TEST REPORT ON

CENTRAL STATES MANUFACTURING, INC.'S PANEL-LOC PLUS PANELS (29 GA., 80 KSI, 36" WIDE) FASTENED TO WOOD SUPPORTS AT 2' 0" & 3' 0" PANEL SPANS IN ACCORDANCE WITH ASTM E455-11 AND AISI S907-08

TESTED FOR:
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TEST WITNESSED BY:
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TESTING DATE: January 16 & 18, 2013
REPORTING DATE: January 29, 2013
ENCON® Project C1877-1

ACCREDITED
TL-327

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TEST SUMMARY

1.1 SUMMARY

Tests were conducted on Central States Manufacturing, Inc.'s 29 ga., 80 ksi Panel-Loc Plus panels at ENCON® Technology, Inc.'s Test Facility, Tulsa, Oklahoma. The purpose of the tests was to determine the diaphragm shear strength and shear stiffness of Panel-Loc Plus panel construction under simulated loading conditions. These tests meet the provisions of ASTM E455-11 and AISI S907-08. The tests are listed below according to date tested.

Test #1 & 2: Panel-Loc Plus panels at four equal spans of 2' 0". The structural fastener spacing was 9" o.c. at the end and interior wood supports. Both tests were conducted on January 16, 2013.

Test #3: Panel-Loc Plus panels at three equal spans of 3' 0". The structural fastener spacing was 9" o.c. at the end and interior wood supports. This test was conducted on January 18, 2013.

The sidelap fasteners spacing for all tests was 24" o.c. The above-defined tests were witnessed by Bala Sockalingam, Ph.D., P.E. of ENCON Technology, Inc.

1.2 PANEL SYSTEM DESCRIPTION

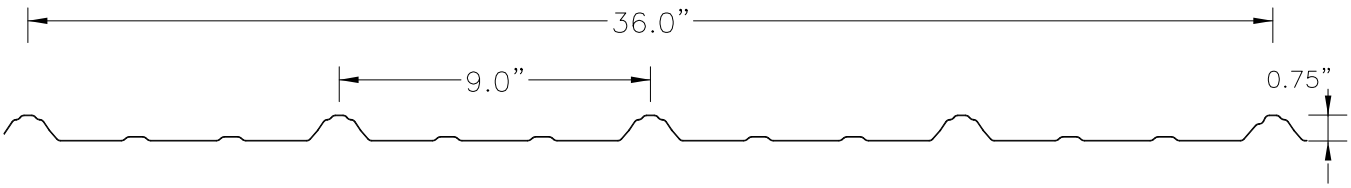
Central States Mfg.'s Panel-Loc Plus panels were 29 ga., 3/4" high and 36" wide through fastened panels. Each panel consisted of five major ribs spaced at 9" o.c. as shown on Page 2.

The panels were fastened to nominal 2" x 6" SPF wood supports with #10 x 1-1/2" long Kwikseal® II Wood Binder screws with washers. The screw spacing was 9" o.c. at the end and interior wood supports. Each panel spanned over four continuous spans of 2' 0" or three continuous spans of 3' 0" with 2" overhang. The sidelap fasteners were #12 x 3/4" long hex head stitch screws with washers and spaced at 24" o.c. The two sides of the panel assembly were not attached to the side post of the interior frame.

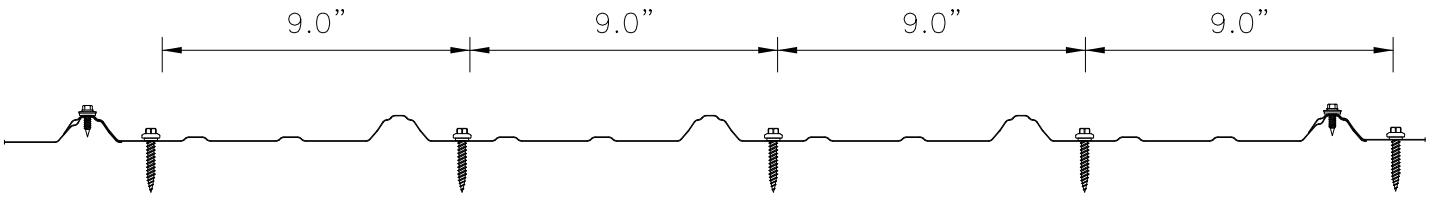
1.3 TEST RESULTS

Load was applied incrementally and deflections of the test construction were recorded for 'no load' condition and at each load increment. The failure mode in Test #1 & #2 was the panel slotting at fasteners near the roller and pinned corners. The average ultimate shear strength from the two test constructions was 291.7 lb/ft and average shear stiffness was 8383.5 lb/in.

The failure mode in Test #3 was the panel buckling near the loaded corner. The ultimate shear strength was 183.3 lb/ft and shear stiffness was 8145.2 lb/in.



29 GA. PANEL–LOC PLUS PANEL



a. AT END & INTERMEDIATE SUPPORTS

TEST SERIES	PANEL SPANS (ft)	SPAN a (ft)	DEPTH b (ft)	MAX. LOAD Pu (lb)	SHEAR STRENGTH Su (lb/ft)	0.4Pu (lb)	DEFL. AT 0.4Pu (in)	SHEAR STIFFNESS G' (lb/in)
1	2–2–2–2	8.33	12.0	3500	291.7	1400	0.119	8166.7
2	2–2–2–2	8.33	12.0	3500	291.7	1400	0.113	8600.3
				AVERAGE	291.7		AVERAGE	8383.5
3	3–3–3	9.33	12.0	2200	183.3	880	0.095	8145.2

NOTES:

1. PANEL THICKNESS WAS 29 GA. AND YIELD STRESS WAS 80 KSI (NOM.).
2. PANEL TO SUPPORT FASTENER WAS #10 X 1.5" LONG WOOD SCREW.
3. PANEL TO PANEL FASTENER WAS #12 X 3/4" LONG STITCH SCREW.
4. PANEL TO PANEL FASTENER SPACING WAS 24" OC.

