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

FINAL REPORT
Consisting of 30 Pages

SwRI® Project No. 01.23842.01.001
Test Date: September 11, 2018
Report Date: November 14, 2018

Prepared for:

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

Submitted by:

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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 resistance of an unrestrained load-bearing floor 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) *Floor 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 floor 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 Floor 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 floor are described in Table 1.

Table 1. Material Description.

Material	Provided By	Received On
MPP panels	Client	August 28, 2018
Nominal ¾-in. thick 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 floor assembly consisted of three MPP panels, that when assembled measured 15 ft 8 in. × 12 ft 8 in. × 6 in. The panels were fabricated with a 4-in. cut for a spline connection and a half lap connection. The floor consisted of two connection joints; one 4-in. half lap connection joint and one 8-in. spline connection joint. To assemble the floor 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 Hilti FS-One Max sealant 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. A final layer of ¾-in. plywood was applied to the unexposed side. Sheets 1, 4, 5, and 8 were secured with 27 2½-in. framing nails with the first nail positioned 1 in. from both edges. A spacing of 9 in. until the next row, and after that a spacing of 12 in. to every row after. Sheets 2, 3, 6, and 7 were secured with 45 2½-in. framing nails with the first nail positioned 1 in. from both edges. A spacing of 9 in. until the next row, and after that a spacing of 12 in. to every row after. The finished dimension of the assembled floor was 15 ft 8 in. × 12 ft 8 in. × 6¾ in.

Once the floor panel connections were complete, Type K ⅛-in. Inconel sheath grounded junction thermocouples were embedded into the panels. The assembled floor was installed in a test frame, provided by SwRI, which supports the perimeter of the floor assembly. The test frame was larger than the assembly, which resulted in a gap that was filled with ceramic blanket insulation. Once the frame was placed top of SwRI's large-horizontal furnace the bottom of the steel frame was then protected around the perimeter with 6-lb ceramic fiber blanket.

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 11, 2018

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

Ambient Temperature: 75.3 °F

Relative Humidity: 86.9%

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 floor, 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 floor was measured using a string potentiometer located at the center of the assembly.

Load: A total load of 18,100 lb, including dead load, was applied using SwRI hydraulic load frame consisting of twelve cylinders with 24 load contact points, each contact point applied 733.125 lb of load. The load was distributed using four nominally 2 × 6-in. wooden members spaced 2 ft apart and spanning the length of the floor (See Drawing A-3 and A-4 for Loading Details).

Observations: Refer to Table 2.

Table 2. Fire Resistance Test Visual Observations.

Time (hr:min:s)	Observation
	Pre-exposure deflection .780 in. Data was zeroed at the start of the test.
0:00:00	Furnace ignited.
0:02:45	Full ignition of wood. Furnace gas to idle in an attempt to follow the furnace time temperature curve.
0:07:00	Temperature decreasing.
0:14:00	Fire reduced to small flames, furnace camera view.
0:15:00	Introducing gas, charring with small flames, furnace camera view.
0:20:00	Steady flames across the sample, furnace camera view.
0:22:00	Flames have increased, furnace camera view.
0:30:00	Steady flames across the sample, furnace camera view.
0:45:00	Steady flames across the sample, furnace camera view, furnace idle.
0:51:30	Furnace idle.
0:56:30	Introduce gas.
0:60:00	Steady flames across the sample, furnace camera view.
1:07:00	Loud popping sound from assembly.
1:15:00	Steady flames across the sample, furnace camera view.
1:30:00	Steady flames across the sample, furnace camera view.
1:45:00	Sample joints are visible from furnace view.
2:00:00	Test Termination.
	Garden hose water was applied to reduce the burning to allow for the removal of the assembly from the furnace for the hose stream application. During the hose stream application there was no passage of water through the assembly and the assembly carried the load. Post-test observation of the panels showed approximately 2¾ in. of sample thickness on the exposed side was mostly consumed by the fire.

Hose Stream Test: Application time at 30 psig 4 min 31 s based on an area of 181 ft²

Rating Obtained: Unrestrained loaded 120-min fire resistance rating with hose stream application.

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

5.0 CONCLUSION

Based on the test results, the unrestrained loaded floor assembly tested, as described in this report, achieved a fire resistance rating of 120 min when tested in accordance with ASTM E119, including a successful hose stream application.

APPENDIX A

CLIENT-PROVIDED DRAWINGS AND THERMOCOUPLE LOCATIONS

(CONSISTING OF 3 PAGES)

