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FIRE PERFORMANCE EVALUATION OF AN UNRESTRAINED LOAD-BEARING WALL ASSEMBLY TESTED IN ACCORDANCE WITH ASTM E119-18, *STANDARD TEST METHODS FOR FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS*

FINAL REPORT
Consisting of 28 Pages

SwRI® Project No. 01.23842.01.002
Test Date: September 13, 2018
Report Date: December 3, 2018

Prepared for:

Freres Lumber Co., Inc.
PO Box 276
Lyons, OR 97358

Submitted by:

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1.0 OBJECTIVE

The objective of the test described in this report was to determine the fire resistance of an unrestrained load-bearing wall assembly in accordance with ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, for Freres Lumber Co., Inc., located in Lyons, Oregon. Testing was conducted by Southwest Research Institute's (SwRI) Fire Technology Department, located in San Antonio, Texas. The assembly was identified by the Client as Mass Plywood Panel (MPP) *Wall Assembly*.

2.0 TEST METHOD

The ASTM E119 test method is intended to evaluate the duration for which a building element will contain a fire, or retain its structural integrity, or display both properties dependent upon the type of building element involved, during a predetermined fire exposure time. The test exposes a specimen to a standard fire controlled to achieve specified temperatures throughout a specified period. When required, the fire exposure is followed by the application of a specified standard fire hose stream applied in accordance with ASTM E2226, *Standard Practice for Application of Hose Stream*.

This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled laboratory conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products, or assemblies under actual fire conditions.

This report describes the test results obtained for an unrestrained load bearing wall assembly. The performance of the assembly is expressed in terms of the transmission of heat and hot gases during the standard fire exposure and penetration of water to the unexposed side of the assembly during the hose stream test. The results presented in this report apply specifically to the materials 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

The *MPP Wall Assembly* consisted of three sections provided by Freres Lumber Co., Inc., and received by SwRI on August 28, 2018. The materials used in the construction of the wall are described in Table 1.

Table 1. Material Description.

Material	Provided By	Received On
MPP panels	Client	August 28, 2018
Nominal ¾-in. think plywood sheets	Client	August 28, 2018
1-in. Plywood Spline	Client	August 28, 2018
5/16 × 4¾-in. ASSY Ecofast screws	Client	August 28, 2018
Hilti FS-One Max sealant	Client	August 28, 2018
8d 2½-in. framing nails	Client	August 28, 2018

3.1 Sample Description

The wall assembly consisted of three MPP panels, that when assembled measured 12 ft × 9 ft × 6¾ in. The wall consisted of two connection joints; one 4-in. half lap connection joint and one 8-in. spline connection joint. To assemble the wall half lap connection, one ½-in. line of Hilti FS-One Max sealant was applied along the bottom half lap joint. The half lap panels were then placed together. The panel's half lap was fastened using 5/16 × 4¾-in. ASSY Ecofast screws, installed with the first screw positioned 1 in. from the edge of the panel with each additional screw installed every 6 in. on center down the length of the joint. To assemble the spline connection, the two panels were butted together and one thick bead of construction adhesive was applied along each panel's top side of the joint. A 1 × 8-in. wide strip of plywood was positioned over the panel's connection and compressed into the adhesive. The panel plywood connection was fastened using 5/16 × 4¾-in. ASSY Ecofast screws, installed with the first screw positioned 1 in. from the edge of the panel with each additional screw installed every 6 in. on center alternating panels down the length of the joint. The finished dimension of the assembled wall was 12 ft × 9 ft × 6¾ in.

Once the wall panel connections were complete, Type K ⅛-in. Inconel sheath grounded junction thermocouples were embedded into the panels. The assembled wall was installed in a vertical test frame with a floating I-Beam located at the top of the test wall. Four jacks were used to position the wall, and two jacks were used when testing the wall. Two hydraulic cylinders were placed between the floating I-Beam and the test frame to apply the load to the test wall during the test. For the test, the frame was secured against SwRI's large-vertical furnace.

Additional information pertaining to the construction of the samples and the materials included in the assemblies is provided in Appendix A. Selected photographs are provided in Appendix B. Client-Provided APA Product Report PR-L325 can be found in Appendix D.

4.0 TEST RESULTS

Fire Resistance Test

Test Date: September 13, 2018

Test Witnesses: Messrs. David Barber (Arup) and Patrick Farrell, representing Freres Lumber Co., Inc.

Ambient Temperature: 78 °F

Relative Humidity: 87%

Instrumentation: The unexposed side of the sample was instrumented with nine thermocouples (TCs) designed in accordance with ASTM E119. One approximately at the center of the wall, one at approximately the center of each quadrant, and one approximately placed between each quadrant.

Twenty four Type K Inconel ⅛-in. grounded junction additional thermocouples were used to measure the assembly temperature at selected locations. Thermocouple locations can be found in Appendix A.

The vertical deflection of the wall was measured using a string potentiometer located at the center of the assembly. A pressure transducer was used to measure the pressure of the hydraulic jacks.

Load: A total load of 147 Kips, including a dead load, was applied using two SwRI hydraulic jacks. Based on calibration of the cylinders rated at 100 tons at 10,000 psig, a hydraulic pressure of 6509 Psi was used. The jacks were placed at the top of the assembly so that the load would be applied from the top.

Observations: Refer to Table 2.

Table 2. Fire Resistance Test Visual Observations.

Time (hr:min:s)	Observation
	Pre-exposure deflection -.027 in.
0:00:00	Furnace ignited. Test started.
0:01:34	Ignition of wood on exposed side.
0:02:00	Furnace burners set to idle.
0:15:00	Steady burning of exposed wood.
0:30:00	Steady burning.
0:45:05	Steady burning.
1:00:00	Steady burning.
1:30:00	Steady burning, can see through the half-lap joint.
1:32:00	Failed cotton pad test.
	Test continued, to evaluate the walls ability to carry the load.
1:38:00	Flickering flame visible.
1:45:00	Steady burning, decrease in intensity of burning.
1:50:00	Gas flow to burners resumed, deflection outward increasing.
1:52:00	Test terminated.

Hose Stream Test: No hose stream test.

Rating Obtained: Unrestrained loaded 92-min fire resistance rating without applying a time-temperature curve correction factor. Unrestrained loaded 114-min fire resistance rating when applying a correction factor. See Section 5.0 for additional information.

Results: The acquired data is located in Appendix C in graphical form.

5.0 CONCLUSION

Based on the test results, the unrestrained loaded wall assembly tested, as described in this report, achieved a fire resistance rating of 92-min without the time-temperature curve correction, achieved a fire resistance rating of 114-min when the correction is applied, the assembly was tested in accordance with ASTM E119, without a hose stream test. The correction was calculated as described in Note 13 of ASTM E119, and that this correction was developed for non-combustible construction and relatively small deviations from the standard time-temperature curve, and the correct therefore may not apply to combustible test specimens.

