ALPHA SYSTEMS, INC.

Full Scale Ceiling Diaphragm Repair Test
on a 11'-9" x 48'-0" Flat Ceiling using
Pemco 3100 Repair Adhesive

9/21/98

This test report contains twenty-one (21) pages, including the cover sheet. Any additions to, alterations of, or unauthorized use of excerpts from this report are expressly forbidden.

98-2830
FULL SCALE CEILING DIAPHRAGM TEST

1. TITLE

Full scale (simple span) flat ceiling diaphragm test.

2. OBJECTIVE

The objective of this test was to determine the horizontal diaphragm strength of a repaired simple span flat ceiling diaphragm constructed per the enclosed details using Alpha Systems, Inc. repair method, processes and Pemco 3100 water-based adhesive as a fastener of the ceiling board to the roof trusses.

3. TESTED FOR

Alpha Systems, Inc.
5120 Beck Dr.
Elkhart, IN 46516

4. TESTING ORGANIZATION

Progressive Engineering, Inc.
58640 State Road 15
Goshen, IN 46528

5. TESTING PERSONNEL

Test Engineer - Evor F. Johns, P.E.
Director of Testing - Greg A. Weeden
Technician - Chad Brower
Technician - Scott Gruver
Technician - Shawn Kaufman
Technician - Jason Holdeman

6. TEST CRITERIA

The tests were conducted in accordance with Progressive Engineering, Inc. Standard No. 89-1 Simple Span Ceiling or Roof Diaphragm Shear Resistance Test Procedure for Manufactured Homes.
7. TEST SPECIMEN MATERIALS

Ceiling Material: 48" x 141" x 5/16" SHEETROCK® MH Gypsum ceiling panels supplied by U.S. Gypsum Co.

Roof Trusses: Third Party certified trusses rated for:
   Roof Live Load of 20 PSF
   Roof Dead Load of 10 PSF
   Truss Spacing 24" o.c.


Adhesive Bead Size: See the attached drawing B2 for minimums, maximums and averages of bead size on the trusses and gypsum.

Repair Adhesive: Pemco 3100 Adhesive. An average bead of 3/8" was used.

Edge Rails: 1 x 3 SPF (ungraded) lumber with 14" long 1 x 3 SPF splice blocks.

Shear Wall Top Plate: 1 x 3 SPF (ungraded) lumber.

Exterior Wall Top Plate: 1 x 4 SPF (ungraded) lumber with 14" long 1 x 4 SPF splice blocks.

Ridge Rail: 1 x 3 SPF (ungraded) lumber.

Staples: Edge rail to truss -
   7/16" c. x 2½" lg. x 15 Ga.
   Edge rail splice blocks -
   1" c. x 1½" lg. x 16 Ga.
   Ridge rail to truss -
   7/16" c. x 2" lg. x 16 Ga.
   Top plate splice blocks -
   1" c. x 1½" lg. x 16 Ga.
   Gypsum to side wall top plates -
   1" c. x 1" lg. x 16 Ga.
   End truss -
   7/16" c. x 2½" lg. x 15 Ga.

Adhesive: PVA adhesive for splice blocks, Sun Adhesives - Product No. 59-10.

Nails: Truss ends to side wall top plates -
   .131" Dia. x 3½" lg. nails
8. ORIGINAL TEST SPECIMEN CONSTRUCTION

One (1) test sample was constructed, 11'-9" x 48'-0" by Progressive Engineering, Inc., and Alpha Systems, Inc. The application of adhesive was applied by Dave Holdread of Alpha Systems, Inc. according to the process described in it's use and application procedure.

A. Twelve (12) gypsum panels were laid out on a concrete floor.

B. 3/4" wide masking tape was applied to all gypsum seams.

C. Roof trusses were placed on the gypsum at 24" o.c. A maximum gap of 1/4" between truss bottom chord and the gypsum was noted due to trusses and floor flatness.

D. The 1 x 3 edge rails were spliced with 1 x 3 x 14" splice blocks to create a 48 foot long rail. The splice blocks were attached with PVA adhesive and six (6) 1" c. x 1½" lg. x 16 Ga. staples on each side of joint.

E. Previously constructed edge rails were stapled to the truss heels with two (2) 7/16" c. x 2½" lg. x 15 Ga. staples at each truss heel.

