Freres Timber

# Summary of ASTM E119 and ASTM E84 Fire Testing

Issue | March 5, 2019



Job number 261791-00

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ARUP

# Contents



## Appendices

# 1 Introduction

This report provides a summary of the fire testing undertaken by Freres Timber for their Mass Plywood Panels (MPP). The fire tests carried out were to meet:

- ASTM E84 "Standard Test Method for Surface Burning Characteristics of Building Materials", as a means to show compliance with Chapter 8 "Interior Finishes", of the International Building Code (IBC).
- ASTM E 119 "Standard Test Methods for Fire Tests of Building Construction and Materials", as means to show compliance with Chapter 7 "Fire and Smoke Protection Features", of the IBC.
    - ASTM E119 tests were undertaken for both floor and wall configurations.

This report provides an introduction to the fire tests, a summary of the results and recommendations. The report is written for and intended for use by Freres Timber.

The ASTM E84 and E119 fire tests were undertaken at Southwest Research Institute (SwRI) and occurred between September 11th and 13th, 2018.

The final fire test reports from SwRI are attached to this summary report as appendices.

Photograph 1 – MPP floor assembly, half lap joint

Photograph 2 – MPP floor assembly, spline joint

# 2 E84 Flammability Test

The MPP panel was tested to ASTM E84 to assess the use as an interior wall or ceiling finish. Interior wall and ceiling finish materials are classified in accordance with ASTM E 84 based on their flame spread and smoke-developed indices.

Photograph 3 – MPP after ASTM E 84 test

The results of the test showed that the MPP met with Class B, with a Flame spread index between 26 to 75 and a smoke developed index between 0 to 450.

The measured spread of flame classification was 45. The smoke development index was 50. The test results showed the panels produce low volumes of smoke similar to solid wood.

# 3 ASTM E119 Floor Test

The floor test summary is as follows:

| | |
|---|---|
| **Panel dimensions** | 15ft 8in x 12ft 8in x 6in (4.78m x 3.86m x 152mm) |
| **Panel connections** | Included both half-lap and single surface spline |
| **Thickness** | 6” (152mm) |
| **Non-exposed side covering** | ¾” ply (19mm) |
| **Applied loading** | 18,100 lb distributed over 24 contact points, 100psf (4.79kPa) |
| **Test result** | The floor passed at 2hrs. |

## 3.1 Test Observations

The furnace time temperature curve was initially increased over that of the standard time temperature profile from ASTM E119, for the first 10 mins, then returned to follow the curve for the rest of the test. The initial increase in the temperature in the furnace would have had a small impact on the panel performance.

Deflections totaled 6.1" (155mm) by test end. These were caused by the increased charring at the panel to panel connections as the test progressed. Deflections were constant through the test and increased in rate every 30 mins.

The applied loading was carried for the full duration of the test.

During the floor test, there was no evidence on the in-furnace camera of any char-fall off (delamination) as the panel burnt.

The test was stopped at 121 mins and water (domestic hose) was applied to the surface 4 mins after the test stopped. After the loading jacks were removed the panel was then removed from the furnace and a hose-stream test was carried out.

Inspections after the hose-stream test showed the panel still retained integrity.

Photograph 4 – MPP after ASTM E 119 floor test

Photograph 5 – MPP after ASTM E 119 floor test, undergoing hose stream test

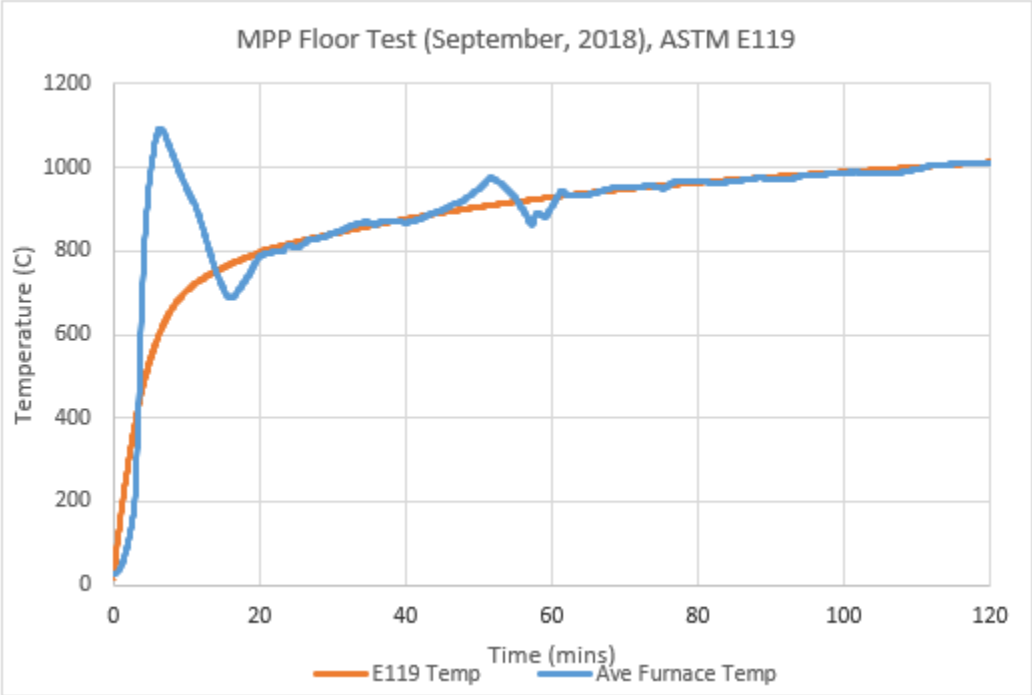


Figure 1 – Floor fire test furnace temperature compared to ASTM E119 curve, showing initial increase over the curve, then a return to the standard temperature

### 3.1.1 Measured Char Rate

After the test was completed, saw cuts were made at a number of points across the panel and the residual depth measured. The char depth was measured at 29 points and the residual depth was 2.8in (70mm). Given the original depth of 6 in (152mm):

- Measured char depth was 3.2in (82mm)
- Exposure time was 125mins (before water was fully applied)
- Measured char rate of 1.55in/hr (0.66mm/min)


Photograph 6 – MPP after ASTM E 119 floor test, measuring char depth

# 4 ASTM E119 Wall Test

The wall test summary is as follows:

| | |
|---|---|
| **Panel dimensions** | 12ft x 9ft x 6” (3.65m x 2.74m x 152mm) |
| **Connections within panel** | Included both half-lap and single surface spline |
| **Thickness** | 6” (152mm) |
| **Non-exposed side covering** | No covering |
| **Applied loading** | 147 kip (654kN), applied at two loading points |
| **Test result** | The floor test passed at 1.5hrs<br>Fire resistance time (adjusted) of 114mins |

## 4.1 Test Observations

The wall test passed at 1.5hrs and failed through integrity at the half-lap connection, with flames coming through and the connection failing a cotton ball test. The connection failed at 1hr 32mins.

The panel continued to carry load for the next 20 mins, as the test was continued and eventually failing under load at 1hr 52mins. This failure was due to insufficient panel thickness (capacity to carry the load) due to charring. The spline connection failed due to integrity at about 1hr 45mins. The loading was applied throughout the test and was only removed at panel failure.

The panel deflections were minor until the last five minutes of the test, when the lack of panel thickness caused the panel to fail midspan. The deflections were about 0.3" outwards for most of the test.

The wall was subject to a very high input time temperature curve for the duration of the test (see Figure 2). The input temperature was increased over that of the standard time temperature input. The increased furnace temperatures induced higher char rates in the timber panel and resulted in earlier than expected failure.

Due to the high furnace temperatures, ASTM E119 allows for an adjustment in the period of fire resistance rating. Based on the temperatures recorded in the test, the adjusted fire resistance time was 114 minutes.

No hose stream test was carried out, given the integrity failure at the spline connection.


Photograph 7 – MPP during ASTM E 119 wall test

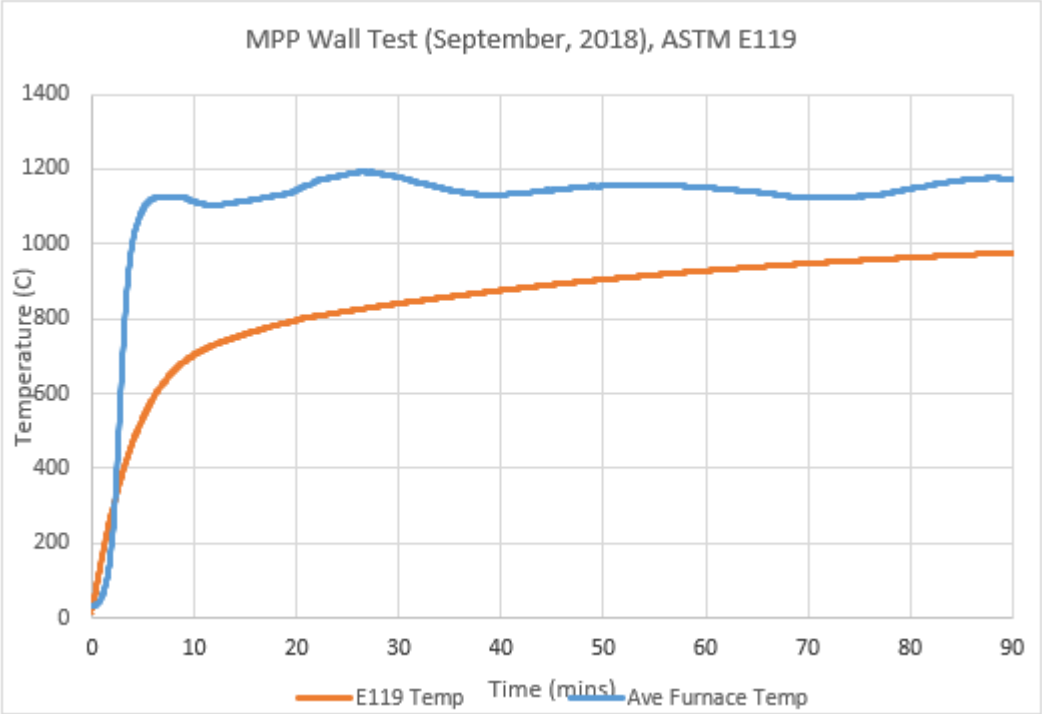


Figure 2 – Wall fire test furnace temperature compared to ASTM E119 curve, showing an increase over the required curve for the full test duration

### 4.1.1 Measured Char Rate

After the test was completed, saw cuts were made at a number of points across the panel and the residual depth measured. The char depth was measured at 50 points and the residual depth was 2.1in (53mm). Given the original depth of 6 in (152mm):

- Measured char depth was 3.9in (100mm)
- Exposure time was 110mins (before water was fully applied)
- Measured char rate of 2.15in/hr (0.91mm/min)

### 4.1.2 Discussion

The MPP wall was subject to a very high input time temperature curve for the duration of the test. The increased furnace temperatures resulted in the following impacts:

- Char rates are directly proportional to heat flux received and hence, the higher the temperature of the furnace, the higher the resultant char rate. The furnace temperature above the ASTM E119 curve resulted in higher char rates in the panel and hence earlier failure than would be expected.

- The panel away from the connections charred at about 2.1in/hr, well over the expected rate of 1.5 in/hr, as measured in the floor test.
- The higher furnace temperatures meant the half-lap connection failed at a much earlier time than expected (1.5hrs).
- The spline would have passed the test if the furnace temperatures were closer to the E119 curve.
- The MPP wall can achieve a 2hr FRR and will need an additional covering layer to the exposed side, as per Section 722.6.2.2 of the IBC.

Photograph 8 – MPP after ASTM E 119 wall test

# 5 Summary and Conclusions

From the above test results, the following has been determined for the MPP:

- Achieved a Class B classification under ASTM E84.
- Achieved a 2hr fire resistance, as a floor, for a 6" (152mm) panel with a ¾" (19mm) layer of ply nailed to the surface, with an applied load of 100psf (4.79kPa).
- Achieved a 1.5hr fire resistance, as a wall, for a 6" (152mm) panel, with an applied load of 147 kip (653kN).

## 5.1 Additional Measures to Reach a 2hr FRR for a 6" MPP Wall

For a 6" MPP in a wall configuration, to achieve a 2hr fire rating, the following will need to be added to the fire exposed side:

- ½" or larger wood structural panel (such as ply); or
- ½" or ⅝" gypsum wallboard; or
- ½" or ⅝" Type X gypsum wallboard.

Any of these options will provide an additional 10mins of fire resistance, as per Section 722.6.2.2 of the IBC, that will allow the MPP wall to attain a 2hr fire resistance rating, given the adjusted fire resistance rating is 114 minutes.

## 5.2 Appendices - Copies of SwRI Reports

The following appendices are attached:

- Appendix A – ASTM E84 test report – SwRI Project No. 01.23842.03.001, report dated September 17, 2018
- Appendix B – ASTM E119 floor test report – SwRI Project No. 01.23842.01.001, report dated November 14, 2018
- Appendix C – ASTM E119 wall test report – SwRI Project No. 01.23842.01.002[1], report dated March 3 2019

# Appendix A

## MPP ASTM E84 Test Report

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***STANDARD TEST METHOD FOR SURFACE BURNING CHARACTERISTICS PERFORMED IN ACCORDANCE WITH ASTM E84-18***

**TRADE NAME: Freres MPP**
**MATERIAL ID: *Mass Plywood Panel***

**FINAL REPORT**
**Consisting of 11 Pages**

**SwRI Project No.: 01.23842.03.001**
**Test Date: September 11, 2018**
**Report Date: September 17, 2018**

**Prepared for:**

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

Submitted by:

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Principal Engineering Technologist
Material Flammability Section

Approved by:

Matthew S. Blais, Ph.D.
Director
Fire Technology Department

## Abstract

This report presents the test results for a specimen submitted by Freres Lumber Co., Inc., located in Lyons, Oregon, and tested at Southwest Research Institute's (SwRI's) Fire Technology Department, located in San Antonio, Texas. The test is conducted in accordance with the procedure outlined in ASTM E84-16, *Standard Test Method for Surface Burning Characteristics of Building Materials* (NFPA 255, ANSI/UL 723 and UBC 8-1).

Material ID: *Mass Plywood Panel*

- Flame Spread Index (FSI): 45
- Smoke Developed Index (SDI): 45

**Test Criteria.**

| Classification | Flame Spread Index | Smoke Developed Index |
|---|---|---|
| **A** | 0 – 25 | 0 – 450 |
| **B** | 26 – 75 | 0 – 450 |
| **C** | 76 – 200 | 0 – 450 |

## 1.0 INTRODUCTION

The purpose of this test method is to determine the relative burning behavior according to the standard ASTM E84 of materials by observing the flame spread along the specimen. Flame Spread and Smoke Developed index are reported in Appendix A. However, there is not necessarily a relationship between these two measurements.

Test specimens are conditioned as appropriate in an atmosphere maintained between 68 °F and 78 °F and 45% to 55% relative humidity. Immediately prior to the test, the specimen is mounted in the furnace with the side to be tested facing the test flame. Cement board is placed on the unexposed side of the specimen to protect the furnace lid assembly. Sometimes, because of the nature of the material undergoing testing, additional support (e.g. wire, wire and rods, rods, and/or bars) is used to ensure that the specimen will remain in position during the test. The use of supporting materials on the underside of the test specimen may lower the Flame Spread Index from that which might be obtained if the specimen could be tested without such support, and the test results do not necessarily relate to indices obtained by testing materials without such support.

Two model building codes (2015 International Building Code®, Chapter 8 *Interior Finishes*, Section 803 *Wall and Ceiling Finishes*; NFPA 5000, Chapter 10 *Interior Finish*, Section 10.3 *Interior Wall or Ceiling Finish Testing and Classification*) classify materials based on the Flame Spread and Smoke Developed indices.

