Fire Performance of ASTM E119 Evaluation of a Non-Load-Bearing Wall Assembly

Indicative testing conducted in accordance with the test methodology described in ASTM E119, Standard Test Methods for Fire Tests of Building Construction and Materials

Conducted For:

WCC
5726 Sonoma Dr
Pleasanton, CA 94566

WFCi Report #18062
Test Dates: December 6, 2018
Report Issued: January 9, 2019
TABLE OF CONTENTS

TABLE OF CONTENTS ...................................................................................................................... 2
INTRODUCTION ................................................................................................................................. 3
SUMMARY OF TEST METHOD .......................................................................................................... 3
SAMPLE DESCRIPTION ..................................................................................................................... 3
  STEEL FRAME ................................................................................................................................. 4
  GYPSUM LAYERS ........................................................................................................................... 4
  TEMPERATURE ............................................................................................................................. 5
TEST RESULTS ................................................................................................................................. 6
  FIRE RESISTANCE TEST .................................................................................................................. 6
  TEMPERATURE DATA ..................................................................................................................... 8
  DEFLECTION DATA ......................................................................................................................... 8
  ADDITIONAL INFORMATION .......................................................................................................... 9
HOSE STREAM RETEST ..................................................................................................................... 9
  TEMPERATURE DATA ..................................................................................................................... 10
CONCLUSION .................................................................................................................................... 11
SIGNATURES ....................................................................................................................................... 12
APPENDIX A: ADDITIONAL FIGURES ............................................................................................ 13
INTRODUCTION

This report documents the fire resistance and hose-stream testing of a non-load-bearing wall assembly for WCC of Pleasanton, CA. The wall assembly tested consisted of a steel frame and Type X gypsum board on each side of the frame with prescribed defects in the gypsum. One fire endurance test and one hose-stream retest were performed for this assembly, performed on December 6, 2018, and were conducted in accordance with ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*. This assembly was intended to pass the fire resistance criteria for a one-hour duration.

SUMMARY OF TEST METHOD

Testing was performed using a vertical fire resistance test configuration employing the fire endurance conditions and standard time-temperature curve described in ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*. The exposed surface of the assemblies was subjected to the standard E119 time-temperature curve, with temperature measurements taken inside the natural gas furnace using 9 thermocouples (TC_F) connected to a computerized data acquisition system. TC_F locations were symmetrically disposed and distributed to show the temperature near (within 6”) the exposed face of the test assembly.

Here are the following criteria to which these tests were judged, according to ASTM E119:

- Wall assembly will have sustained the applied load (non-loaded, weight of assembly) for the indicated time (1-hr, in this instance) without passage of flame or gases hot enough to ignite cotton waste
- Wall assembly will have not developed an opening that permits the projection of water from the hose stream beyond the unexposed surface (applicable for hose-stream portion of the test)
- Transmission of heat through the wall will not have risen the temperature on its unexposed side more than 139°C (average) above its initial temperature, or if a temperature higher than 30% (181°C) of the specified limit occurs at any one point (single-point) on the unexposed side of the assembly.

SAMPLE DESCRIPTION

One 10’×10’ assembly was constructed at WFCi. The steel frame assembly (Figure 1, Figure 2) consisted of one layer of ½” Type X gypsum board on each side of the 3¾” deep steel studs. Specific details of each component of the assembly are found below.

![Figure 1. Overall assembly showing (a) exposed face and (b) unexposed face.](image-url)
**Steel Frame**

The 10’×10’ assembly (Figure 2) was framed 24” on center (cavity-centered) with 3½” deep steel C-studs (3½” CD Prostud NS 20 362PDS125-30, G40) with both an upper and lower track.

![Figure 2. Assembly layers showing the steel frame.](image)

**Gypsum Layers**

One layer of ⅝” Type X gypsum board (USG Firecode® X 240 11/01/18 R 05:01, R1319-240 Type SCX) was fastened on each side of the steel frame. Gypsum panels were shipped as 4’×12’ boards and cut to sections as shown below. The assembly had vertically-applied panels with alternating joints by one cavity (24”) from exposed to unexposed. The average mass of the gypsum board was 2.26 lb/ft². The average thickness of the board at the cut (butt) and tapered edges was 0.626” and 0.561”, respectively. The fire endurance panels were fastened with Type S (1¼”) screws at 8” on center on edge and 12” on center in the field. The joints and fastener heads were coated with 2 layers of joint compound, including 2” taped joints. Various defects also had 2 layers of joint compound.