F. The ridge rail was then stapled to the trusses with two (2) 7/16" c. x 2" lg. x 16 Ga. staples.

G. The entire framework was squared-up with the gypsum.

H. The adhesive was then applied to the assembly. The Alphaseal 5200 Adhesive is a two-part polyurethane adhesive manufactured by Alpha Systems, Inc. The components were preheated and pumped at a ratio of 1 to 1 in accordance with the manufacturer's instructions. The adhesive was applied to both sides of the bottom chord of the trusses at all gypsum seams and to one side of the bottom chord of field trusses. The intersection of the ceiling board and edge rail were not foamed. The foam was held 3" short of the edge rail on both ends of all trusses. The end trusses were not foamed.

I. The 1 x 4 side wall top plates were spliced with 1 x 4 x 14" splice blocks to create 48 foot long plates. The splice blocks were attached with PVA adhesive and six (6) 1" c. x 1½" lg. x 16 Ga. staples on each side of joint.

J. Exactly two (2) minutes after applying the final adhesive bead, the sample was lifted up and the shearwall and exterior wall top plates were placed under the ceiling.
K. The two (2) end trusses were stapled along the trusses at 3" o.c. into the top plates with 7/16" x 2½" x 15 Ga. staples.

L. One (1) 3½" lg. x .131" Dia. nail was toe-nailed in the heel of each truss end. See drawings for details.

9. **REPAIRED CEILING TEST**

The previously mentioned test sample was repaired using the following repair method and adhesive.

A. **Repair Method**

1. The first two (2) pieces of Gypsum, on each end of the test sample, were cut with a hog-nose saw along the inside wall line and removed.

2. All remaining Alphaseal 5200 adhesive was scraped off with a chisel and hand scraper.

3. Between each truss a piece of 1 x 4 was attached to the top plate and allowed to project past the inside edge of the 1 x 4 plate a minimum of 1½" to allow for fastening of the replacement gypsum board. These were stapled from the top side of the 1 x 4 plate using 1" c. x 1½" x 16 Ga. staples.

4. A 2 x 3 cut 130" was placed at each end wall truss. A 1/4" bead of Pemco 3100 was applied to each gusset plate and the 2 x 3 was then fastened to each plate using a 7/16" c. x 2½" lg. x 15 Ga. staple.

5. The replacement gypsum was cut to fit. 3/8" beads of Pemco 3100 were applied to the gypsum and positioned to contact the 2 x 3 or truss required.

6. 1 x 3 x 12' were used to hold the replacement gypsum in place until the Pemco 3100 set up. One (1) 1 x 3 was placed in the center and one (1) 1 x 3 at each side of the gypsum board. All the 1 x 3s were screwed to the trusses using 2" screws 12" o.c.
10. TEST INFORMATION

The test sample was supported by appliance rollers at 4'-0" o.c. around perimeter of sample on a concrete floor. A bearing support was placed at both ends of the test sample. Three (3) loading cylinders were located on the opposite side of the test sample. The load was applied from the cylinders through steel I-beams, to nine (9) 18" bearing blocks to uniformly apply the load to the ceiling. Five (5) dial indicators were placed along the bearing side of the test sample to measure deflections. The splice block adhesive and Pemco 3100 Adhesive were allowed to cure for a minimum of 24 hours before any loads were applied. See attached drawings for details.

11. TEST EQUIPMENT

A. Three (3) Enerpac Model P-39 hydraulic hand pumps.
B. Three (3) Enerpac Model RC-1010 hydraulic cylinders.
C. Five (5) dial indicators.
   2" movement - .001 increments.
D. Three (3) Omega digital meters.
E. Three (3) Omega pressure transducers.
F. Three (3) 9 ft. I-beams.
G. Six (6) 6 ft. I-beams.
H. Five (5) rigid bearings bolted to floor.

12. PROCEDURE

A. The loads were generated using three (3) 1 ½" diameter x 10" stroke hydraulic cylinders, one at each load point. The applied forces were measured with three (3) digital meters and pressure transducers. A permanent record of the applied forces was made on the attached data sheets.

B. The loads were generated by applying hydraulic pressure to create mechanical force until the required load was indicated on the digital meters.

C. The entire ceiling assembly was loaded in increments of 1/4 L.L. Each load was held for 10 minutes before the deflection readings were taken. After the 1 ½ L.L. deflection reading was taken, the assembly was then loaded, at a rate of approximately 1800 pounds per minute, until a failure occurred.

13. DATA SHEETS

See attached data sheets for actual deflections.
14. ANALYSIS OF RESULTS

Assuming a conservative deflection limit of .500 inches and a factor of safety of 2.5, the following values were obtained.