This standard should be used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled 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 the test may be used as elements of a fire-hazard assessment or a fire-risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard or fire risk of a particular end use.

The results apply specifically to the specimens 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. More detailed results with graphical illustrations may be found in Appendix A.

## 2.0 DESCRIPTION OF SPECIMEN

| | |
|---|---|
| MATERIAL ID:* | *Mass Plywood Panel* |
| TRADE NAME:* | Freres MPP |
| DATE RECEIVED: | August 28, 2018 |
| DESCRIPTION:* | 3-inch thick F16-3 per APA Product Report (PR-L325) |
| THICKNESS: | 76 mm (nominal) |
| WEIGHT: | 206.4 kg (nominal) (tested) |
| COLOR: | Brown |
| SUBSTRATE: | N/A |
| ADHESIVE: | N/A |
| SPECIMEN SIZE: | 7620 × 610 mm (nominal) (1 piece) |
| PREPARED BY: | SwRI Personnel |
| CONDITIONING TIME: | 7 days at 73.4 °F ± 5 °F (23 °C ± 2.8 °C), 50% ± 5% humidity |
| SUPPORT USED: | None |
| WITNESSED BY: | Patrick Farrell and Dave Barber |

* From Client's material description and/or instructions

**APPENDIX A**

**TEST RESULTS**

**(CONSISTING OF 6 PAGES)**

Client: Freres Lumber Co., Inc.
SwRI Project No.: 01.23842.03.001
Test Date: September 11, 2018
Material I.D.: *Mass Plywood Panel*

**TEST RESULTS**

| | |
|---|---|
| ROUNDED FLAME SPREAD INDEX (FSI): | 45 |
| ROUNDED SMOKE DEVELOPED INDEX (SDI): | 45 |

**TEST DATA**

| | |
|---|---|
| UNROUNDED FSI: | 45.2 |
| UNROUNDED SDI: | 43.8 |
| FS*TIME AREA (Ft*Min): | 87.7 |
| SMOKE AREA (%*Min): | 54.0 |
| FUEL AREA (°F*Min): | 5883.6 |

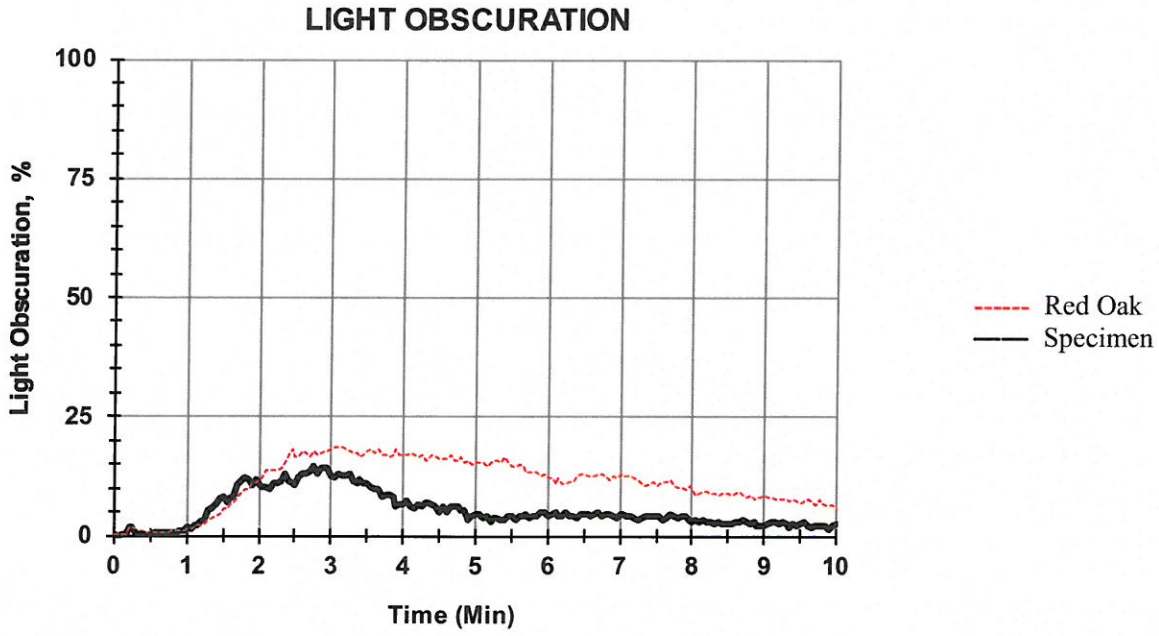
**OBSERVATIONS DURING TEST**

| | |
|---|---|
| IGNITION TIME (Min: S): | 0:33 |
| MAXIMUM FLAME FRONT ADVANCE (Ft.): | 12.0 |
| TIME TO MAXIMUM ADVANCE (Min: S): | 10:00 |
| MAXIMUM TEMP. AT EXPOSED TC (°F): | 755 |
| TIME TO MAXIMUM TEMP. (Min: S): | 10:00 |
| TOTAL FUEL BURNED (Cu. Ft.): | 52.0 |
| DRIPPING (Min: S): | None |
| FLAMING ON FLOOR (Min: S): | None |
| AFTERFLAME TOP (Min: S): | 2:42 |
| AFTERFLAME FLOOR (Min: S): | None |
| SAGGING (Min: S): | None |
| DELAMINATION (Min: S): | None |
| SHRINKAGE (Min: S): | None |
| FALLOUT (Min: S): | 2:11 |

**CALIBRATION DATA**

| | |
|---|---|
| RED OAK SMOKE AREA (%*Min): | 111.3 |
| RED OAK FUEL AREA (°F*Min): | 1133.2 |
| GRC BOARD FUEL AREA (°F*Min): | 4720 |

Client: Freres Lumber Co., Inc.
SwRI Project No.: 01.23842.03.001
Test Date: September 11, 2018
Material I.D.: *Mass Plywood Panel*



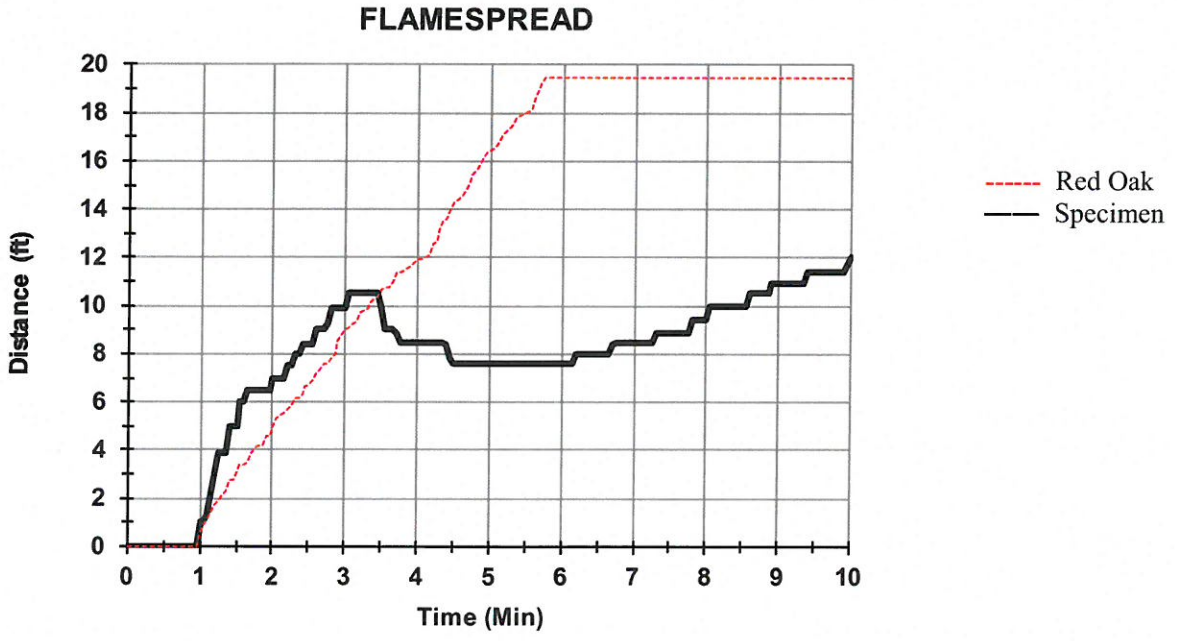



**Figure A-3. Pre-test**

**Figure A-4 Posttest of the exposed side at the front of the sample.**

**Figure A-5. Posttest of the exposed side towards the end sample.**

**Figure A-6. Posttest of the exposed side from the end of the sample.**

# Appendix B

# MPP ASTM E119 Floor Test Report

SOUTHWEST RESEARCH INSTITUTE

2

CHEMISTRY AND CHEMICAL ENGINEERING DIVISION

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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:

KF Bill B Bendele

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Principal Technologist
Fire Resistance Section

Approved by:

Karen C. Carpenter

Karen C. Carpenter, M
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.<br>During the hose stream application there was no passage of water through the assembly and the assembly carried the load.<br>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 $ft^2$

**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)

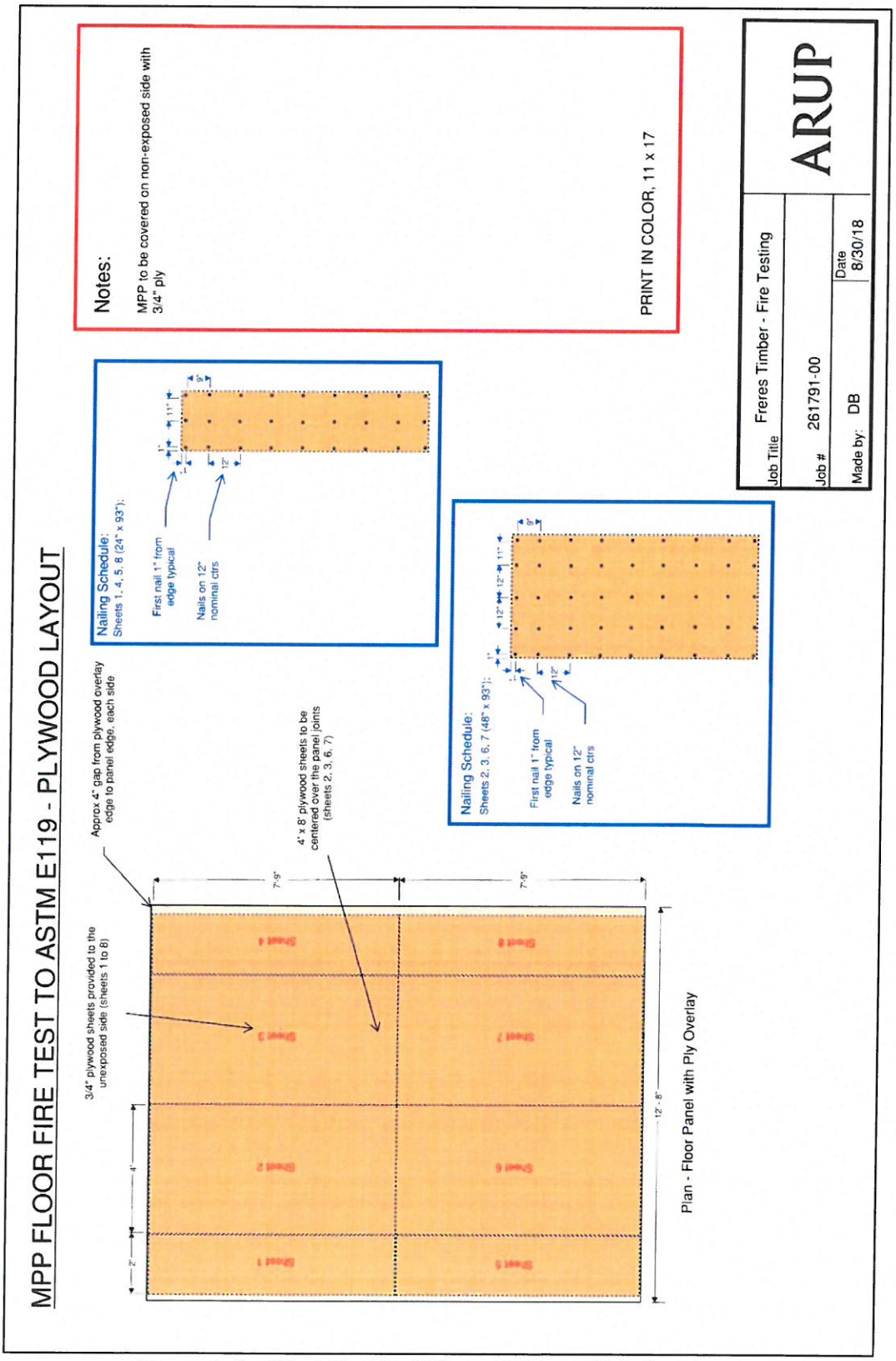
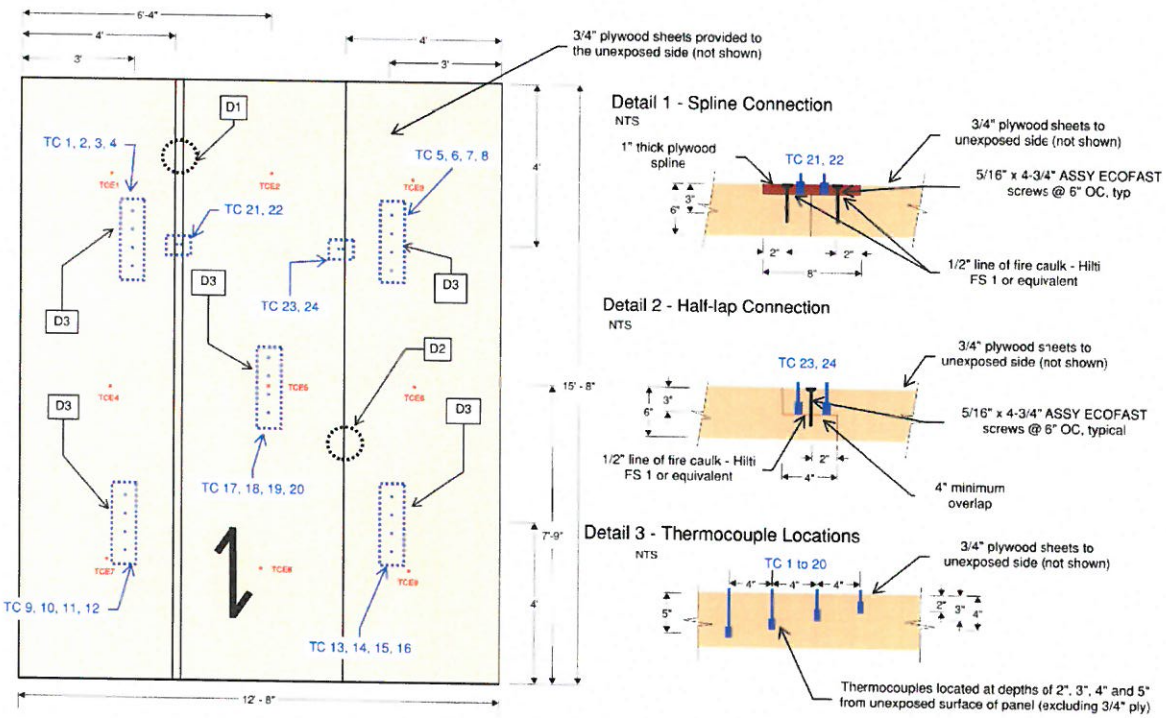