APPENDIX A

CLIENT-PROVIDED DRAWING AND THERMOCOUPLE LOCATIONS

(CONSISTING OF 1 PAGE)

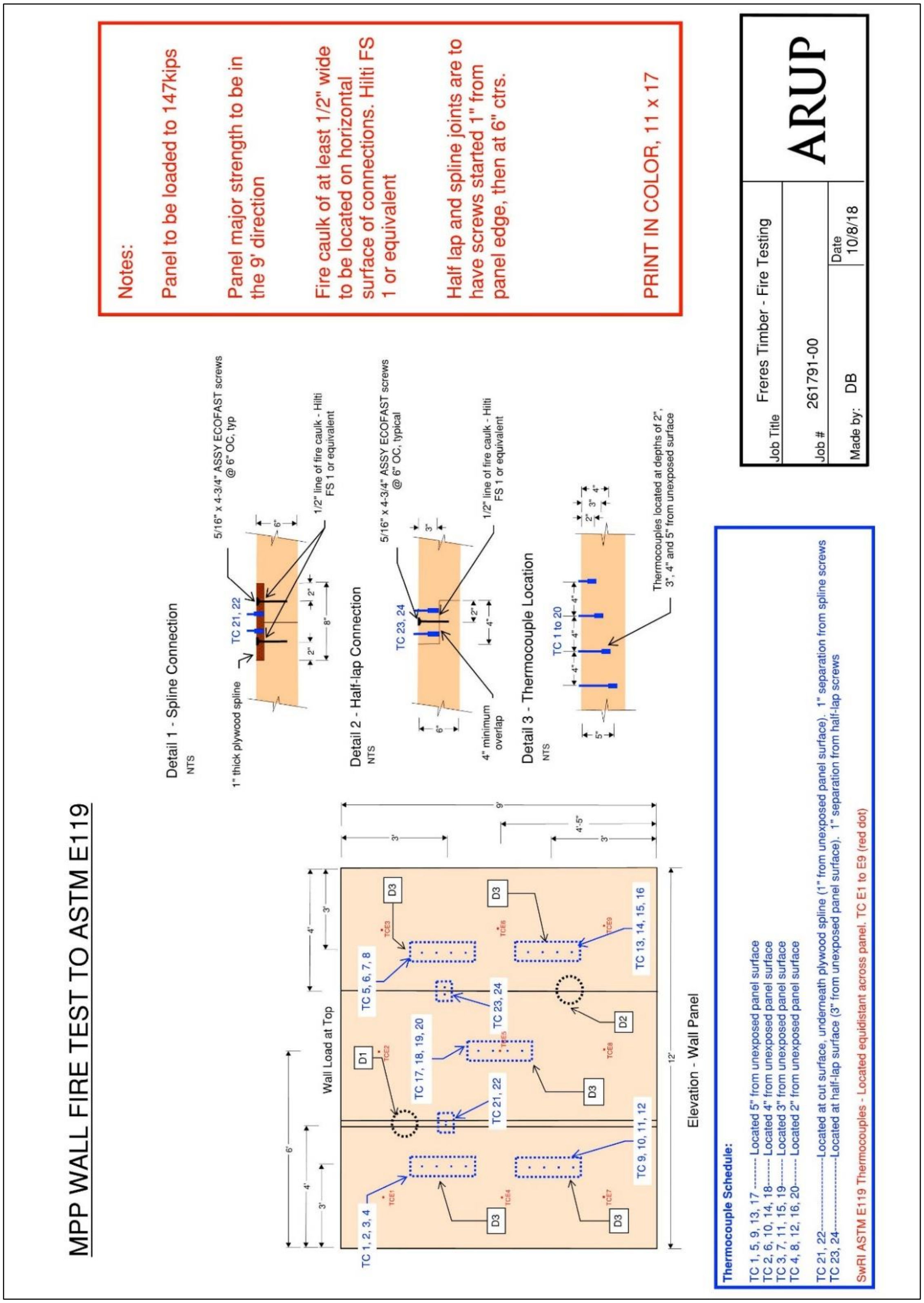

Figure A-1. Client-Provided Drawing with Thermocouple Locations.

APPENDIX B

TEST PHOTOGRAPHS

(CONSISTING OF 8 PAGES)

Figure B-1. Hilti FS-One Max and Hardware.

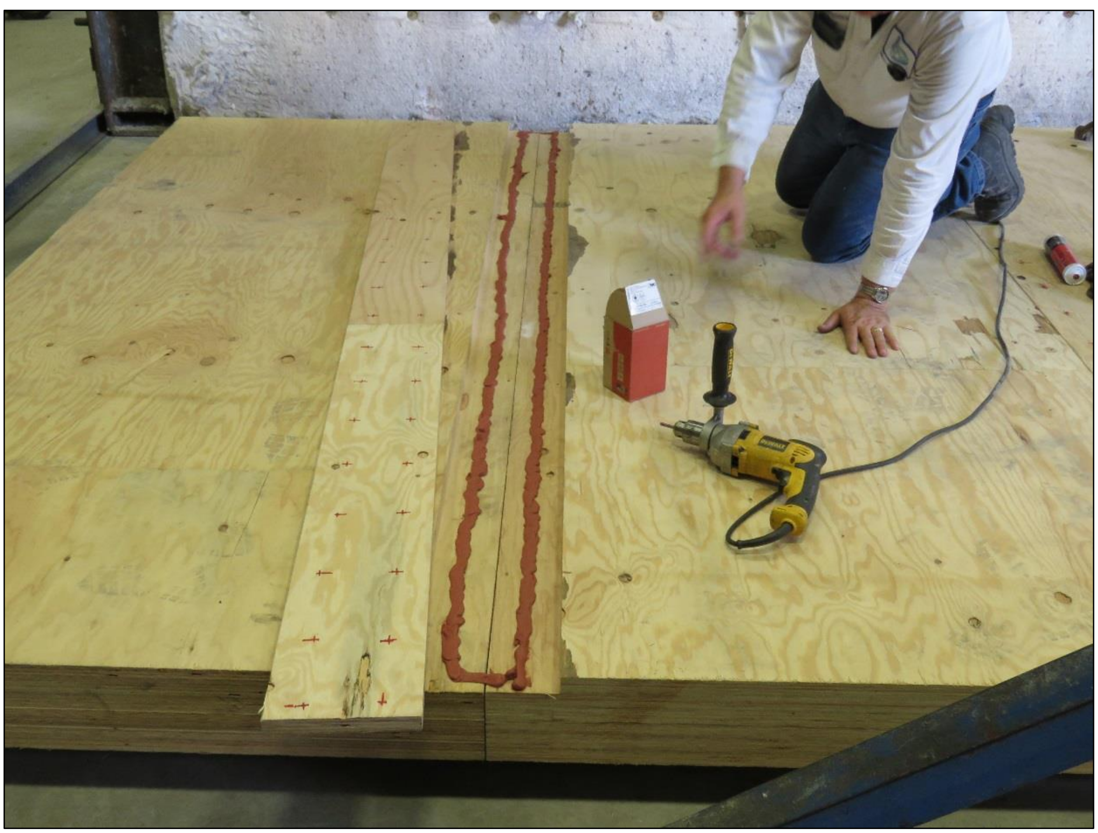

Figure B-2. Application of Construction Adhesive in the Spline Connection prior to Spline Installation.