Defects were purposefully introduced to the gypsum board as follows with stud and board locations defined in Figure 2 and Figure 3:

- Joint Gap: ⅛” gap along whole length of vertical joint
  - Exposed Side: Stud 5 (joint 2-3 [between boards #2 & #3])
  - Unexposed Side: Stud 2
- Removed Screw from Field (not on stud)
  - Fire Resistance
    - Exposed Side: Cavity 1-2 (between studs 1 & 2), 41½” from bottom, 14½” from assembly side
    - Unexposed Side: Cavity 4-5, 41½” from bottom, 14½” from joint (1-2)
  - Hose-Stream Retest
    - Exposed Side: Cavity 2-3, 41½” from bottom, 14½” from joint (1-2)
    - Unexposed Side: Cavity 4-5, 41½” from bottom, 14½” from joint (1-2)
- **Face Paper Tear in Field**: 2” (wide) × ¾” (tall)
  - **Fire Resistance**
    - Exposed Side: Cavity 2-3, 49½” from bottom, 11” from joint (1-2)
    - Unexposed Side: Cavity 5-6, 49½” from bottom, 11” from assembly side
  - **Hose-Stream Retest**
    - Exposed Side: Cavity 1-2, 49½” from bottom, 11” from assembly side
    - Unexposed Side: Cavity 5-6, 49½” from bottom, 11” from assembly side
- **Face Paper Chip/Gouge in Field**: 1½” (wide) × ½” (tall) × ¼” (deep)
  - Exposed Side: Cavity 3-4, 36½” from bottom, 20½” from joint (1-2)
  - Unexposed Side: Cavity 2-3, 36½” from bottom, 20½” from joint (2-3)
- **Back Paper Abrasion in Field**: ~6” (wide) × 1¾” (tall)
  - Exposed Side: Cavity 5-6, 21” from bottom, 12” from assembly side
  - Unexposed Side: Cavity 1-2, 21” from bottom, 12” from assembly side

---

**Temperature**

To obtain representative thermal information of the samples during the tests, the fire endurance assembly was instrumented with sample thermocouples (TC$_S$). There were TC$_S$ placed in two groups (Figure 4):

- **Finish TC$_S$ (1-5)**: Placed at relative center and quarter points of assembly between gypsum and studs.
- **Unexposed TC$_S$ (6-16)**: Placed at center and quarter points of assembly (TC$_S$6-10) as well as other points (TC$_S$11-16) throughout the assembly with two (TC$_S$15-16) over specific defects. Each unexposed TCS was covered with a 6”×6” ceramic pad.
Figure 4. Sample thermocouple locations showing (a) finish TCs and (b) unexposed TCs.

TEST RESULTS

Testing of the fire endurance and hose-stream retest wall assemblies took place on December 6, 2018, respectively. The assembly was fixed in place within the sample holder and insulated on the perimeter edges with ceramic wool insulation. The furnace temperature, sample temperatures, and furnace pressure, were continuously monitored at 1 Hz until test termination. Also, horizontal deflection was measured every 5 minutes during the test. These data, as well as additional photographs, are presented below.

Fire Resistance Test

Test Date & Time: 12/6/18, 9:55 AM

Furnace: Large-scale vertical exposure E119 furnace – 1-hr fire exposure

Laboratory Conditions: 15°C, 34% RH

Witnesses: Robert Grupe (Grupe Gypsum), Michael Gardner (WACA)

Table 1. Observations for fire resistance wall test.

