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 #19066
Test Dates: September 13, 2019
Report Issued: September 26, 2019
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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 double-layer Type X gypsum board on each side of the frame with a prescribed \( \frac{1}{4}'' \) gap defect in the base layer gypsum. One fire endurance test and one hose-stream retest were performed for this assembly, performed on September 13, 2019, 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 two-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 (TCF) connected to a computerized data acquisition system. TCF 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 (2-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

Two 10’×10’ assemblies were constructed at WFCi. Each steel frame assembly (Figure 1, Figure 2) consisted of two layers of \( \frac{3}{8}'' \) Type X gypsum board on each side of the \( \frac{3}{4}'' \) deep steel studs. Specific details of each component of the assembly are found below.

![Figure 1. General schematics of assembly.](image-url)
Figure 2. Overall assembly showing (a) exposed face and (b) unexposed face.

**Steel Frame**

The 10’×10’ assembly (Figure 3) was framed 24” on center (cavity-centered) with 3½” deep steel C-studs (3¾” CD Prostud NS 20 362PDS125-30, G40) with both an upper and lower track (3½” CD Protrack NS 20 362PDT125-30, G40) with ⅜” float on each stud end.

Figure 3. Assembly layers showing the steel frame.

**Gypsum Layers**

Two layers of ⅜” Type X gypsum board (USG Firecode® X 240 05/02/19 20:23, R1319-240 Type SCX) was fastened on each side of the steel frame (Figure 4). 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, and from face to base layers. The average mass of the gypsum board was 2.28 lb/ft². The average thickness of the board at the cut (butt) and tapered edges was 0.626” and 0.567”, respectively. The base layer panels were fastened with Type S (1¼”) screws at 16” on center on edge and in the field with a ⅜” distance from vertical joint edge. The base layer panels were fastened with Type S (1⅜”) screws at 12” on center on edge and in the field with a ⅜” distance from vertical joint edge.
joints and fastener heads on the face layer only were coated with 2 layers of joint compound, including 2” paper tape on the joints.

A gap defect was purposefully introduced to the gypsum base layer with a single ¼” vertical joint gap as identified in Figure 4. Base layer screws were angled slightly to be able to fasten to the stud flange. No joint compound was placed in the ¼” joint gap.

Figure 4. Assembly gypsum layers showing (a) exposed base, (b) exposed face, (c) unexposed base, and (d) unexposed face.
Temperature

To obtain representative thermal information of the samples during the tests, the fire endurance assembly was instrumented with sample thermocouples (TCs). There were TCs placed in two groups (Figure 5):

- Finish TCs (1-5): Placed at relative center and quarter points of assembly between gypsum and studs.
- Unexposed TCs (6-15): Placed at center and quarter points of assembly (TCs6-10) as well as other points (TCs11-15) throughout the assembly near defects. Each unexposed TC was covered with a 6”×6” ceramic pad.

![Figure 5. Sample thermocouple locations showing (a) finish TCs and (b) unexposed TCs.](image)

**TEST RESULTS**

Testing of the fire endurance and hose-stream retest wall assemblies took place on September 13, 2019, 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 5-10 minutes during the test. These data, as well as additional photographs, are presented below.

**Fire Resistance Test**

**Test Date & Time:** 9/13/19, 8:00 AM

**Furnace:** Large-scale vertical exposure E119 furnace – 2-hr fire exposure

**Laboratory Conditions:** 21°C, 72% 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>01:15</td>
<td>Gypsum paper ignition</td>
</tr>
<tr>
<td>21:00</td>
<td>Small sections of joint compound fallen</td>
</tr>
<tr>
<td>37:00</td>
<td>Approximately ¾” face layer joint gap</td>
</tr>
<tr>
<td>47:39</td>
<td>TCs1-5 &gt; 154°C – finish threshold</td>
</tr>
<tr>
<td>1:12:00</td>
<td>Bowing face layer gypsum</td>
</tr>
<tr>
<td>1:33:00</td>
<td>Face layer gypsum section fallen (middle board)</td>
</tr>
<tr>
<td>1:43:00</td>
<td>More fallen face layer sections</td>
</tr>
<tr>
<td>1:48:00</td>
<td>Approximately ¾” base layer joint gap</td>
</tr>
<tr>
<td>1:57:00</td>
<td>Visible side of stud flange</td>
</tr>
<tr>
<td>1:58:45</td>
<td>Visible fasteners on unexposed side through joint compound</td>
</tr>
<tr>
<td>2:03:15</td>
<td>Terminate test</td>
</tr>
</tbody>
</table>

Figure 6. Wall assembly during fire resistance test showing (a) joint gap – 37 min, (b) fallen face section – 95 min, (c) base gap – 108 min, and (d) visible fasteners – 119 min.

