STATIC LOAD TEST FOR SHEAR RESISTANCE OF Framed Walls for Manufactured Homes:

Prepared for:
Alpha Systems, LLC
5120 Beck Drive
Elkhart, Indiana 46516
Web: www.alphallc.us

Test Report: ALP072610-8
Issued: August 6, 2010

Prepared By:
Dale Arter
Director of Testing

Reviewed By:
Eric Landaw, P.E.
Test Engineer

This report contains only findings and results arrived at after employing the specific test procedures listed herein. It does not constitute a recommendation for, endorsement of, or certification of the product or material tested. NTA, Inc. makes no warranty, expressed or implied, except that the test has been performed, and a report prepared, based upon the specimen furnished by the client. Extrapolation of data, from the test data provided herein, to the batch or lot from which the specimens were obtained may not correlate and should be interpreted with extreme caution. NTA, Inc. assumes no responsibility for variations in quality, composition, appearance, performance, or other features of similar materials produced by the client, other persons, or under conditions over which NTA, Inc. has no control. NTA, Inc. has issued this report for the exclusive use of the client to whom it is addressed. Any use or duplication of this report shall not be made without their consent. This report shall only be reproduced in its entirety.

ALP072610-8
1. INTRODUCTION
   1.1. GENERAL
   This test measures the resistance of a framed wall assembly, sheathed with sheet materials, to a racking load such as would be imposed by winds blowing on a wall oriented at 90° to the wall assembly. The strength of such an assembly is often difficult to calculate based on engineering mechanics alone. For this reason, Section 3280.401(b) of the Federal Manufactured Home Construction and Safety Standards (FMHCSS) allows for ultimate load tests to establish the design strength of structural assemblies to be used in manufactured housing construction.

   1.2. OBJECTIVE AND SCOPE
   NTA, Inc. conducted racking load tests on wall assemblies at the NTA test facility in Nappanee, Indiana. The purpose of this evaluation is to assess the racking resistance of a typical section of sheathed wall framing in accordance with Section 3280.305 of the Federal Manufactured Home Construction and Safety Standards (FMHCSS). The tested assemblies were constructed as specified by the client.

2. TEST PROGRAM
   2.1. DEVIATIONS FROM TEST STANDARD
   The testing detailed herein was performed with no modifications to the test standard(s).

   2.2. DESCRIPTION OF TEST SPECIMENS
   Each specimen consisted of a 96-in. x 96-in. wall assembly constructed as specified in Table 1 and as shown in Figure 1. Sheathing attachment was as specified in Table 2. The adhesive fillet sizes were specified by the client. Accordingly, gypsum was adhered to Side A first followed by the adherence of gypsum to Side B a day later; attachments were as described in Table 2. Following the completion of construction, each specimen was allowed to cure for a minimum of seven days prior to testing.

<table>
<thead>
<tr>
<th>Location</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Studs</td>
<td>Single, 2x3 Stud Grade SPF, 16-in. oc</td>
</tr>
<tr>
<td>Top Plate</td>
<td>Single 1x3 Un-graded SPF</td>
</tr>
<tr>
<td>Bottom Plate</td>
<td>Single 1x3 Un-graded SPF</td>
</tr>
<tr>
<td>Sheathing Side A</td>
<td>5/16-in. x 48-in. x 96-in. American Gypsum Wallboard (Applied Vertically)</td>
</tr>
<tr>
<td>Sheathing Side A</td>
<td>Joint Treatment</td>
</tr>
<tr>
<td>Sheathing Side B</td>
<td>5/16-in. x 48-in. x 96-in. American Gypsum Wallboard (Applied Vertically)</td>
</tr>
<tr>
<td>Sheathing Side B</td>
<td>Joint Treatment</td>
</tr>
</tbody>
</table>