<table>
<thead>
<tr>
<th>Test Time (hr:mm:ss)</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:00</td>
<td>Start test</td>
</tr>
<tr>
<td>01:20</td>
<td>Paper ignition – out at 2:20</td>
</tr>
<tr>
<td>03:40</td>
<td>Some joint compound flaking off</td>
</tr>
<tr>
<td>16:00</td>
<td>Joint compound fallen from paper tear and removed fastener</td>
</tr>
<tr>
<td>19:00</td>
<td>Joint 2-3 exposed – fallen compound at joint</td>
</tr>
<tr>
<td>21:14</td>
<td>TCs1-5 &gt; 154°C – finish failure</td>
</tr>
<tr>
<td>Time</td>
<td>Event Description</td>
</tr>
<tr>
<td>------</td>
<td>-------------------</td>
</tr>
<tr>
<td>25:40</td>
<td>Joint 1-2 exposed</td>
</tr>
<tr>
<td>27:00</td>
<td>Cracks in Board #1</td>
</tr>
<tr>
<td>28:10</td>
<td>Joints opening up slightly</td>
</tr>
<tr>
<td>29:10</td>
<td>Crack in unexposed Joint 1-2</td>
</tr>
<tr>
<td>39:00</td>
<td>Crack in unexposed Joint 2-3</td>
</tr>
<tr>
<td>40:45</td>
<td>Screws darkening on unexposed side</td>
</tr>
<tr>
<td>51:20</td>
<td>Extended exposed-side cracking on Board #3</td>
</tr>
<tr>
<td>55:00</td>
<td>Board #2 starting to warp</td>
</tr>
<tr>
<td>1:00:55</td>
<td>Joint compound flaking out of chip defect</td>
</tr>
<tr>
<td>1:01:40</td>
<td>TC₅₀₁₆ - 154°C &amp; TC₅₀₈ &gt; 196°C – assembly failure</td>
</tr>
<tr>
<td>1:03:00</td>
<td>Terminate test</td>
</tr>
</tbody>
</table>

Figure 5. Wall assembly during fire resistance test showing (a) fallen compound – 25 min, (b) gypsum crack – 28 min, (c) darkened fasteners – 48 min, (d) gypsum cracking – 52 min, and (e) near end of test – 61 min.
The test was terminated at 63 m 0 s after the temperature thresholds had been surpassed. No flames passed through the assembly at that time. Thus, this fulfilled the requirement of flames or gases hot enough to ignite cotton waste for a 63 min period.

**Temperature Data**

The furnace temperature followed the standard time-temperature curve as shown in Figure 6a. A comparison of the area under the time-temperature curve with the standard is also shown in Figure 6b. The area (0.4%) is well below the 10% recommended for a 1-hr test.

![Figure 6](image1.png)

**Figure 6.** Furnace comparison with standard showing (a) temperature and (b) area under the curve.

The temperature profiles for this sample are grouped as finish TC₅ and unexposed TC₅ as shown in Figure 7. TC₅1-5 superseded the average finish temperature threshold (139°C + ambient) at 21 m 14 s, giving a finish rating of 21 min, rounding to the nearest integral minute. The unexposed temperature surpassed the average unexposed temperature threshold (139°C + ambient) and the single-point unexposed temperature threshold (181°C + ambient, TC₅8) at 61 m 40 s. Therefore, this assembly passed the heat transmission requirement for the 1-hr duration, and had a 62 minute rating, rounding to the nearest integral minute.

![Figure 7](image2.png)

**Figure 7.** Sample temperatures showing (a) finish TC₅ and (b) unexposed TC₅.

**Deflection Data**

Horizontal deflection measurements were taken every five minutes at three locations along the horizontal midline on the unexposed sample surface to monitor horizontal movement and/or buckling of the sample. It can be seen in Figure 8 that the horizontal deflection (toward the furnace) reached approximately 1½” deflection, but receded to approximately ¾” by the end of the test.
Additional Information

Following the test (Figure 9), the assembly was removed from the furnace and allowed to cool. There was some shrinkage of the gypsum joints, but the gypsum remained in place. The defects did not appear to be significantly affected.