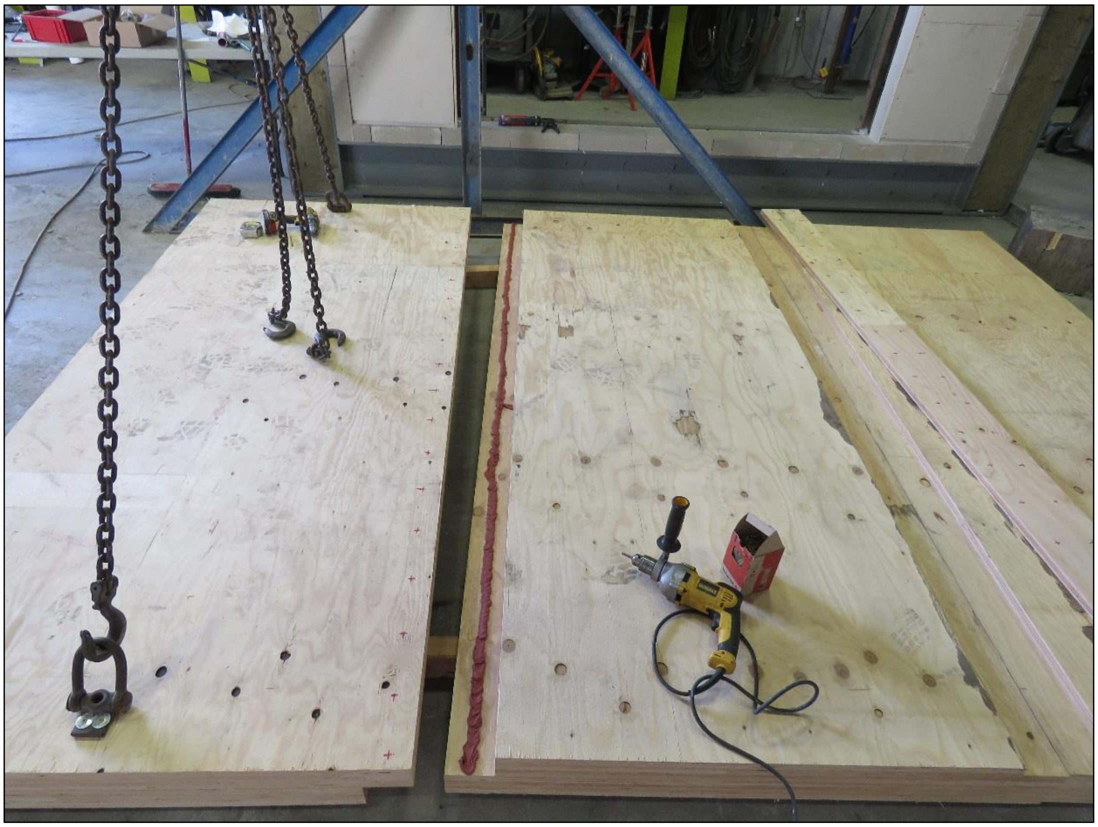

Figure B-3. Half Lap Connection with Construction Adhesive Applied.

Figure B-4. MMP Assembly Exposed Side prior to Testing.

Figure B-5. Unexposed Face prior to Testing.

Figure B-6. Unexposed Face 30 min into the Test.

Figure B-7. Unexposed Face 45 min into the Test.

Figure B-8. Unexposed Face 1 h into the Test.

Figure B-9. Exposed Face 1 h 16 min, Flaming Visible on Top Right.

Figure B-10. Exposed Face 1 h 24 min, Flaming Visible through Joint.

Figure B-11. Cotton Test.

Figure B-12. Cotton Test Results.

Figure B-13. Exposed Face 1 h 52 min, Large Opening at Joint, Flaming Visible.

Figure B-14. Exposed Side immediately after Test Ended.


Figure B-15. Unexposed Side immediately after Test Ended.

APPENDIX C

GRAPHICAL TEST DATA

(CONSISTING OF 6 PAGES)

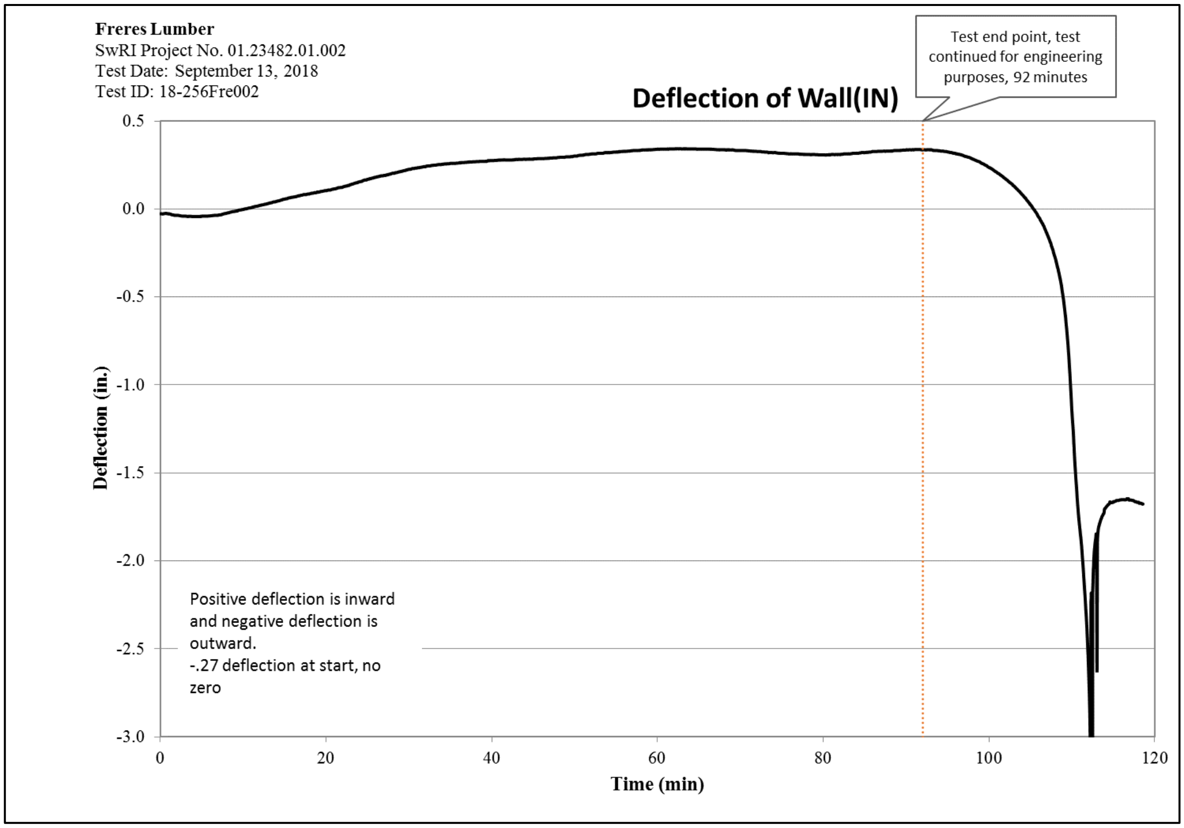

Figure C-1. Deflection into Furnace vs. Time.

