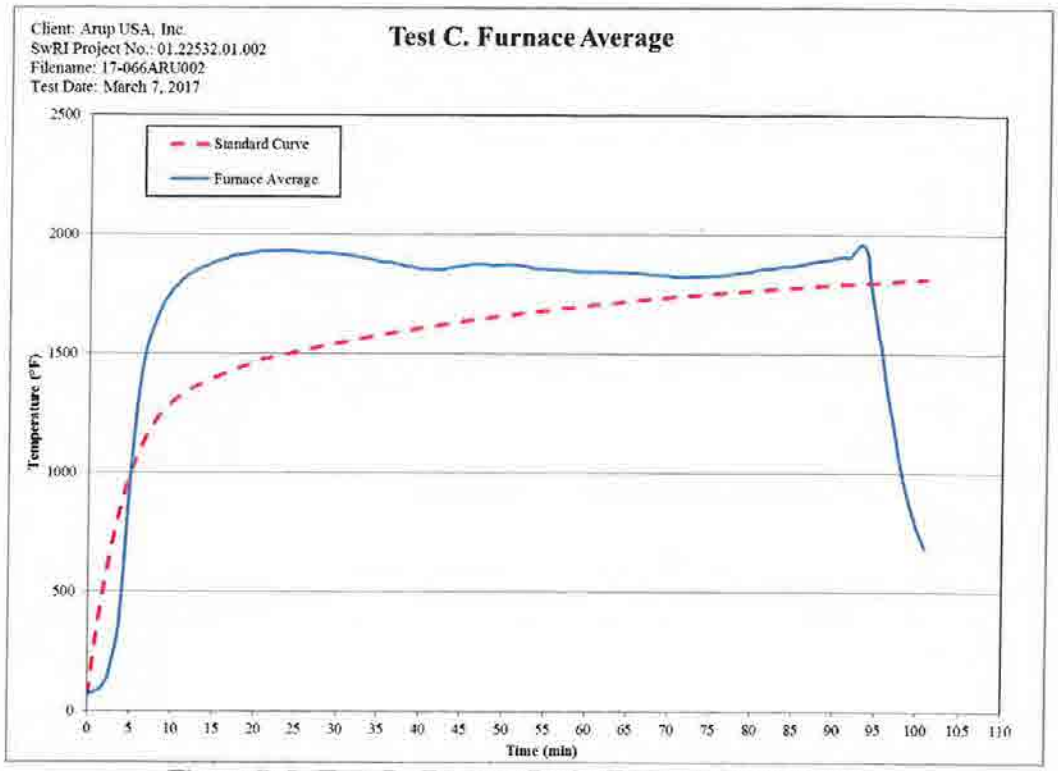

Figure D-5. Test C: Furnace Probe Temperature Average.

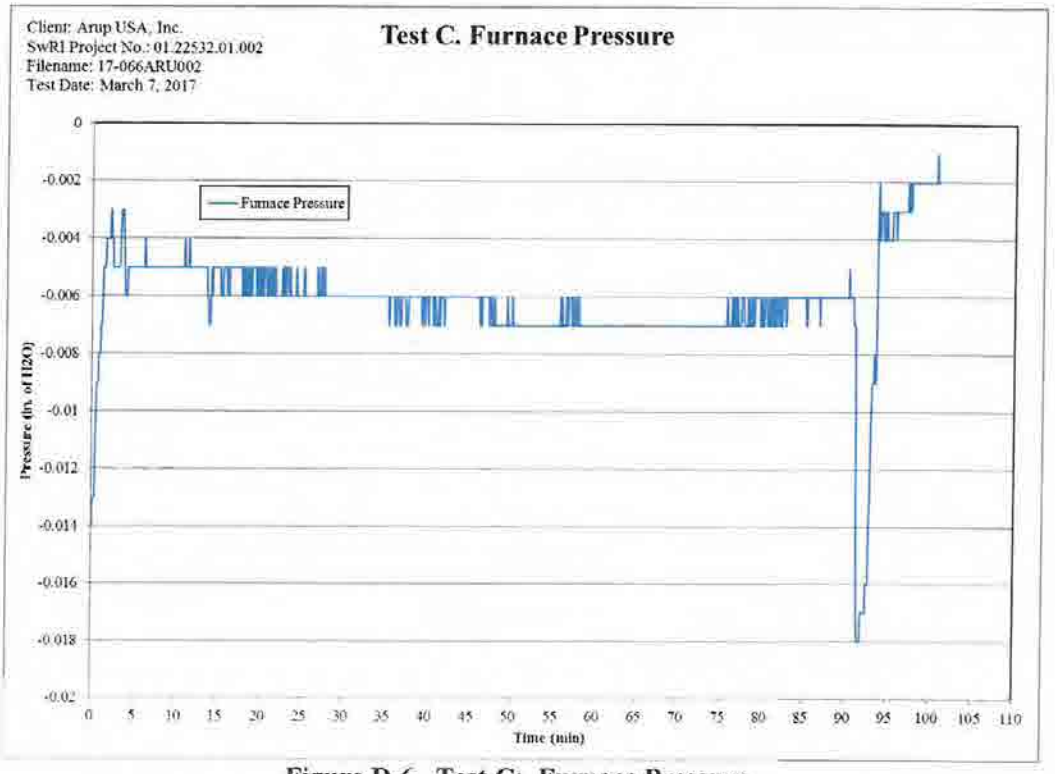

Figure D-6. Test C: Furnace Pressure.

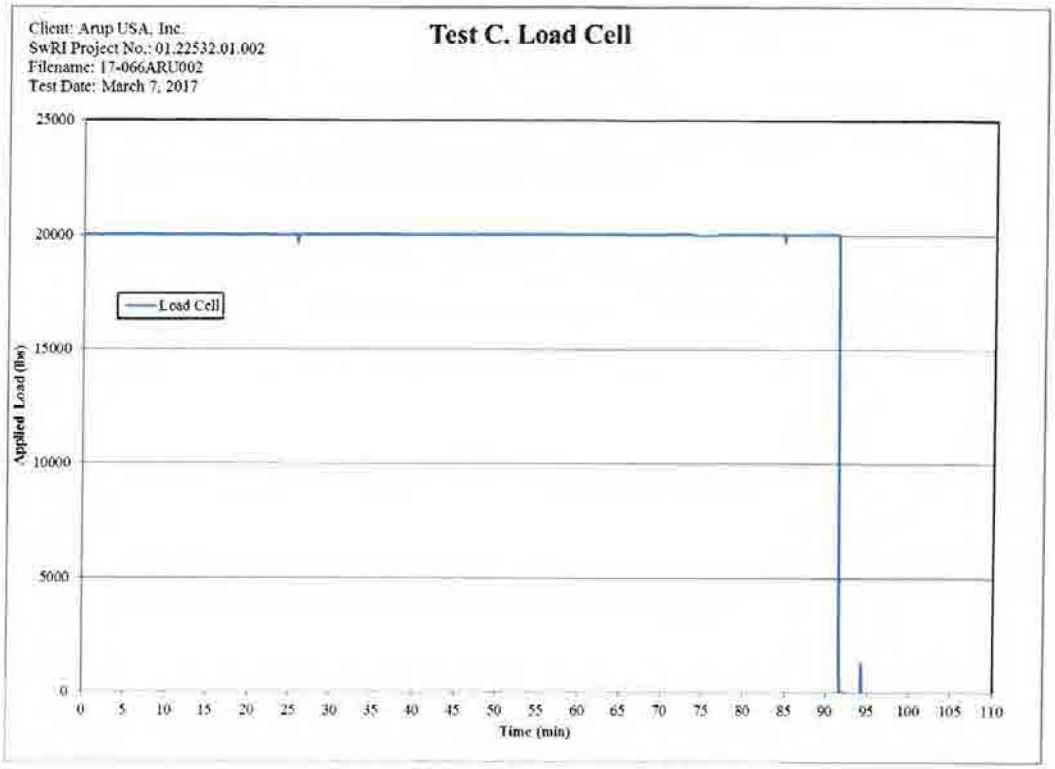

Figure D-7. Test C: Load Data.

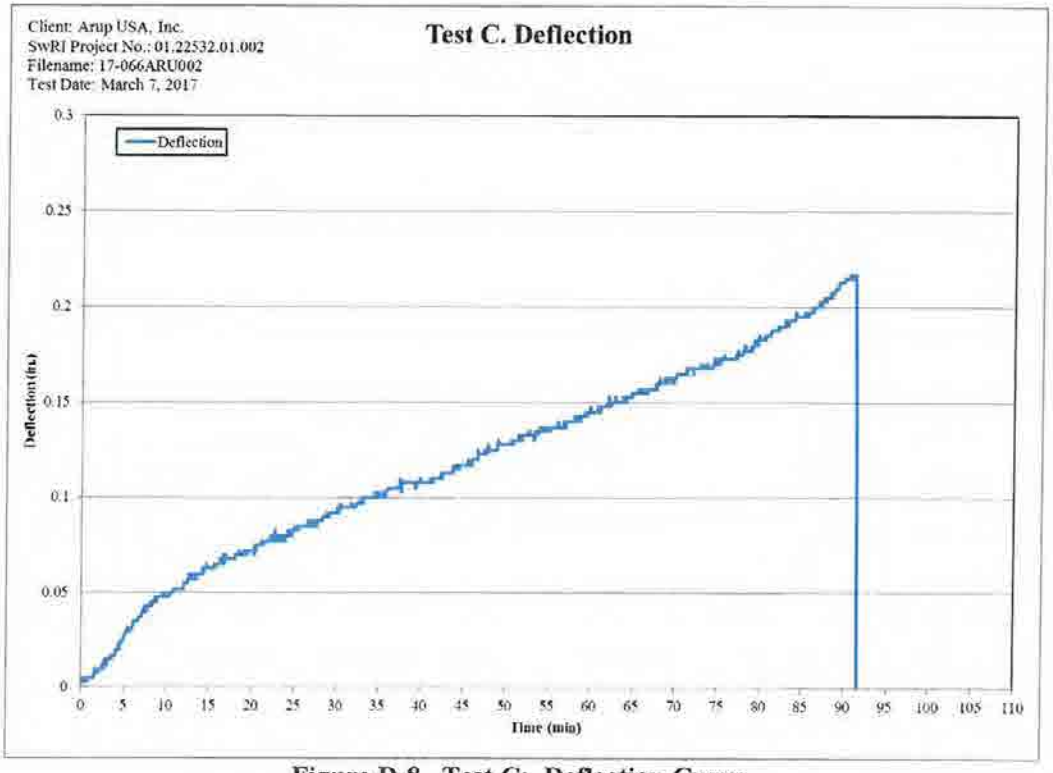

Figure D-8. Test C: Deflection Curve.

APPENDIX E

PHOTOGRAPHIC DOCUMENTATION OF THE TEST AND POST TEST

(CONSISTING OF 5 PAGES)

Figure E-1. View of the Assembly and Applied Load Equipment at Start of Test.

Figure E-2. View of the Test Assembly at 30 min 6 s.

Figure E-3. View of the Test Assembly at 1 h 40 s.

Figure E-4. View of the Test Assembly at 1 h 30 min.