**Figure A-1. Client-Provided Plywood Layout Details.**

**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 | |

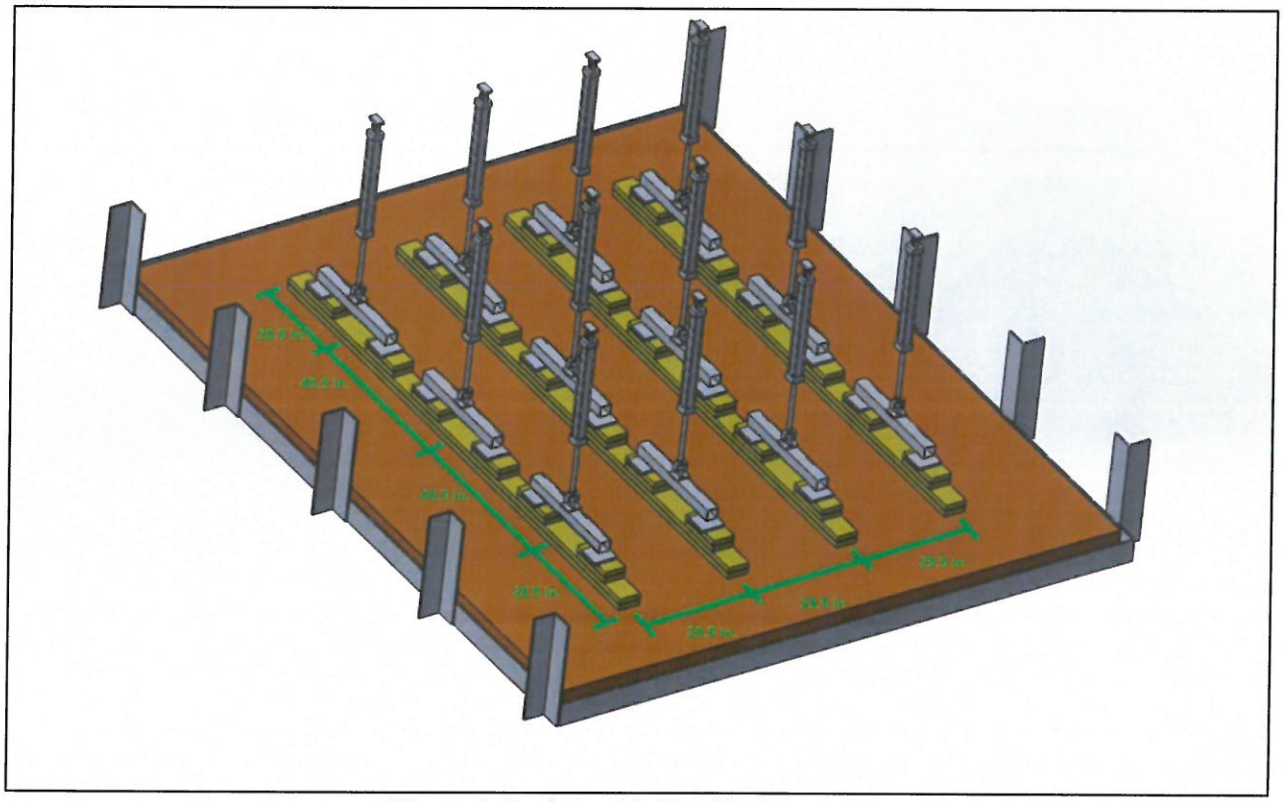


**Figure A-3. Assembly Loading Layout.**

**Loading Information:**

**Applied Load: 100 lbs/psf**

**Area Rounded 181 ft$^2$ (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 in$^2$)**

**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.**

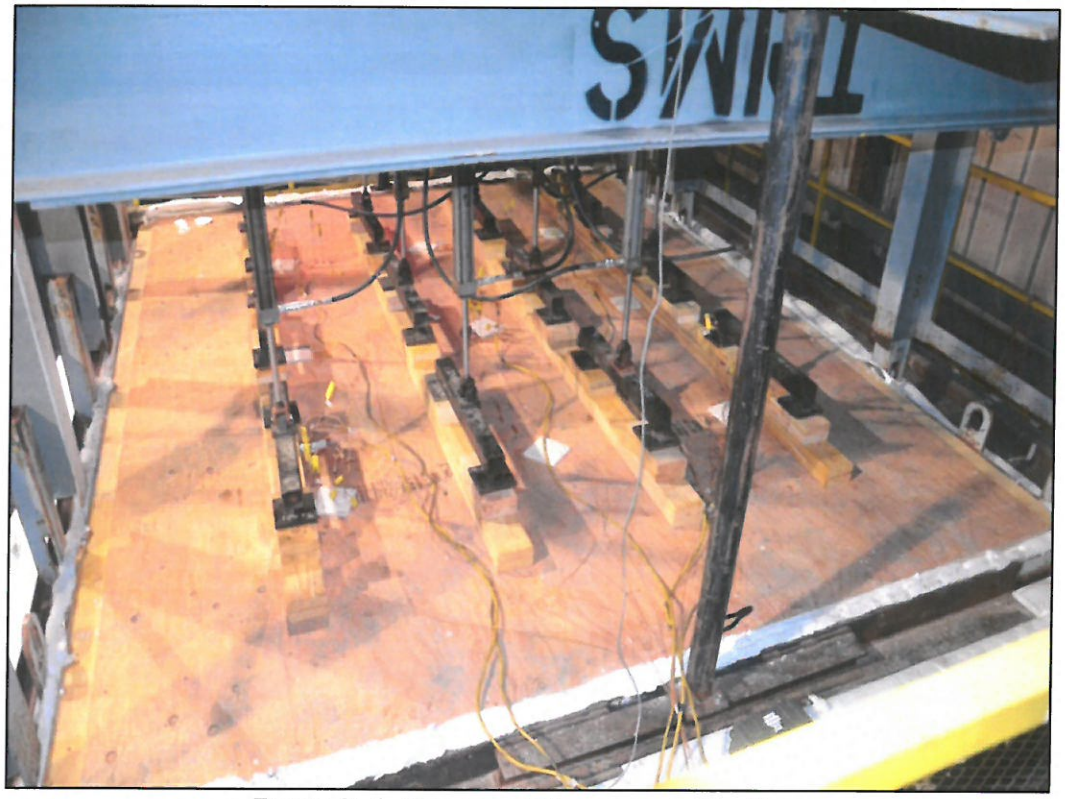


**Figure B-6. Unexposed Face prior to Testing.**

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

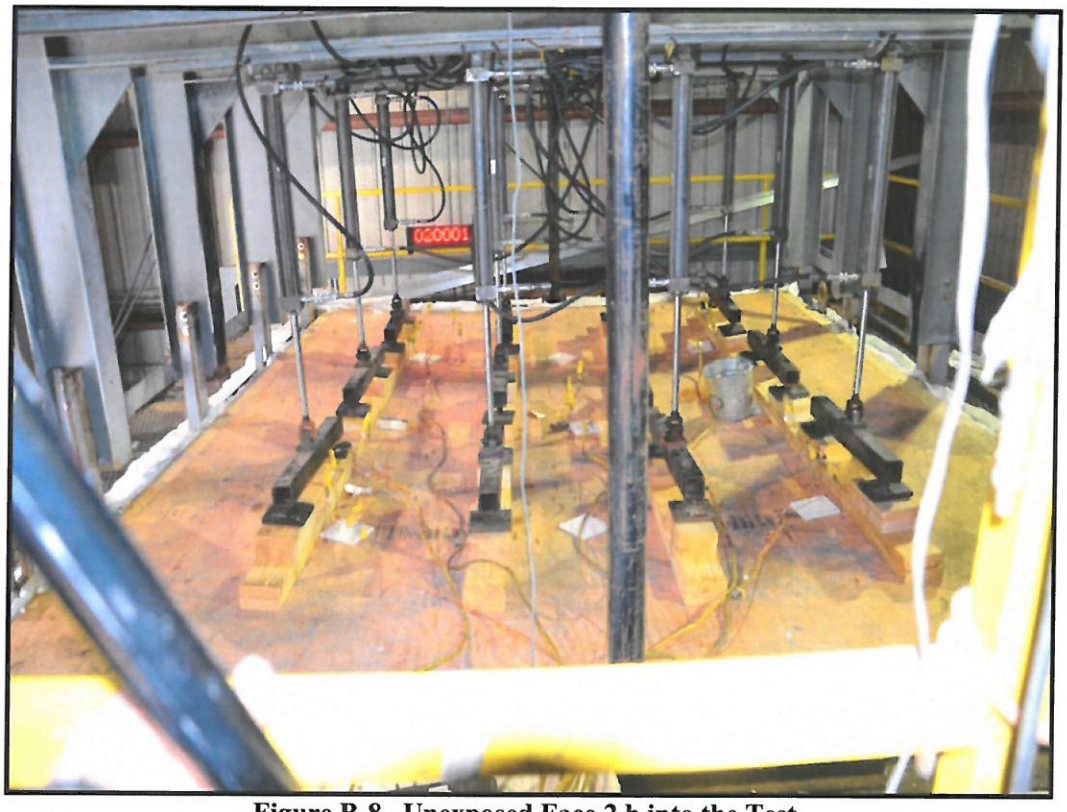


**Figure B-8. Unexposed Face 2 h into the Test.**


**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.**

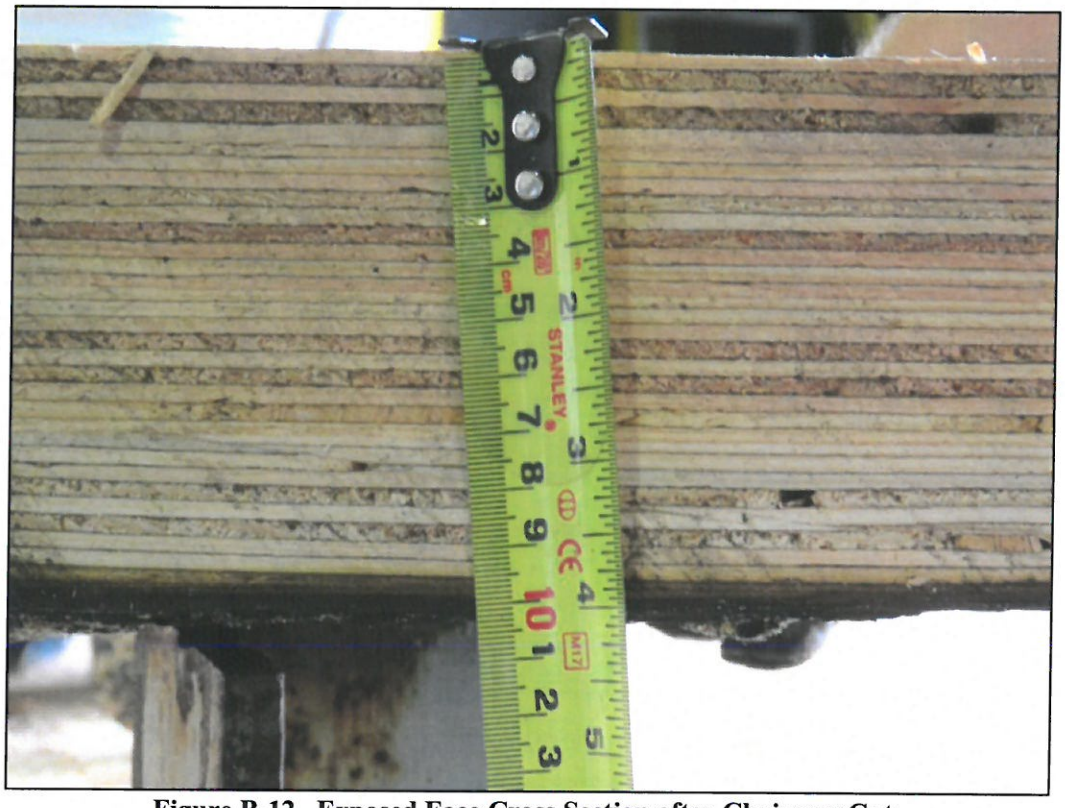



**Figure B-12. Exposed Face Cross Section after Chainsaw Cut.**

**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)

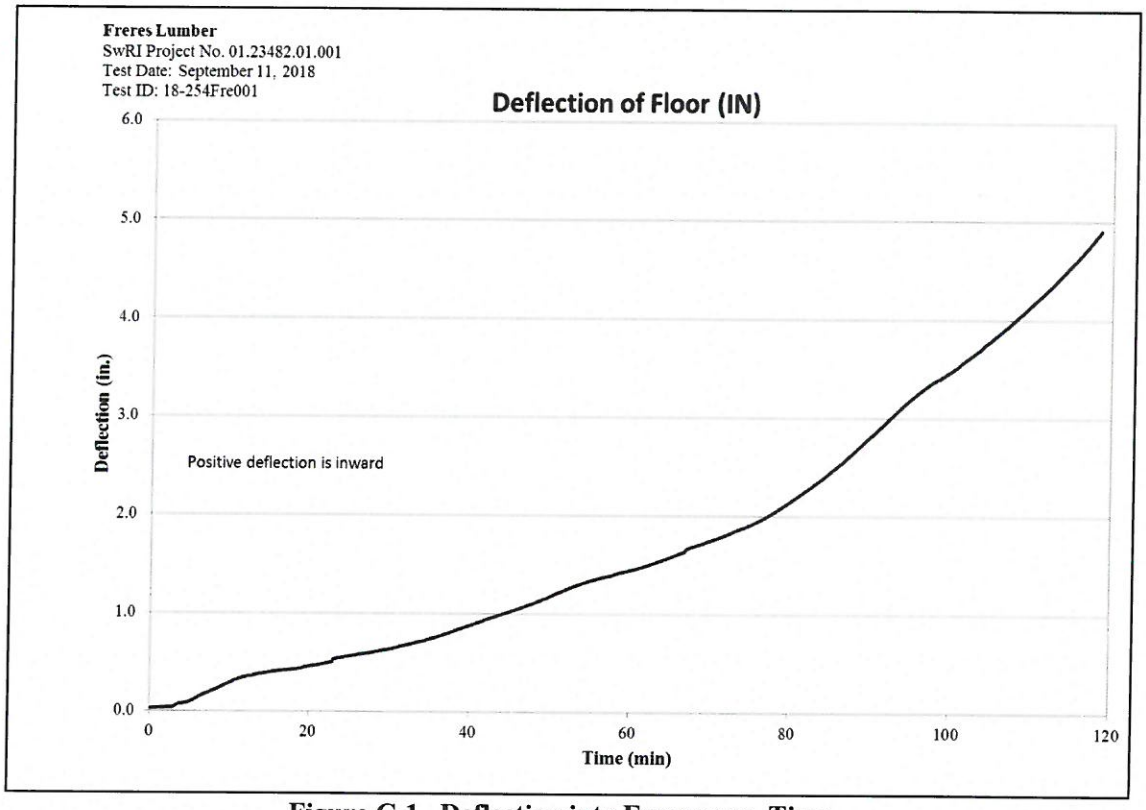



**Figure C-1. Deflection into Furnace vs. Time.**

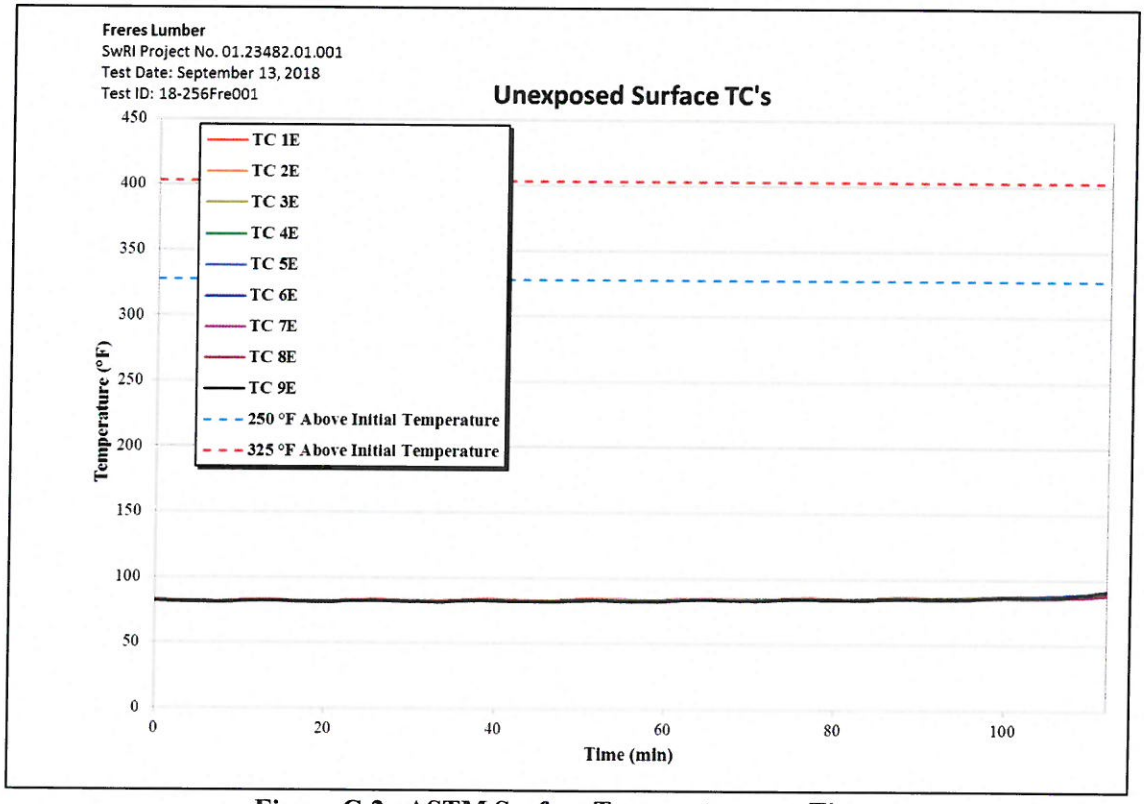



**Figure C-2. ASTM Surface Temperatures vs. Time.**

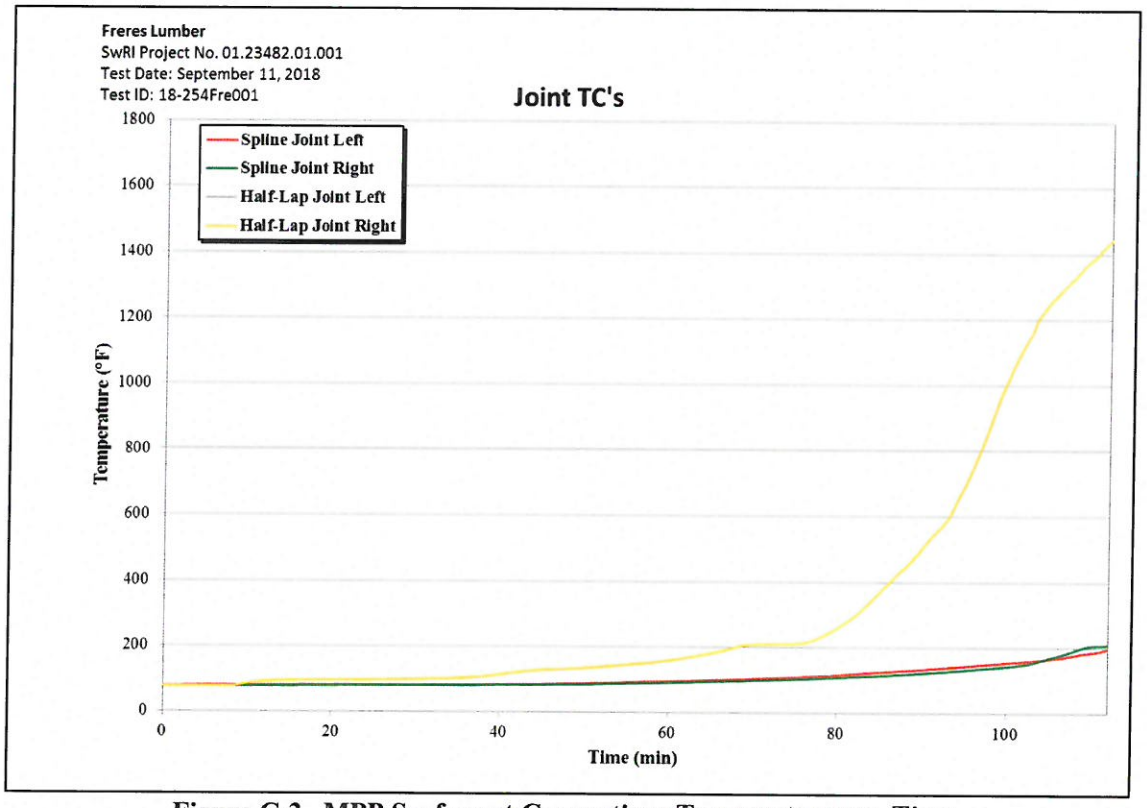



**Figure C-3. MPP Surface at Connections Temperatures vs. Time.**

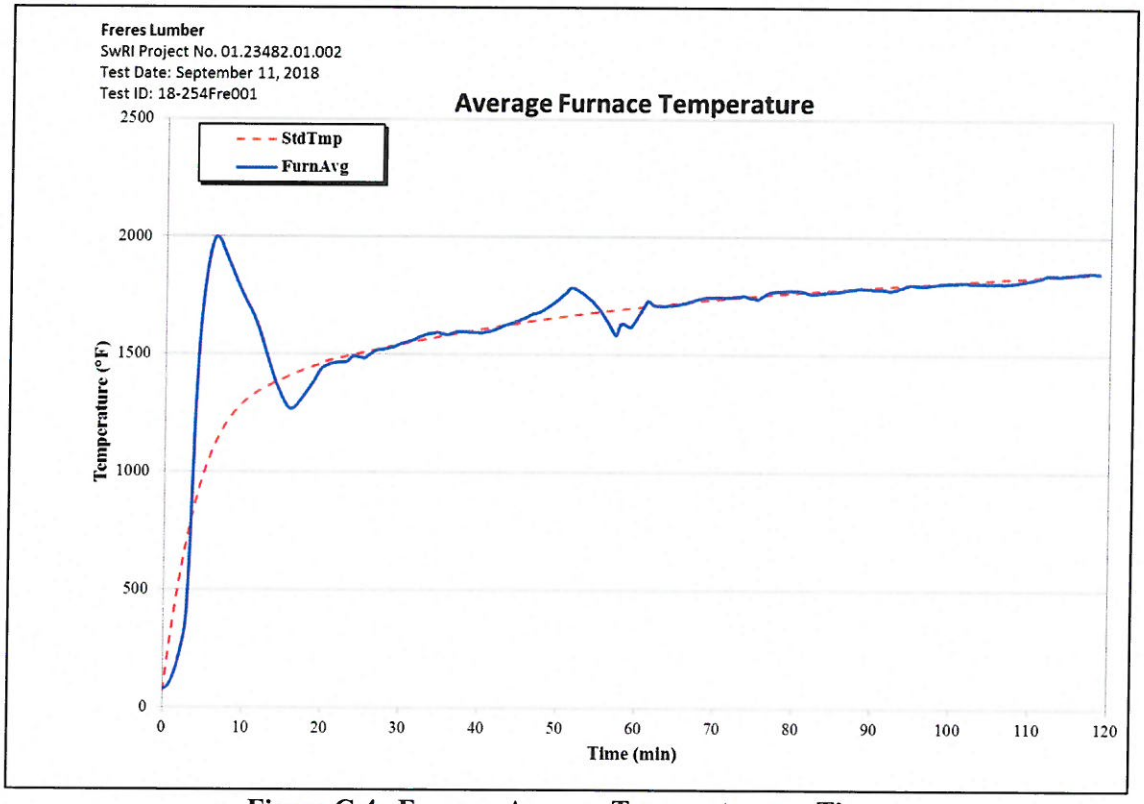