The test was terminated at 123 m 15 s after sufficient energy was applied to the wall based on the time-temperature area. 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 123 min period.
**Temperature Data**

The furnace temperature followed the standard time-temperature curve as shown in Figure 7a. A comparison of the area under the time-temperature curve with the standard is also shown in Figure 7b. The area (0.3%) is well below the 7.5% recommended for a 2-hr test.

![Figure 7. Furnace comparison with standard showing (a) temperature and (b) area under the curve.](image)

The temperature profiles for this sample are grouped as finish TC₅ and unexposed TC₅ as shown in Figure 8. TC₅1-5 superseded the average finish temperature threshold (139°C + ambient) at 47 m 39 s, giving a finish rating of 48 min, rounding to the nearest integral minute. The unexposed temperature did not surpass the average temperature threshold (139°C + ambient) or the single-point temperature threshold (181°C + ambient) for the duration of the test. Therefore, this assembly passed the heat transmission requirement for the 2-hr duration, and had a 123 minute rating, rounding to the nearest integral minute.

![Figure 8. Sample temperatures showing (a) finish TC₅ and (b) unexposed TC₅.](image)

**Deflection Data**

Horizontal deflection measurements were taken every 5 to 10 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 9 that the horizontal deflection (toward the furnace) reached approximately 1½” deflection, but began to recede slightly by the end of the test.
Additional Information

Following the test (Figure 10), the assembly was removed from the furnace and allowed to cool. There was some shrinkage of the gypsum joints, but the base layer gypsum remained in place. After some time, the base layer was removed allowing the studs to be exposed. Some cracking was observed in the unexposed base layer as well as some warping of the steel studs.

Hose Stream Retest

A separate yet identical assembly was constructed to undergo the hose stream requirements of the standard, which allows the 2 hr assembly to be fire tested at half the resistance time (60 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 2½ min (2½ min/100 ft² for
2-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:** 9/13/19, 11:05 AM

**Furnace:** Large-scale vertical exposure E119 furnace – 60 min fire exposure with hose-stream

**Laboratory Conditions:** 25°C, 66% 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>01:15</td>
<td>Paper ignition</td>
</tr>
<tr>
<td>1:00:00</td>
<td>No significant change – furnace off</td>
</tr>
<tr>
<td>~1:03:00</td>
<td>Begin hose-stream</td>
</tr>
<tr>
<td>~1:05:30</td>
<td>Stop hose-stream – no water penetration</td>
</tr>
</tbody>
</table>

Figure 11. Wall assembly showing (a) exposed gypsum – 4 min, (b) after furnace, (c) during 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 12a. A comparison of the area under the time-temperature curve with the standard is also shown in Figure 12b. The area (0.7%) is below the 10% recommended for a 1-hr test.

![Temperature Data Graphs](image)

Figure 12. Furnace comparison with standard showing (a) temperature and (b) area under the curve.

CONCLUSION

The non-load-bearing wall assembly with gap defects as detailed above met all the necessary requirements for the 2-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 48 min, rounding to the nearest integral minute. The assembly did not allow flames to pass through the wall assembly for the 123 min test, and the assembly did not surpass the average temperature threshold (139°C + ambient) or single-point threshold (181°C + ambient) during the 123 min test. In addition, a separate wall assembly was subjected to a hose-stream following a 60-min fire resistance test for 2½ min, and did not develop an opening that permits the projection of water from the hose stream beyond the unexposed surface.
SIGNATURES

Reviewed and Approved by,

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Testing performed by,

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Technical Director

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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) studs, (b) track, and (c-d) gypsum.

Figure A 2. Construction of assembly showing (a) frame, (b) base gypsum, (c) base layer gap, and (d) face gypsum.
Figure A 3. Additional images during fire endurance test at (a) 23 min, (b) 82 min, (c) 104 min, and (d) 117 min.

Figure A 4. Additional images after fire endurance test showing (a-b) gypsum, (c) unexposed, and (d) studs.
Figure A 5. Additional images during hose-stream retest (a) before test, (b-c) after hose-stream, (d) after hose-stream.

Figure A 6. Furnace pressure for (a) fire endurance and (b) hose-stream retest.