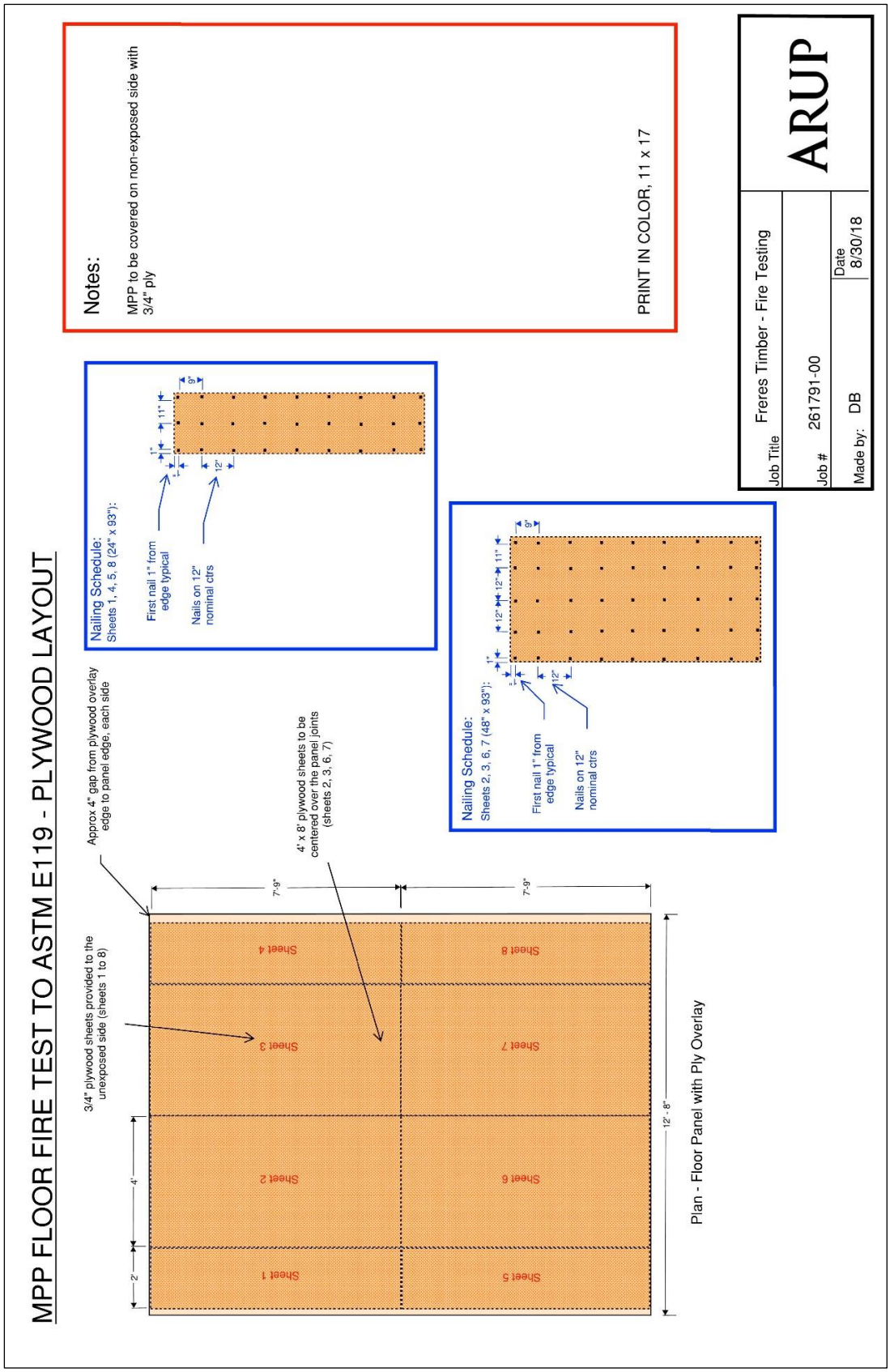
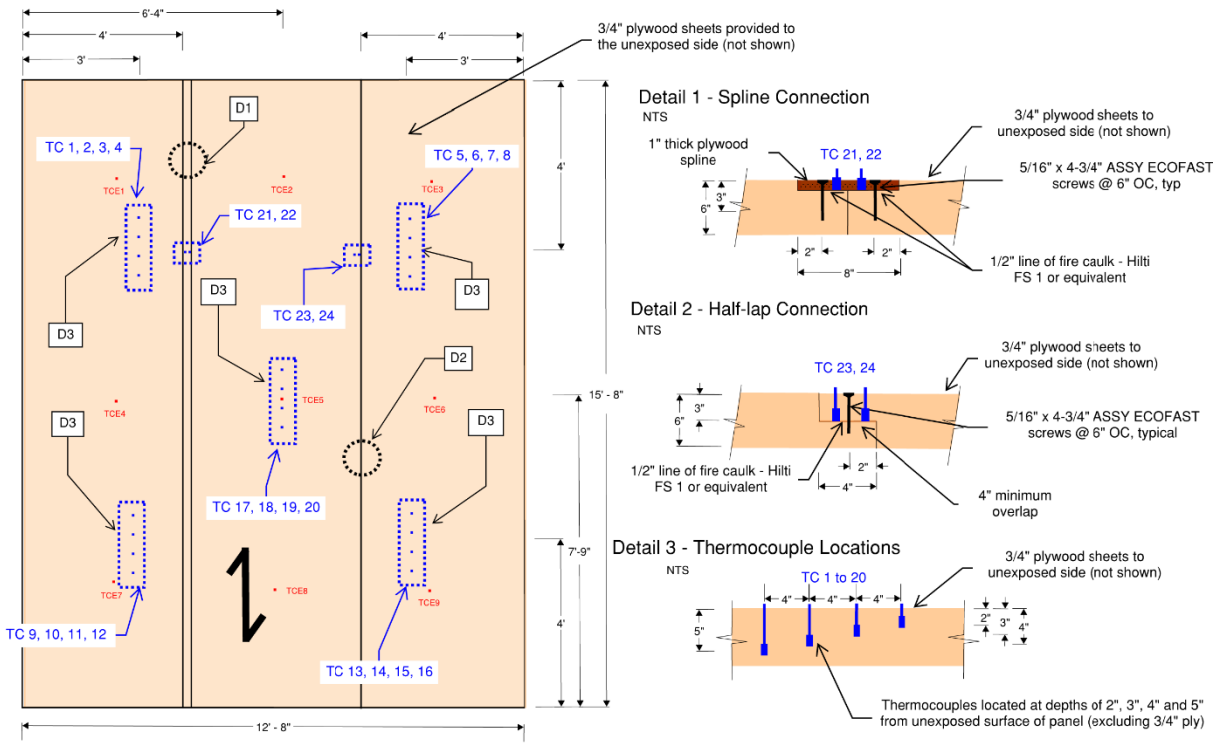


Figure A-1. Client-Provided Plywood Layout Details.

Figure A-2. Client-Provided Drawing of Thermocouple Locations and Floor Details.

MPP FLOOR FIRE TEST TO ASTM E119



Plan - Floor Panel

Thermocouple Schedule:

TC 1, 5, 9, 13, 17 -------- Located 5" from unexposed panel surface (excluding plywood)
TC 2, 6, 10, 14, 18------- Located 4" from unexposed panel surface (excluding plywood)
TC 3, 7, 11, 15, 19------- Located 3" from unexposed panel surface (excluding plywood)
TC 4, 8, 12, 16, 20------- Located 2" from unexposed panel surface (excluding plywood)

TC 21, 22----------Located at cut surface, underneath plywood spline (1" from unexposed panel surface). 1" separation from spline screws
TC 23, 24----------Located at half-lap surface (3" from unexposed panel surface). 1" separation from half-lap screws

SwRI ASTM E119 Thermocouples - Located equidistant across panel. TC E1 to E9 (red dot)

Notes:

MPP to be covered on non-exposed side with 3/4" ply.

Panel to be loaded to UDL of 100psf

Panel major strength to be in the 15'-8" direction

Fire caulk of at least 1/2" wide to be located on horizontal surface of connections. Hilti FS 1 or equivalent

Half lap and spline joints are to have screws started 1" from panel edge, then at 6" ctrs.

PRINT IN COLOR, 11 x 17

Job Title	Freres Timber - Fire Testing	ARUP
Job #	261791-00	
Made by: DB	Date 10/8/18	