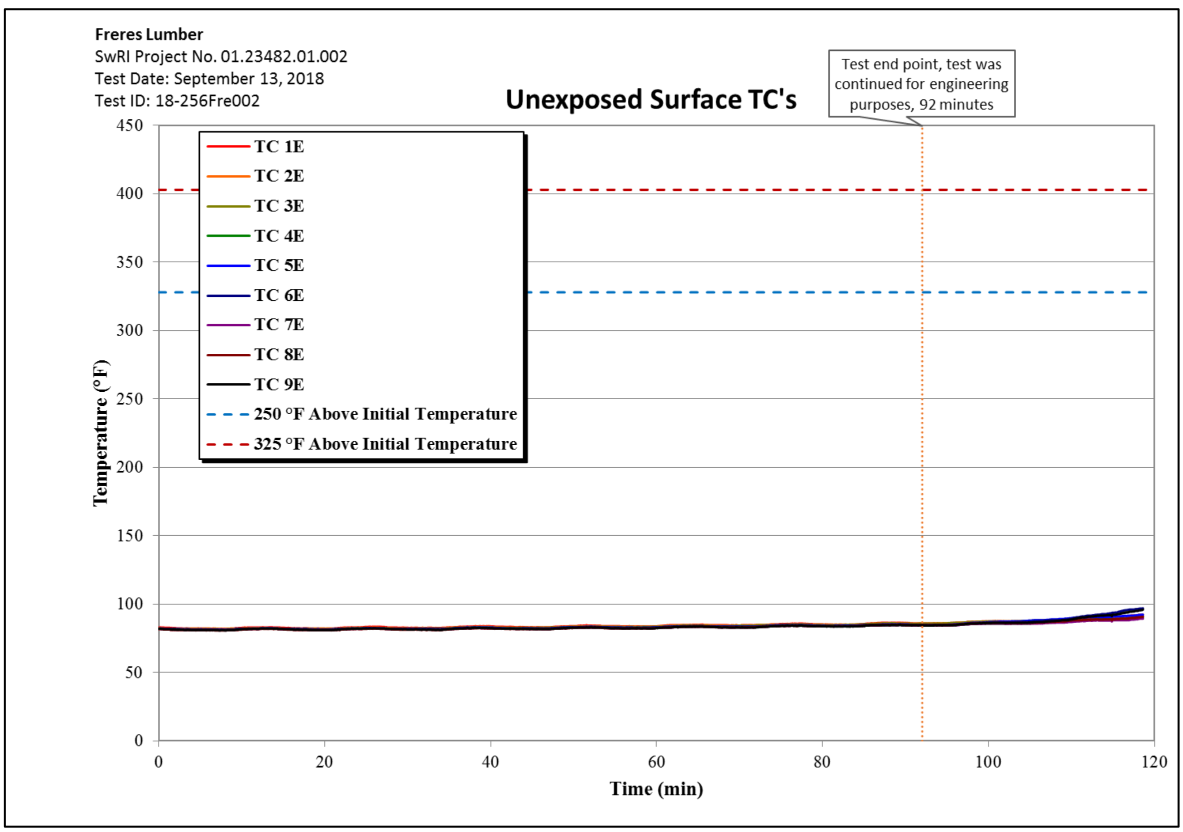

Figure C-2. Surface Temperatures vs. Time.

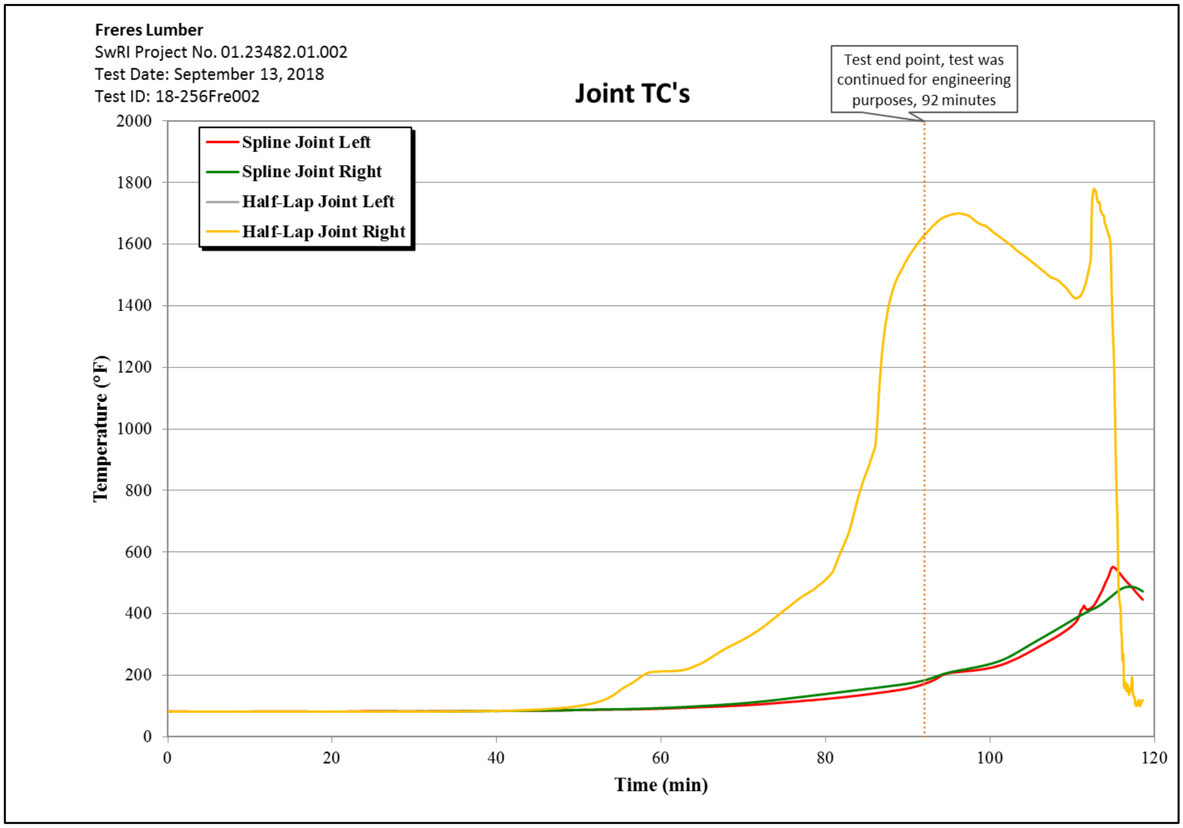

Figure C-3. Joint Connections Temperatures vs. Time.

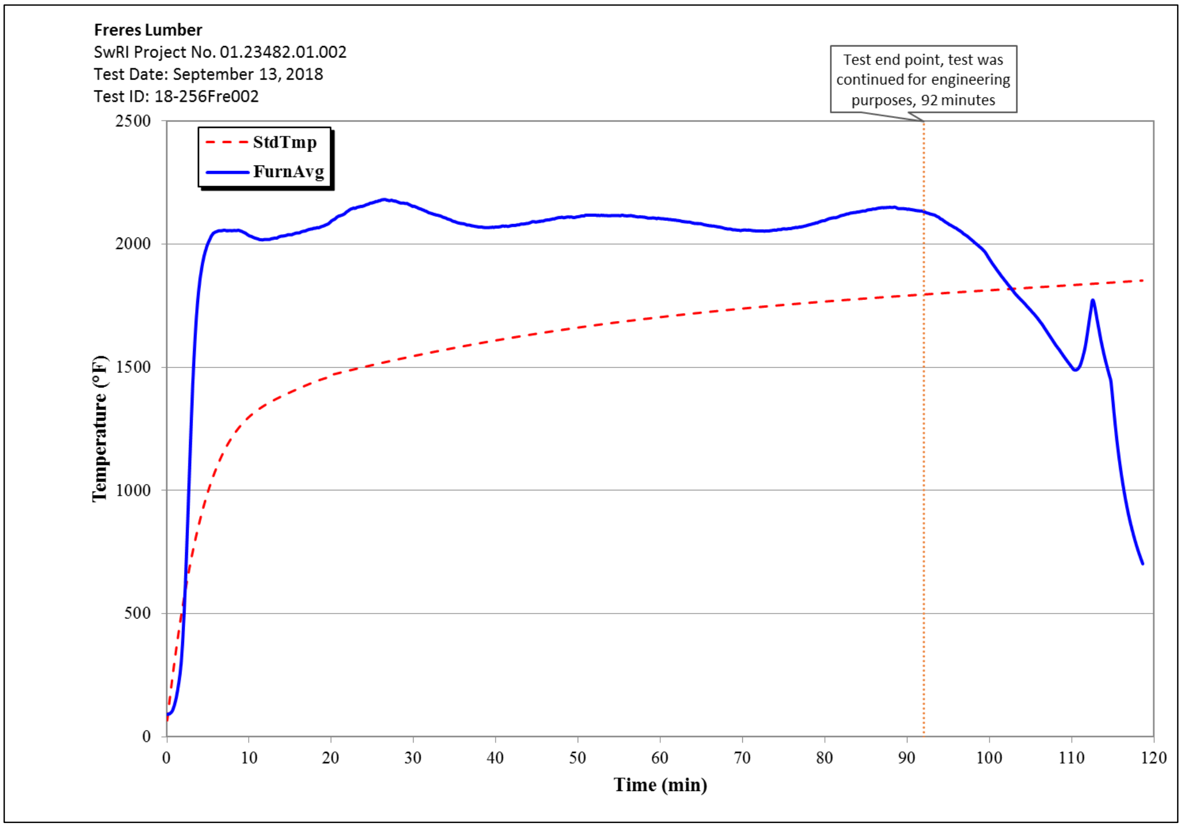

Figure C-4. Furnace Average Temperature vs. Time.