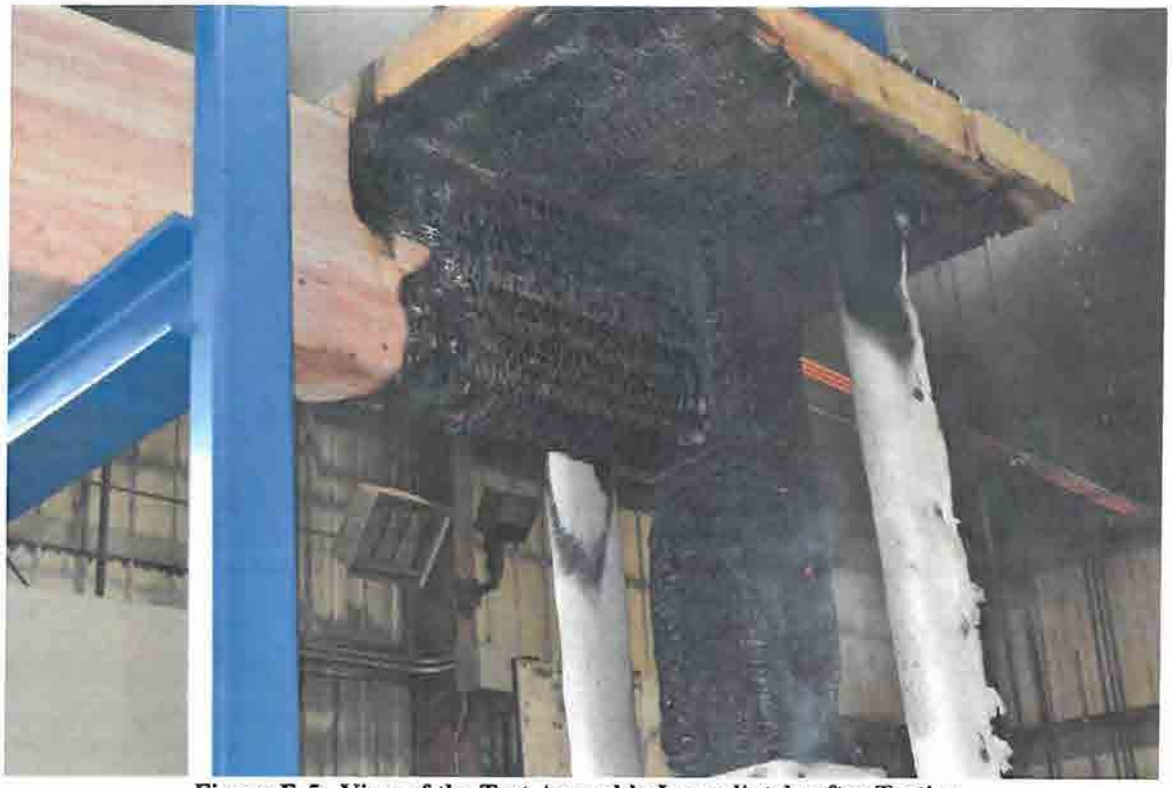

Figure E-5. View of the Test Assembly Immediately after Testing.

Figure E-6. Post Test Picture of the Beam (Mislabeled B, Should be C).

Figure E-7. Post Test Picture of the Cut Column (Mislabeled B, Should be C).

Figure E-8. Post Test Picture of the Steel Connection on Beam.

Figure E-7. Post Test Picture of the Steel Connection on Column (Mislabeled B, Should be C).

Appendix C

Fire Test 3 Report (22532.01.002)

SOUTHWEST RESEARCH INSTITUTE

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CHEMISTRY AND CHEMICAL ENGINEERING DIVISION

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FIRE PERFORMANCE EVALUATION OF A LOAD BEARING GLULAM BEAM TO COLUMN CONNECTION, INCLUDING A CLT PANEL, TESTED IN GENERAL ACCORDANCE WITH ASTM E119-16a, *STANDARD TEST METHODS FOR FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS*

FINAL REPORT
Consisting of 32 Pages

SwRI® Project No. 01.22532.01.003
Test Date: March 9, 2017
Report Date: May 26, 2017

Prepared For:

Softwood Lumber Board
1101 K Street N.W., Suite 700
Washington, DC 20005

Submitted by:

Bill B. Bendele
Principal Engineering Technologist
Fire Resistance Section

Approved by:

Karen C. Carpenter, M.S.
Manager
Fire Resistance Section

1.0 OBJECTIVE

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2.0 TEST METHOD

The ASTM E119 test method is intended to evaluate the duration for which the assembly tested will contain a fire, or retain its structural integrity, or display both properties dependent upon the type of assembly involved, during a predetermined fire exposure time.

ASTM E119 measures the response of the assembly to exposure in terms of the transmission of heat and hot gases through the assembly. This standard should be used to measure and describe the properties of materials, products, or assemblies in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fire hazard or fire risk of materials, products, or assemblies under actual fire conditions. However, results of this test may be used as elements of a fire risk assessment, which takes into account all the factors that are pertinent to an assessment of the fire hazard of a particular end use.

This report describes the testing and analysis of the assembly tested and the results obtained. The results presented in this report apply specifically to the material tested, in the manner tested, and not to the entire production of these or similar materials, nor to the performance when used in combination with other materials.

3.0 TEST ASSEMBLY DESCRIPTION AND STEEL SELF-REACTING LOAD FRAME

The column, beam, beam connections and CLT panel were prepared before shipping to SwRI. SwRI assembled the test pieces the week of March 6, 2017. The material used in construction of the assembly is described in table 1.

Table 1. Material Description.

Product Name/Description	Supplier	Provided By	Received On
CLT Deck Panel/5ply, Industrial Grade	DR Johnson, Riddle Laminators	Client	February 21, 2017
Glulam Beam Industrial Grade	DR Johnson, Riddle Laminators	Client	February 21, 2017
Glulam Column Industrial Grade	DR Johnson, Riddle Laminators	Client	February 21, 2017
Double Ricon S VS 200 × 80 Connection	MyTiCon	Client	February 21, 2017
Structural Screws	MyTiCon	Client	February 21, 2017
Fire Stop	Hilti, Inc.	Client	February 28, 2017

The test assembly consisted of steel connection pieces designed as a double slip and lock hardware, a CLT panel with slots to accommodate the steel self-reacting load frame assembly, beam and column. The assembly components included a column that measured 16.5 × 16.5 in. and a beam that measured 24 in. in depth and 10.75 in. in width. Structural screws, as supplied by MyTiCon, were used to secure the steel connection pieces to the column and beam. With the double slip and lock hardware secured to the beam and to the column, an overhead crane was used to slip the beam hardware into the column hardware. The connected beam and column was then placed in the steel self-reacting frame and the CLT panel was lifted, set on the beam and fasten to the beam with screws.

SwRI designed and fabricated a steel self-reacting load frame that supported the base of the column on one end inside the furnace and the beam on the other end outside of the furnace. The portion of the load frame that was inside the furnace is insulated and water cooled to protect the load frame from the heat exposure. The bending load was applied with a servo controlled hydraulic actuator attached to the upper horizontal beam. A load cell and an MTS control system was used to control the applied force during the test. A string potentiometer was used to measure the extension of the jack during the test.

For application of the load a 5 × 6 × 1-in. steel plate was positioned on the top of the CLT panel and the load was applied to the steel plate. Assembly drawings, pictures, details of the test items and self-reacting load frame can be found in Appendix A.

4.0 INSTRUMENTATION

The Client provided test item thermocouple locations and drilled the holes in the wood members for installation of ⅛-in. Inconel sheathed Type K grounded junction thermocouples. When the thermocouple locations were prepped, SwRI inserted the thermocouple in the drilled hole until it would make contact with the wood or metal temperature measurement location. Nine additional thermocouples were used to record and verify furnace conditions and specimen performance in regards to the ASTM E119 test specification. Five were located on top of the CLT panel and four were probes located to record furnace temperature. The probes were positioned 12 in. from the exposed face of the beam and at the bottom of the beam elevation. A computer based data acquisition system was used to record the applied load, displacement and temperature measurements. The test item thermocouple locations can be found in Appendix B. Instrument calibration information can be found in Appendix C.

5.0 TEST RESULTS

Test Date:	March 9, 2017
Test Witness:	Mr. David Barber, representing Arup USA Inc.
Specimen ID:	Specimen B: Double Ricon S VS 200 × 80 Connection
Ambient Temperatures:	78 °F
Relative Humidity:	34%
Observations:	Refer to Table 2.
Rating Obtained:	91 min, based on when the test was terminated

Load: 20,000 lb applied to the steel plate on the CLT panel

Results: The acquired data for the test is located in Appendix D in graphical form. Photographic documentation of the test can be found in Appendix E.

Deviation: The test was conducted in general accordance with ASTM E119 since the test was not to evaluate heat transmission. The intent of the test was to provide a rating of the integrity of the load bearing CLT panel fastened to a beam to column connection when exposed to the fire conditions stated in ASTM E119-16a, *Standard Test Methods for Fire Test of Building Construction And Materials.*

Table 2. Fire Resistance Test Visual Observations.

Time (Min:S)	Observation
	Pre-test application of the 20,000 lb.
0:00	Start of test, furnace ignited and data acquisition initiated, deflection measurement is zero before the start of the test.
1:20	Wood has ignited.
2:15	Furnace gas is controlled to idle.
10:00	Resume furnace gas.
13:00	Furnace gas is controlled to idle.
15:00	Deflection at 0.05 in.; resume furnace gas.
25:00	Deflection at 0.065 in.
30:00	Furnace gas is controlled to idle.
40:00	Deflection at 0.092 in.
50:00	Deflection at 0.110 in.
60:00	Deflection at 0.130 in.
70:00	Deflection at 0.148 in.
80:00	Deflection at 0.170 in.
90:00	Deflection at 0.208 in.
91:00	Terminate the test.

6.0 POST TEST

After the tested assembly was removed from the furnace and steel reaction load frame, a chainsaw was used to cut a cross section in the thinness area of the column and beam. Table 3 provides the measurements of the locations and pictures can be found in Appendix D.

Table 3. Post Test Measurements.

Test Items	Measurements
Beam original dimension	24 × 10.75 in.
Post Test Beam measurement, middle of the beam	No measurement × 6 in.
Column original dimension	16.50 × 16.50 in.
Post Test Column measurement	No measurement × 11.5 in.

7.0 CONCLUSION

Based on the test results, the load bearing CLT panel, fastened to a glulam beam to column connection, constructed as described herein, obtained a 91-min fire endurance rating when tested in general accordance with ASTM E119-16a.

APPENDIX A

CONSTRUCTION PICTURES AND CLIENT-PROVIDED ASSEMBLY DRAWINGS

(CONSISTING OF 7 PAGES)

Figure A-1. Unexposed Side of CLT Panel.