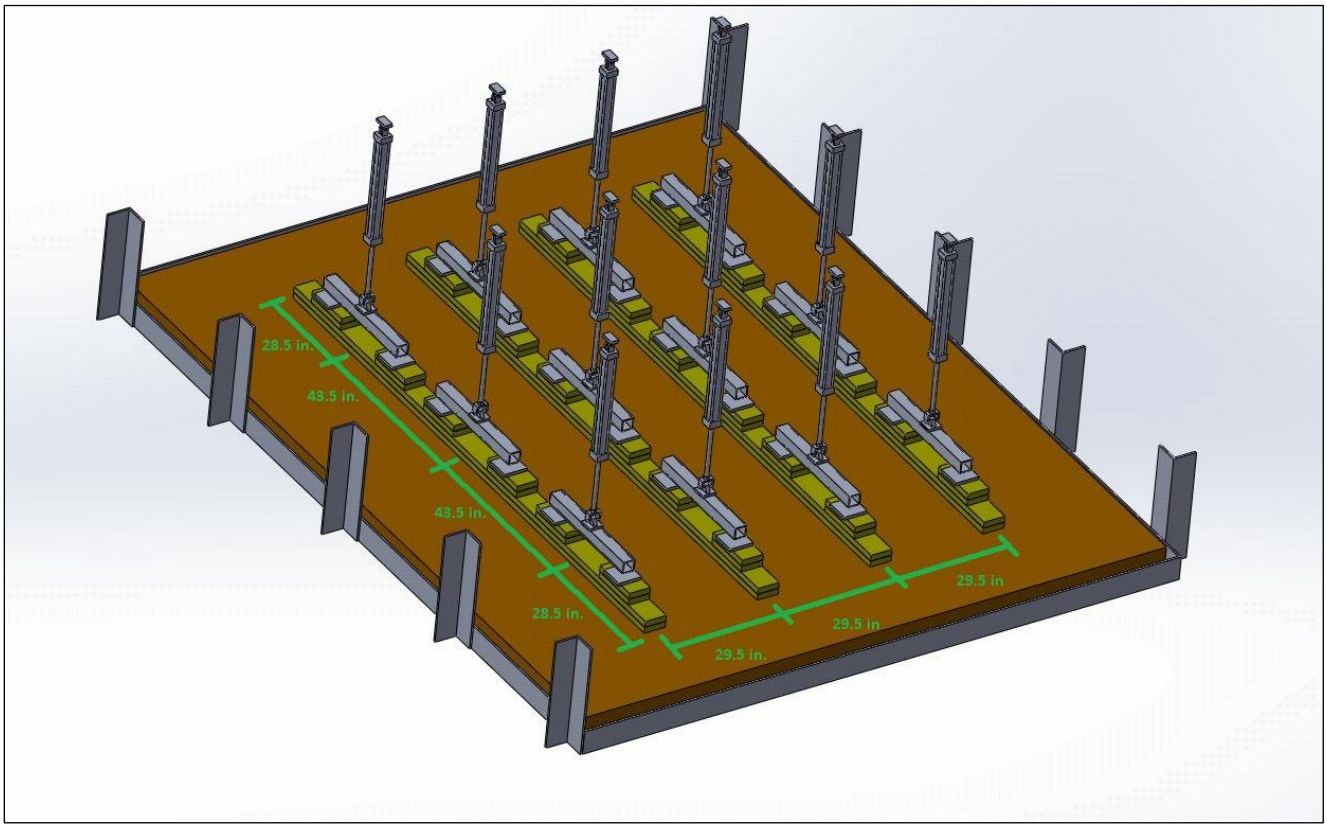


Figure A-3. Assembly Loading Layout.

Loading Information:
Applied Load: 100 lbs/psf
Area Rounded 181 ft² (Clear Span 12' × 15'1")
Total Appied Load 18,100 lb
Dead Load:
Steel Plates (6×6") Wood Runners and Bars: 505 lbs
Hydraluic Load: 17,595 lb
12 Jacks
Load per Jack: 1466.25 lb
Load per Point (24 points): 733.125 lb
Pressure Required 466.7 psig
12 Jack Bore: 2" (Area 3.14 in²)

Figure A-4. Loading Information.

APPENDIX B

TEST PHOTOGRAPHS

(CONSISTING OF 8 PAGES)

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

Figure B-2. HILTI FS-One Max Applied to Lap Joint.

Figure B-3. Application of Construction Adhesive in the Spline Connection prior to Spline Installation.

Figure B-4. Assembled Spline and Lap Joints.

Figure B-5. Inside of Furnace prior to Testing View from the Furnace Door.

Figure B-6. Unexposed Face prior to Testing.

Figure B-7. Unexposed Face 1 h 27 min into Testing.

Figure B-8. Unexposed Face 2 h into the Test.

Figure B-9. Exposed Face upon Removal from furnace.

Figure B-10. Unexposed Face Positioned for Hose Stream.

Figure B-11. Application of the Hose Stream.

Figure B-12. Exposed Face Cross Section after Chainsaw Cut.

Figure B-13. Exposed Face Cross Section of the Lap Connection after Chainsaw Cut.

Figure B-14. Exposed Face Cross Section of the Spline Connection after Chainsaw Cut.

Figure B-15. Exposed Face Post Testing and Cuts.

APPENDIX C

GRAPHICAL TEST DATA

(CONSISTING OF 6 PAGES)

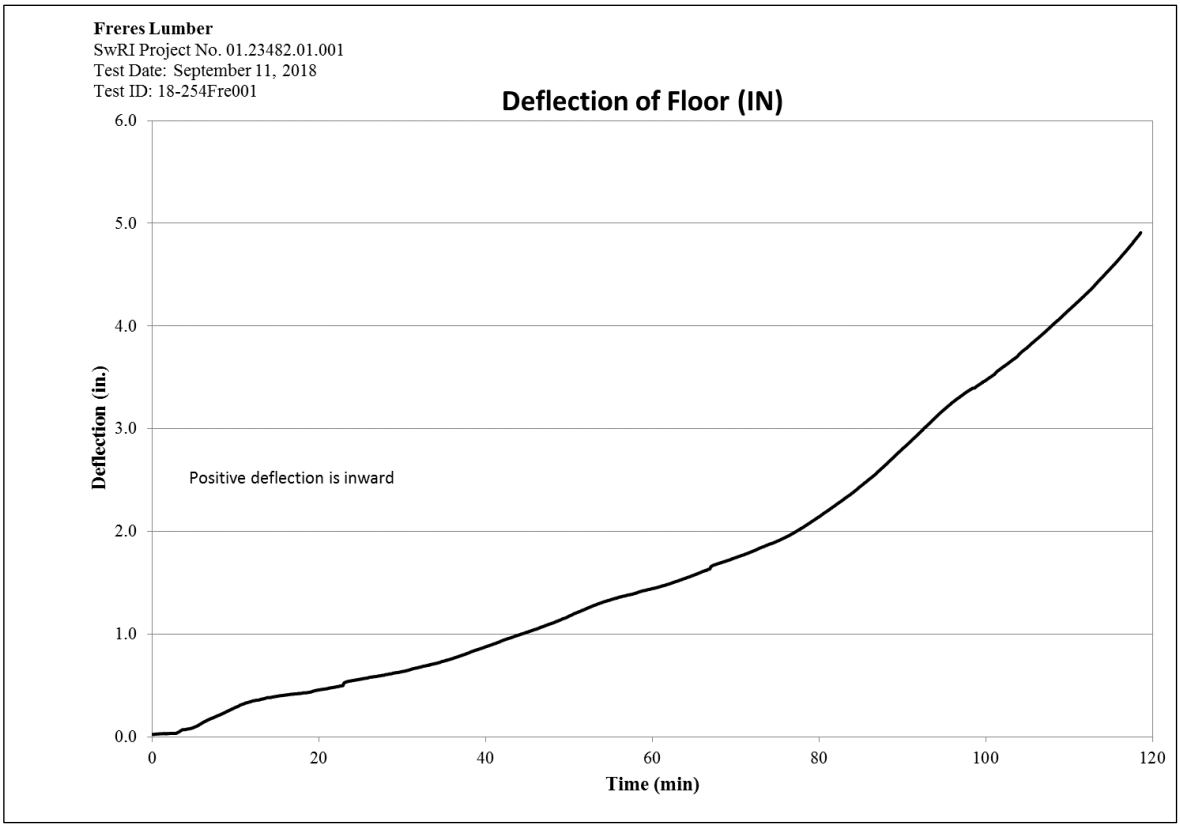


Figure C-1. Deflection into Furnace vs. Time.