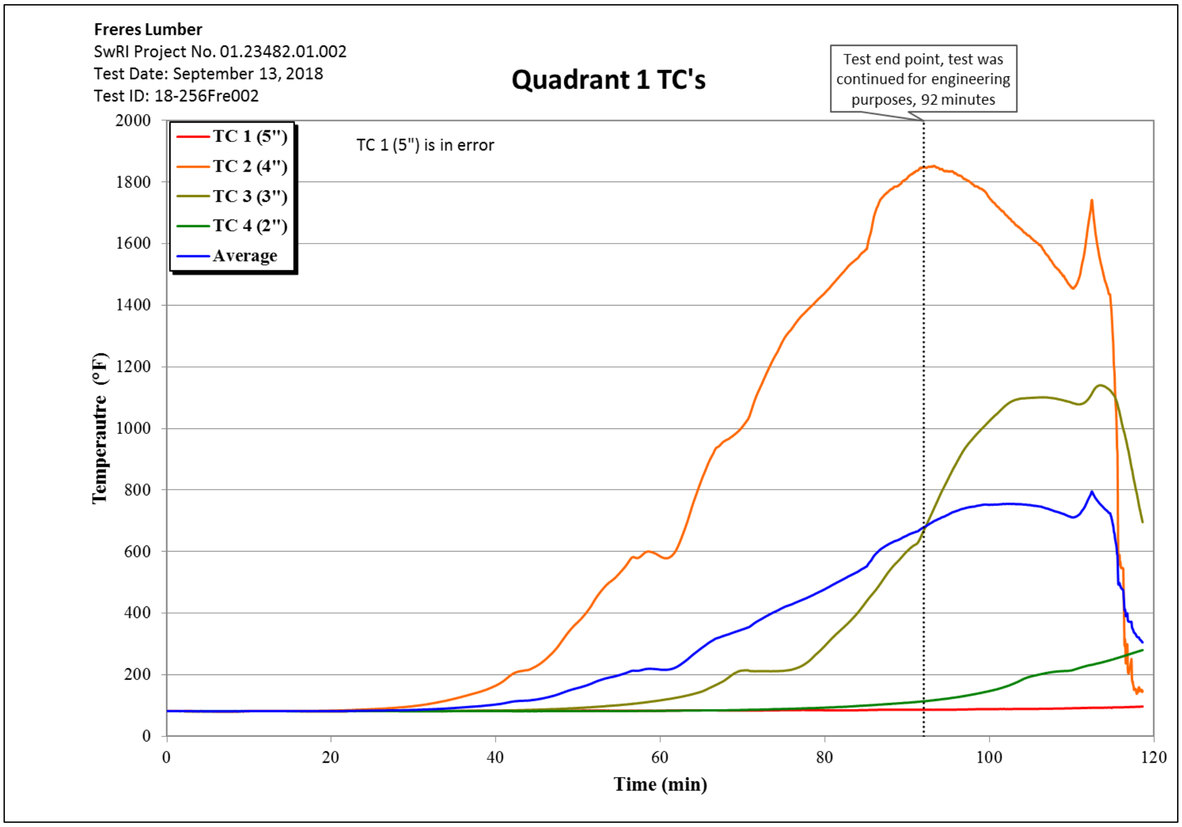

Figure C-5. Engineering Embedded Temperatures vs. Time Quadrant 1.

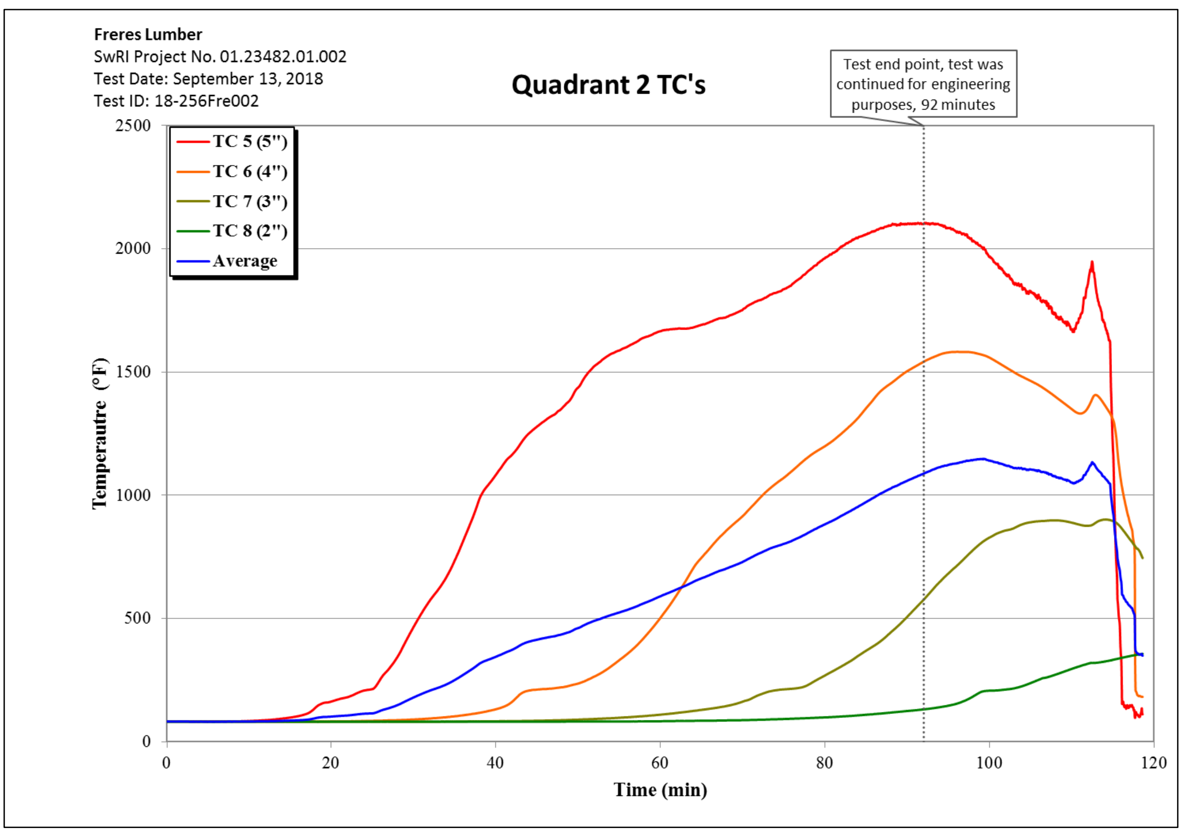

Figure C-6. Engineering Embedded Temperatures vs. Time Quadrant 2.