Table 1: Materials
Table 2: Fastening Schedule

<table>
<thead>
<tr>
<th>Connection</th>
<th>Fastener</th>
<th>Quantity or Spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top plate to Studs</td>
<td>7/16-in. x 1-3/4-in. x 15 Ga. Staple</td>
<td>2</td>
</tr>
<tr>
<td>Bottom Plate to Studs</td>
<td>7/16-in. x 1-3/4-in. x 15 Ga. Staple</td>
<td>2</td>
</tr>
<tr>
<td>Sheathing A to Framing (Mechanical)</td>
<td>None</td>
<td>N/A</td>
</tr>
<tr>
<td>Sheathing A to Framing (Adhesive)</td>
<td>AlphaSeal 5200 Two-Component Polyurethane Adhesive System by Alpha Systems, LLC</td>
<td>5/8-in. Height x 1-1/16-in. Width Average Measured Fillet Size (Additional details are provided in the NTA 10-04 documentation sheets in the appendix.)</td>
</tr>
<tr>
<td>Sheathing B to Framing (Mechanical)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Sheathing B to Framing (Adhesive)</td>
<td>Pemco 3100 PVA Adhesive by Alpha Systems, LLC</td>
<td>(1) Ø1/4-in. average bead size per framing member, except (2) Ø1/4-in. beads at center stud</td>
</tr>
</tbody>
</table>

2.3. PREPARATION FOR TESTING

Prior to placement in the racking fixture (Figure 2 and Figure 3), a steel loading and reaction bar are attached to the top and bottom, respectively, of each assembly. With these bars in place, each specimen is positioned in the racking fixture.

A hydraulic cylinder is used to apply the racking force to the loading bar at the top of the specimen, as shown in Figure 2. The applied load is monitored using an in-line load cell. Digital deflection indicators, with a resolution of 0.001 inch, are positioned at three corners of the specimen, as shown in Figure 2.

2.4. TEST PROCEDURE

Each test is conducted in accordance with 24 CFR §3280.401(b). Additional test procedures are based on ASTM E 72, Standard Methods of Conducting Strength Tests of Panels for Building Construction. Accordingly, each specimen is loaded at a uniform rate of 395 lbs/min. in order to reach 790 pounds in not less than two minutes. Deflection readings are recorded for at least every 200 lbs of load. The applied load is then removed and the specimen was given time to recover. After which, residual deflection readings are taken. This cycle of loading and unloading is continued up to a load of 2360 lbs, after which the load is increased to ultimate.
3. TEST RESULTS

Overall, the three specimens behaved similarly. This similarity is seen in both the ultimate loads, provided in Table 3, and in the load-deflection plots, shown in Figure A4. Table 3 provides a summary of the ultimate and design shear loads, as well as the failure mode. Additional test data are provided in the Appendix.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Ultimate Load (lbs)</th>
<th>Design Shear Load(^a) (plf)</th>
<th>Failure Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>32930</td>
<td>9245</td>
<td>462</td>
<td><em>Paper shear and gypsum failure along bottom plate on side with PVA Adhesive.</em></td>
</tr>
<tr>
<td>32931</td>
<td>9867</td>
<td>493</td>
<td><em>Paper shear and gypsum failure along bottom plate on side with PVA adhesive and adhesive failure on side with two-part polyurethane adhesive.</em></td>
</tr>
<tr>
<td>32932</td>
<td>8929</td>
<td>446</td>
<td><em>Paper shear and gypsum failure along bottom plate on side with PVA adhesive.</em></td>
</tr>
<tr>
<td><strong>Average Value</strong></td>
<td><strong>9347</strong></td>
<td><strong>467</strong></td>
<td>--</td>
</tr>
</tbody>
</table>

\(^a\) Design shear load determined using the equation \(P_{allowable} = P_{ultimate} / (2.5 \times 8 \text{ ft})\). A factor of safety of 2.5 is applied in accordance with 24 CFR §3280.401(b).
4. CONCLUSION

Three similar assemblies were tested and assessed in accordance with the ultimate load
test procedures of the FMHCSS\(^1\). The conditions of test and overall findings are
summarized in Table 4 below. The specimens tested in this investigation were
constructed to simulate those produced under typical manufacturing conditions; however,
construction methods and quality can vary greatly, thereby effecting performance.
Additionally, actual assembly performance may vary depending on tie-down and support
conditions. Designs utilizing the findings in this report must be reviewed by a
professional engineer to ensure proper construction and use.