Live Load = 2585 lbs./11.75 ft. = 220 PLF (Deflection limit not reached)

Average Ultimate Load = 6278.5 lbs./11.75 ft. = 534.3 PLF

Design Shear = 534.3/2.5 = 213.7 PLF

15. CONCLUSION

These results can be compared with the full scale ceiling diaphragm test performed on 6/26/98, #98-1558.

The average load reached to produce failure in test #98-1558 was 222 PLF.

The maximum load reached to produce failure in the repaired ceiling was 213.7 PLF. This load is greater than any load reached in the three test samples in test #98-1558.

The repaired ceiling diaphragm using Alpha Systems, Inc. adhesive and repair method as described in test report #98-2830 produced similar failure and a higher load to produce.
Ceiling Width: 141"
Design Load: 220 P.L.F.

TEST No. 6 (Repair)

<table>
<thead>
<tr>
<th>Loading Increments</th>
<th>Total Ceiling Load (lbs.)</th>
<th>Load No. 1 (lbs.)</th>
<th>Load No. 2 (lbs.)</th>
<th>Load No. 3 (lbs.)</th>
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<tbody>
<tr>
<td>No Load</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>1/4 L.L.</td>
<td>1293</td>
<td>431</td>
<td>431</td>
<td>431</td>
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<tr>
<td>1/2 L.L.</td>
<td>2585</td>
<td>862</td>
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<tr>
<td>3/4 L.L.</td>
<td>3878</td>
<td>1293</td>
<td>1293</td>
<td>1293</td>
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<tr>
<td>Live Load</td>
<td>5170</td>
<td>1723</td>
<td>1723</td>
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<tr>
<td>1-1/4 L.L.</td>
<td>6463</td>
<td>2154</td>
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<td>1-1/2 L.L.</td>
<td>7755</td>
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<tr>
<td>1-3/4 L.L.</td>
<td>9048</td>
<td>3016</td>
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<tr>
<td>2.0 L.L.</td>
<td>10340</td>
<td>3447</td>
<td>3447</td>
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<tr>
<td>2-1/4 L.L.</td>
<td>11,633</td>
<td>3878</td>
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<td>2-1/2 L.L.</td>
<td>12,925</td>
<td>4308</td>
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Ultimate Load 12557

|                  | 4254                       | 4159             | 4144             |

Design Load 213.7 P.L.F.
**PROGRESSIVE ENGINEERING, Inc.**  
**CEILING DIAPHRAGM TEST**

Test No. 6 Repair  
Date: 9/24/98  
Temp. & Humidity During Construction: 80 deg. F / 58%  
Temp. & Humidity During Test: 72 deg. F / 50%

<table>
<thead>
<tr>
<th>Time Load/Reading</th>
<th>Load Increment</th>
<th>Load (lbs.)</th>
<th>Indicator #2 Reading</th>
<th>Indicator #2 Deflection</th>
<th>Indicator #3 Reading</th>
<th>Indicator #3 Deflection</th>
<th>Indicator #4 Reading</th>
<th>Indicator #4 Deflection</th>
<th>RESULTANT DEFLECTION</th>
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<tbody>
<tr>
<td>1:30</td>
<td>No Load</td>
<td>0 lbs.</td>
<td>.180</td>
<td>---</td>
<td>.327</td>
<td>---</td>
<td>.166</td>
<td>---</td>
<td>.070</td>
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<tr>
<td>1:31/1:41</td>
<td>1/4 Live Load</td>
<td>1628 lbs.</td>
<td>.267</td>
<td>.087</td>
<td>.417</td>
<td>.090</td>
<td>.232</td>
<td>.066</td>
<td>.170</td>
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<tr>
<td>1:42/1:52</td>
<td>1/2 Live Load</td>
<td>3255 lbs.</td>
<td>.418</td>
<td>.238</td>
<td>.570</td>
<td>.243</td>
<td>.346</td>
<td>.180</td>
<td>.278</td>
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<tr>
<td>1:53/2:03</td>
<td>3/4 Live Load</td>
<td>4883 lbs.</td>
<td>.538</td>
<td>.358</td>
<td>.705</td>
<td>.378</td>
<td>.445</td>
<td>.279</td>
<td>.401</td>
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<tr>
<td>2:04/2:14</td>
<td>Live Load</td>
<td>6510 lbs.</td>
<td>.682</td>
<td>.502</td>
<td>.855</td>
<td>.528</td>
<td>.552</td>
<td>.386</td>
<td>.533</td>
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<tr>
<td>2:15/2:25</td>
<td>1-1/4 Live Load</td>
<td>8138 lbs.</td>
<td>.813</td>
<td>.633</td>
<td>1.000</td>
<td>.673</td>
<td>.658</td>
<td>.492</td>
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Mode of Failure: Gypsum paper failure along 1st seam on end #2.