**Figure C-4. Furnace Average Temperature vs. Time.**

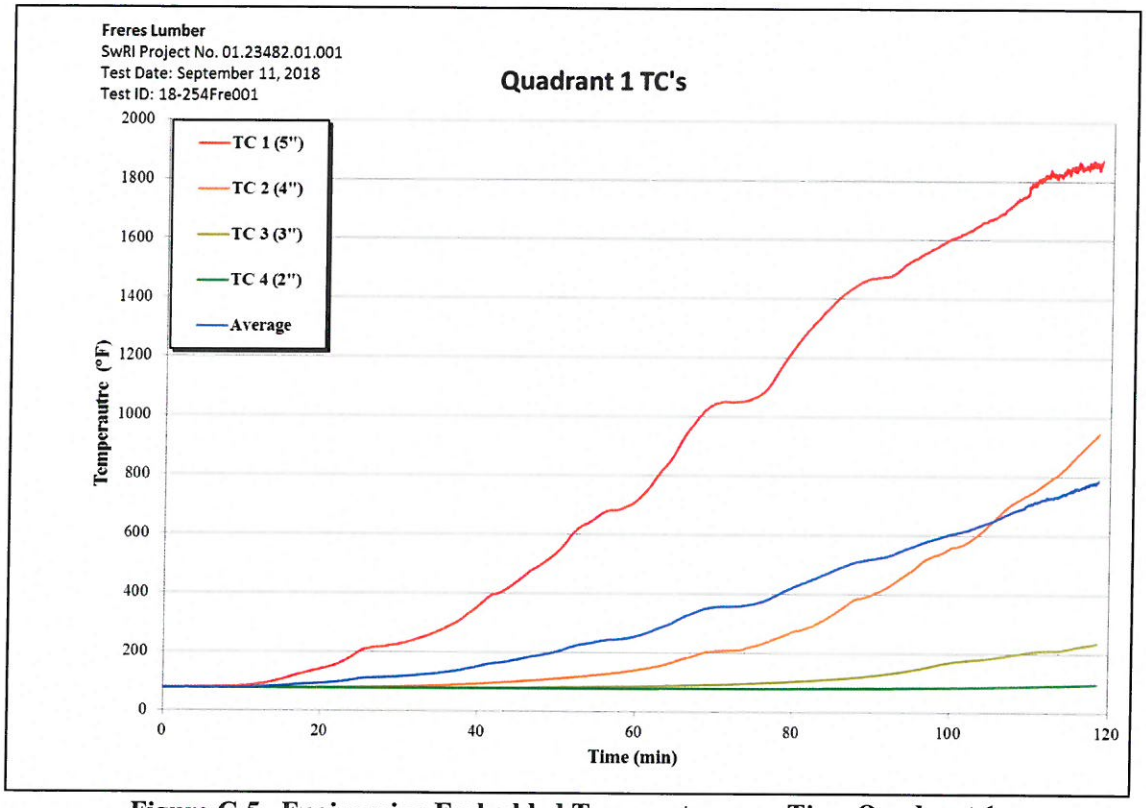



**Figure C-5. Engineering Embedded Temperatures vs. Time Quadrant 1.**

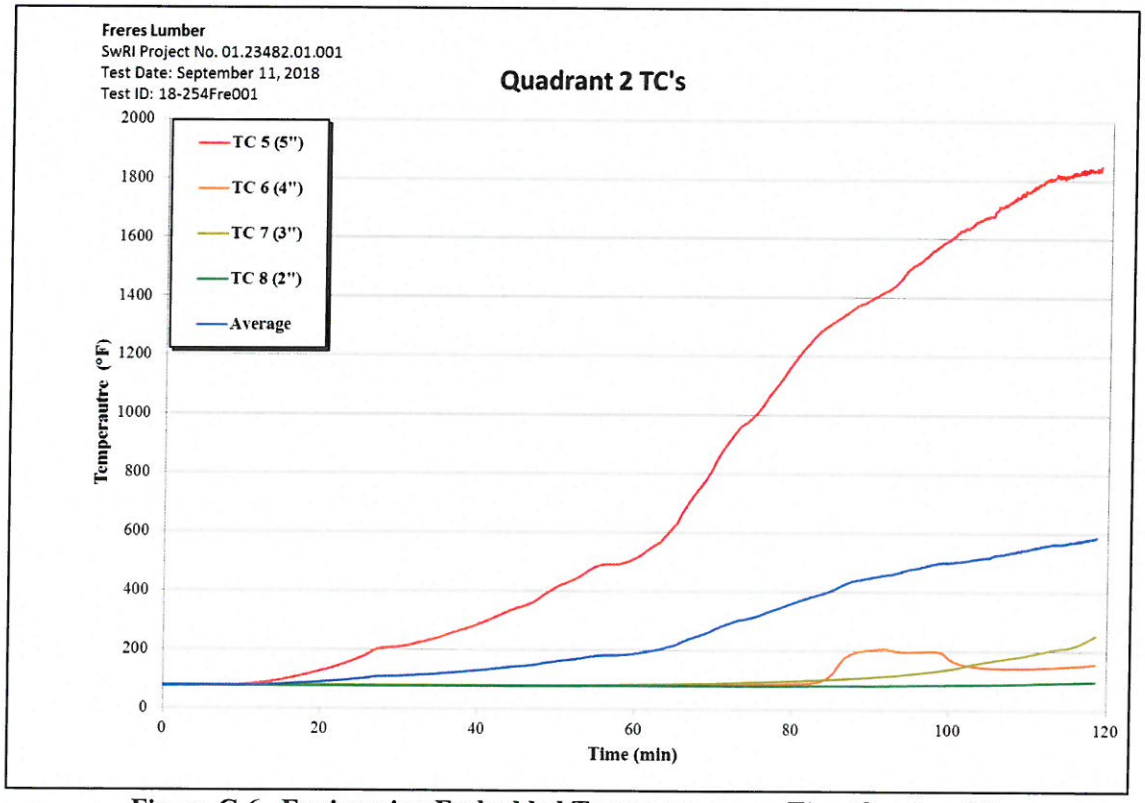



**Figure C-6. Engineering Embedded Temperatures vs. Time Quadrant 2.**

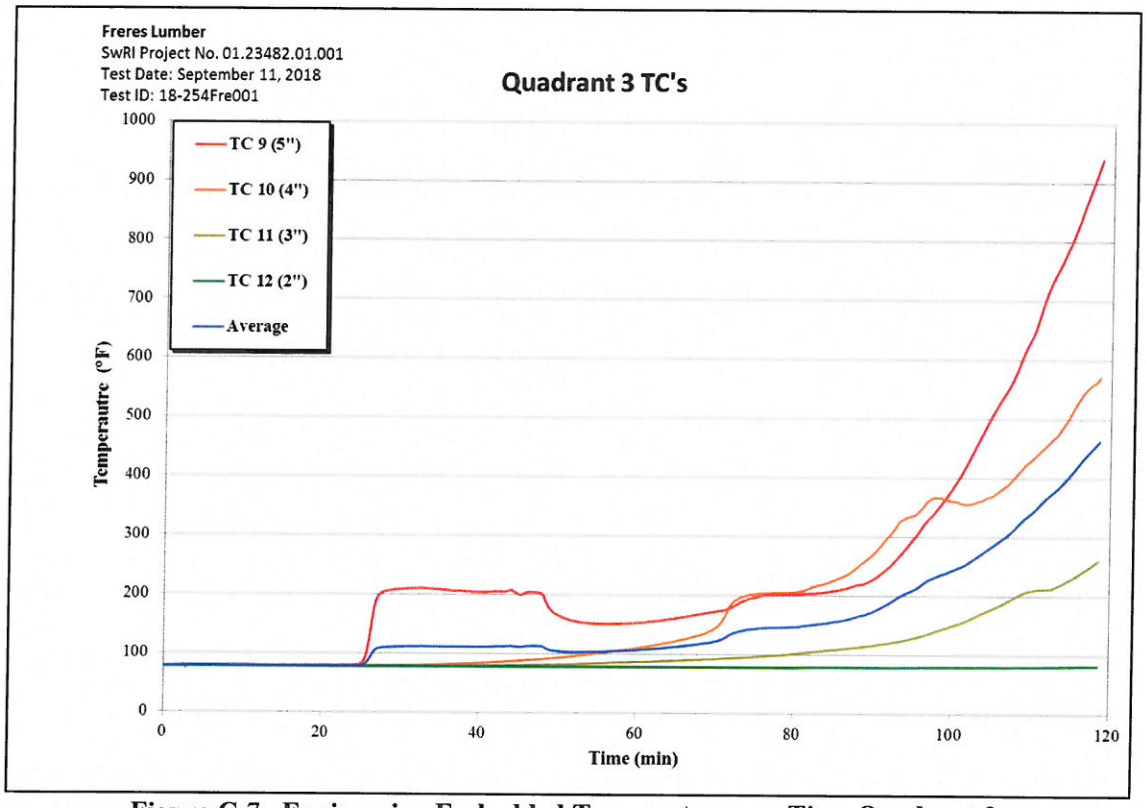



**Figure C-7. Engineering Embedded Temperatures vs. Time Quadrant 3.**

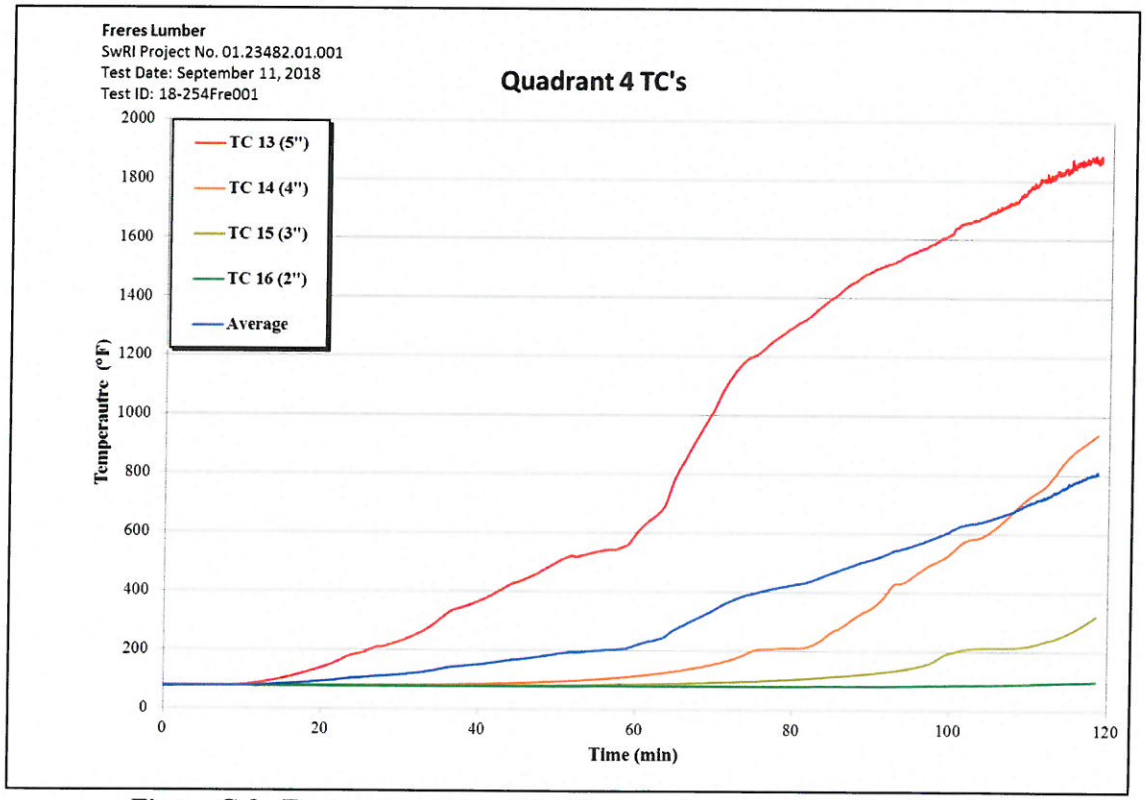



**Figure C-8. Engineering Embedded Temperatures vs. Time Quadrant 4.**

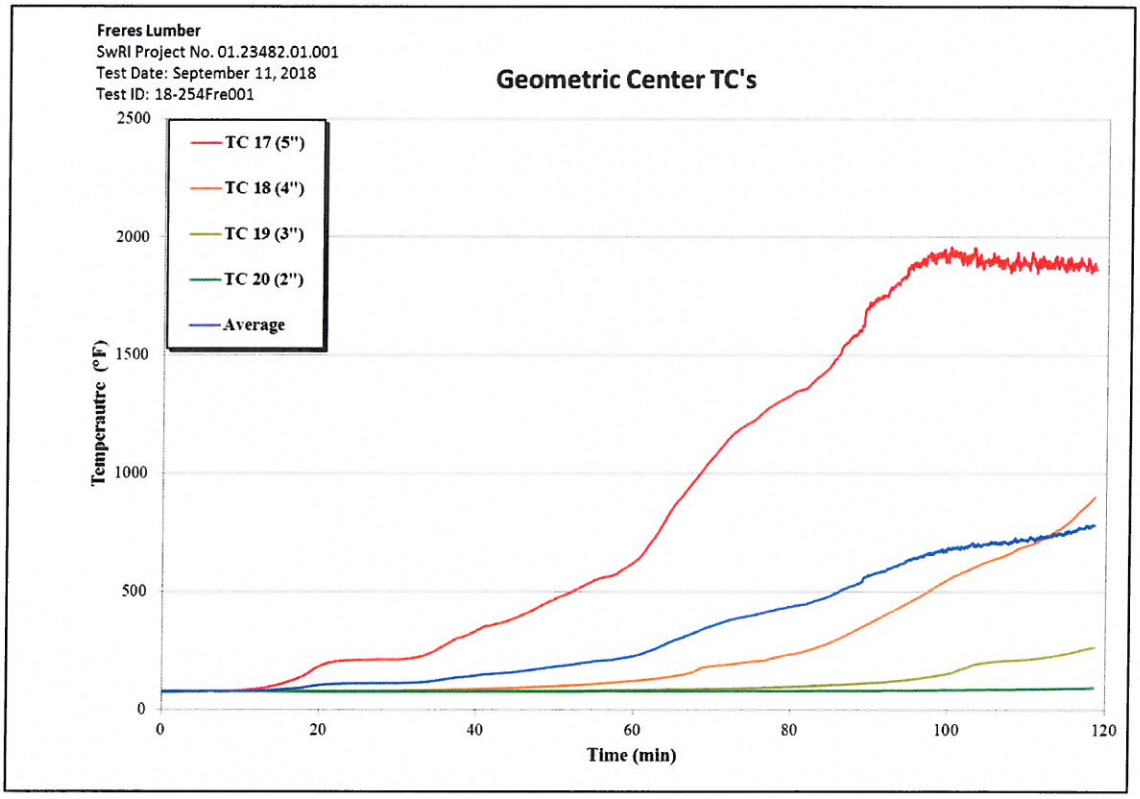



**Figure C-9. Engineering Embedded Temperatures vs. Time Quadrant GC.**

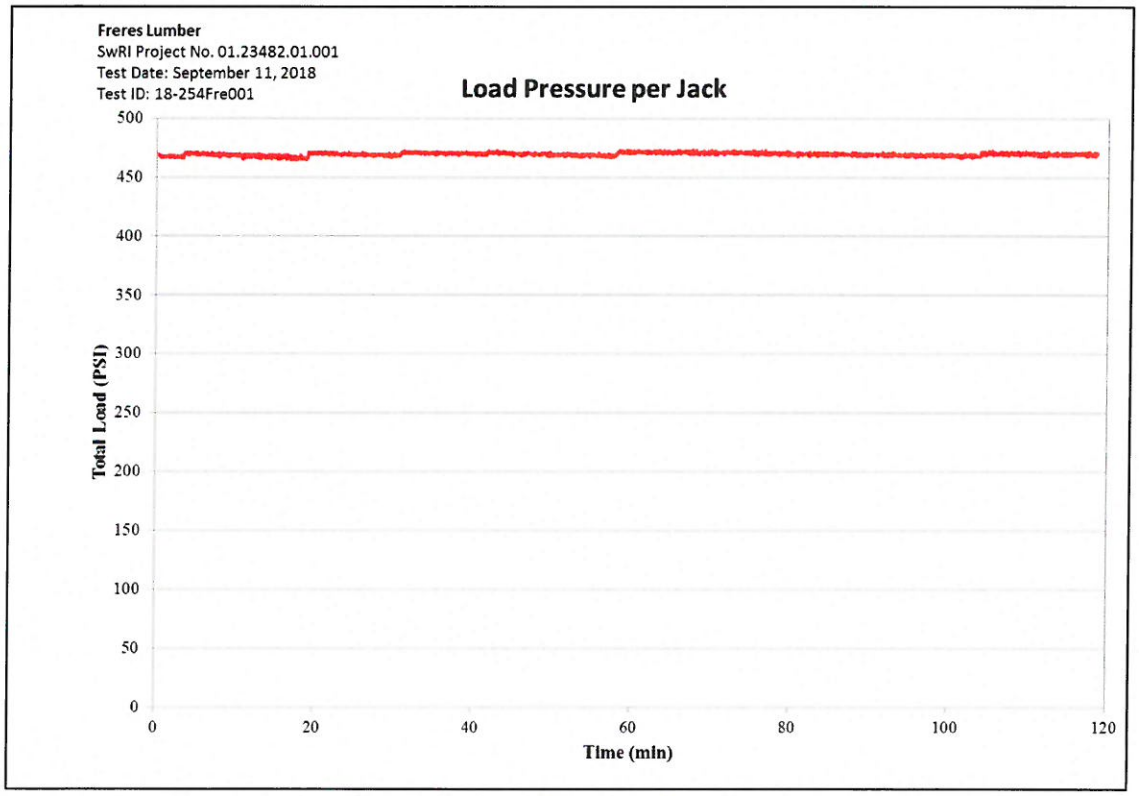



**Figure C-10. Applied Load vs. Time.**

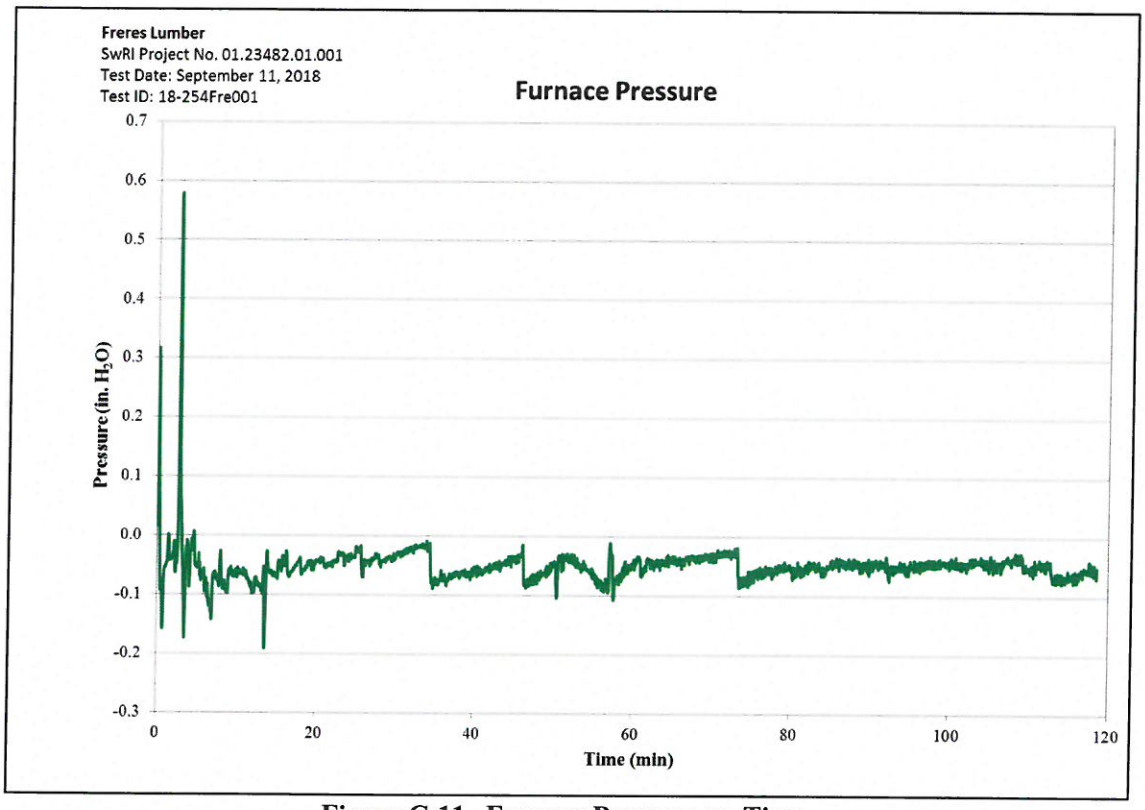



**Figure C-11. Furnace Pressure vs. Time.**

## 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.

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: $\delta$ = 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: $\delta$ = 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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***APA – THE ENGINEERED WOOD ASSOCIATION***
**HEADQUARTERS**
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**PRODUCT SUPPORT HELP DESK**
(253) 620-7400 • *E-mail Address:* help@apawood.org

**DISCLAIMER**

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07-03

# Appendix C

# MPP ASTM E119 Wall Test Report

SOUTHWEST RESEARCH INSTITUTE

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CHEMISTRY AND CHEMICAL ENGINEERING DIVISION

FIRE TECHNOLOGY DEPARTMENT
WWW.FIRE.SWRI.ORG
FAX (210) 522-3377

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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 REVISED**
**Consisting of 28 Pages**

**SwRI Project No. 01.23842.01.002[1]**
**Test Date: September 13, 2018**
**Report Date: December 3, 2018**
**Revised Report Date: March 3, 2019**

**Prepa ed for:**

**Frere Lumber Co., Inc.**
**PO Box 276**
**Lyons, OR 97358**

Submitted by:

Bill Bendele
Principal Technologist
Fire Resistance Section

Approved by:

Kare C. Carpenter, M. ., 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 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.* The report was revised to correct the material description by removing reference to ¾ plywood sheets and adjusting the material thickness throughout the final report.