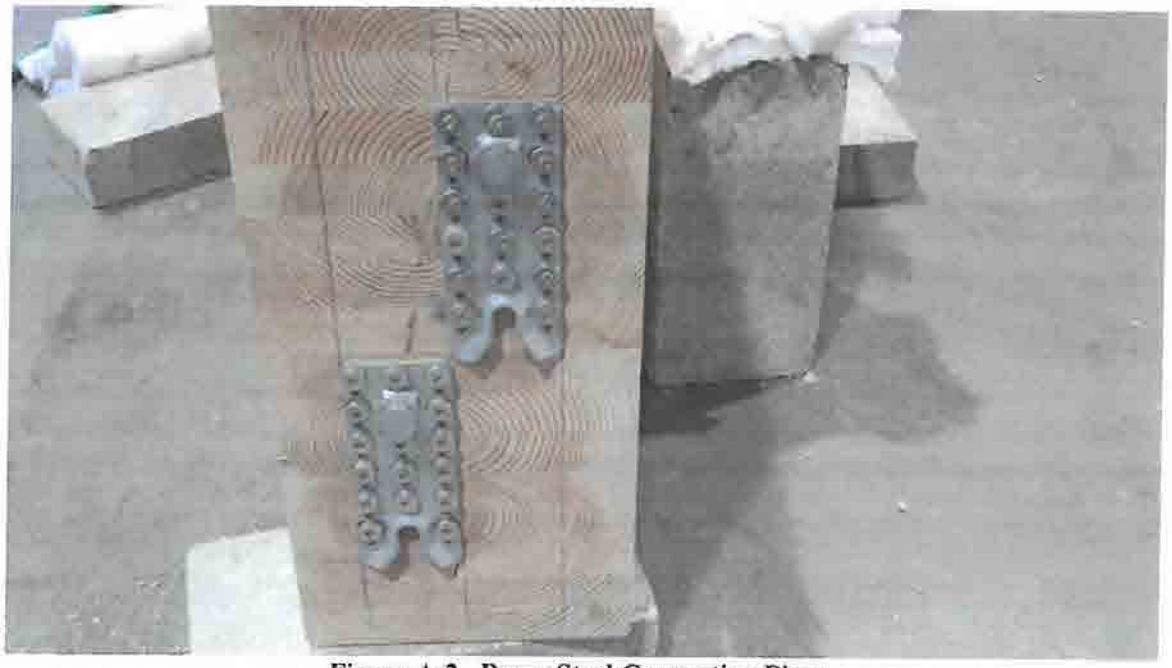

Figure A-2. Beam Steel Connection Piece.

Figure A-3. Column Steel Connection Piece.

Figure A-4. Typical Beam and Column Connection.

Figure A-5. Test Assembly Instrumented and Placed Inside Furnace.

Figure A-6. Load Application Instrumentation.

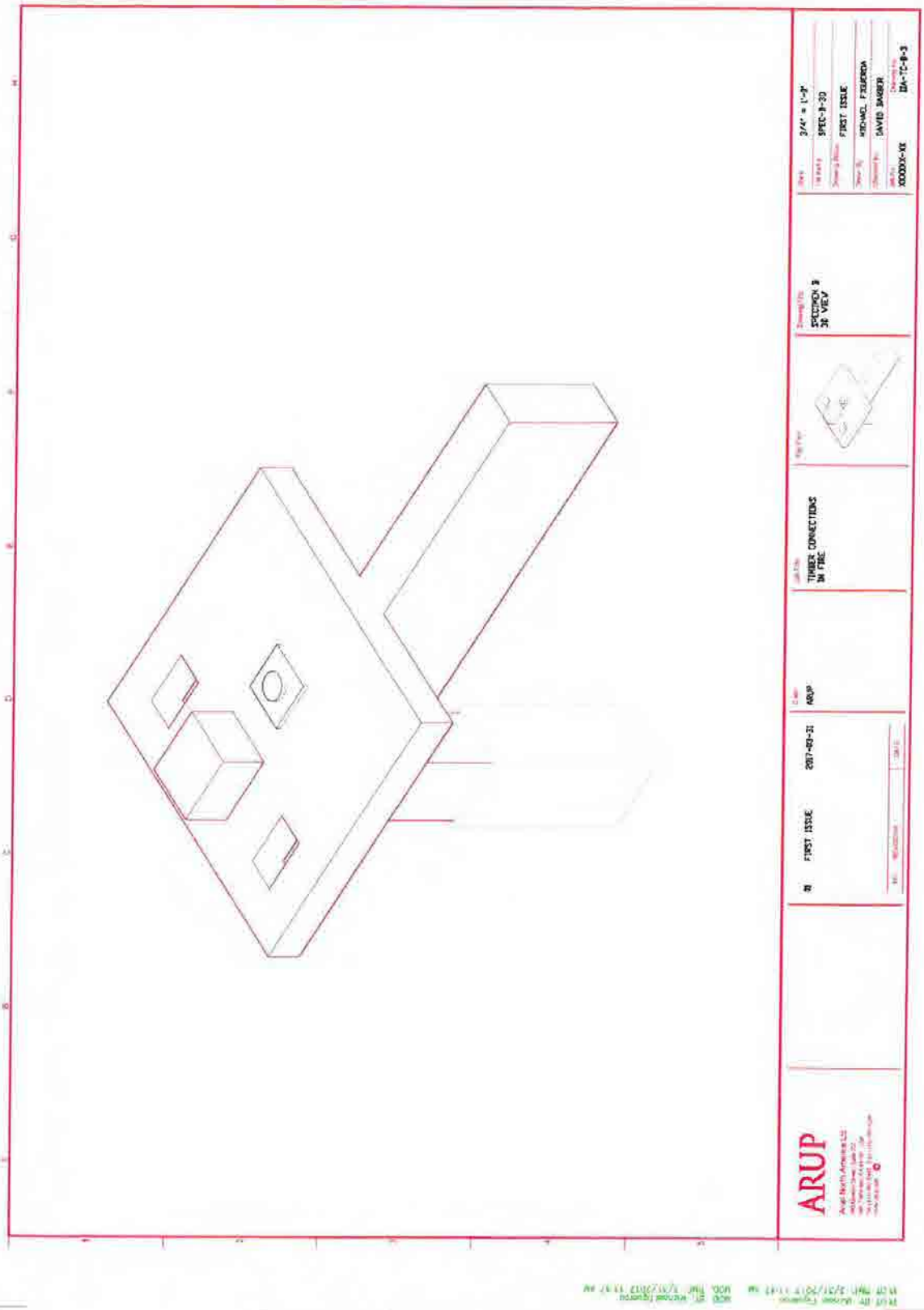

Figure A-7. Client-Provided Drawing.

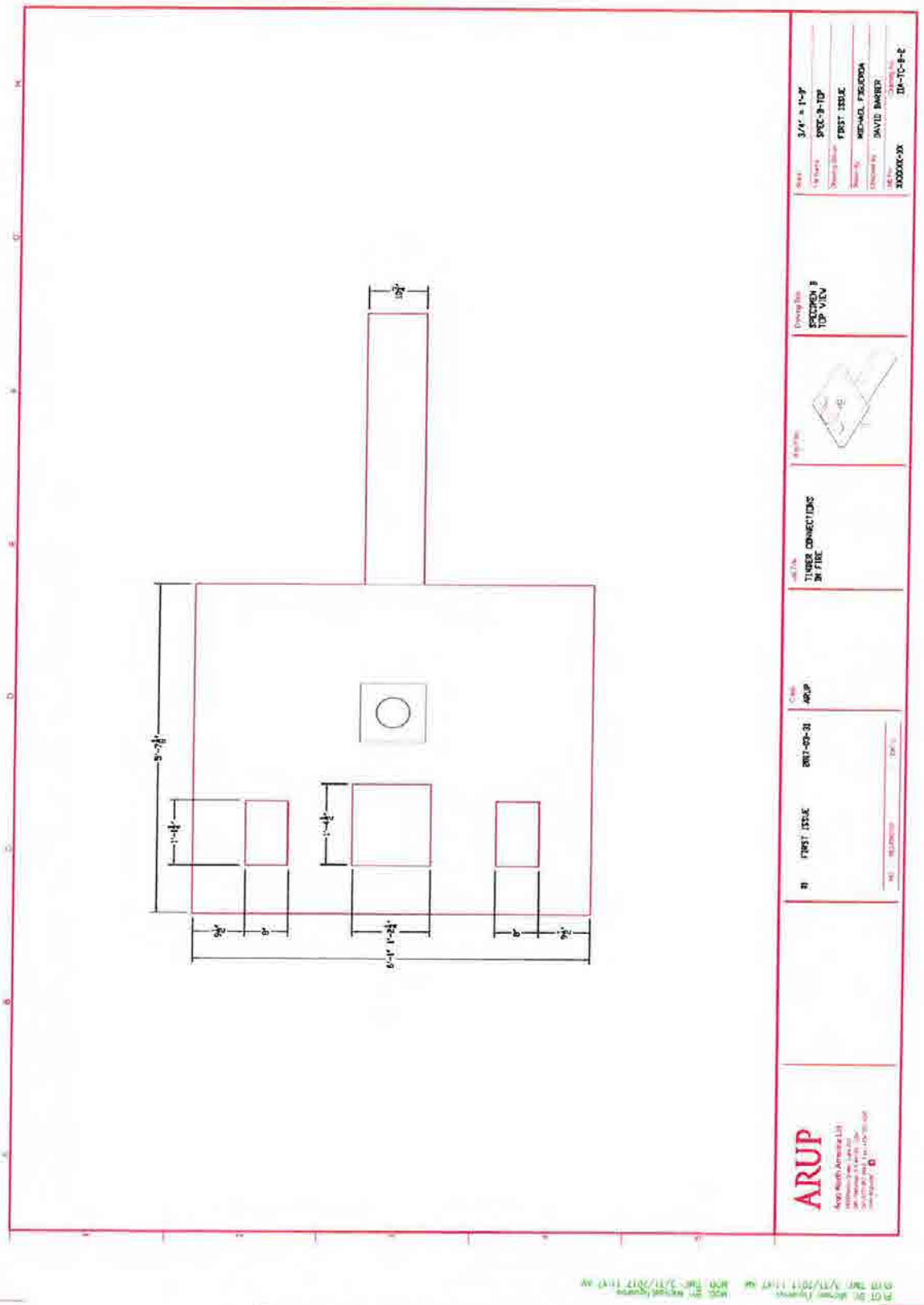

Figure A-8. Client-Provided Drawing.