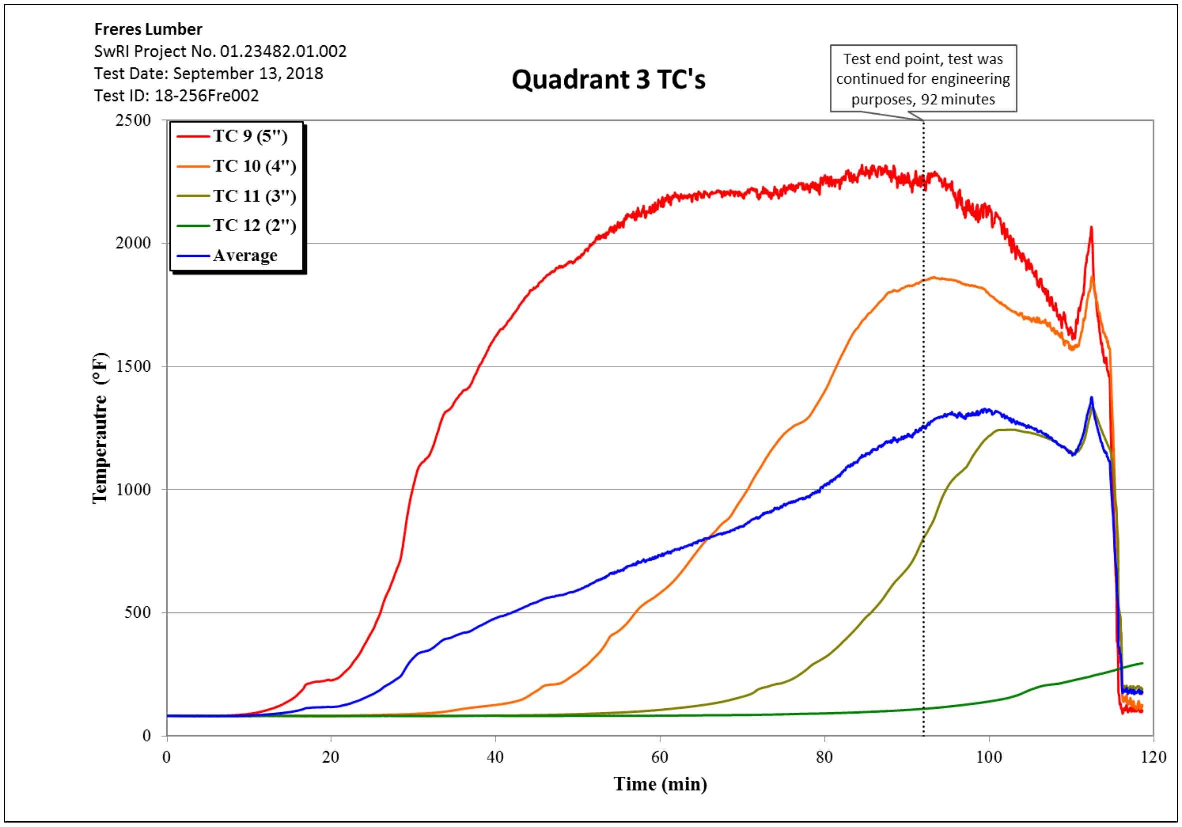

Figure C-7. Engineering Embedded Temperatures vs. Time Quadrant 3.

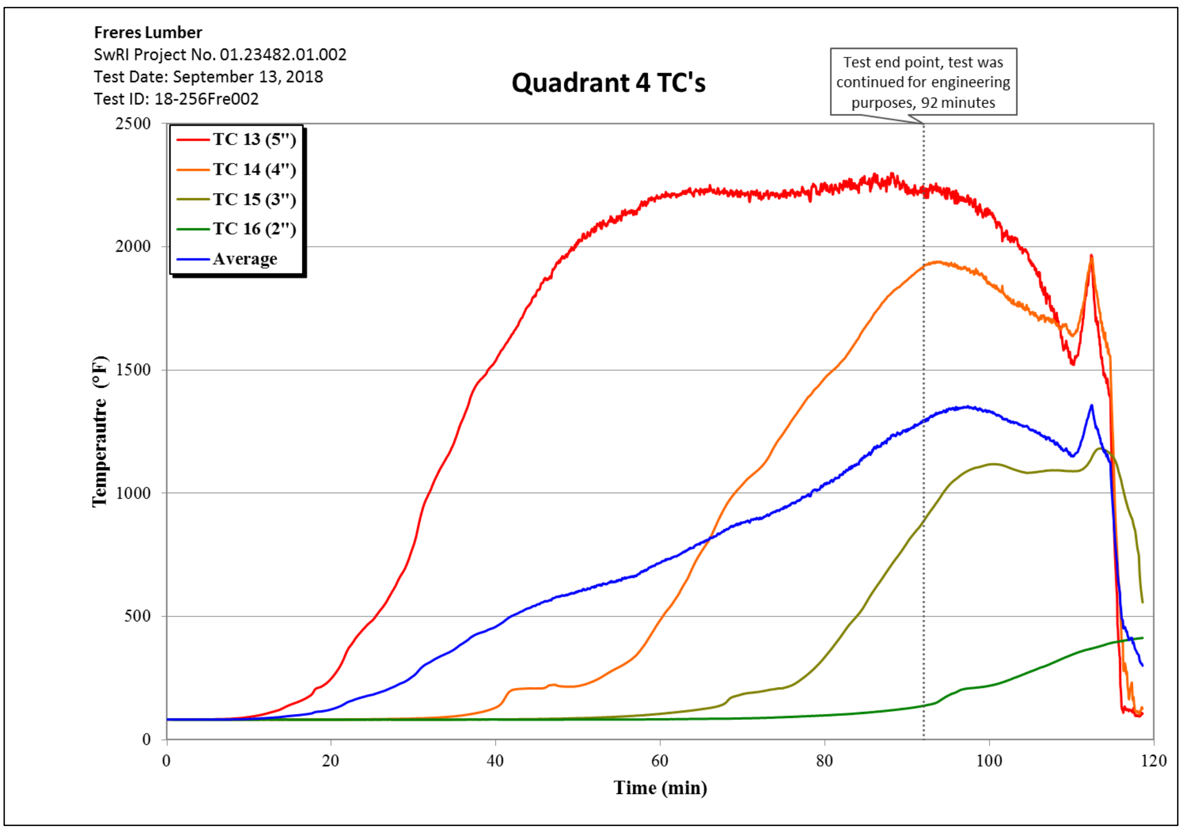

Figure C-8. Engineering Embedded Temperatures vs. Time Quadrant 4.