## 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 |
| 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 × 6 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 × 6 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)

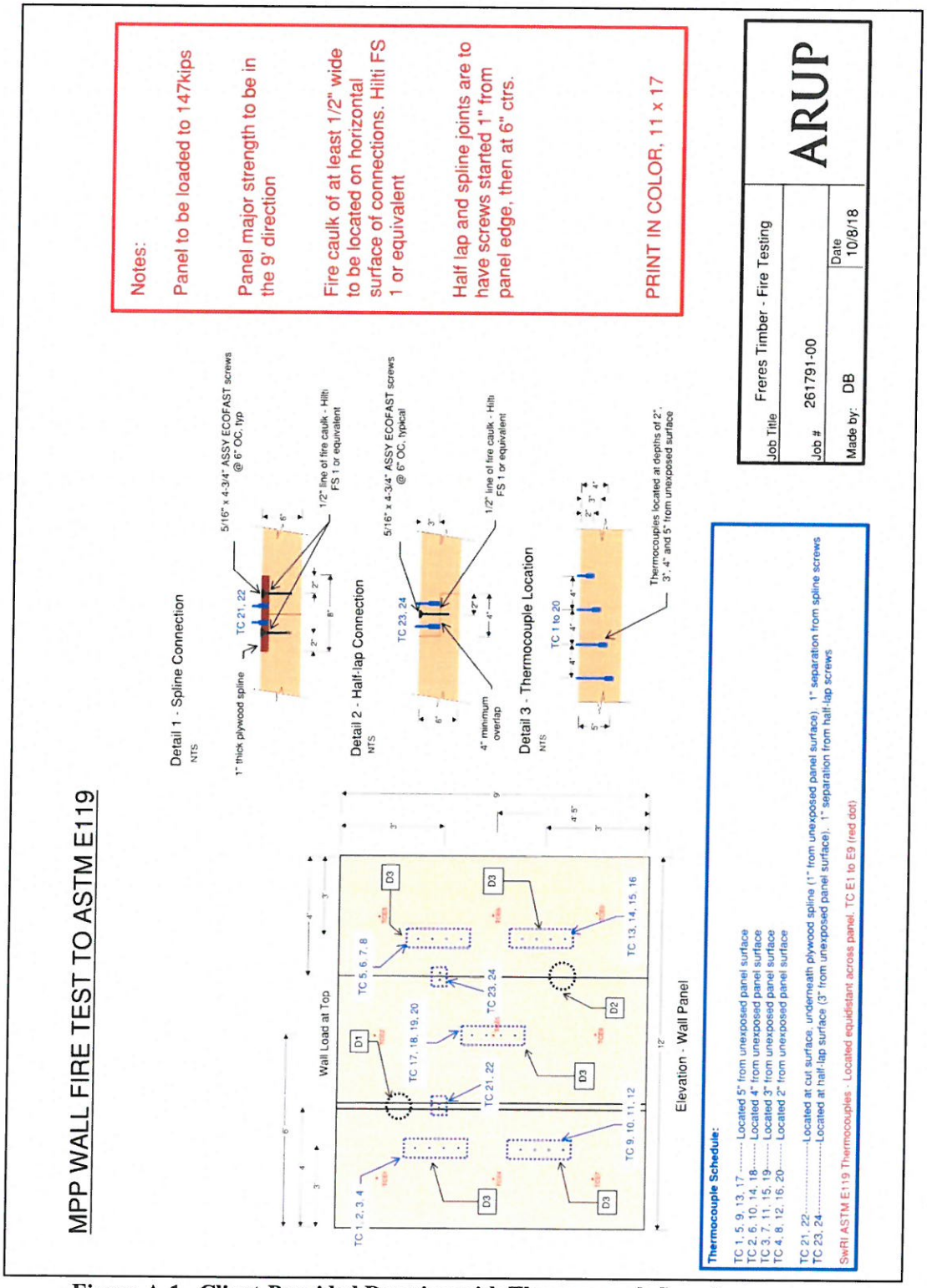


**Figure A-1. Client-Provided Drawing with Thermocouple Locations.**

## APPENDIX B

## TEST PHOTOGRAPHS

## (CONSISTING OF 8 PAGES)


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

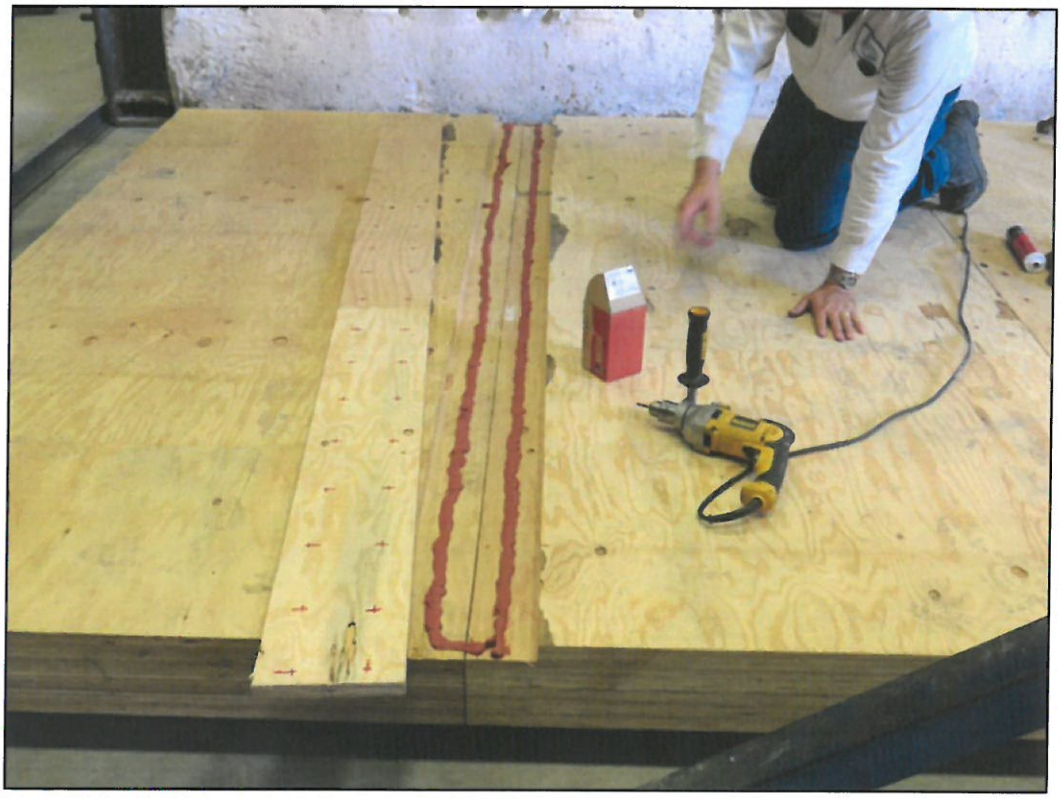

**Figure B-2. Application of Construction Adhesive in the Spline Connection prior to Spline Installation.**

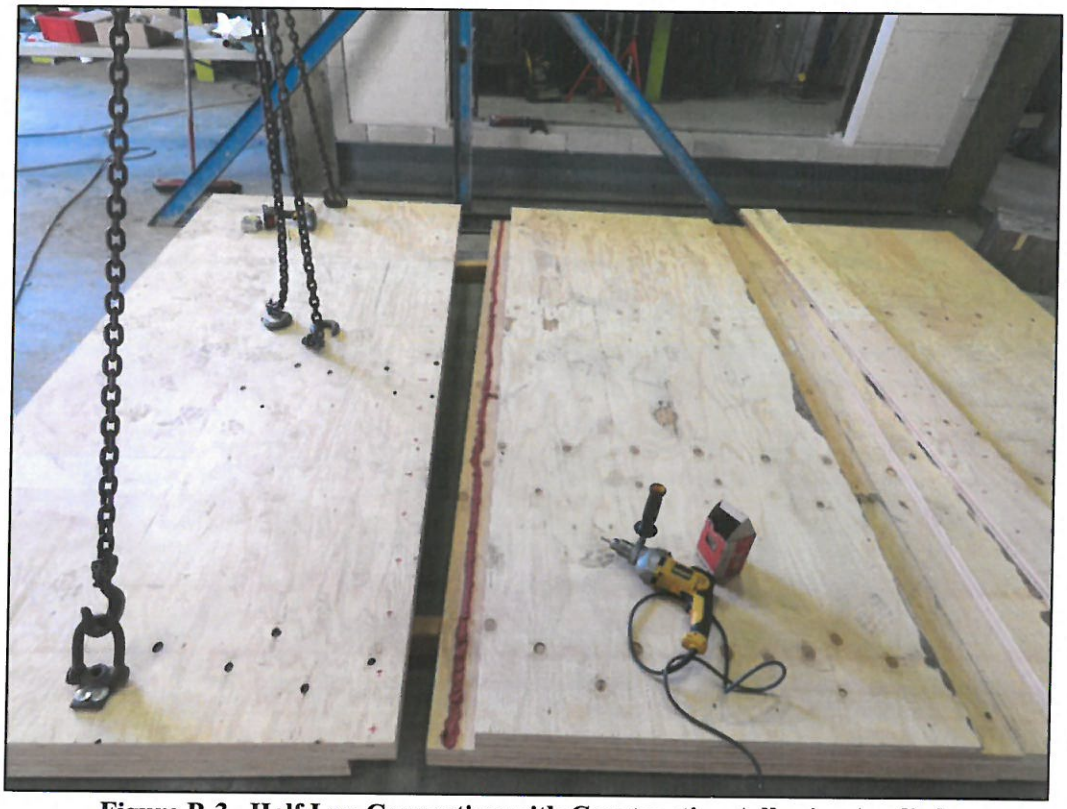

**Figure B-3. Half Lap Connection with Construction Adhesive Applied.**

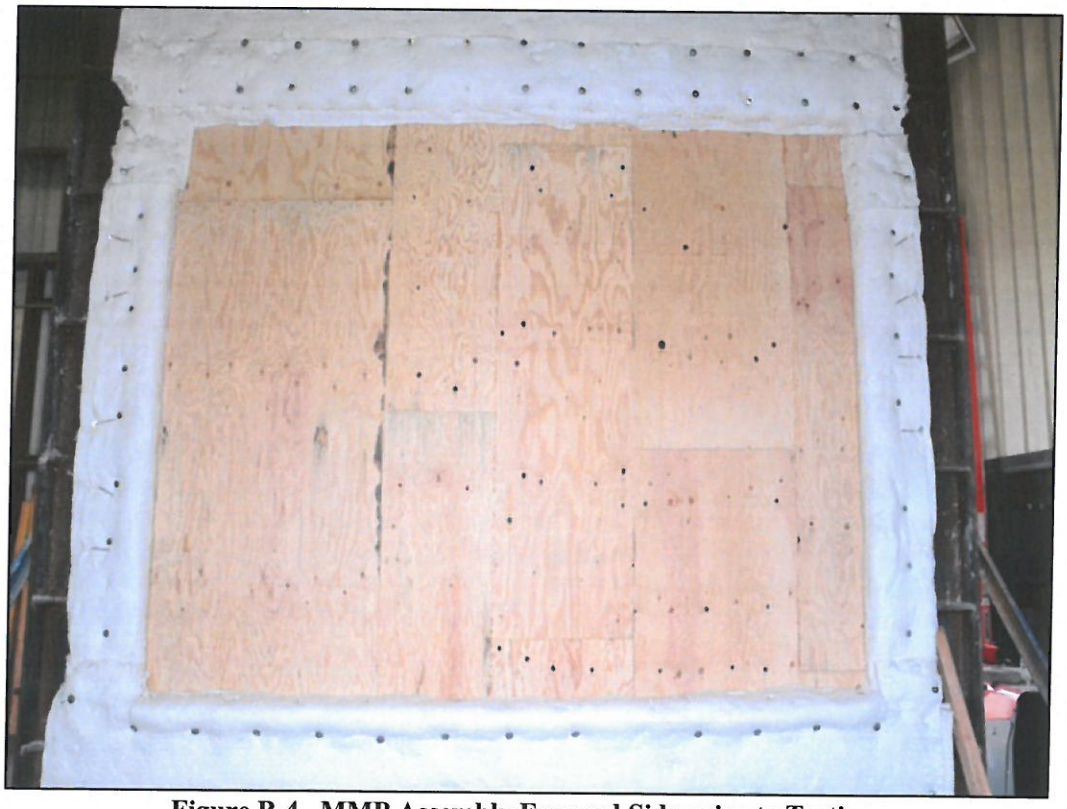

**Figure B-4. MMP Assembly Exposed Side prior to Testing.**

**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.**

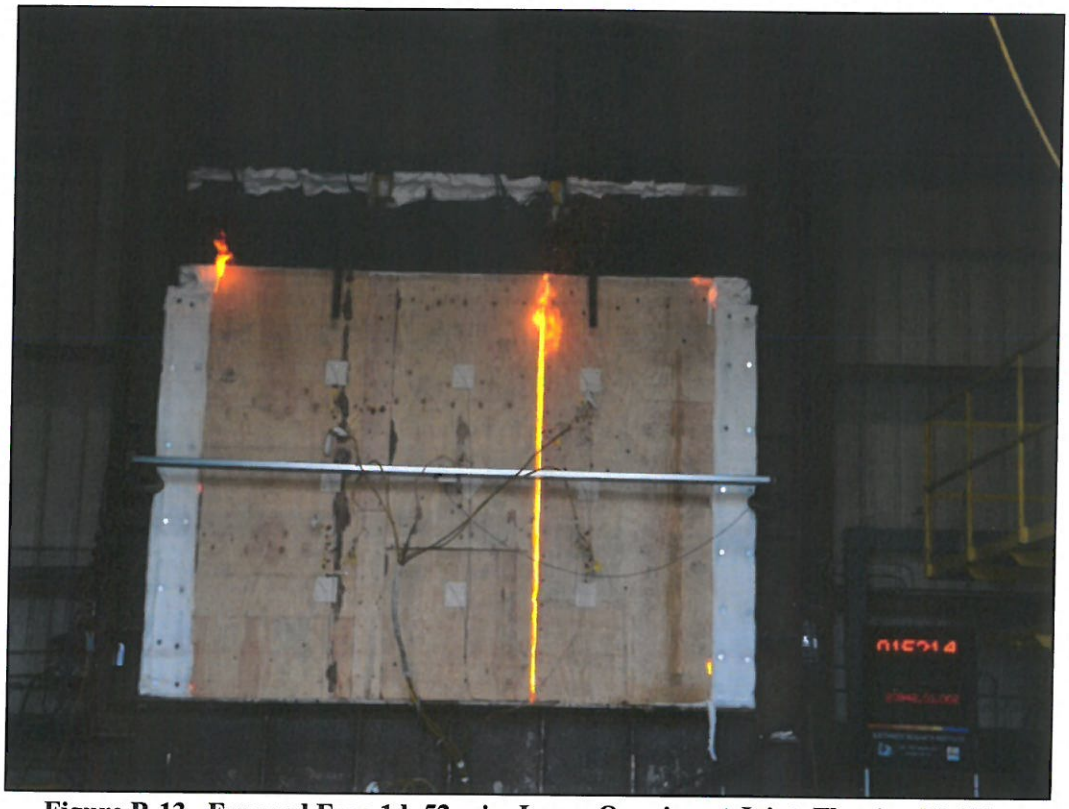