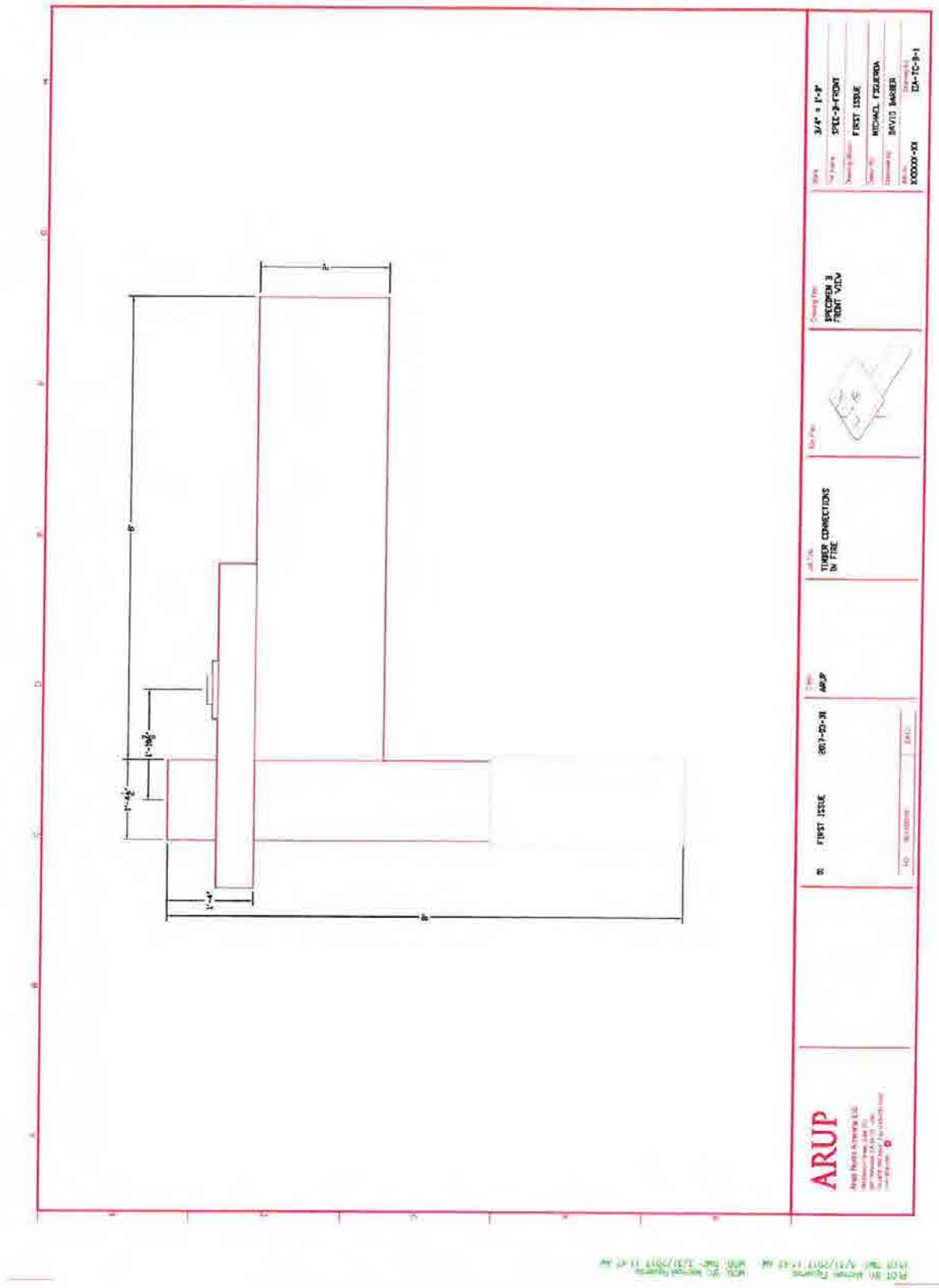

Figure A-9. Client-Provided Drawing.

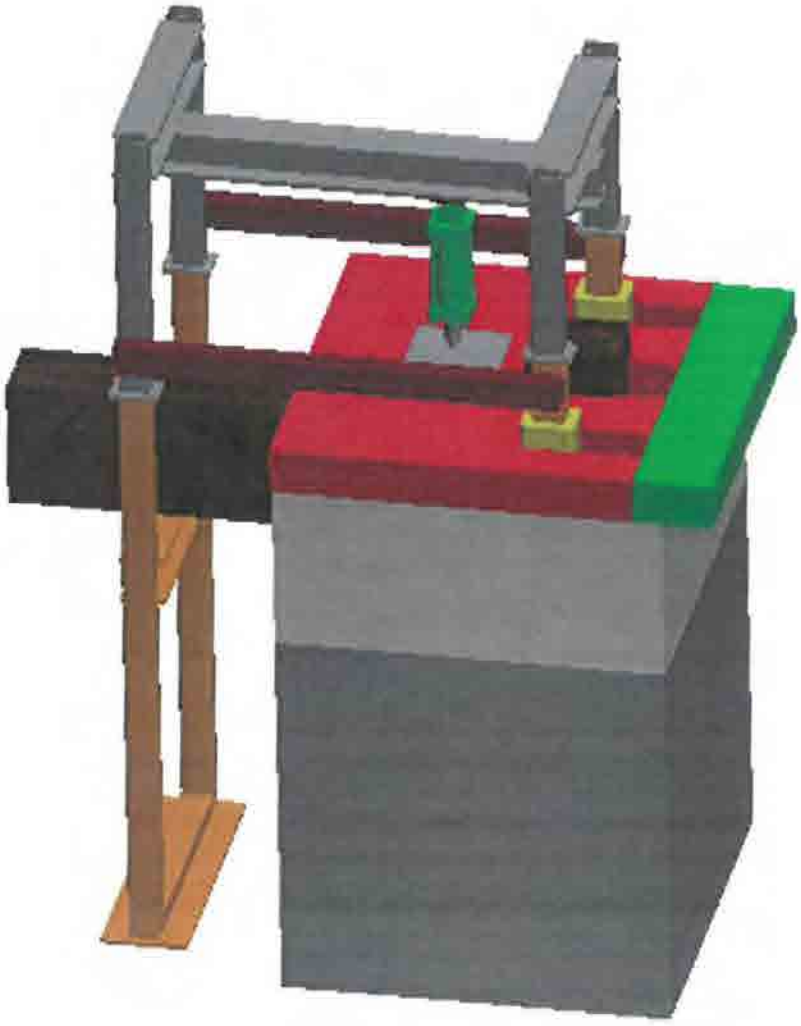

Figure A-10. Load Frame and Furnace Rendering.

APPENDIX B

THERMOCOUPLE LOCATIONS

(CONSISTING OF 5 PAGES)

Table B-1. Thermocouple Locations.

Thermocouple Number	Description
1	Located centrally at the connector.
2	Located centrally at the connector.
3	Located 16 in. from the beam connector (approx.). Hole drilled in from top of beam, to a depth of 4 in. Located 1 in. from right hand side of the beam.
4	Located 18 in. from the beam connector (approx.). Hole drilled in from top of beam, to a depth of 4 in. Located 2 in. from right hand side of the beam.
5	Located 16 in. from beam connector (approx.). Hole drilled in from top of beam, to a depth of 4 in. Located 1 in. from left hand side of the beam.
6	Located 18 in. from beam connector (approx.). Hole drilled in from top of beam, to a depth of 4 in. Located 2 in. from left hand side of the beam.
7	Located 2 ft 2 in. from CLT front edge. Located 1 ft 9 in. from CLT side. Hole drilled in from top of CLT, to a depth of 6".
8	Located 2 ft 2 in. from CLT front edge. Located 1 ft 6 in. from CLT side. Hole drilled in from top of CLT, to a depth of 5.5 in.
9	Located 2 ft 2 in. from CLT front edge. Located 1 ft 3 in. from CLT side. Hole drilled in from top of CLT, to a depth of 5 in.
10	Located 2 ft 2 in. from CLT front edge. Located 1 ft from CLT side. Hole drilled in from top of CLT, to a depth of 4.5 in.
11	Located centrally at the connector.
12	Located centrally at the connector.

Figure B-1. CLT Panel Orientation for Thermocouple Installation.

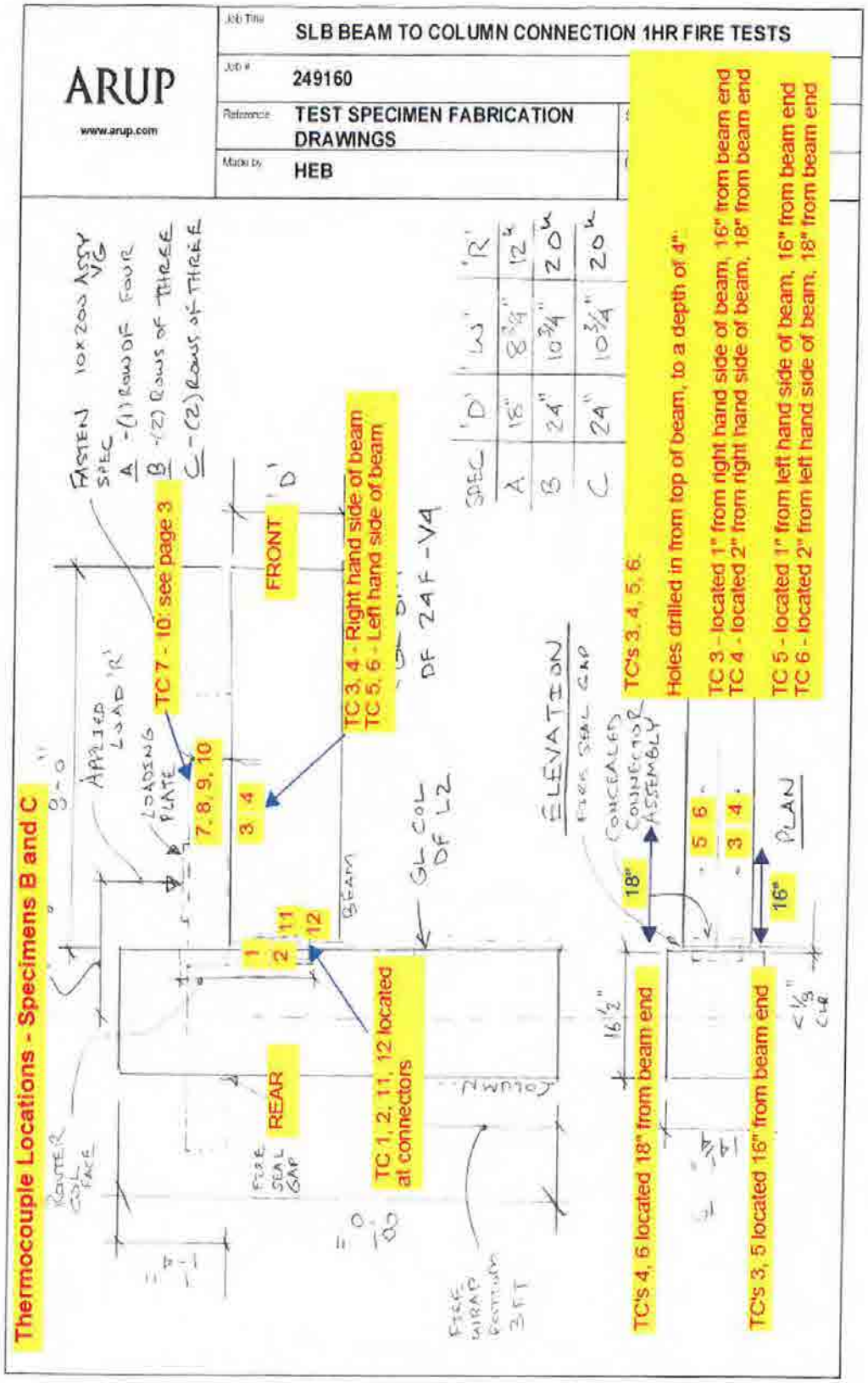

Figure B-2. Thermocouple Locations.