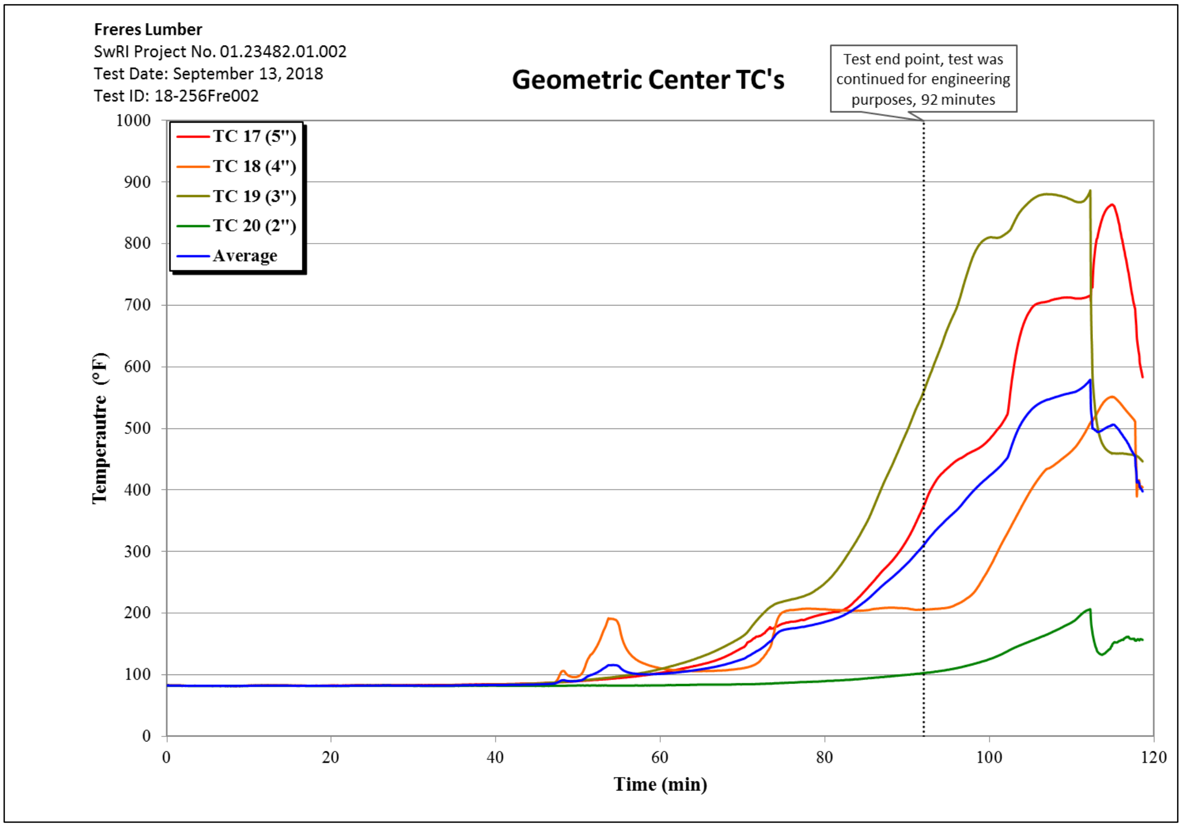

Figure C-9. Engineering Embedded Temperatures vs. Time Quadrant Geometric Center.

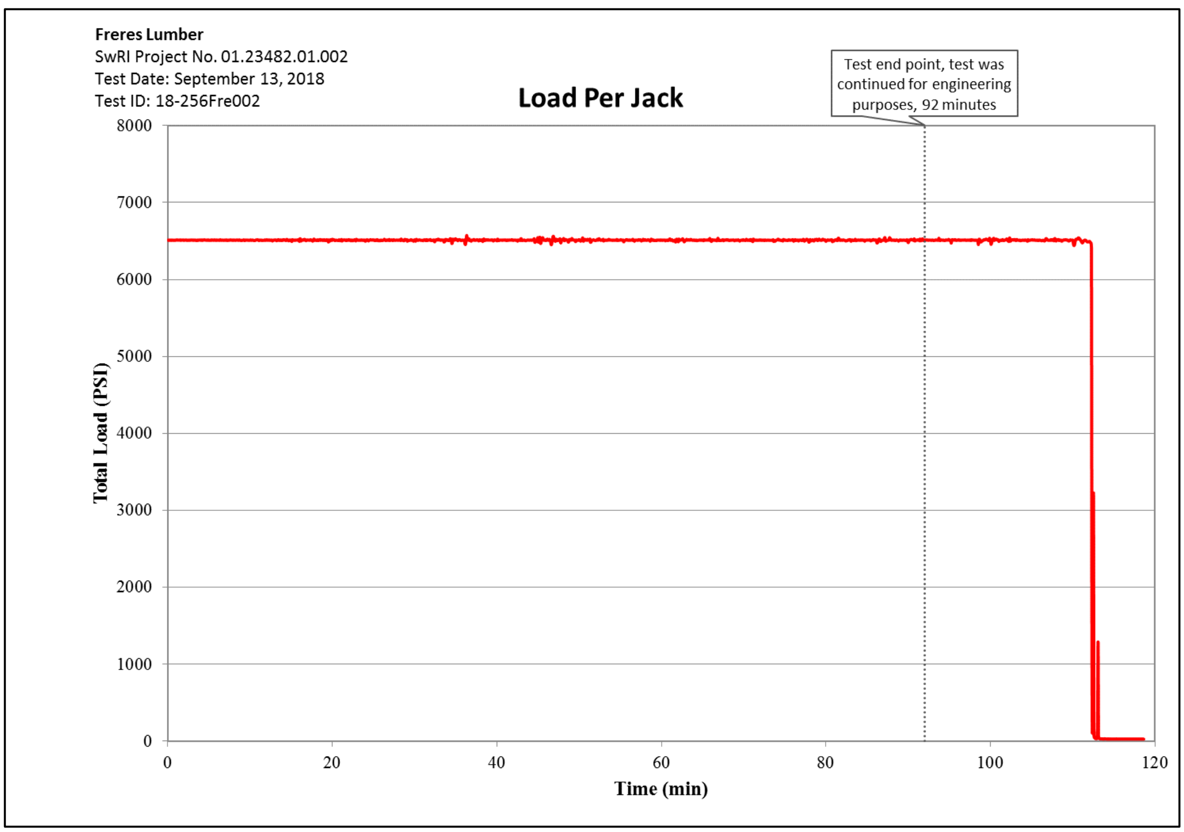

Figure C-10. Applied Load vs. Time.

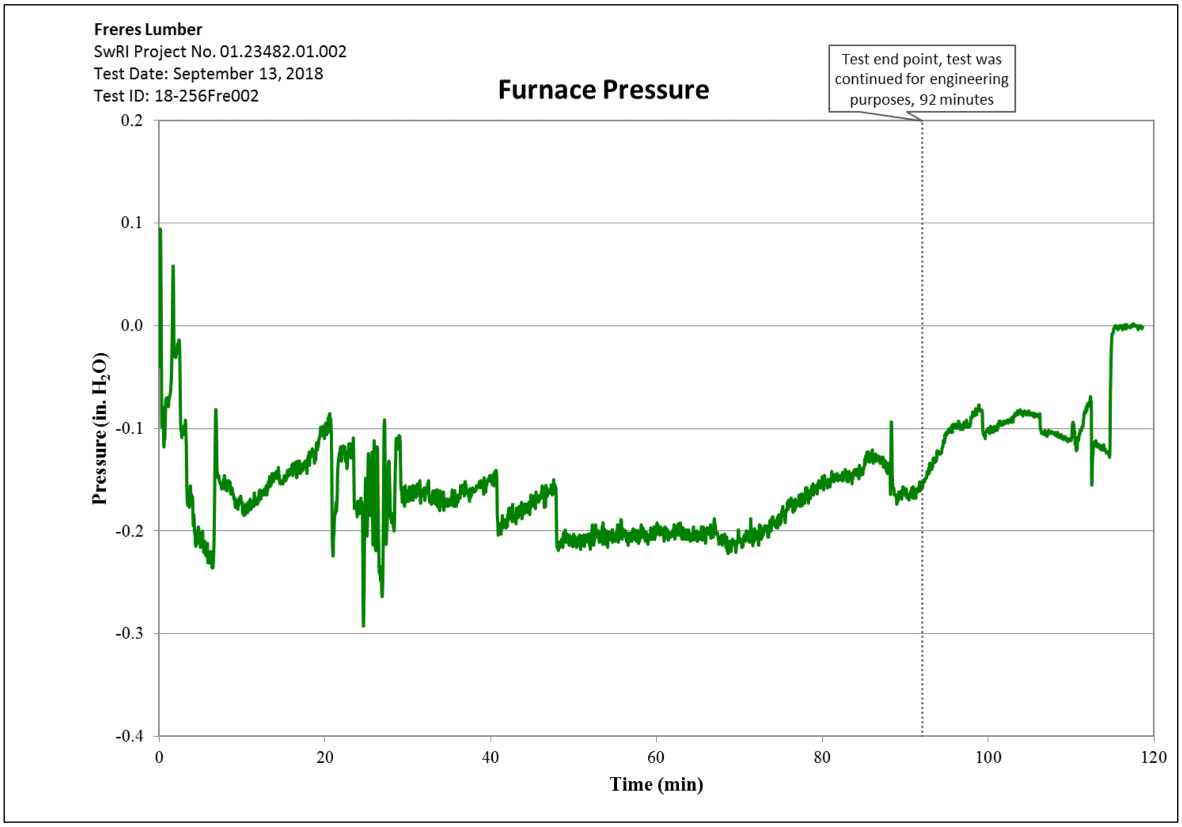

Figure C-11. Furnace Pressure vs. Time.