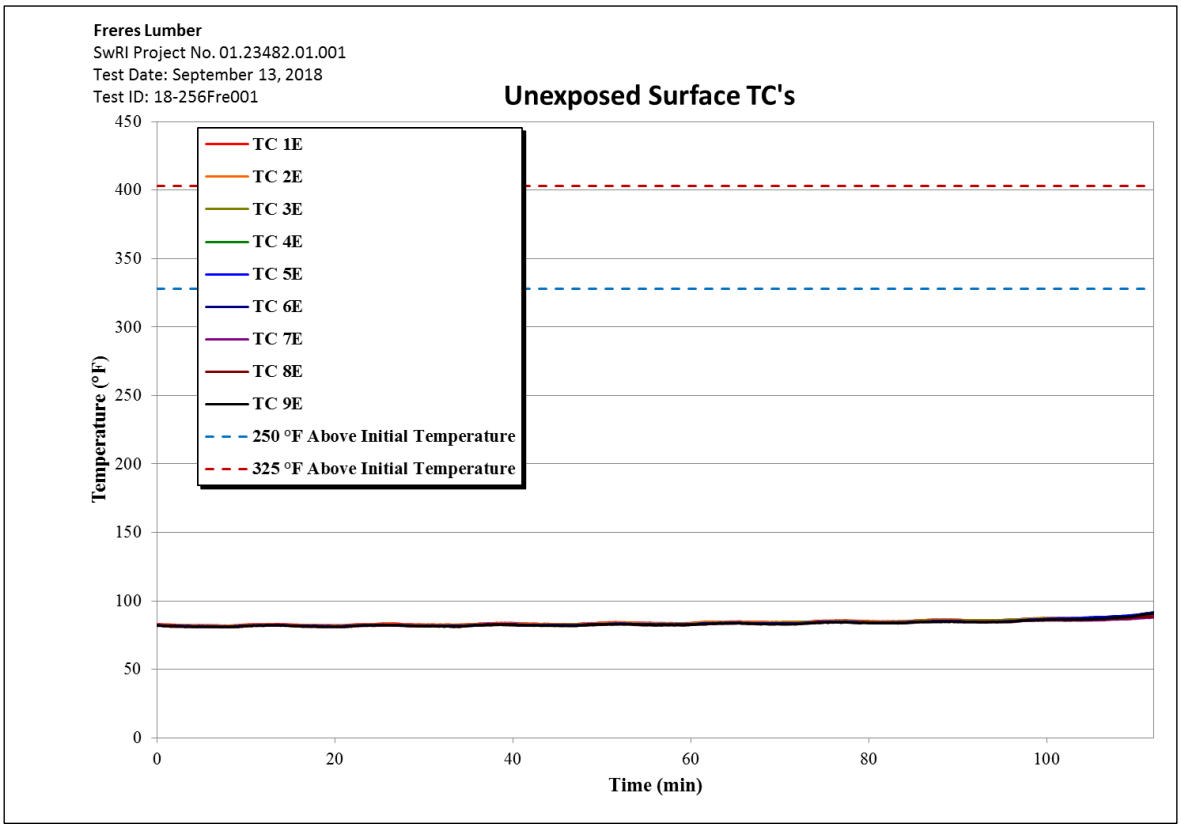


Figure C-2. ASTM Surface Temperatures vs. Time.

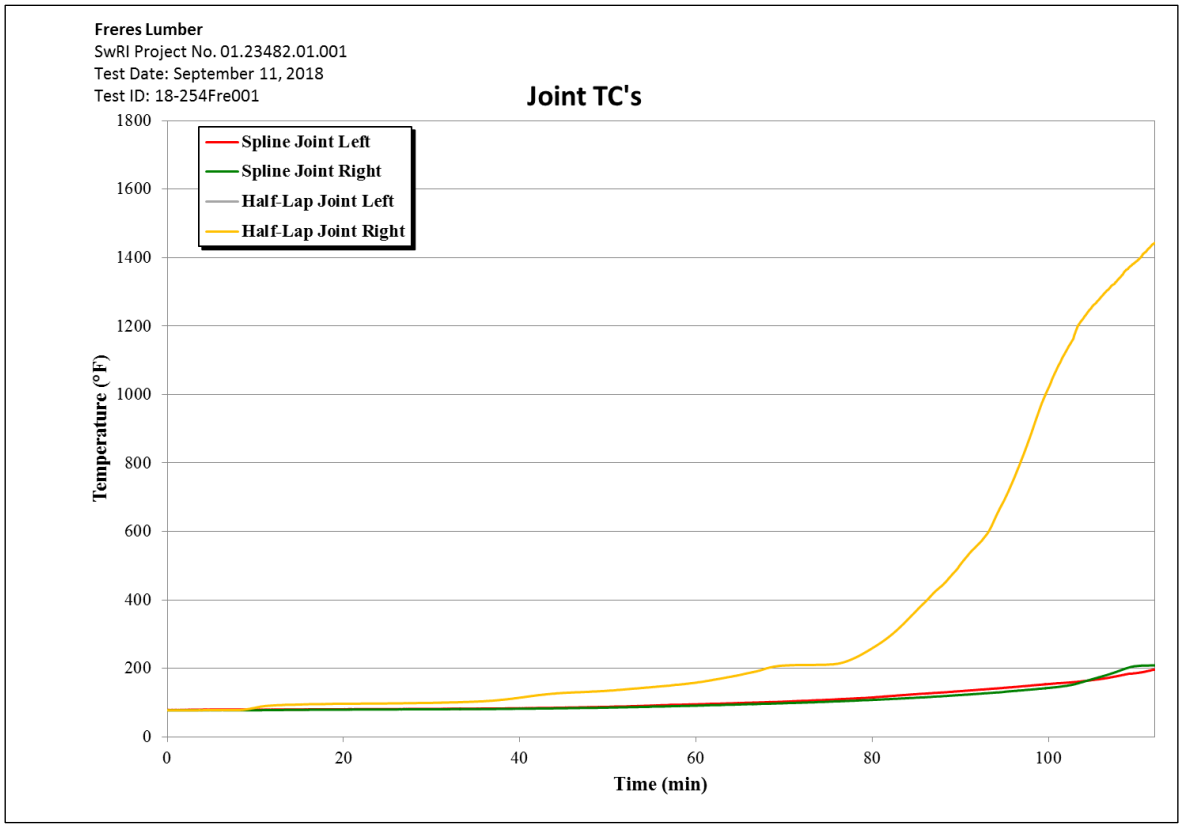


Figure C-3. MPP Surface at Connections Temperatures vs. Time.