*Alpha Systems*
PROGRESSIVE ENGINEERING, Inc.
CEILING DIAPHRAGM TEST

Test No. 6 Repair
Date: 9/24/98

<table>
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<tr>
<th>Time Load/Reading</th>
<th>Load Increment</th>
<th>Load (lbs.)</th>
<th>Bearing Points</th>
<th>AVERAGE BEARING DEFLECTION</th>
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<td></td>
<td>Indicator #1</td>
<td>Indicator #5</td>
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<tr>
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<td></td>
<td>Reading</td>
<td>Deflection</td>
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<td>No Load</td>
<td>0 lbs.</td>
<td>.171</td>
<td>.096</td>
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<td>1:31/1:41</td>
<td>1/4 Live Load</td>
<td>1628 lbs.</td>
<td>.209</td>
<td>.038</td>
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<td>1:42/1:52</td>
<td>1/2 Live Load</td>
<td>3255 lbs.</td>
<td>.313</td>
<td>.142</td>
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<tr>
<td>1:53/2:03</td>
<td>3/4 Live Load</td>
<td>4883 lbs.</td>
<td>.364</td>
<td>.193</td>
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<tr>
<td>2:04/2:14</td>
<td>Live Load</td>
<td>6510 lbs.</td>
<td>.413</td>
<td>.242</td>
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<tr>
<td>2:15/2:25</td>
<td>1-1/4 Live Load</td>
<td>8138 lbs.</td>
<td>.428</td>
<td>.257</td>
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Alpha Systems
Repaired Ceiling Test

Deflection in Inches

- Original Average
- Repaired Test

No Load 1/4 Live Load 1/2 Live Load 3/4 Live Load Live Load 1-1/4 Live Load

Alpha Systems
(6) 1" c. X 1 1/4" lg.
X 16 GA. STAPLES
EA. 1/2 OF SPLICE

**TOP PLATE SPLICE**

**GLUE PATTERN**

1 X 4

14"

1 X 4

EDGE RAIL SPLICE

**GLUE PATTERN**

1 X 3

**TRUSS BOTTOM CHORD**

7/16" c. X 2 1/2" lg.
X 15 GA. STAPLES
@ 3" O.C.

1 X 3

TOP PLATE

**GYPSUM**

**TRUSS FASTENING TO SIDEWALLS**

TOE-NAIL
.131" DIA. x
3 1/2" Lg.

1" C. X 1" LG.
X 16 GA.
STAPLES @
4" O.C.

TRUSS FASTENING

ALPHASEAL 5200

(2) 7/16" x 2 1/2"
X 15 GA. STAPLES

THIRD PARTY CERTIFIED TRUSS

1 X 4 TOP PLATE

1" C. X 1" LEG
X 16 GA. STAPLES
@ 4" O.C.

**END WALL FASTENING**

1 X 3 RIDGE RAIL

(2) 7/16" C. X 2" LG.
X 16 GA. STAPLES

RIDGE RAIL FASTENING

THIS DRAWING IS A PART OF TEST REPORT NO. 98-2830

D.L. LEHMANN

REVISED ON

DATE: 9/21/98

SCALE: 1/25" = 1'

JOB NO.: 98-2830

PROGRESSIVE ENGINEERING, INC.
TESTING LABORATORY

58640 State Road 15
CORBIN, KENTUCKY 40701
Telephone (219) 533-0337

**DETAILS**

ALPHA SYSTEMS
(2) 2 x 3 x 65-3/8" Backers
Attached to bottom chord of the 5th truss from each end with 4" round washer head #8 screws.
(1) Screw @ each end and @ each truss post.

(1) 2 x 3 x 139-1/2" Backer
Attached to bottom chord of both end trusses with 2-1/2" round washer head #8 screws.
(1) Screw @ each end and @ each truss post.
SECTION B-B

ONE 1/4" BEAD OF PEMCO 3100 ADHESIVE AT CENTER OF NON SEAM TRUSSES & TWO 1/4" BEADS AT SEAMS.

TEMPORARY 1 x 3's

SECTION D-D

2x3 BACKER ATTACHED TO TRUSS

TRUSS BOTT. CHORD

2x3 BACKER ATTACHED TO TRUSS WITH 2-1/2" ROUND WASHER HEAD SCREWS AND (1) 1/4" BEAD OF PEMCO 3100 ADHESIVE ON THE TRUSS AND ON REMAINING GYPSUM.