<table>
<thead>
<tr>
<th>Wall Construction</th>
<th>Allowable Shear Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double-Sided with 5/16-in. American Gypsum Wall Board</td>
<td>467 plf</td>
</tr>
<tr>
<td>(Installed Vertically) on each side, Adhered with AlphaSeal 5200 by Alpha Systems, LLC on one side and Pemco 3100 by Alpha Systems, LLC on the other side Fastened and constructed as detailed herein</td>
<td></td>
</tr>
</tbody>
</table>

It must be noted that NTA, Inc. did not oversee or verify the sampling procedure used by
the client when selecting the sample material(s). Materials provided by NTA, Inc. were
obtained through common suppliers and were inspected upon receipt to verify that the
materials were of average quality. The data provided herein were obtained based on
FMHCSS\(^1\) test procedures and assessed based on FMHCSS\(^1\) criteria and should not be
used for other types of construction. For use in manufactured housing, these results are
subject to DAPIA review and approval.

PREPARED BY: Dale Arter
Director of Testing

REVIEWED BY: Eric Landau, P.E.
Test Engineer

ALP072610-8
REFERENCES


FIGURES

Side A: (2) 48-in. x 96-in. 5/16-in American Gypsum, Attached Vertically with AlphaSeal 5200 Adhesive (One fillet per member, except at the center stud which has one bead on each side) and no mechanical fasteners.

Side B: (2) 48-in. x 96-in. 5/16-in American Gypsum, Attached Vertically with Pemco 3100 Adhesive (One ¼-in. bead per member, except at the center stud which has two ¼-in. beads) and ¼-in. x 1-in. x 19 Ga. Staples, 6-in. oc edge / 24-in. oc field

Figure 1: Specimen Construction

Note:
Top plate and bottom plate securely fastened to metal framing with wood screws

Dial Indicator #1

W8x15

8'-0" x 8'-0" Wall Sample

Screws Into Top Plate

A

Hydraulic Cylinder and Load Cell

Steel Loading Bar

1/2" Diameter Tie-Down

Dial Indicator #3

Hydraulic Pump

I-Beam securely fastened

Steel Reaction Bar

Figure 2: Racking Test Fixture
Figure 3: Racking Test Fixture Detail A-A

Figure 4: AlphaSeal 5200 Adhesive
Figure 5: Application of AlphaSeal 5200 Adhesive

Figure 6: Specimen #32931 Prior to Testing
APPENDIX

Racking Test for Wall Assemblies to be used in Manufactured Homes:
Specimen Construction

Client: Alpha Systems, LLC
Job Number: ALP072610-8
Test Method: FMHCS, Section 3280.401(b), Ultimate Load
Text Procedure (based on ASTM E72)

Nominal Specimen Size: 96-in. x 96-in.

Framing Specifications:
- Studs: (1) 2 x 3 Stud SPF @ 16-in oc (Spec. #32605)
- Top Plate: (1) 1 x 3 Ungraded SPF (Spec. #32554)
- Bottom Plate: (1) 1 x 3 Ungraded SPF (Spec. #32554)

Panel Specifications:
- Sheathing, Side A: 1 Layer(s) 5/16-in. American Gypsum 48 x 96-in. (Spec. #32418)
- Sheathing, Side B: 1 Layer(s) 5/16-in. American Gypsum 48 x 96-in. (Spec. #32418)

NOTES: Vertically applied 5/16-in. gypsum on both sides of walls; applied with AlphaSeal 5200 on one side and Pemco 3100 on the second side.