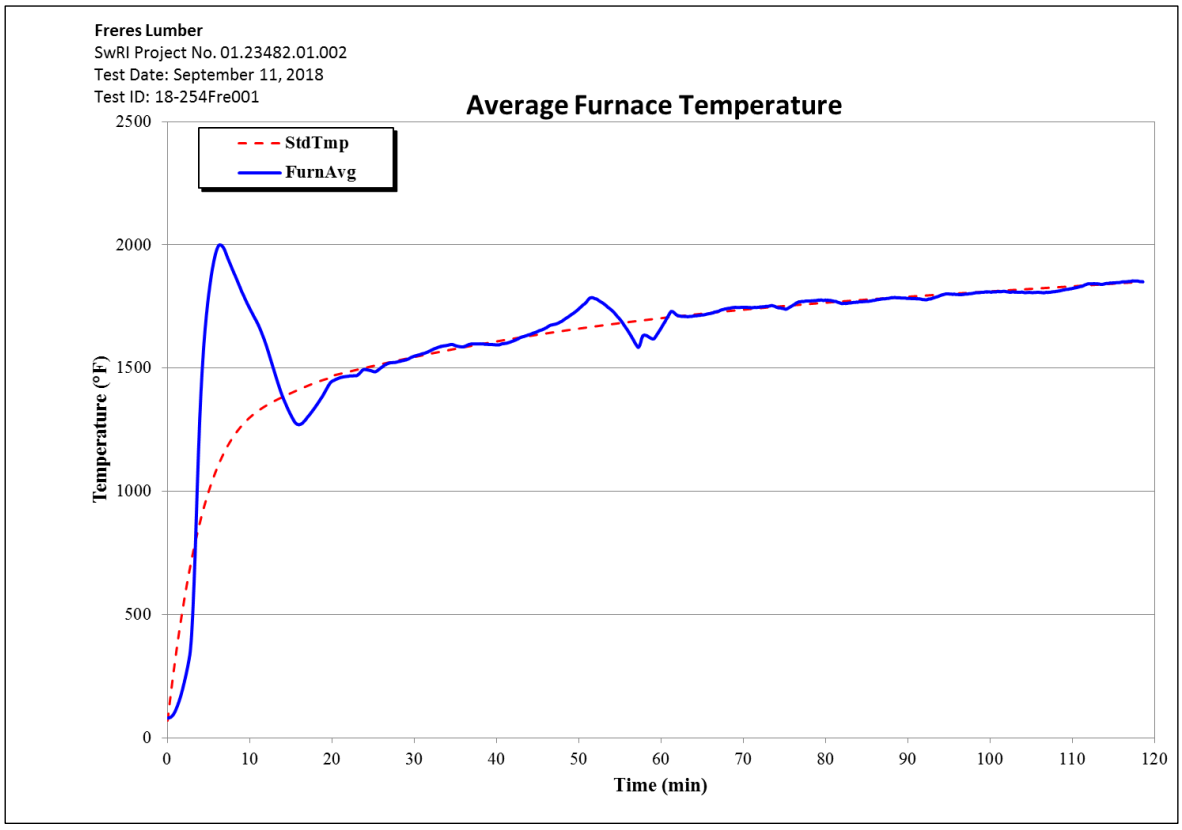


Figure C-4. Furnace Average Temperature vs. Time.

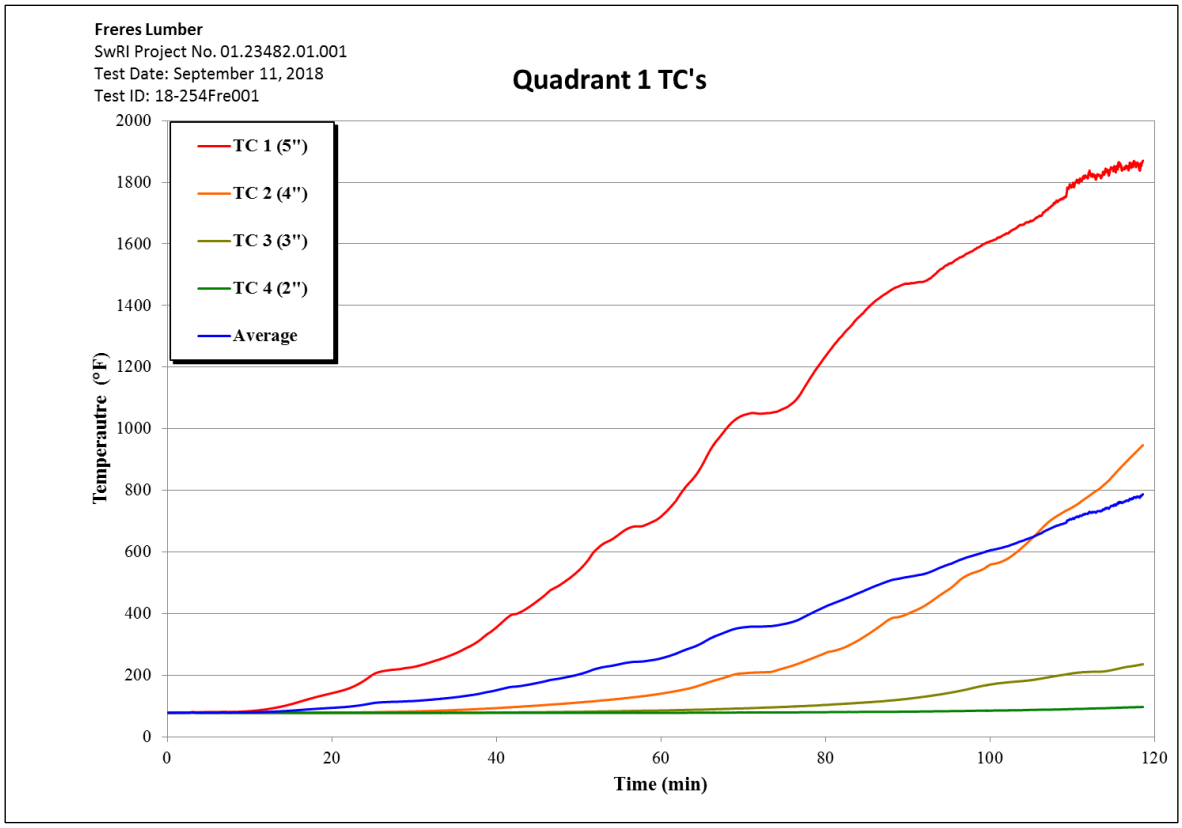


Figure C-5. Engineering Embedded Temperatures vs. Time Quadrant 1.