1/4" BEAD OF PEMCO 3100 ADHESIVE

1/4" BEAD OF PEMCO 3100 ADHESIVE

HEEL BLOCKING

(2) .131" DIA. x 3-1/2" LG. NAILS INTO BLOCKING

2x3 BLOCKING

.131" DIA. x 3-1/2" LG. NAIL TOE NAILED INTO TRUSS

SECTION A-A

TRUSS BOTT. CHORD

END TRUSS FASTENED TO TOP PLATE WITH 7/16" C. x 2-1/2" x 15 GA. STAPLES @ 3' O. C.

1x3 TOP PLATE

SECTION C-C

REPLACEMENT GYPSUM ATTACHED WITH 1/4" BEAD OF PEMCO 3100 ADHESIVE.

TEMPORARY 1 x 3

END TRUSS FASTENING

THIS DRAWING IS A PART OF TEST REPORT NO. 98-2830

CLIENT: ALPHA SYSTEMS

DATE: 9/22/98

SCHEDULE: 1-1/2" x 1-1/2" x 15 GA. STAPLES @ 3' O. C.

JOB NO. 98-2830

CONSTRUCTION DETAILS

B5

PROGRESSIVE ENGINEERING, INC.

TESTING LABORATORY

58660 State Road 15
GOSHEN, INDIANA 46526

Telephone: (219) 530-0337
<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>QTY.</th>
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<tbody>
<tr>
<td>TOP CHORD</td>
<td>1-1/2&quot; x 1-1/2&quot; Ripped From #2 Grade S.P.F.</td>
<td>1</td>
</tr>
<tr>
<td>BOTT. CHORD</td>
<td>1-1/2&quot; x 1-1/2&quot; Ripped From #2 Grade S.P.F.</td>
<td>1</td>
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<tr>
<td>POSTS</td>
<td>1-1/2&quot; x 1-1/2&quot; Ripped From #3 Grade S.P.F.</td>
<td>3</td>
</tr>
<tr>
<td>HEEL BLOCKS</td>
<td>1-1/2&quot; x 0&quot; x 15&quot; #3 Grade S.P.F.</td>
<td>2</td>
</tr>
<tr>
<td>GUSSETS</td>
<td>Cut From 1/4&quot; Luan (Both Sides)</td>
<td>10</td>
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NOTE: Grades Noted are Minimums

--- DESIGN LOADS ---

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<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
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<td>LIVE LOAD</td>
<td>30 P.S.F.</td>
</tr>
<tr>
<td>TOP CHORD</td>
<td>DEAD LOAD</td>
<td>9 P.S.F.</td>
</tr>
<tr>
<td>BTM. CHORD</td>
<td>DEAD LOAD</td>
<td>6 P.S.F.</td>
</tr>
<tr>
<td>TRUSS SPACING</td>
<td>16&quot; O.C.</td>
<td>TOTAL 45 P.S.F.</td>
</tr>
<tr>
<td>CLEAR SPAN</td>
<td>134&quot;</td>
<td>TOTAL 45 P.S.F.</td>
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--- ALTERNATE DESIGN LOADS ---

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<td>TOP CHORD</td>
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<td>BTM. CHORD</td>
<td>DEAD LOAD</td>
<td>4 P.S.F.</td>
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<td>TOTAL 30 P.S.F.</td>
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<tr>
<td>CLEAR SPAN</td>
<td>134&quot;</td>
<td>TOTAL 30 P.S.F.</td>
</tr>
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</table>

1/8" Bead of Glue Between Heel Block & Chords

NOTES:
1) TESTED PER SECTION 280.402(d) OF THE FEDERAL STANDARD
2) STAPLES – QUANTITIES SHOWN IN CIRCLES ABOVE
GUSSETS – 3/8" C. x 3/4" lg. x 18 ga.
THRU CHORDS – 7/16" x 2-1/2 lg. x 15 ga.
3) GLUE TYPE – P.V.A.–34, ELIXER, W–17
4) GLUE AMOUNT – 80% min. COVERAGE ON ALL GUSSETS
5) GRAIN ON ALL GUSSETS TO BE IN VERTICAL POSITION
6) GUSSETS MAY BE 1/8" SMALLER max. THAN SIZE NOTED

R.J. COLE, INC.
21790 Beck Dr. Elkhart, Indiana

Progressive Engineering Inc.
TRUSS NUMBER: B12–5
DATE: 4/9/92
DRAWN BY: G. WEEDEN
REVISIONS: 4/9/92
REVIEWED BY: G. WEEDEN
SHAPING NUMBER: 92–820
Test Set-up

Repaired Test at failed area