Mechanical Fastening Schedule:
- Top plate-to-Stud: (2) 7/16 x 1-3/4 15g. Staple (Spec. #12765)
- Bottom plate-to-Stud: (2) 7/16 x 1-3/4 15g. Staple (Spec. #12765)
- Top plate-to-top plate (if double): n/a
- Bottom plate-to-bottom plate (if double): n/a
- Stud-to-stud (if double): n/a
- Sheathing A: n/a
- Sheathing B: 1/4 x 1-in. 19ga. Staple @ 6/24-in. oc (edge/field) (Spec. #23346)

Adhesive Application:
- Sheathing, Side A
  - Adhesive: AlphaSeal 5200 Two-Part Polyurethane Foam Adhesive (Spec. #32917)
  - Application: Min. 3/8 x 3/4-in. dia. average bead size
  - Bead Qty: (1) Top-Plate, (1) Bottom-Plate, (1) Edge Stud, (2) Center Stud, (1) Interior Stud
  - Adhesive Cure Time: 8 days

- Sheathing, Side B
  - Adhesive: Pemco 3100 (Spec. #31797)
  - Application: 1/4-in. dia. average bead size
  - Bead Qty: (1) Top-Plate, (1) Bottom-Plate, (1) Edge Stud, (2) Center Stud, (1) Interior Stud
  - Adhesive Cure Time: 7 days

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APPENDIX

Racking Test for Wall Assemblies to be used in Manufactured Homes:
Specimen 1

Client: Alpha Systems, LLC
Job Number: ALP072610-8
Test Method: FMHCSS, Section 3280.401(b), Ultimate Load
Test Procedure (Based on ASTM E72)

Performed By: Todd Ferguson
Witnessed By: Jacob Yoder
Test Location: NTA, Inc.
Nappanee, Indiana

General:
Specimen No.: 032930
Wood MC: 11.9%-14.6%
Received: 7/14/2010
Fabrication Date: 7/19/2010
Test Date: 7/27/2010

Ambient Conditions:
Ambient Temp.: 72.8 deg. F
Ambient R.H.: 52.8% RH
Sensor Asset No.: 00587

Apparatus:
Shearwall Rack: 00022
Signal Conditioner: 00757
Load-to-Specimen Load Cell: 00932
Uplift Load Cell 1: 00745
Uplift Load Cell 2: 00746
Indicator #1: 00057
Indicator #2: 00458
Indicator #3: 00055
Timing Device: 00757

Specimen 1 Test Deflection Data

<table>
<thead>
<tr>
<th>Load Stages (lbs)</th>
<th>Measured Deflections (in.)</th>
<th>Net Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gauge 1</td>
<td>Gauge 2</td>
</tr>
<tr>
<td>REF 0</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>790</td>
<td>0.073</td>
<td>0.008</td>
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<td>0</td>
<td>0.024</td>
<td>0.008</td>
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<tr>
<td>1570</td>
<td>0.132</td>
<td>0.015</td>
</tr>
<tr>
<td>0</td>
<td>0.037</td>
<td>0.013</td>
</tr>
<tr>
<td>2360</td>
<td>0.189</td>
<td>0.021</td>
</tr>
<tr>
<td>0</td>
<td>0.052</td>
<td>0.018</td>
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<td>2160</td>
<td>0.241</td>
<td>0.032</td>
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<tr>
<td>3950</td>
<td>0.298</td>
<td>0.040</td>
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<tr>
<td>4740</td>
<td>0.358</td>
<td>0.042</td>
</tr>
<tr>
<td>5530</td>
<td>0.425</td>
<td>0.044</td>
</tr>
<tr>
<td>6320</td>
<td>0.502</td>
<td>0.049</td>
</tr>
<tr>
<td>7110</td>
<td>0.608</td>
<td>0.061</td>
</tr>
</tbody>
</table>

A "--" denotes that data for this point was not collected.
Avg. Loading Rate: 398 lbs/min.
Ultimate Load: 9245 lbs

Failure Mode:
Paper shear and gypsum failure along bottom plate on PVA side.