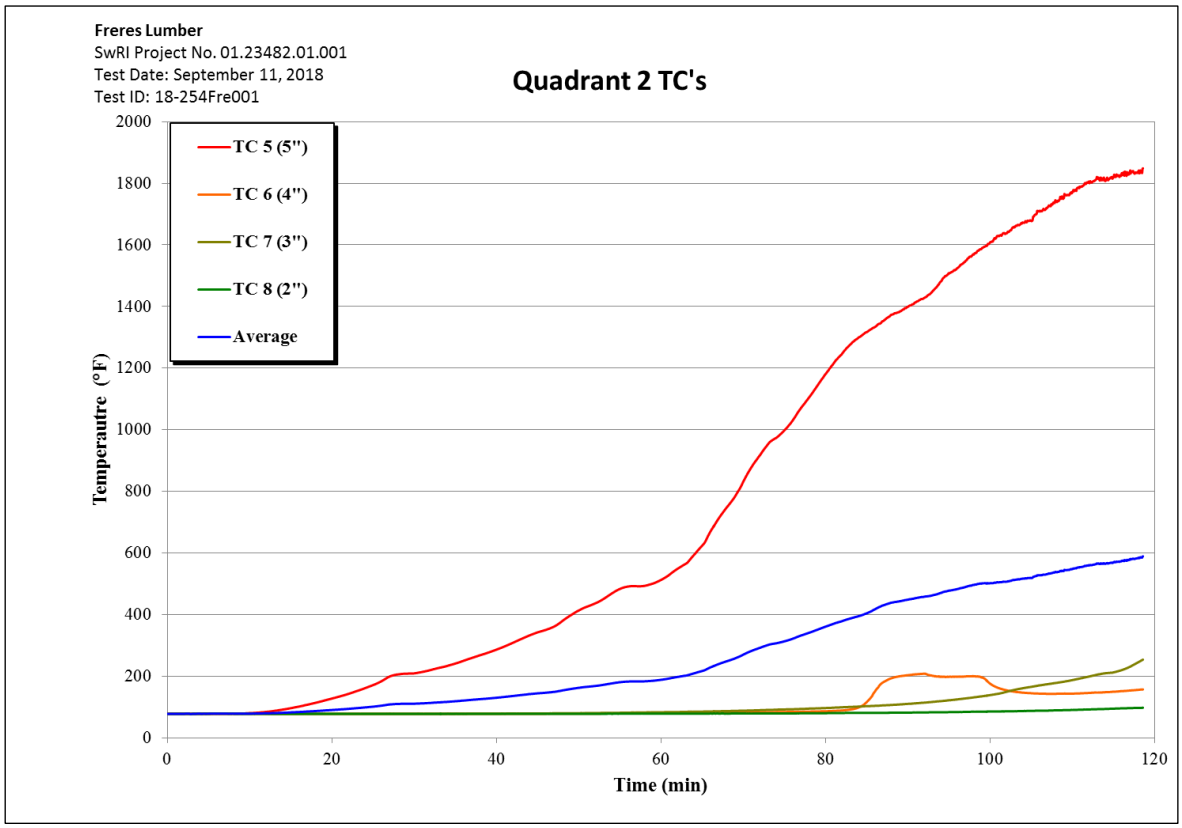


Figure C-6. Engineering Embedded Temperatures vs. Time Quadrant 2.

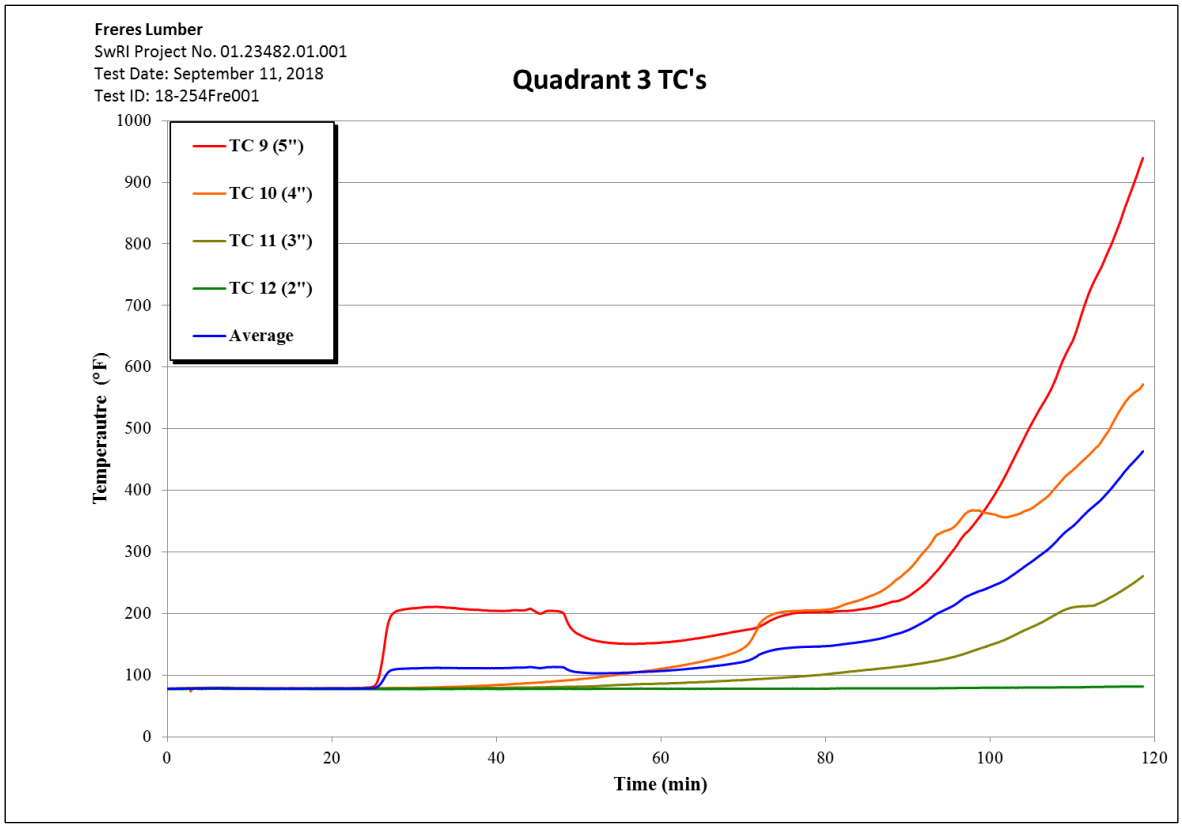


Figure C-7. Engineering Embedded Temperatures vs. Time Quadrant 3.