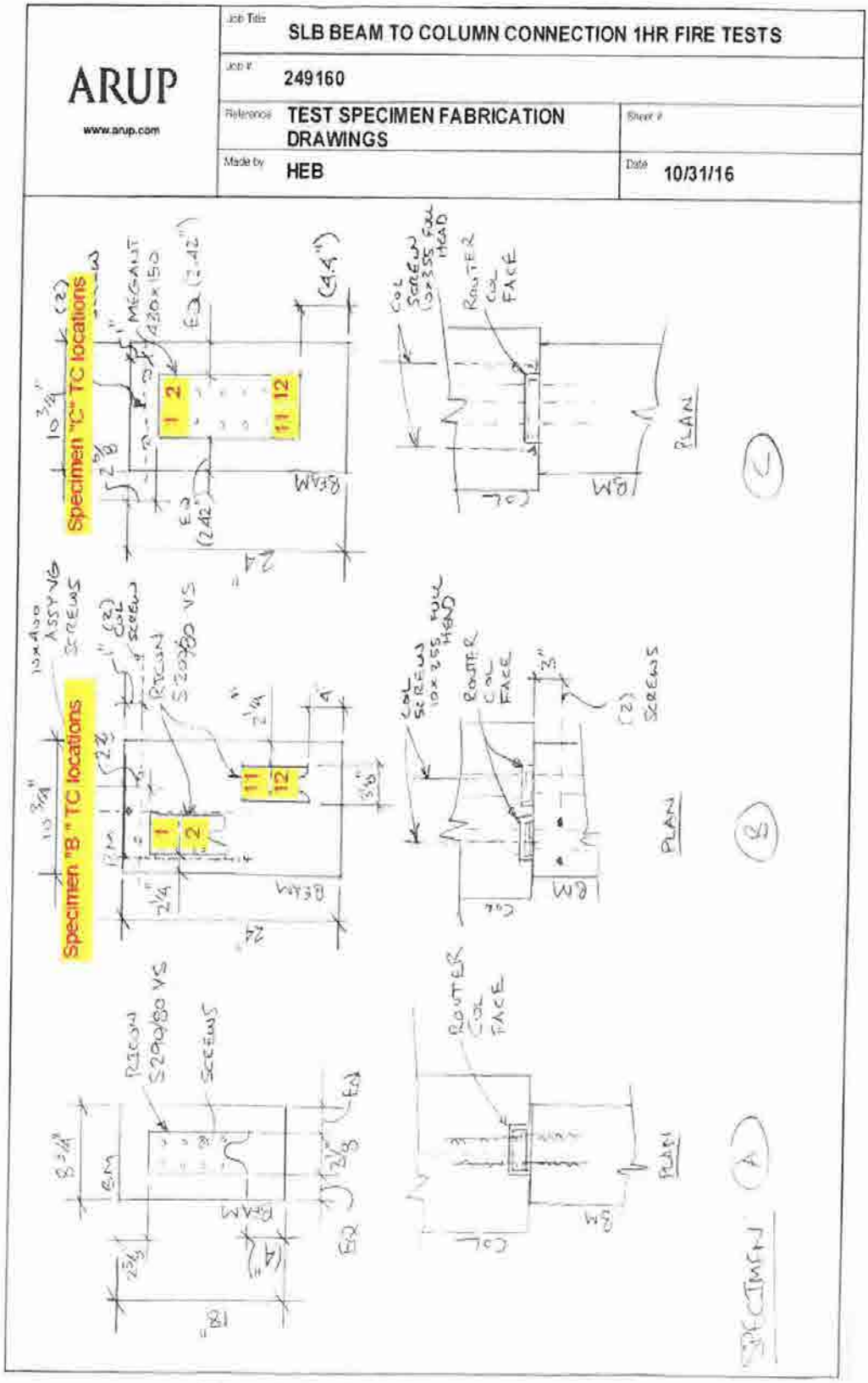

Figure B-3. Thermocouple Locations.

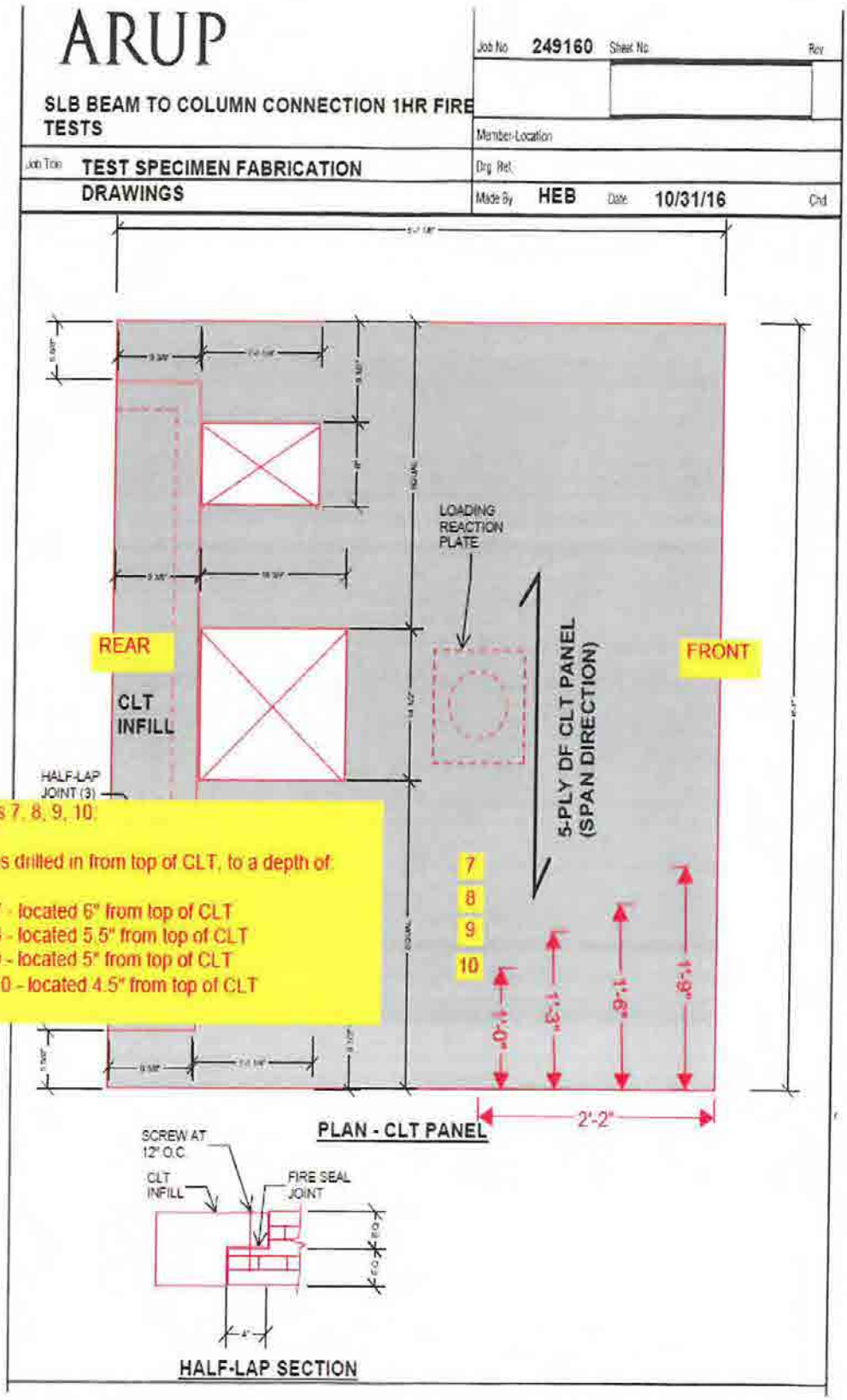

Figure B-4. Thermocouple Locations.

APPENDIX C

EQUIPMENT CALIBRATION DOCUMENTATION

(CONSISTING OF 1 PAGE)

Table C-1. Equipment Calibration Documentation.

Item	Make	Model	Serial No.	Cal Due
Data Acquisition Unit	Yokogawa	DU100-11	91R420032	May 20, 2017
Data Acquisition Unit	Yokogawa	DU100-11	91R420030	May 19, 2017
Data Acquisition Unit	Yokogawa	DU100-11	12VB42119	May 19, 2017
Position Transducer	Celesco	SPD-25-3	L2524245C	January 12, 2018
Furnace Pressure Transducer	Setra	264	2708707	September 11, 2016
Load Cell	Strainsert	SPHC-2XO	Q14372-14	July 26, 2017
Humidity/Temp Indicator	Vaisala	HM 34	W2420016	September 23, 2017

APPENDIX D

GRAPHICAL TEST DATA

(CONSISTING OF 4 PAGES)

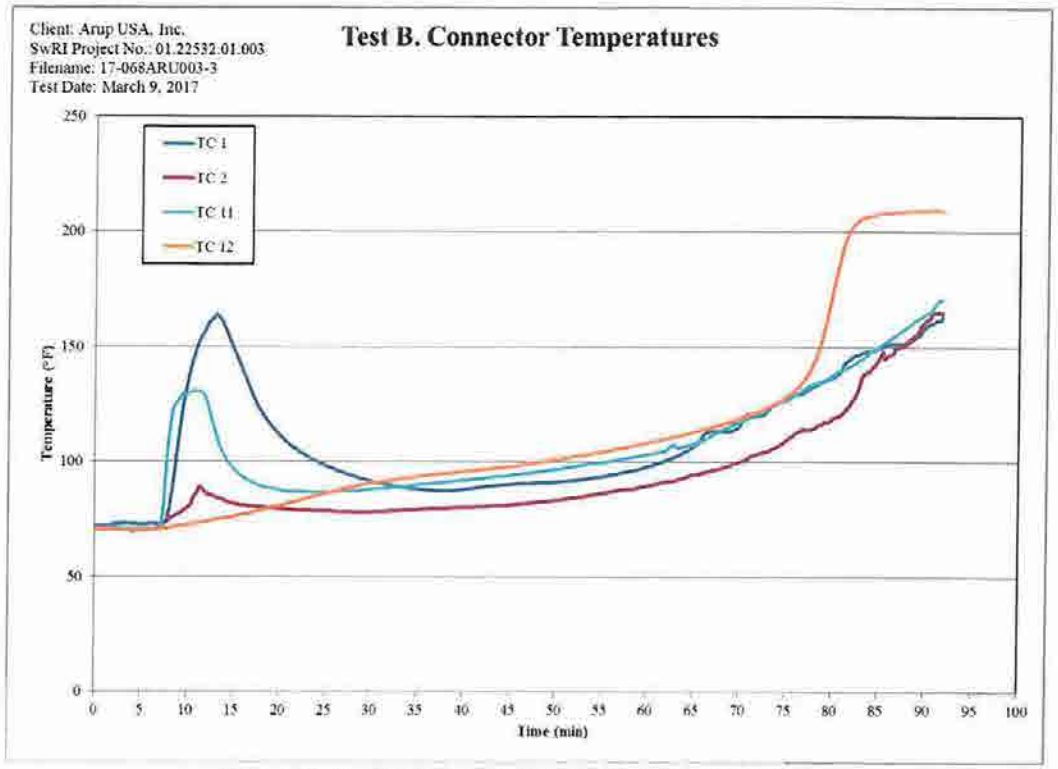

Figure D-1. Test B: Connector TC Temperatures.