![Failure Diagram](image-url)
APPENDIX

Racking Test for Wall Assemblies to be used in Manufactured Homes:
Specimen 2

Client: Alpha Systems, LLC
Job Number: ALP072610-8
Test Method: FMHCSS, Section 3280.401(b), Ultimate Load
Test Procedure (Based on ASTM E72)

Performed By: Todd Ferguson
Witnessed By: Jacob Yoder
Test Location: NTA, Inc.
Nappanee, Indiana

General:
Specimen No.: 032931
Wood MC: 11.2%-13.5%
Received: 7/14/2010
Fabrication Date: 7/19/2010
Test Date: 7/27/2010

Ambient Conditions:
Ambient Temp.: 73 deg. F
Ambient R.H.: 51.7% RH
Sensor Asset No.: 00587

Apparatus:
Shearwall Rack: 00022
Signal Conditioner: 00757
Load-to-Specimen Load Cell: 00932
Uplift Load Cell 1: 00745
Uplift Load Cell 2: 00746
Indicator #1: 00057
Indicator #2: 00458
Indicator #3: 00055
Timing Device: 00757

Specimen 2 Test Deflection Data

<table>
<thead>
<tr>
<th>Load Stages (lbs)</th>
<th>Measured Deflections (in.)</th>
<th>Net Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gauge 1</td>
<td>Gauge 2</td>
</tr>
<tr>
<td>REF 0</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>790</td>
<td>0.046</td>
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<tr>
<td>0</td>
<td>0.009</td>
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<tr>
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<td>0.115</td>
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<tr>
<td>0</td>
<td>0.031</td>
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<td>0.022</td>
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<td>0.292</td>
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<td>0.373</td>
<td>0.033</td>
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<tr>
<td>5530</td>
<td>0.464</td>
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<tr>
<td>6320</td>
<td>0.553</td>
<td>0.056</td>
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<tr>
<td>7110</td>
<td>0.653</td>
<td>0.064</td>
</tr>
</tbody>
</table>

A "--" denotes that data for this point was not collected.
Avg. Loading Rate: 395 lbs/min.
Ultimate Load: 9867 lbs

Failure Mode:
Paper shear and gypsum failure along bottom plate on PVA side with adhesive failure on Polyurethane side.

Figure A2: Specimen 2 Failure Diagram
APPENDIX

Racking Test for Wall Assemblies to be used in Manufactured Homes:
Specimen 3

Client: Alpha Systems, LLC
Job Number: ALP072610-8
Test Method: FMHCSS, Section 3280.401(b), Ultimate Load
Test Procedure (Based on ASTM E72)

Performed By: Todd Ferguson
Witnessed By: Jacob Yoder
Test Location: NTA, Inc.
Nappanee, Indiana

General:
Specimen No.: 032932
Wood MC: 11.6%-13.5%
Received: 7/14/2010
Fabrication Date: 7/19/2010
Test Date: 7/27/2010

Ambient Conditions:
Ambient Temp.: 72.8 deg. F
Ambient R.H.: 51.2% RH
Sensor Asset No.: 00587

Apparatus:
Shearwall Rack: 00022
Signal Conditioner: 00757
Load-to-Specimen Load Cell: 00932
Uplift Load Cell 1: 00745
Uplift Load Cell 2: 00746
Indicator #1: 00057
Indicator #2: 00458
Indicator #3: 00055
Timing Device: 00757

<table>
<thead>
<tr>
<th>Load Stages (lbs)</th>
<th>Measured Deflections (in.)</th>
<th>Net Deflection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gauge 1</td>
<td>Gauge 2</td>
</tr>
<tr>
<td>REF</td>
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</tr>
<tr>
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<tr>
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<td>0.064</td>
</tr>
<tr>
<td>7110</td>
<td>0.531</td>
<td>0.075</td>
</tr>
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</table>

A "--" denotes that data for this point was not collected.