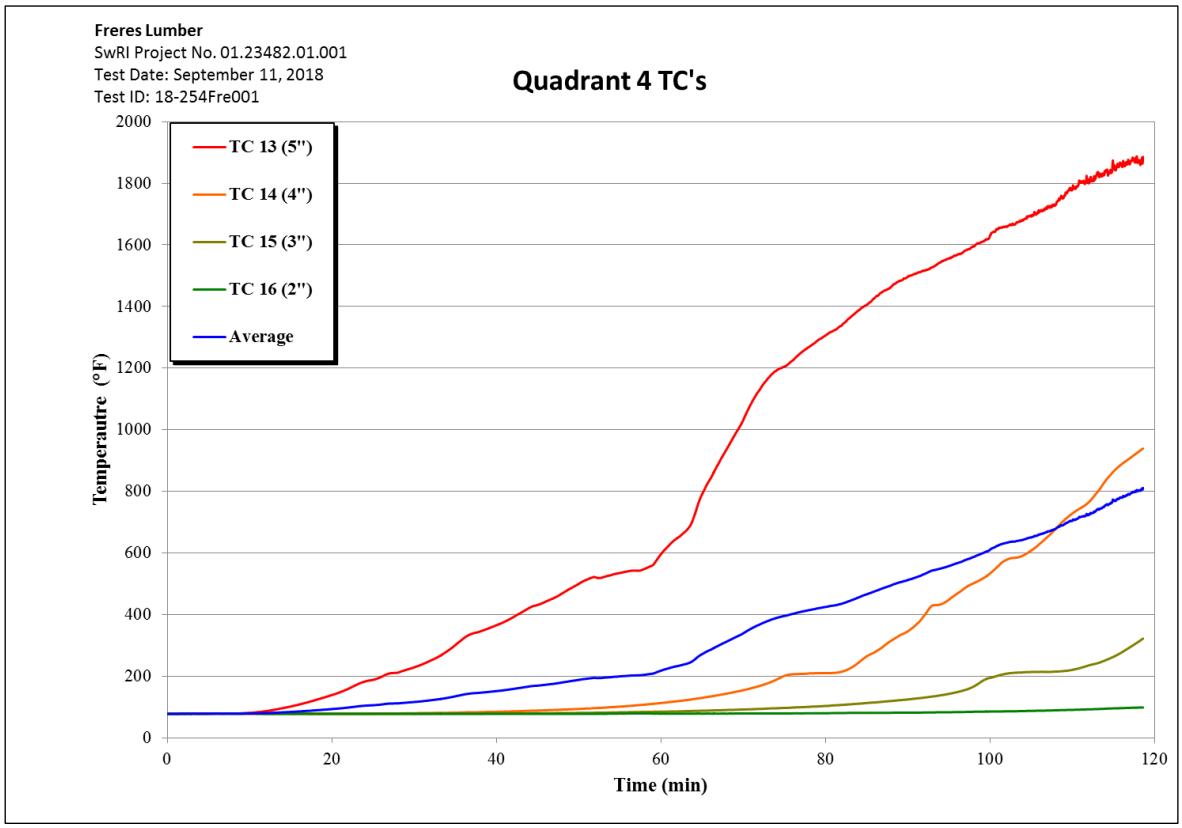


Figure C-8. Engineering Embedded Temperatures vs. Time Quadrant 4.

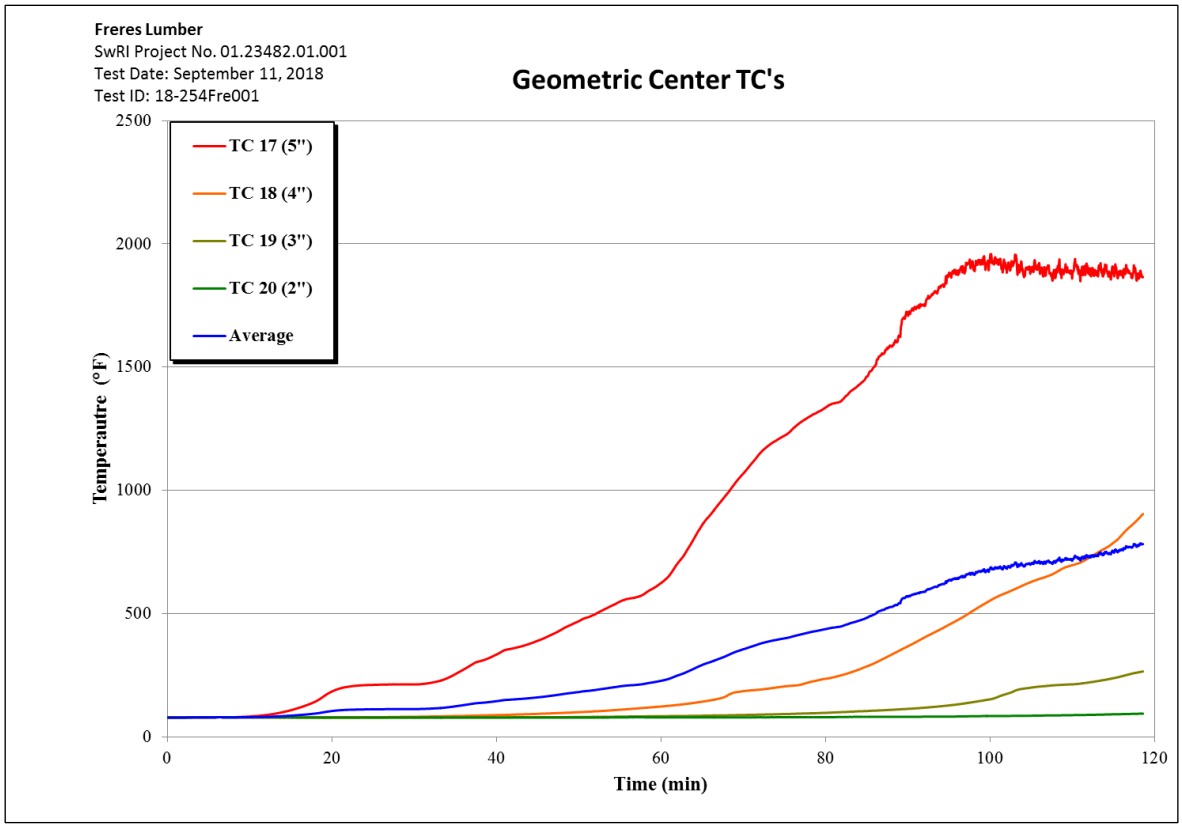


Figure C-9. Engineering Embedded Temperatures vs. Time Quadrant GC.