**Figure B-13. Exposed Face 1 h 52 min, Large Opening at Joint, Flaming Visible.**

**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)

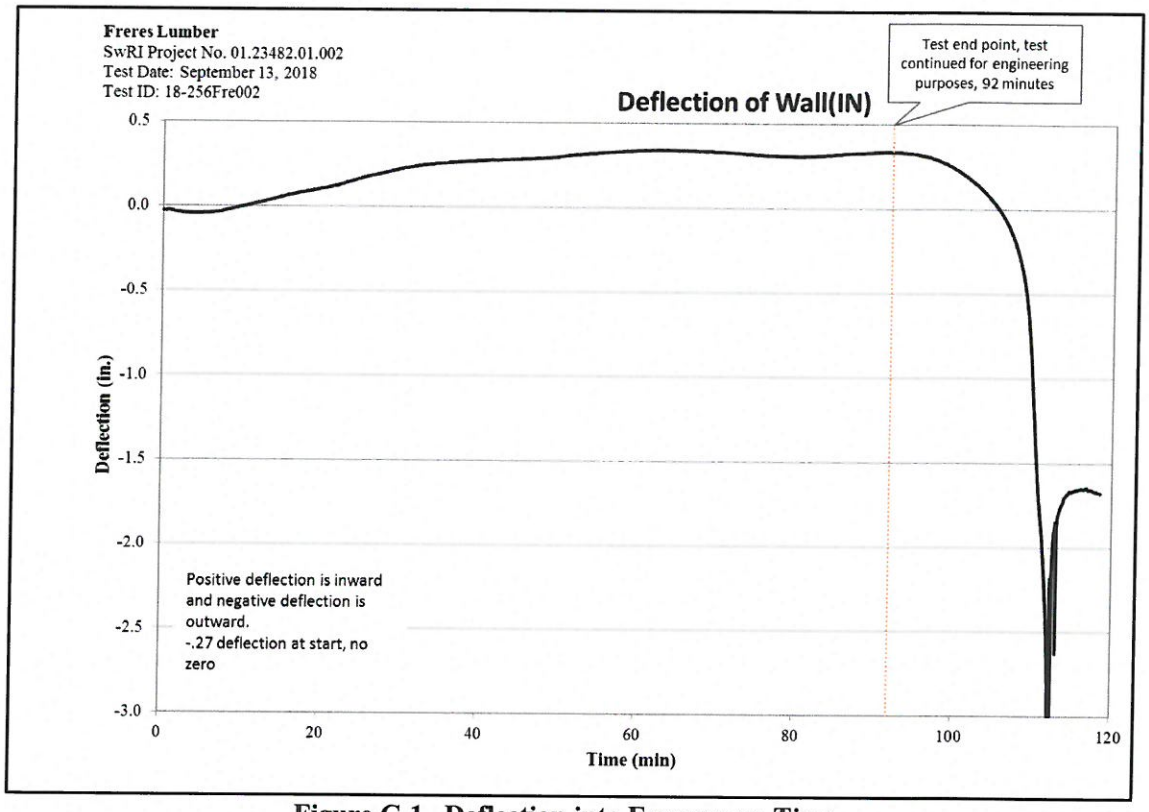


**Figure C-1. Deflection into Furnace vs. Time.**

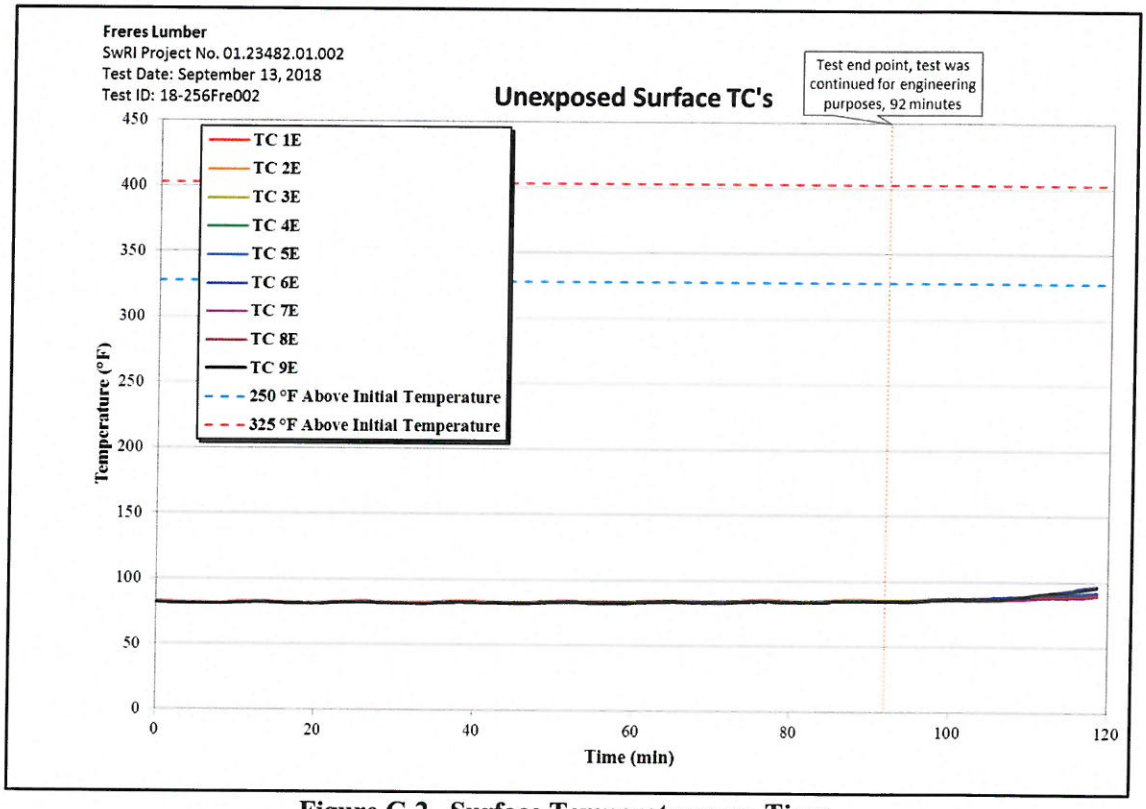


**Figure C-2. Surface Temperatures vs. Time.**

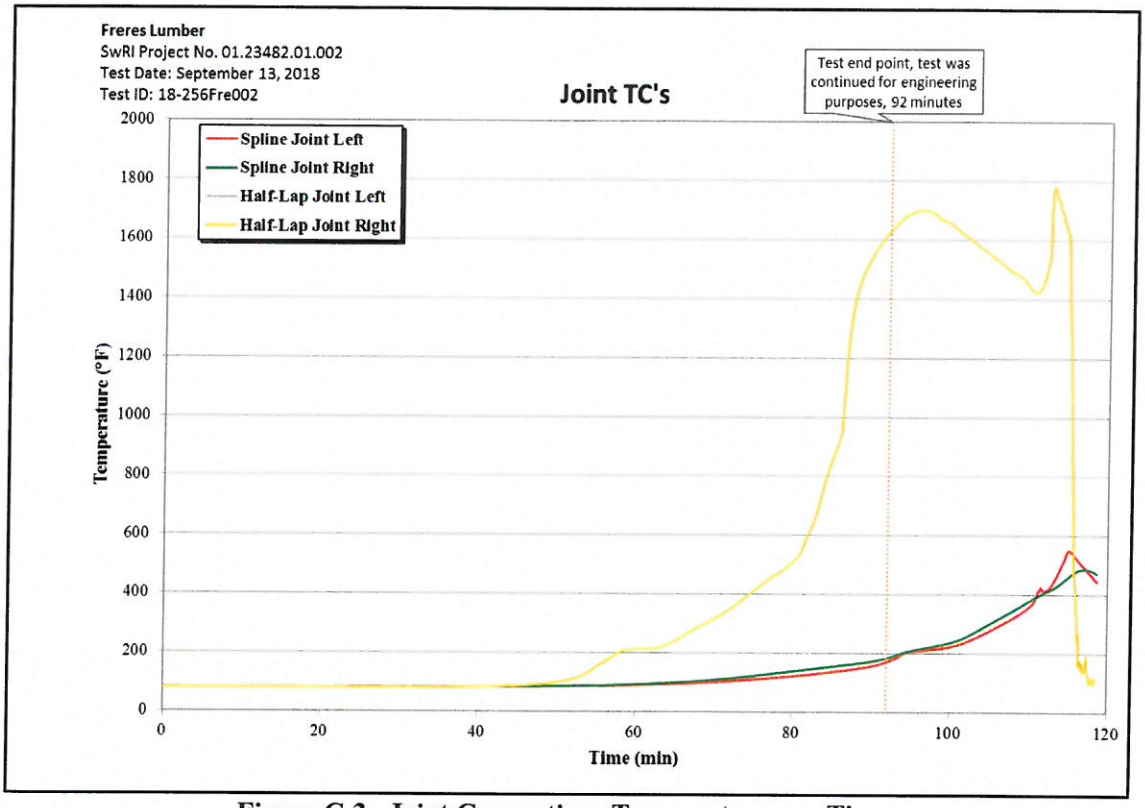


**Figure C-3. Joint Connections Temperatures vs. Time.**

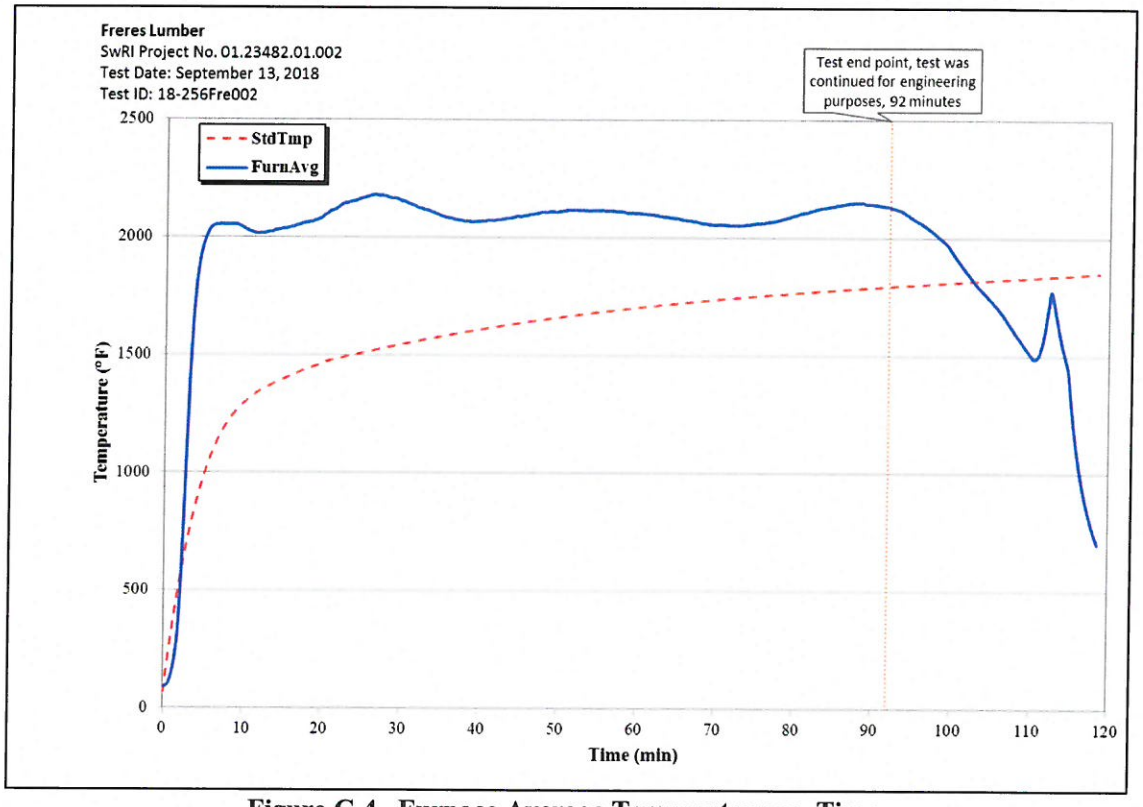


**Figure C-4. Furnace Average Temperature vs. Time.**

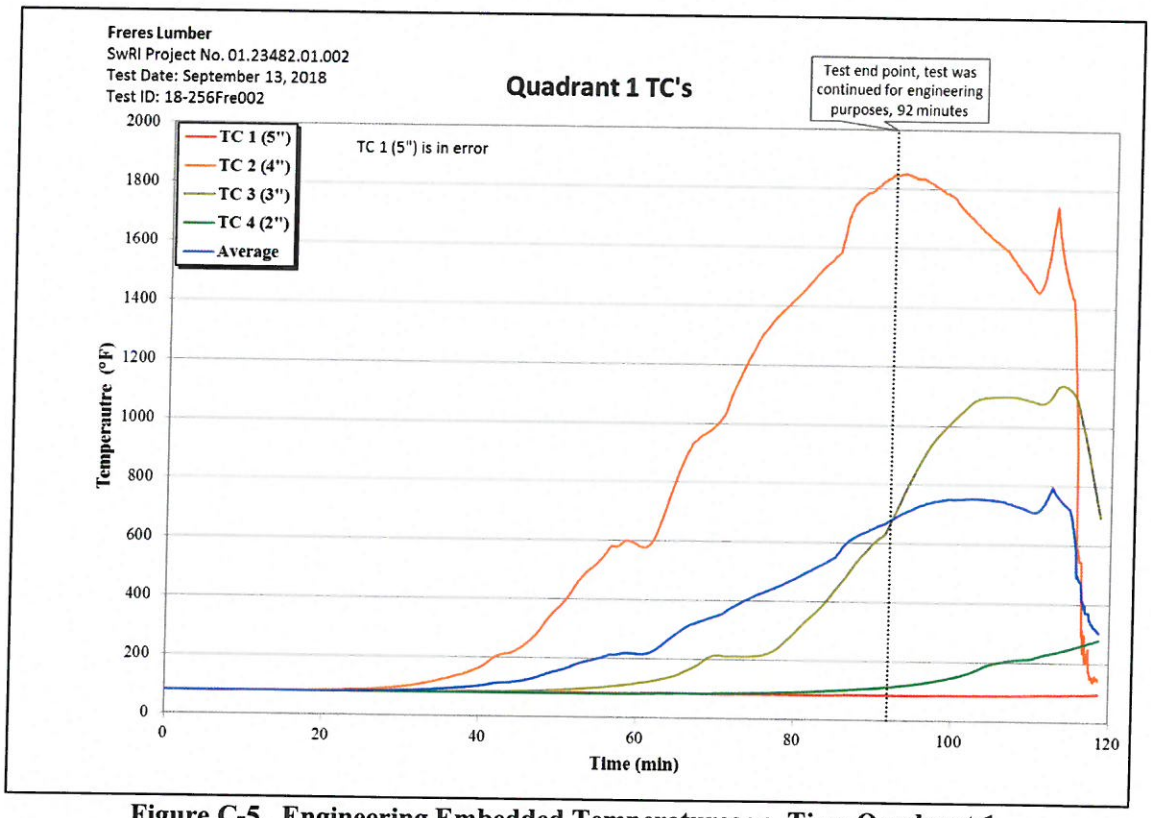


**Figure C-5. Engineering Embedded Temperatures vs. Time Quadrant 1.**

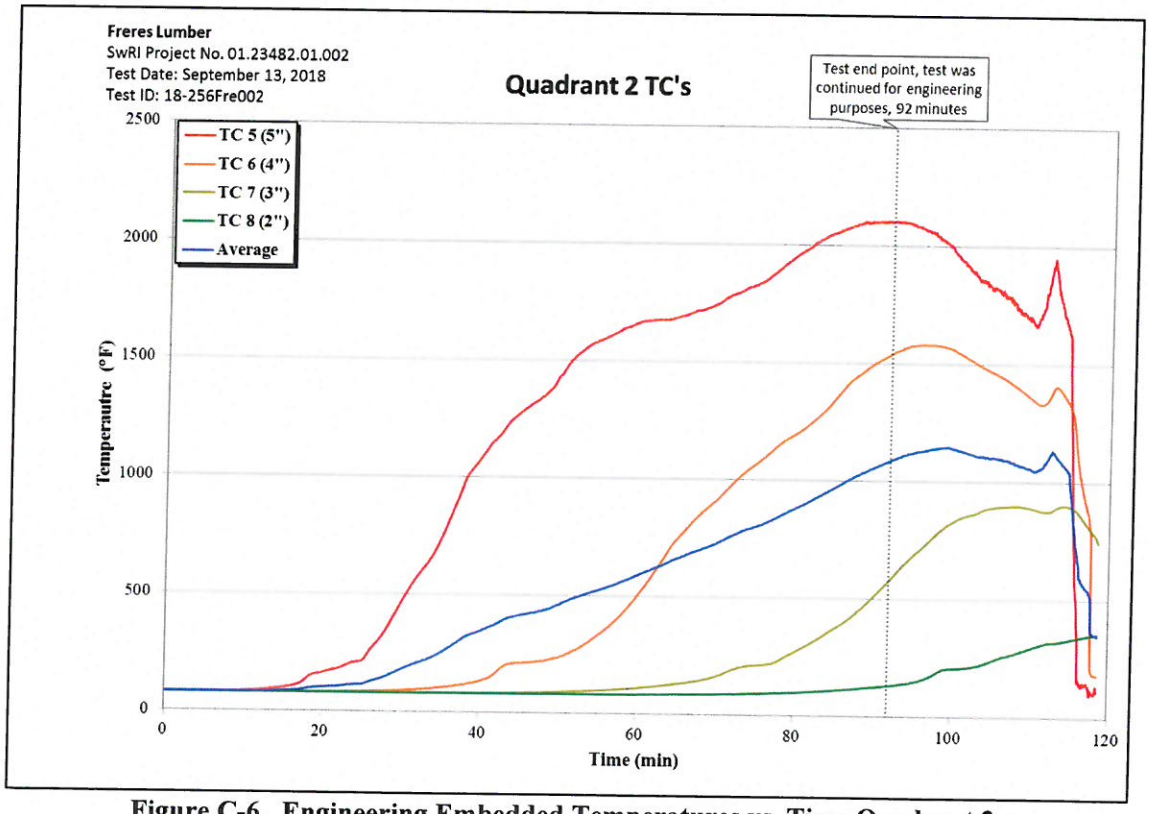


**Figure C-6. Engineering Embedded Temperatures vs. Time Quadrant 2.**

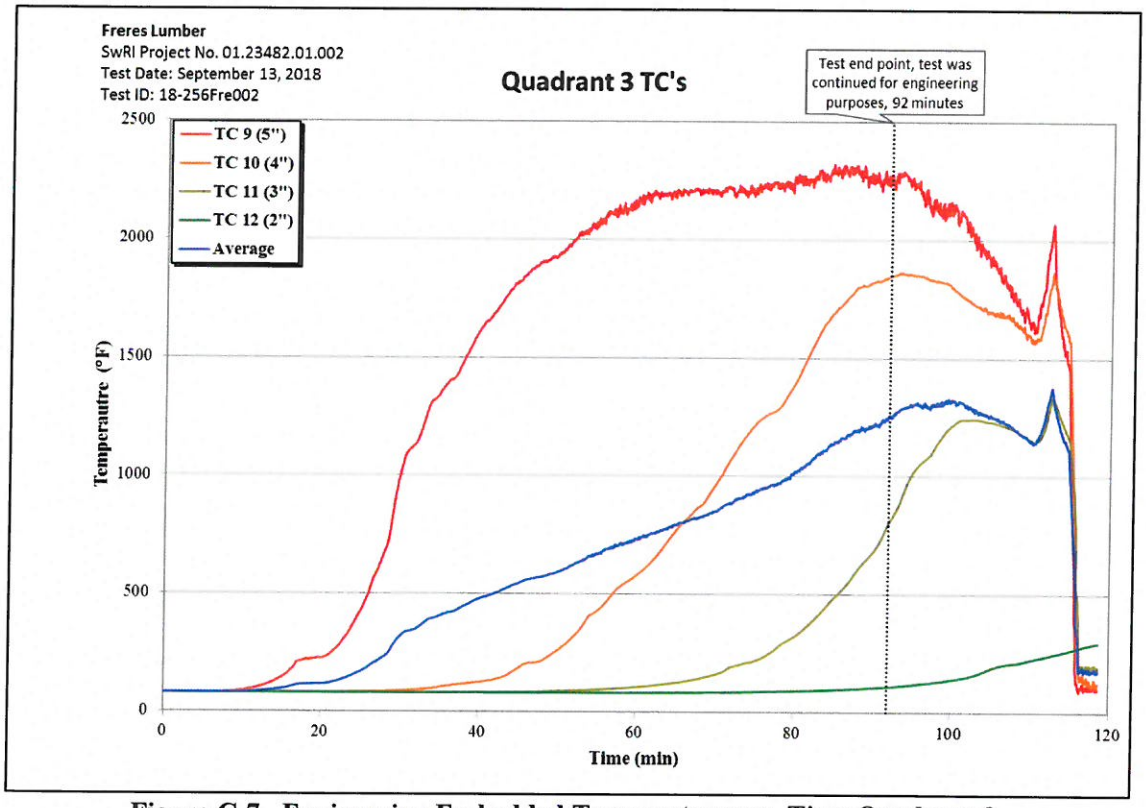


**Figure C-7. Engineering Embedded Temperatures vs. Time Quadrant 3.**

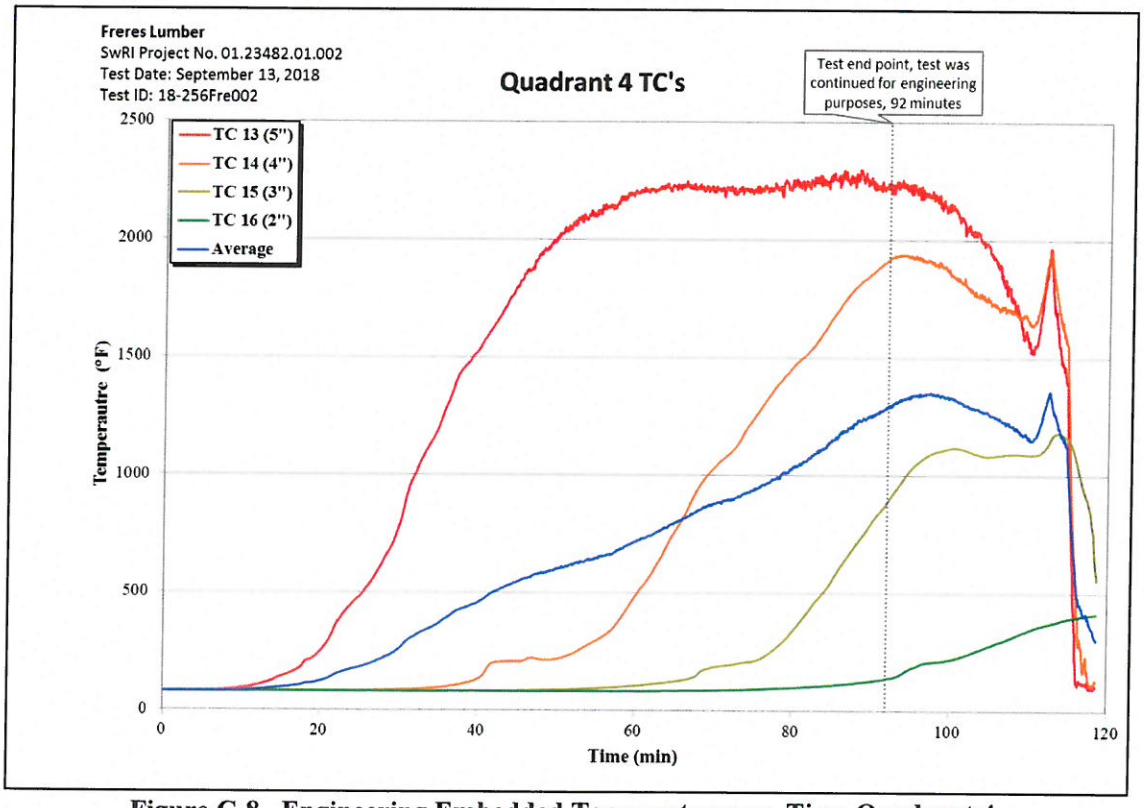