APPENDIX D

CLIENT-PROVIDED APA PRODUCT REPORT PR-L325

(CONSISTING OF 4 PAGES)

APA PRODUCT REPORT

www.apawood.org

FRERES Mass Panel Products **PR-L325**
Freres Lumber Co., Inc. Revised August 20, 2018

Products: Freres Mass Panel Products
Freres Lumber Co., Inc., 14114th St., Lyons, Oregon 97358
(503) 859-2121
www.frereslumber.com

1. Basis of the product report:
   - 2018, 2015, and 2012 International Building Code (IBC): Section 104.11 Alternative materials
   - 2018, 2015, and 2012 International Residential Code (IRC): Section R104.11 Alternative materials
   - ANSI/APA PRG 320-2017 Performance Rated Cross-Laminated Timber
   - ASTM D5456-14b, D5456-13, and D5456-09 recognized by the 2018 IBC and IRC, 2015 IBC and IRC, and 2012 IBC and IRC, respectively
   - APA Report T2018P-21 and other qualification data

2. Product description:
   Freres mass panel products (MPP) are manufactured with 1-inch-thick Freres 1.6E Douglas-fir LVL in accordance with custom layups of ANSI/APA PRG 320 through product qualification and mathematical models using principles of engineering mechanics. The LVL layers are parallel laminated, bonded with structural adhesives, and pressed to form a solid panel. Freres MPP can be used in floor, roof, and wall applications, and is manufactured in a plank billet with nominal widths of 2 to 144 inches, thicknesses of 2 to 12 inches, and lengths up to 48 feet.

3. Design properties:
   Freres MPP shall be designed with the design properties and capacities provided in Table 1, or recommendations provided by the manufacturer. The design adjustment factors shall be based on the recommendations provided by the manufacturer and approved by the engineer of record. The lateral resistance of Freres MPP, when used as shearwalls or diaphragms, depends on the panel-to-panel connection and anchorage designs, and shall be consulted with the manufacturer and approved by the engineer of record.

4. Product installation:
   Freres MPP shall be installed in accordance with the recommendations provided by the manufacturer and the engineering drawing approved by the engineer of record. Permissible details shall be in accordance with the engineering drawing.

5. Fire-rated assemblies:
   Fire-rated assemblies shall be constructed in accordance with the recommendations provided by the manufacturer. Procedures specified in Chapter 16 of the 2015 National Design Specification for Wood Construction (NDS) shall be permitted for use in designing Freres MPP for a fire exposure up to 2 hours.

6. Limitations:
   a) Freres MPP shall be designed in accordance with principles of mechanics using the design properties specified in this report or provided by the manufacturer.
   b) Freres MPP products shall be limited to dry service conditions where the average equilibrium moisture content of solid-sawn lumber is less than 16 percent.
   c) Design properties for Freres MPP, when used as beams or lintels with loads applied parallel to the face-bond gluelines, are beyond the scope of this report.

d) Freres MPP shall be manufactured in accordance with proprietary Freres MPP manufacturing specifications documented in the in-plant manufacturing standard approved by APA.
e) Freres MPP is produced at the Freres facility in Lyons, Oregon under a quality assurance program audited by APA.
f) Properties shown in this report are limited to MPP manufactured with 1-inch-thick Freres 1.6E Douglas-fir LVL.
g) This report is subject to re-examination in one year.

7. Identification:
Freres MPP described in this report is identified by a label bearing the manufacturer's name (Freres) and/or trademark, the APA assigned plant number (1121), the product standard (ANSI/APA PRG 320 or ASTM D5456), the APA logo, the MPP thickness, the report number PR-L325, and a means of identifying the date of manufacture.

Table 1. ASD Reference Design Values[a,b,c] for Freres MPP (For Use in the U.S.)

MPP Layup	Layup ID	Thickness, t_p (in.)	Major Strength Direction				Minor Strength Direction			
			$(F_bS)_{eff,f,0}$ (lbf-ft/ft)	$(EI)_{eff,f,0}$ (10^6 lbf-in.^{2}/ft)	$(GA)_{eff,f,0}$ (10^6 lbf/ft)	$V_{s,0}$ (lbf/ft)	$(F_bS)_{eff,f,90}$ (lbf-ft/ft)	$(EI)_{eff,f,90}$ (10^6 lbf-in.^{2}/ft)	$(GA)_{eff,f,90}$ (10^6 lbf/ft)	$V_{s,90}$ (lbf/ft)
F16	F16-2	2	1,110	16	0.82	2,190	210	2.8	0.17	695
	F16-3	3	1,870	51	1.23	2,190	355	9.0	0.26	695
	F16-4	4	3,325	122	1.64	2,925	630	21	0.34	930
	F16-5	5	5,200	238	2.05	3,650	985	42	0.43	1,160
	F16-6	6	7,500	410	2.46	4,375	1,420	72	0.69	1,390
	F16-7	7	10,200	652	2.66	5,100	1,930	114	0.81	1,630
	F16-8	8	13,325	973	3.04	5,825	2,525	170	0.91	1,860
	F16-9	9	16,850	1,385	3.42	6,575	3,200	242	1.04	2,090
	F16-10	10	20,825	1,900	3.80	7,300	3,950	333	1.15	2,320
	F16-11	11	25,175	2,529	4.18	8,025	4,775	443	1.27	2,550
	F16-12	12	29,975	3,283	4.56	8,750	5,675	575	1.38	2,775

For SI: 1 in. = 25.4 mm; 1 ft = 304.8 mm; 1 lbf = 4.448N

(a) Tabulated values are allowable design values.
(b) Tabulated values are limited to MPP manufactured with 1-inch-thick Freres 1.6E Douglas-fir LVL.
(c) Deflection under a specified uniformly distributed load, w, acting perpendicular to the face of a single-span panel may be calculated as a sum of the deflections due to moment and shear effects using the effective bending stiffness, $(EI)_{eff}$, and the effective in-plane (planar) shear rigidity, $(GA)_{eff}$, as follows:

$$\delta = \frac{22.5wL^4}{(EI)_{eff}} + \frac{3wL^2}{2(GA)_{eff}} \quad [1]$$

where: δ = Estimated deflection, inches; w = uniform load, plf;
L = span, feet; $(EI)_{eff}$ = tabulated effective bending stiffness, 10^6 lbf-in.^{2}/ft; and
$(GA)_{eff}$ = tabulated effective in-plane (planar) shear rigidity, 10^6 lbf/ft

For a concentrated line load, P, located in the middle of a single span MPP panel acting perpendicular to the panel, the deflection may be calculated as follows:

$$\delta = \frac{36PL^3}{(EI)_{eff}} + \frac{3PL}{(GA)_{eff}} \quad [2]$$

where: δ = Estimated deflection, inches; P = concentrated line load, lbf;
L = span, feet; $(EI)_{eff}$ = tabulated effective bending stiffness, 10^6 lbf-in.^{2}/ft; and
$(GA)_{eff}$ = tabulated effective in-plane (planar) shear rigidity, 10^6 lbf/ft

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