Avg. Loading Rate: 396 lbs/min.
Ultimate Load: 8929 lbs

Failure Mode:
Paper shear and gypsum failure along bottom plate on PVA side.
APPENDIX

Racking Test for Wall Assemblies to be used in Manufactured Homes:
Results Summary

Client: Alpha Systems, LLC
Job Number: ALP072610-8
Test Method: FMHCSS, Section 3280.401(b), Ultimate Load
Test Procedure (Based on ASTM E72)

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>Ultimate Load (lbs)</th>
<th>Design Load (plf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>32930</td>
<td>9245</td>
</tr>
<tr>
<td>2</td>
<td>32931</td>
<td>9867</td>
</tr>
<tr>
<td>3</td>
<td>32932</td>
<td>8929</td>
</tr>
</tbody>
</table>

Average Ultimate Load: 9347 lbs
Average Shear Strength*: 467 plf

* As required in FMHCSS, Section 3280.401(b), Ultimate Load Test Procedure, the average ultimate load is divided by a factor of safety of 2.5 to arrive at the allowable shear strength.

Figure A4: Load vs. Deflection Plot

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Client: Alpha Systems, LLC
Job Number: ALP072610-8
Test Location: NTA, Inc.
    Nappanee, Indiana

Applied By: Alpha Systems, LLC
Witnessed By: Todd Ferguson
Application Date: 7/19/2010

NTA 10-04
Application of Spray Foam
Summary

Spray Foam Description:

Component A:
Manufacturer and Plant: Alpha Systems, LLC
Material Description: AlphaSeal 5200 A Isocyanate
Lot/Batch #: 781
Date of Mfg: 6/11/2010
Date Received: 7/14/2010
Expiration Date: 12/11/2010

Component B:
Manufacturer and Plant: Alpha Systems, LLC
Material Description: AlphaSeal 5200 B Resin (No Label on Barrel)
Lot/Batch #: 783
Date of Mfg: 7/16/2010
Date Received: 7/19/2010
Expiration Date: 1/16/2010

Mixture:
Manufacturer: Alpha Systems, LLC
Trade Name/Designation: AlphaSeal 5200 Two-Part Polyurethane Foam

Sheathing A: American Gypsum 48 x 96-in Square Edge (Applied Vertically)
Sheathing B: N/A

Preparation:
Surface Prep: n/a

Moisture Content of Materials: See Construction Datasheets

Material Temp. at Application: n/a

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APPENDIX

Application:
Applied at 1 or Both Member Sides: Vertical Gypsum center seam only one to get 2 beads one on each side of framing member
Mix Ratio: 1:1 ration
Flow Rates: Varies with gun
Pressures: 1000 psi fluid (resin/ISO) ±250 psi
Gasses Used: Compressed air
Spray Gun:
Tip Type: 55 Mixing chamber
Manufacturer: Graco
Model: D

Number of Spray Passes: Single Pass is typical with spot touch ups when necessary
Max Bead Size Allowed (H x W): n/a
Min Bead Size Allowed (H x W): 3/8" H x 3/4" W

Spraying Conditions:
Ambient Temp.: 78.4°F
Ambient R.H.: 60.1%
Sensor Asset No.: 578
Open Time: n/a
Closed Time: 2 minutes

Curing Conditions:
Minimum Reaction Time: 2 minutes (Samples may not be moved during this period)
Minimum Cure Time: 24 hrs
Temperature: 73.4
R.H.: 50
Cure Time Prior to Trimming:
Trimming Procedure: N/A (They do not trim.)

Pot Life: 6 months
Storage Temperature: Above 60°F
Storage Life: 6 months
Application Notes: 6-8 second cream time changed from the 3-5 second from previous time.

Nominal Specs:
Spray Foam Bead Width (Sheathing A): 7/8-in.
Spray Foam Bead Height (Sheathing A): 1/2-in.
Spray Foam Bead Width (Sheathing B): N/A
Spray Foam Bead Height (Sheathing B): N/A

Spray Foam Depth: N/A
Sheathing Applied to: N/A

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Spray Foam Measurements:
Framing Member Descriptions
#1: Stud #1
#2: Stud #2
#3: Stud #3
#4: Stud #4
#5: Stud #5
#6: Stud #6
#7: Stud #7
#8: Top Plate
#9: Bottom Plate

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Overall Averages: 5/8 1/8 9/16 1/8

Conditioning:
Temperature: 73.4°F
R.H. 50%
Start Date: 7/19/2010
Time Period: 24 hrs

Conditioning Notes: After sprayed - moved to ambient lab conditions

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