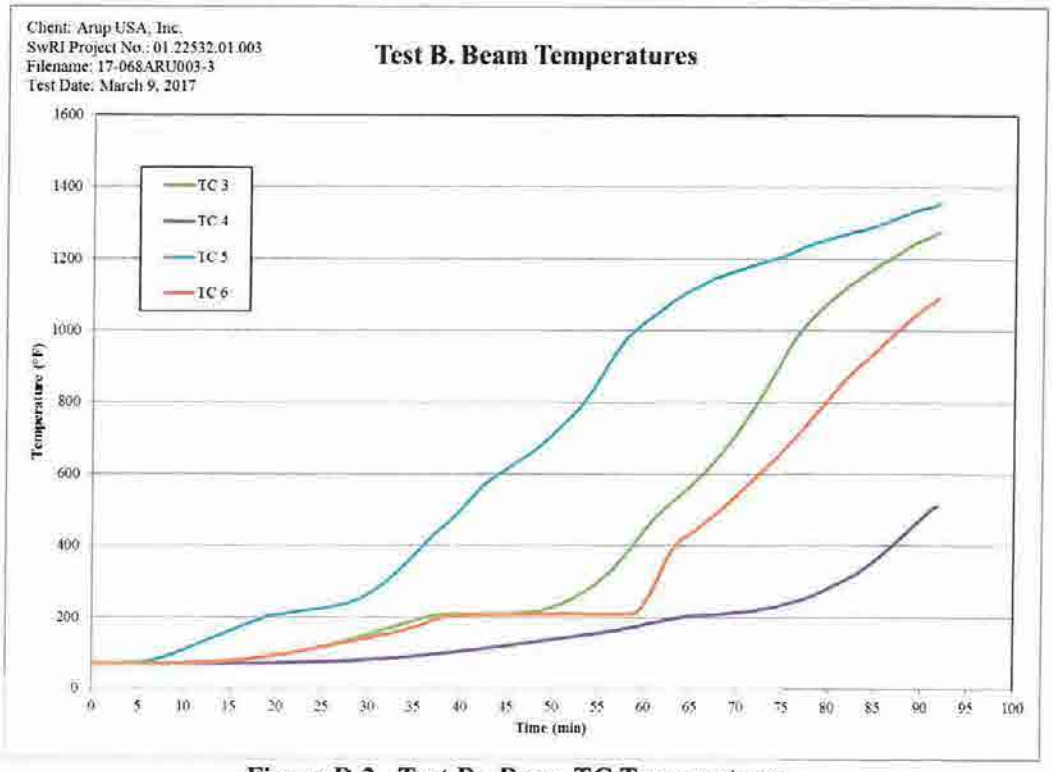

Figure D-2. Test B: Beam TC Temperatures.

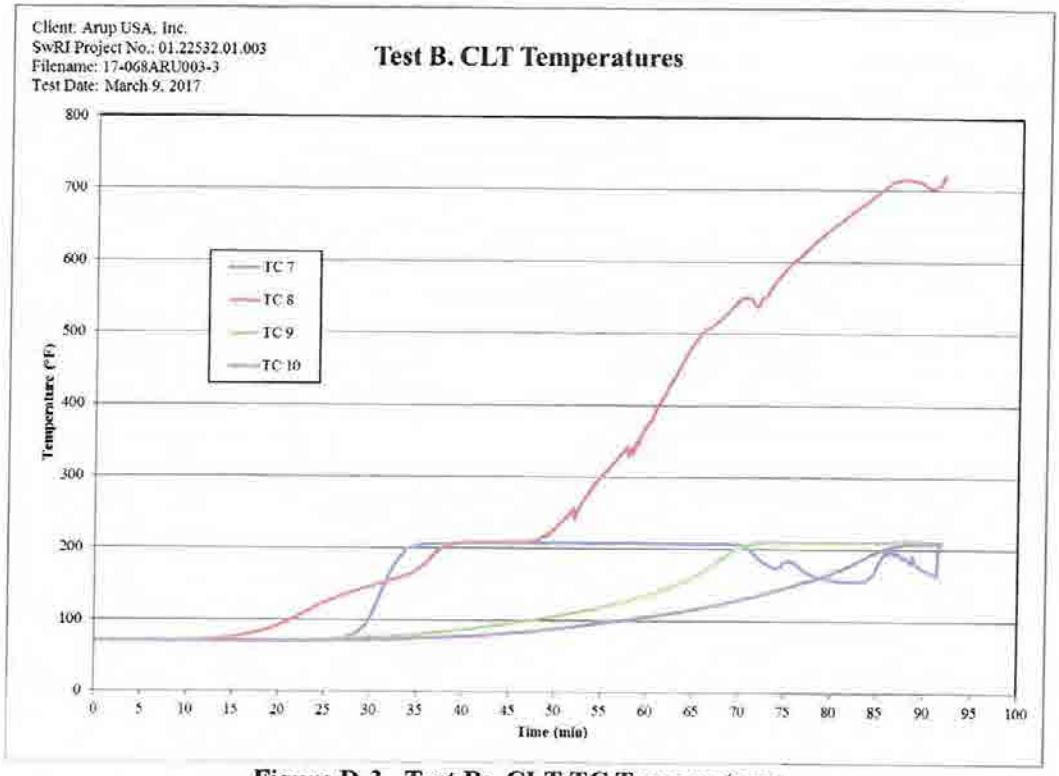

Figure D-3. Test B: CLT TC Temperatures.

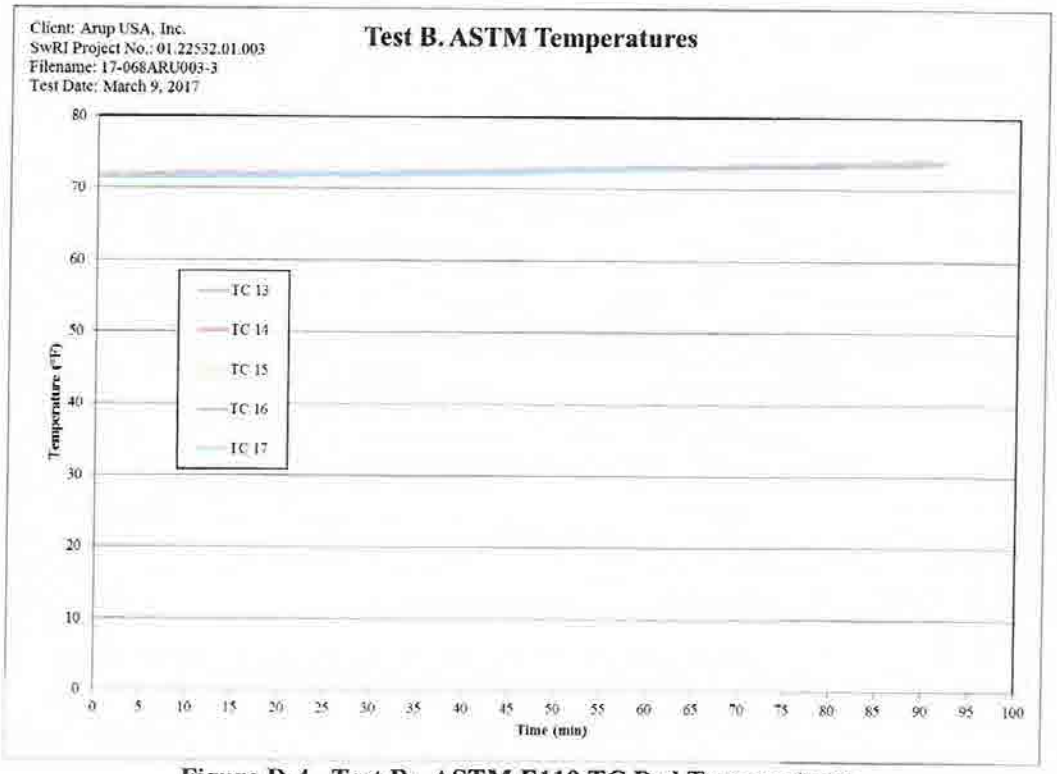

Figure D-4. Test B: ASTM E119 TC Pad Temperatures.

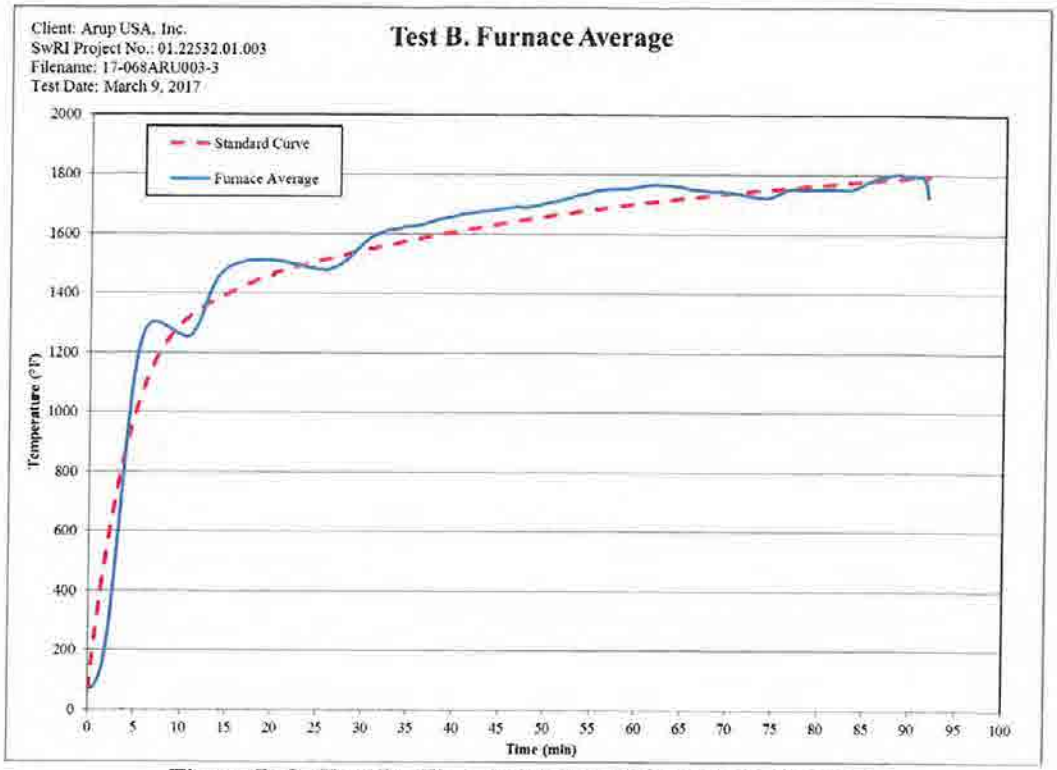

Figure D-5. Test B: Furnace Probe Temperature Average.