Hose Stream Retest

A separate yet identical assembly was constructed to undergo the hose stream requirements of the standard, which allows the 1 hr assembly to be fire tested at half the resistance time (30 min), and then have the hose stream application. Directly following the fire resistance portion of the test, the assembly was backed away from the furnace to perform the hose stream portion. For this portion, a water hose stream was applied at a pressure of 30 psi for 1 min (1 min/100 ft² for 1-hr resistance, ASTM E2226, Standard Practice for Application of Hose Stream). Hose stream application began approximately 3 min following removal from the furnace.

Test Date & Time: 12/6/18, 1:25 PM

Furnace: Large-scale vertical exposure E119 furnace – 30 min fire exposure with hose-stream

Laboratory Conditions: 16°C, 33% RH

Witnesses: Robert Grupe (Grupe Gypsum), Michael Gardner (WACA)
Table 2. Observations for hose-stream retest.

<table>
<thead>
<tr>
<th>Test Time (hr:mm:ss)</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:00</td>
<td>Start test</td>
</tr>
<tr>
<td>01:40</td>
<td>Paper ignition</td>
</tr>
<tr>
<td>12:30</td>
<td>Joint 1-2 exposed – joint compound fallen</td>
</tr>
<tr>
<td>14:00</td>
<td>Joint compound fallen from paper tear and missing screw</td>
</tr>
<tr>
<td>23:00</td>
<td>Joint compound falling from chip defect</td>
</tr>
<tr>
<td>24:30</td>
<td>Joint 2-3 exposed</td>
</tr>
<tr>
<td>30:00</td>
<td>Furnace off</td>
</tr>
<tr>
<td>~33:00</td>
<td>Start hose-stream</td>
</tr>
<tr>
<td>~34:00</td>
<td>Stop hose-stream – no water penetration</td>
</tr>
</tbody>
</table>

Figure 10. Wall assembly showing (a) fallen compound – 25 min, (b) after furnace, (c) after test – exposed, and (d) after test - unexposed.

No holes or penetrations developed in the assembly that permitted the projection of water from the hose stream beyond the unexposed surface, thus fulfilling this hose-stream requirement of the standard.

Temperature Data

The furnace temperature followed the standard time-temperature curve as shown in Figure 11a. A comparison of the area under the time-temperature curve with the standard is also shown in Figure 11b. The area (1.2%) is below the 10% recommended for a 1-hr test.
CONCLUSION

The non-load-bearing wall assembly with defects as detailed above met all the necessary requirements for the 1-hr fire endurance test, according to ASTM E119 test, *Standard Test Methods for Fire Tests of Building Construction and Materials*. The fire resistance assembly had a finish rating of 21 min, rounding to the nearest integral minute. The assembly did not allow flames to pass through the wall assembly for the 63 min test, and the assembly lasted 62 min before superseding an average temperature threshold (139°C + ambient) and single-point threshold (181°C + ambient), rounding to the nearest integral minute. In addition, a separate wall assembly was subjected to a hose-stream following a 30-min fire resistance test for 1 min, and did not develop an opening that permits the projection of water from the hose stream beyond the unexposed surface.
SIGNATURES

Testing performed by,

Mike White
Laboratory Manager

Reviewed and Approved by,

Brent M. Pickett, Ph.D.
Technical Director

WESTERN FIRE CENTER AUTHORIZES THE CLIENT NAMED HEREIN TO REPRODUCE THIS REPORT ONLY IF REPRODUCED IN ITS ENTIRETY.

The test specimen identification is as provided by the client, and WFCi accepts no responsibility for any inaccuracies therein. WFCi did not select the specimen and has not verified the composition, manufacturing techniques, or quality assurance procedures.
APPENDIX A: ADDITIONAL FIGURES

Figure A 1. Identification of (a-b) gypsum.

Figure A 2. Construction of assembly showing (a) frame, (b) gypsum, (c) removed screw and paper tear, (d) joint gap, (e) abrasion, and (f) paper tear and chip.
Figure A 3. Additional images during fire endurance test at (a) 17 min, (b) 26 min, (c) 47 min, and (d) 58 min.
Figure A 4. Additional images during hose-stream retest: (a) 2 min, (b) 23 min, (c) before test, after hose-stream with (d) abrasion, and (e) chip.

Figure A 5. Furnace pressure for (a) fire endurance and (b) hose-stream retest.