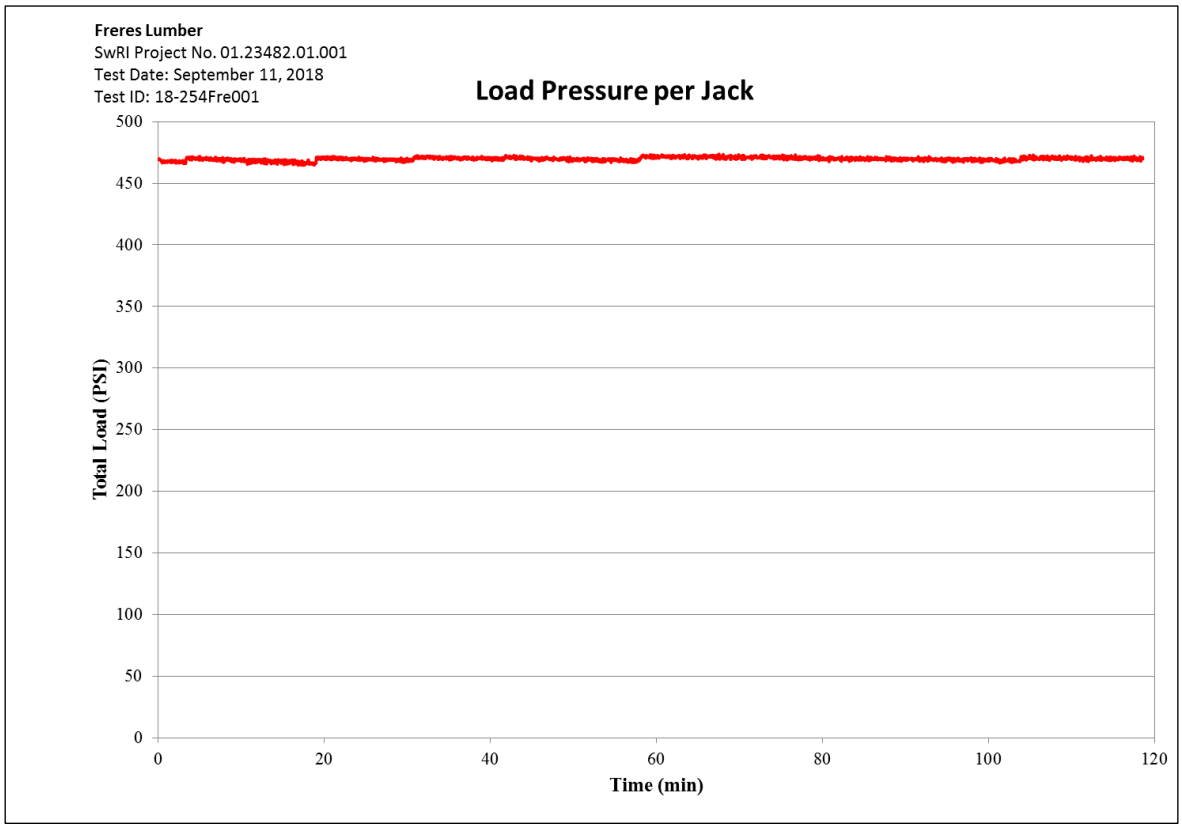


Figure C-10. Applied Load vs. Time.

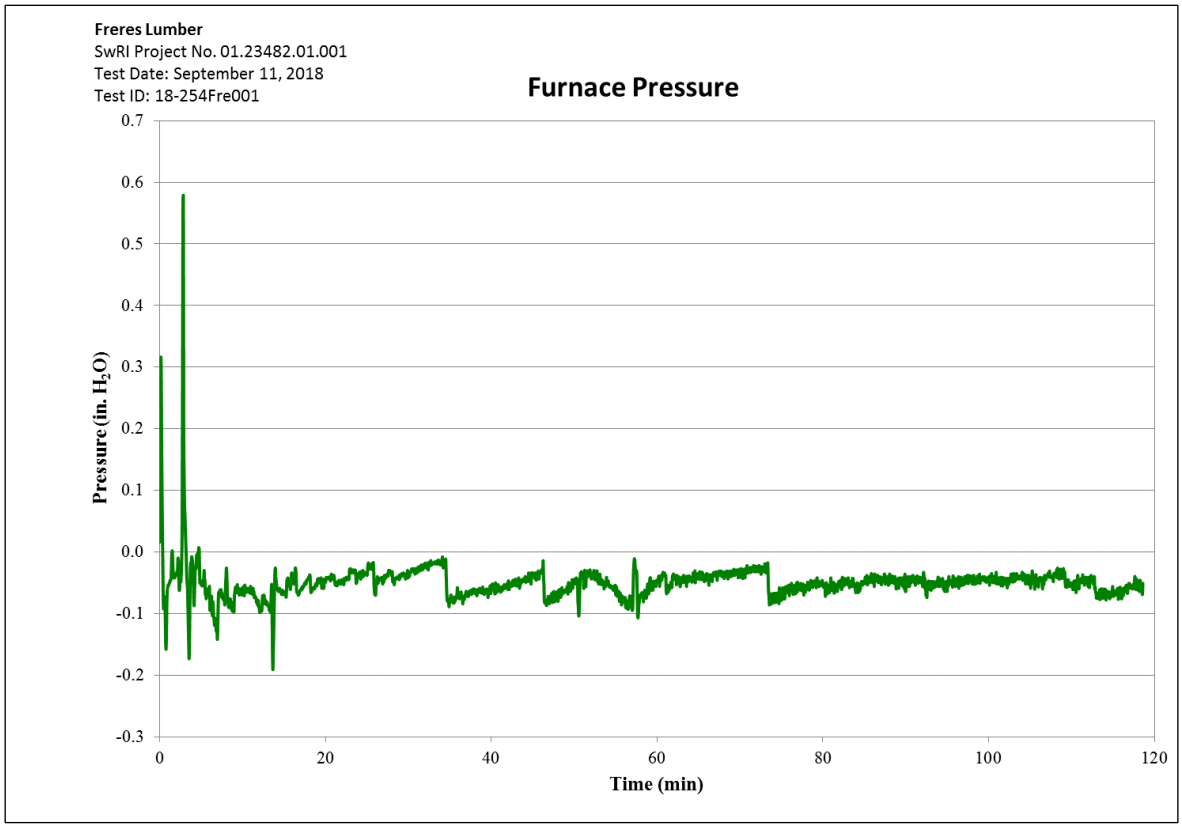


Figure C-11. Furnace Pressure vs. Time.

APPENDIX D

CLIENT-PROVIDED APA PRODUCT REPORT PR-L325

(CONSISTING OF 4 PAGES)

APA PRODUCT REPORT

www.apawood.org

FRERES Mass Panel Products
Freres Lumber Co., Inc.

PR-L325

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.

07-03

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

APA – The Engineered Wood Association is an approved national standards developer accredited by American National Standards Institute (ANSI). APA publishes ANSI standards and Voluntary Product Standards for wood structural panels and engineered wood products. APA is an accredited certification body under ISO/IEC 17065 by Standards Council of Canada (SCC), an accredited inspection agency under ISO/IEC 17020 by International Code Council (ICC) International Accreditation Service (IAS), and an accredited testing organization under ISO/IEC 17025 by IAS. APA is also an approved Product Certification Agency, Testing Laboratory, Quality Assurance Entity, and Validation Entity by the State of Florida, and an approved testing laboratory by City of Los Angeles.

APA – THE ENGINEERED WOOD ASSOCIATION
HEADQUARTERS
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Phone: (253) 565-6600 • Fax: (253) 565-7265 • Internet Address: www.apawood.org

PRODUCT SUPPORT HELP DESK
(253) 620-7400 • *E-mail Address*: help@apawood.org

DISCLAIMER

 07-03