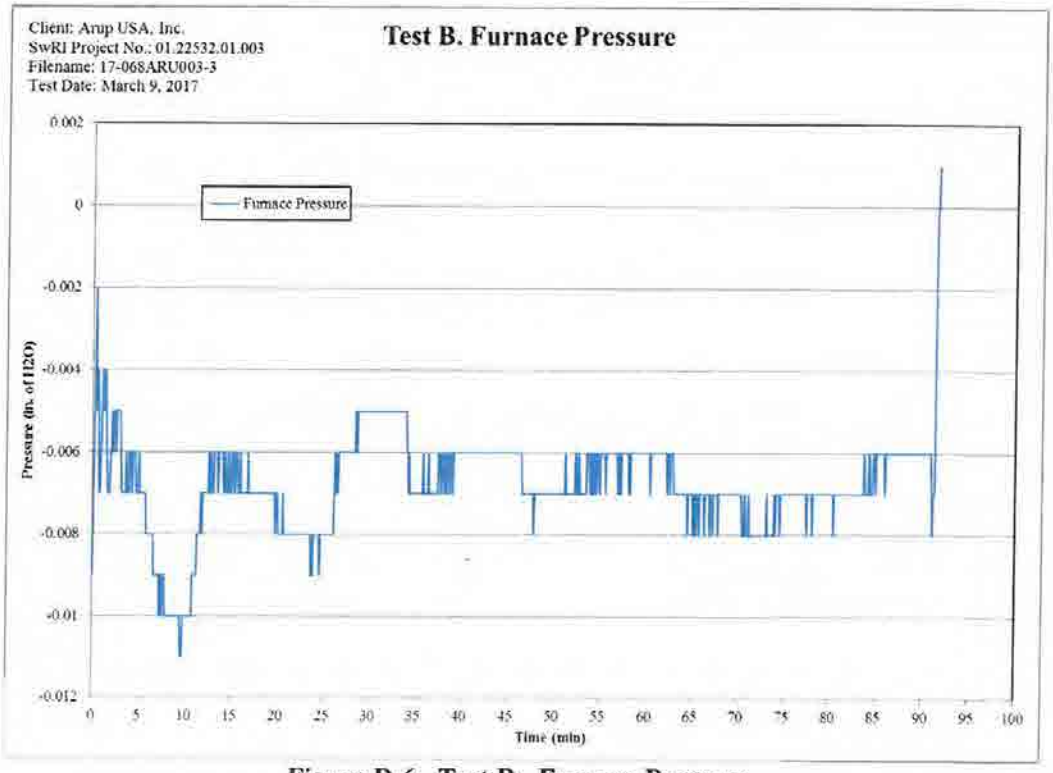

Figure D-6. Test B: Furnace Pressure.

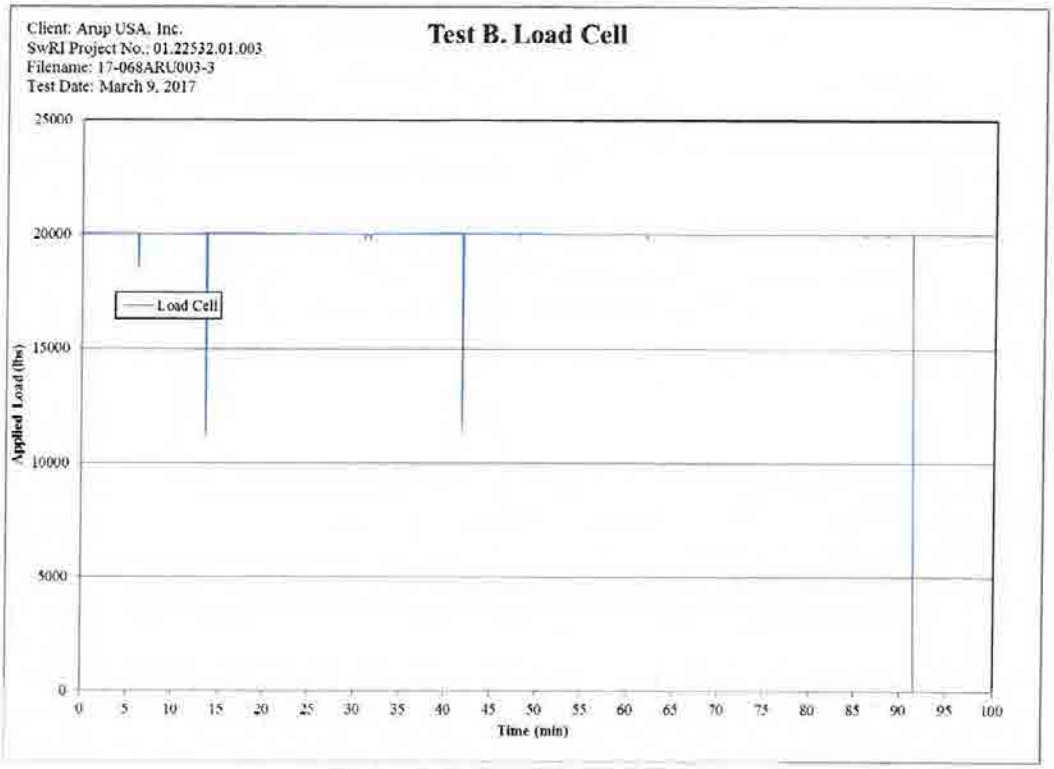

Figure D-7. Test B: Load Data.

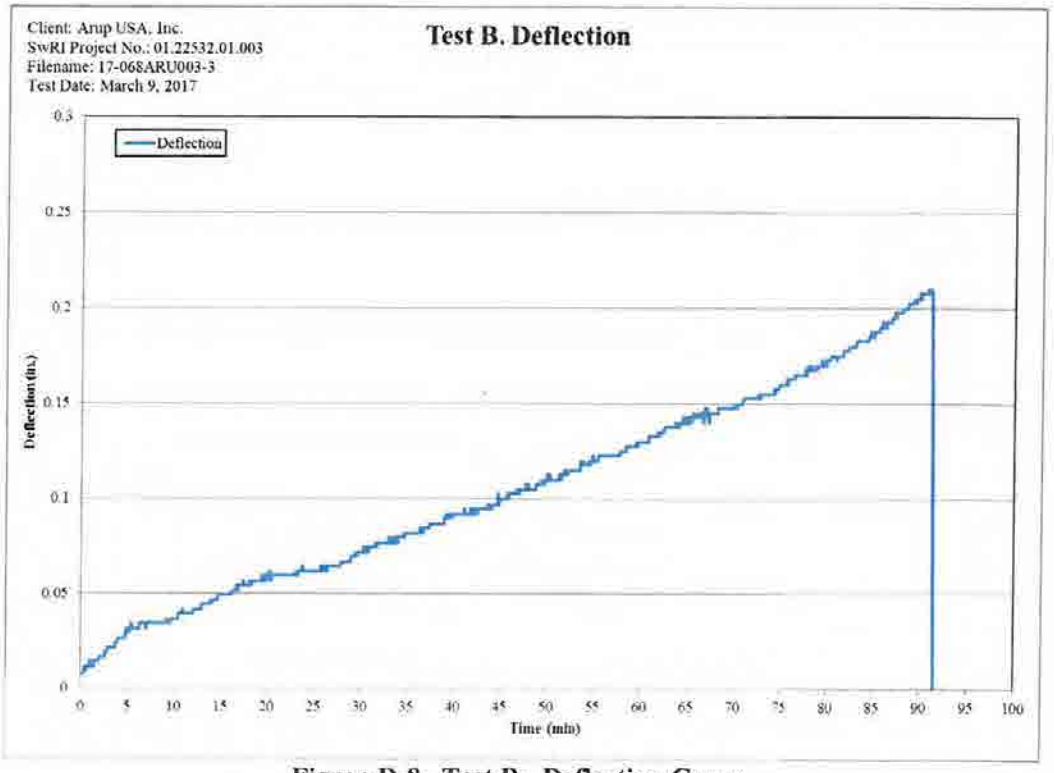

Figure D-8. Test B: Deflection Curve.

APPENDIX E

PHOTOGRAPHIC DOCUMENTATION OF THE TEST AND POST TEST

(CONSISTING OF 5 PAGES)

Figure E-1. View of Test Assembly at Start of Test.

Figure E-2. View of Test Assembly at 43 min.

Figure E-3. View of the Assembly at 1 h 30 min.

Figure E-4. View of Connection immediately after Test.

Figure E-5. View of Connection immediately after Test.

Figure E-6. Base of Beam after Fire Exposure.

Figure E-7. Post Test Picture of the Beam.

Figure E-6. Post Test Picture of the Column.

Figure E-7. Post Test Picture of the CLT Panel.

PAE Living Building

Engineering Judgment Report #4

Protection of Steel Attachments

Client Name: ZGF Architects

Client Address: 1223 SW Washington Street Ste 200, Portland, OR 97205

Date: 12/5/2019

Table of Contents

1 PROJECT OVERVIEW

The PAE Living Building is a new 5-story, Type III building of CLT construction in Portland, Oregon. The building is fully protected by automatic sprinklers and a fire alarm system.

The Fire Life Safety Plan Examiner has identified two concerns with BDS Comments (175, 176), both regarding the protection of steel members during a fire scenario.

Code Unlimited has been asked to provide analysis for the fire protection of these members, to ensure they will be provided the minimum fire protection as required by OSSC.

2 APPLICABLE CODES, STANDARDS, AND REFERENCES

- 2014 Oregon Structural Specialty Code (OSSC) including Appendix N, which refers to International Fire Code

3 APPROACH

- The proposed ceiling assembly has been analyzed in accordance with 2014 OSSC Section 703.3 **Alternative Methods for Determining Fire Resistance**.
- The proposed design has been evaluated by an Oregon Licensed Fire Protection Engineer.

4 PROPOSED DESIGN

Continuous fire rating must be maintained for primary structural frame members, including attachments and fasteners. The steel floor supports, and steel fasteners are a weak link in wood structures as steel fails quickly once heated to critical temperatures.