**Figure C-8. Engineering Embedded Temperatures vs. Time Quadrant 4.**

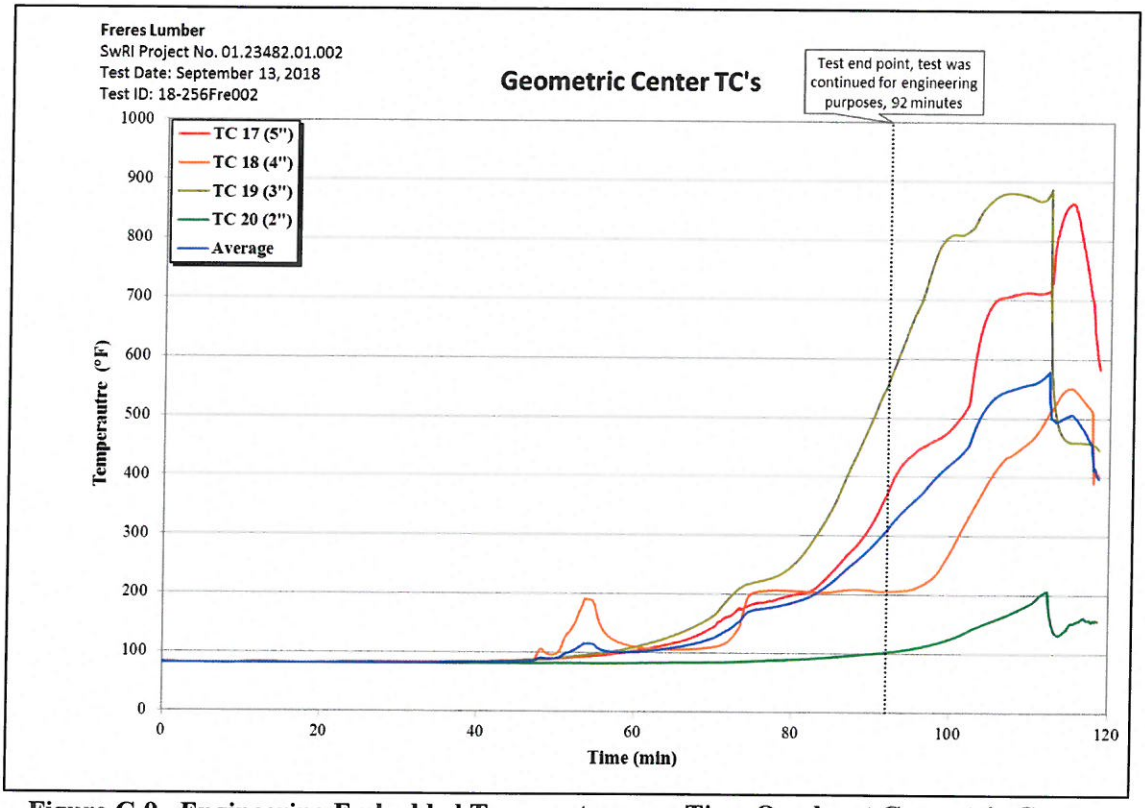


**Figure C-9. Engineering Embedded Temperatures vs. Time Quadrant Geometric Center.**

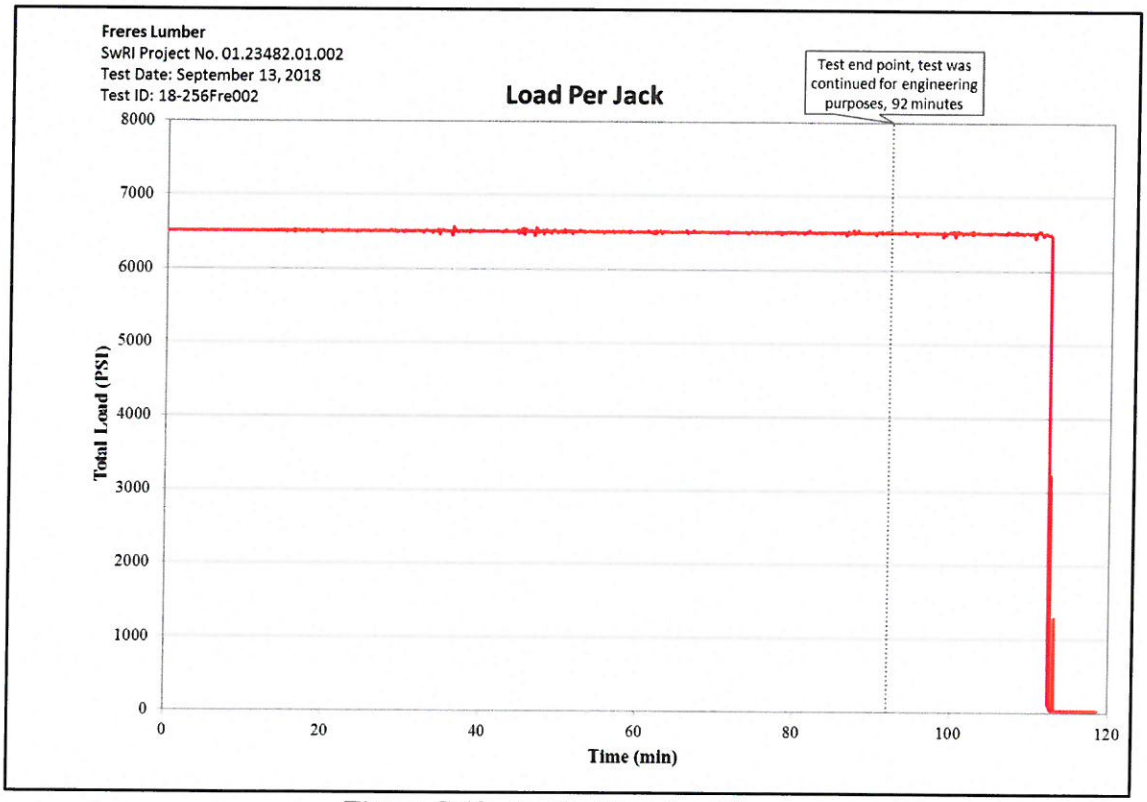


**Figure C-10. Applied Load vs. Time.**

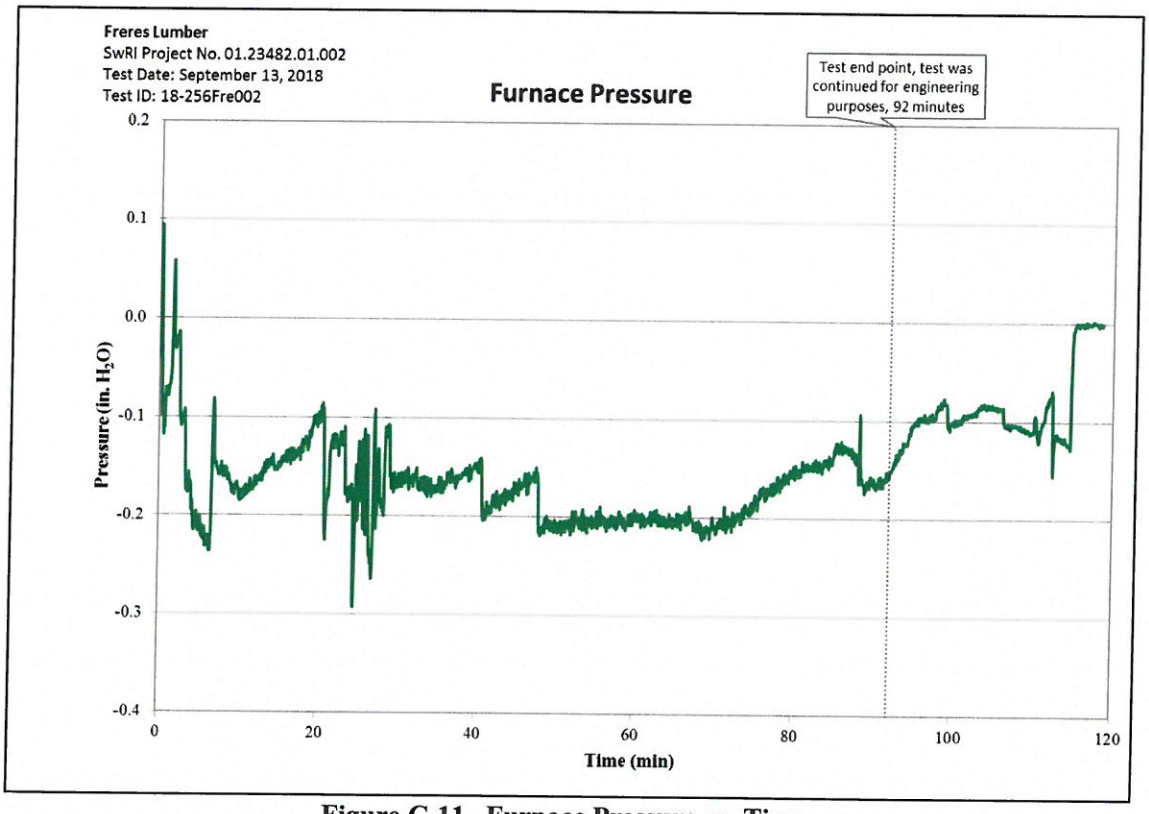


**Figure C-11. Furnace Pressure vs. Time.**

## APPENDIX D

## CLIENT-PROVIDED APA PRODUCT REPORT PR-L325

## (CONSISTING OF 4 PAGES)

# APA PRODUCT REPORT

www.apawood.org

## FRERES Mass Panel Products
## 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.



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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: $\delta$ = 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: $\delta$ = 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.

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