The protection outlined in the review below will meet the concerns from the FLS Review:

Comments

Item #1 (Appeal Item#1)

RE: BDS comment 175 (Summary of comment): The City FLS review: lag screw heads are not protected from above. (See Fig. 1)

Item #2 (Appeal Item#2)

RE: BDS Comment 176 (Summary of comment): The city FLS review: Detail how the glulam beam is able to protect the embedded plate from thermal heat gain and the fire caulk provides gap protection. (See Fig. 1)

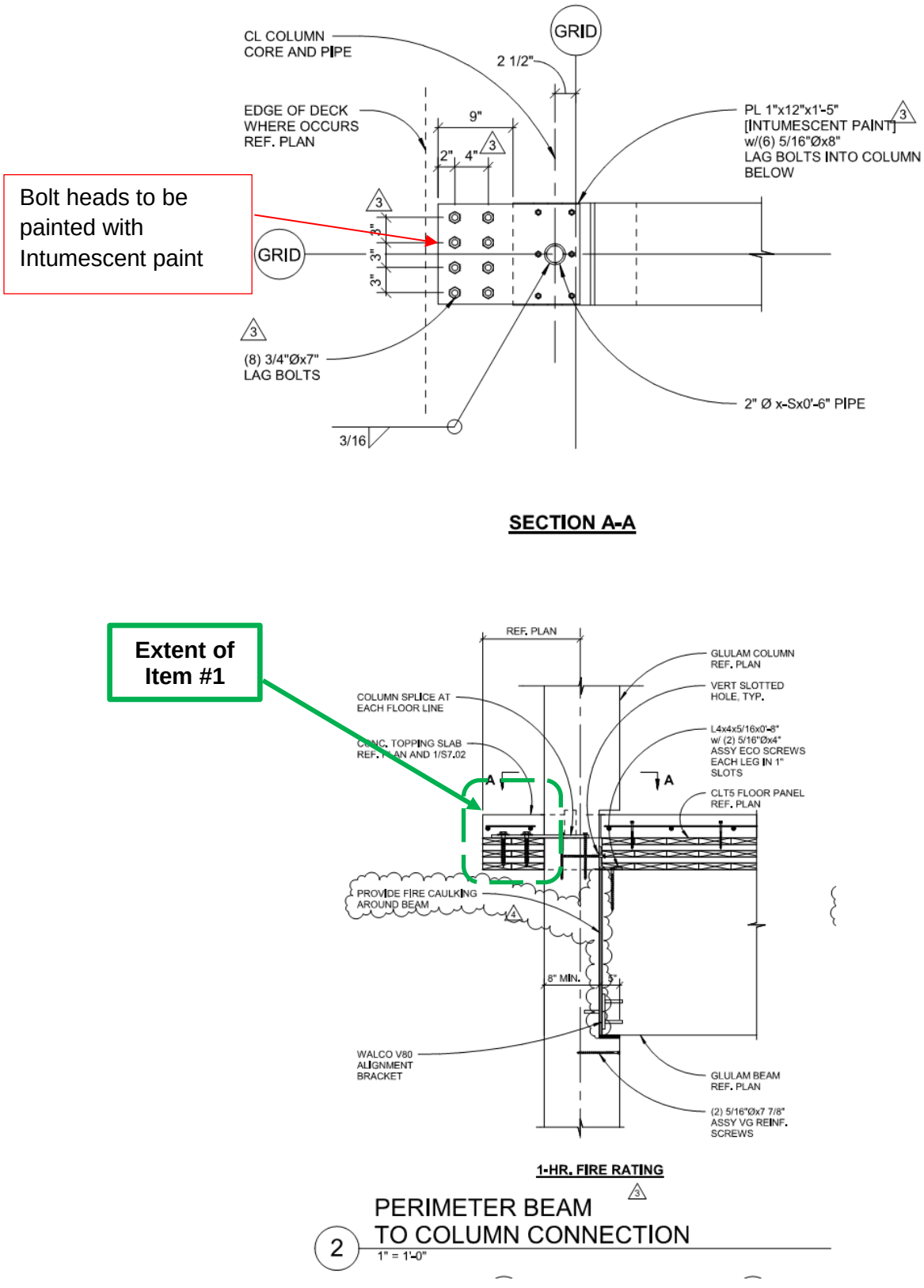

Figure 1. Proposed Connection Assembly -1 Hr

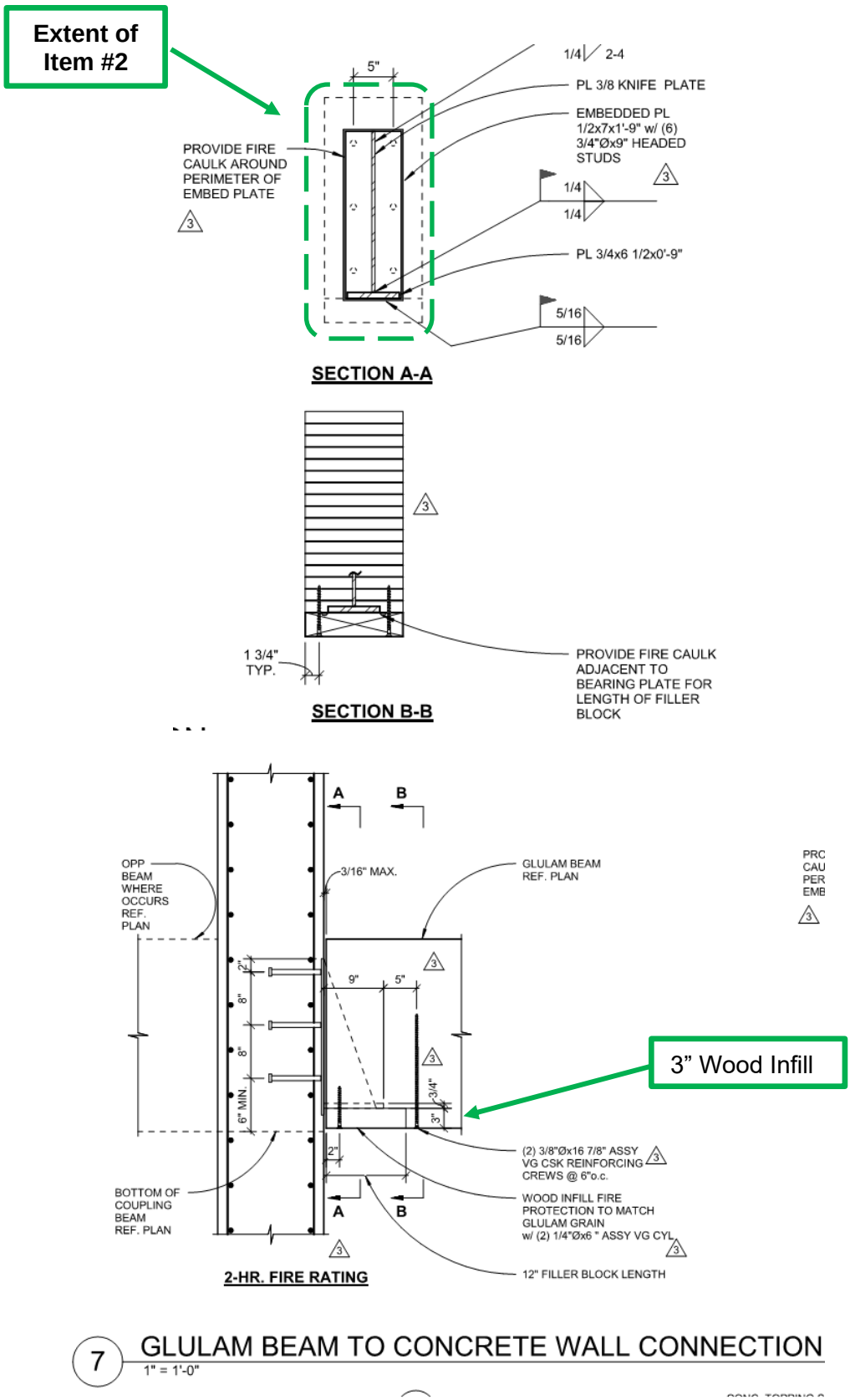

Figure 2. Proposed Connection Assembly -2 Hr

5 ASSEMBLY ANALYSIS

5.1 Item#1 (BDS Comment 175)

Item #1. To ensure the steel bolt attachments are protected for 1-hour, intumescent paint will be added to the top surface bolt heads. 2" concrete topping will provide less than 1 hour of protection from heat, while the additional coating will provide a full 1 hour of protection. (Fig.1)

Note: This is a conservative protection measure. ASTM: E119 does not perform tests with a fire located above the member as convective heat rises and radiative heat transfer is a smaller contributing component in the overall failure of an assembly.

5.2 Item#2 (BDS Comment 176)

Item #2. The steel bracket protection will be through two measures; Wood charring, or the Glulam Beam/Column(wall) gap protection provided through the intumescent fire caulking.

5.2.1 Wood charring evaluation

The fire resistance of wood is permitted by OSSC Section 722.1 to be calculated using Chapter 16 of ANSI/AF&PA *National Design Specification for Wood Construction (NDS).* NDS TR10 specifies an effective char layer depth of 3.2" where 2-hour of fire resistance is required based on equation 16.2-1 shown in **Figure** 4. Table 16.2.1A of the NDS is reproduced below in **Figure** 4.

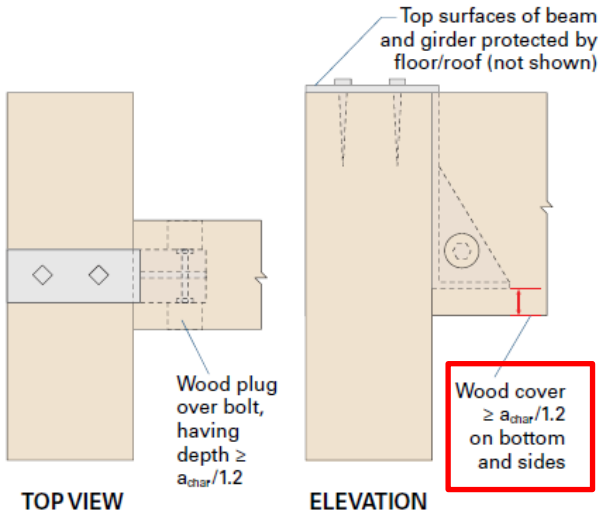

Figure 3-8 Beam to girder – concealed connection

Figure 3: Figure 3-8 in the NDS

Table 16.2.1A Effective Char Rates and Char Depths (for β_n = 1.5 in./hr.)

Required Fire Endurance (hr.)	Effective Char Rate, β_{eff} (in./hr.)	Effective Char Depth, a_{char} (in.)
1-Hour	1.8	1.8
1½-Hour	1.67	2.5
2-Hour	1.58	3.2

Figure 4: Table 16.2.1A of the NDS

NDS Calculation

Per **Figure** 3 and **Figure 4**, char rate calculation for wood protection can be estimated at:
Minimum wood thickness=3.2/1.2
Minimum wood thickness=2.66"

From the NDS calculation, 3" wood charring provides more than 2 hours of fire endurance for the steel bracket assembly.

5.2.1 Gap Protection evaluation

A ½" wide bead of Fire Caulking applied 1.5" from the beam edge shall be applied around all steel brackets as called out in (Fig.2). This will match the 2017 ASTM E119 testing performed industry testing for protection of connectors. *See Glulam Testing Summary Report Dated 6/5/17*(Attached). Specifically, Section 4.2 and images after fire testing (Fig. 8, Fig 11). The Images provide visual confirmation on the protection provided by the installation of fire caulking in this manner. It should be noted, this has become the adopted practice for Oregon and Washington CLT building projects in the last 2 years.

The figure 2 detail shows a Glulam Beam to Concrete exterior wall connection, it should be noted that the concrete wall will provide a beneficial heat sink during a fire. Thereby extending the protection duration for the assembly well beyond that of a wood/wood connection with a potential for half the gap dimension opening during a fire. Intumescent caulking is required to expand a minimum of three times its dry thickness.

6 SUMMARY

The Steel bracket assemblies are to be protected for the full required fire duration. These assemblies will be protected through the following as detailed above.

- Top surface bolts (Fig.1) to be protected through a combination of 2" Concrete cover and intumescent paint.
- Steel Brackets (Fig.2) will be protected through wood charring as evaluated through the NDS calculation and Intumescent Fire Caulking.

7 CONCLUSION

As documented above, the steel assemblies will be protected through tested protection measures to meet the minimum fire rating requirements per the OSSC.

Franklin Callfas
Principal/Fire Protection Engineer
Code Unlimited