2.1 DESCRIPTION OF TEST

OBJECTIVES

Tests were conducted to determine shear strength and shear stiffness of the panels under simulated loading conditions. The test method consisted of the following:

1. assembling the test panel on an interior test frame to form a typical roof or wall construction;
2. loading the test frame incrementally; and
3. observing, measuring, and recording the deflections, deformations, and nature of any failures of principal or critical elements of the test construction.

The increments of load application were chosen such that a sufficient number of readings were obtained to determine the load deformation curve of the system.

TEST SETUP

The test setup consisted of an exterior reaction truss and interior panel support frame as shown in the applicable drawings in the appendix. The L-shaped reaction truss was constructed of two built-up tube sections with cross-braced angle sections to form a truss. The panel support frame was constructed of wood supports having equal or lower strength and stiffness than that intended for use in the typical constructions. All the connections in the interior frame were pinned.

Both the truss and frame lay in the same horizontal plane. The reaction frame was supported by short columns, which rested on the laboratory floor. Two corners of the interior frame were connected to the exterior frame with a hinge and roller. The side opposite to these corners was held up by columns with roller bases. The interior supports were attached to the side post with pinned connections.

LOADING DEVICE

Load was applied using a 10 kip capacity hydraulic ram and manual pump. The load was monitored with a calibrated 10 kip capacity load cell and associated instrumentation. The accuracy of the load cell was estimated to be $\pm$ 0.01 kips. The hydraulic ram was attached to the reaction truss and the load cell was attached to the interior frame. The load was applied parallel to and in close proximity to one of the points of contact between the diaphragm web and frame.

DEFLECTION MEASUREMENT

Deflection measurements were taken by means of dial indicators calibrated to 1/1000 of an inch. Deflections were measured at locations as shown on the drawings in the appendix. The deflection locations are based on AISI S907-08.

DESCRIPTION OF TEST

DIAPHRAGM SIZE

The overall dimension of each construction was in excess of 12' x 8' 4" or 9' 4". The panels covered four equal spans of 2' 0" or three equal spans of 3' 0". The construction width contained four full panels. The panels were attached to the end and interior wood supports with self-drilling screws. The panels were not attached to the side member of the interior frame. The details of the methods of construction are depicted in the enclosed test drawings. All the material used in the construction represented a typical construction.

NUMBER OF TESTS

Minimum of two panel assemblies was tested for panel span of 2' 0" to determine the shear strength and stiffness. As per Section 8.2 of ASTM E455, the duplicate test for panel span of 3' 0" was waived due to testing span variability.

TEST PROCEDURE

Prior to the diaphragm construction, the interior frame was loaded to determine its bare frame stiffness. The bare frame stiffness was insignificant, deflecting 1" under a 10-lb load. The loading procedure on the completed diaphragm construction consisted of loads applied in increments. The diaphragm was loaded to 20% of the anticipated ultimate load and unloaded. Deflection measurements were recorded at 'no load' conditions. The diaphragm was loaded in 250-lb increments until failure for Test #1 & #2 and in 200-lb increments until failure for Test #3. Deflection measurements were recorded at every load increment.

TEST DURATION

The test was stopped when the test specimen was unable to carry additional load or visual failure of one or more components of the diaphragm occurred.

2.2 CALCULATIONS

The ultimate shear strength S_u (lb/ft) of a given construction is
where

$$S_u = \frac{P_u}{b}$$

P_u = maximum applied load in the cantilever beam test (lb),
b = depth of diaphragm (ft).

The net shear deflections (Δ) at any load level in the cantilever beam test is

$$\Delta = \Delta_3 - \left[\Delta_2 + \frac{a}{b}(\Delta_1 + \Delta_4) \right]$$

where Δ_1, Δ_2, Δ_3 and Δ_4 are measured deformations with appropriate signs at locations shown in the test drawings.

DESCRIPTION OF TEST

The apparent shear stiffness G' (lb/in) of a given construction is

$$G' = \frac{P}{\Delta}\left(\frac{a}{b}\right)$$

where

P = $0.4P_u$ in the cantilever beam test (lb),
a = span of diaphragm (ft).
Δ = Net shear deflection of diaphragm (in) at $0.4P_u$ load.

The shear stiffness calculation is based on AISI S907-08.

TEST RESULTS

3.1 SPECIMEN IDENTIFICATION

Manufacturer:	Central States Manufacturing, Inc
Model Type:	Panel-Loc Plus Panel
Dimensions:	0.75" high, 36" wide coverage
Panel Thickness:	29 ga.
Base Metal Thickness:	0.0136"
Panel Yield Stress:	80 ksi (100 ksi tested)
Panel Fasteners:	#10 x 1.5" long hex head wood screws with washers (Sealtite Building Fasteners Kwikseal® II Wood Binder)
Panel Fasteners Spacing:	9" o.c.
Support Thickness:	Nom. 2" x 6" SPF
Sidelap Fasteners:	#12 x 3/4" long hex head stitch screws with washers (Sealtite Building Fasteners)
Sidelap Fasteners Spacing:	24" o.c.

Note: All the test materials were supplied by or purchased for Central States Manufacturing and were not sampled by ENCON.

TEST RESULTS

3.2 TEST #1: 29 GA. PANEL-LOC PLUS AT FOUR EQUAL SPAN OF 2' 0"

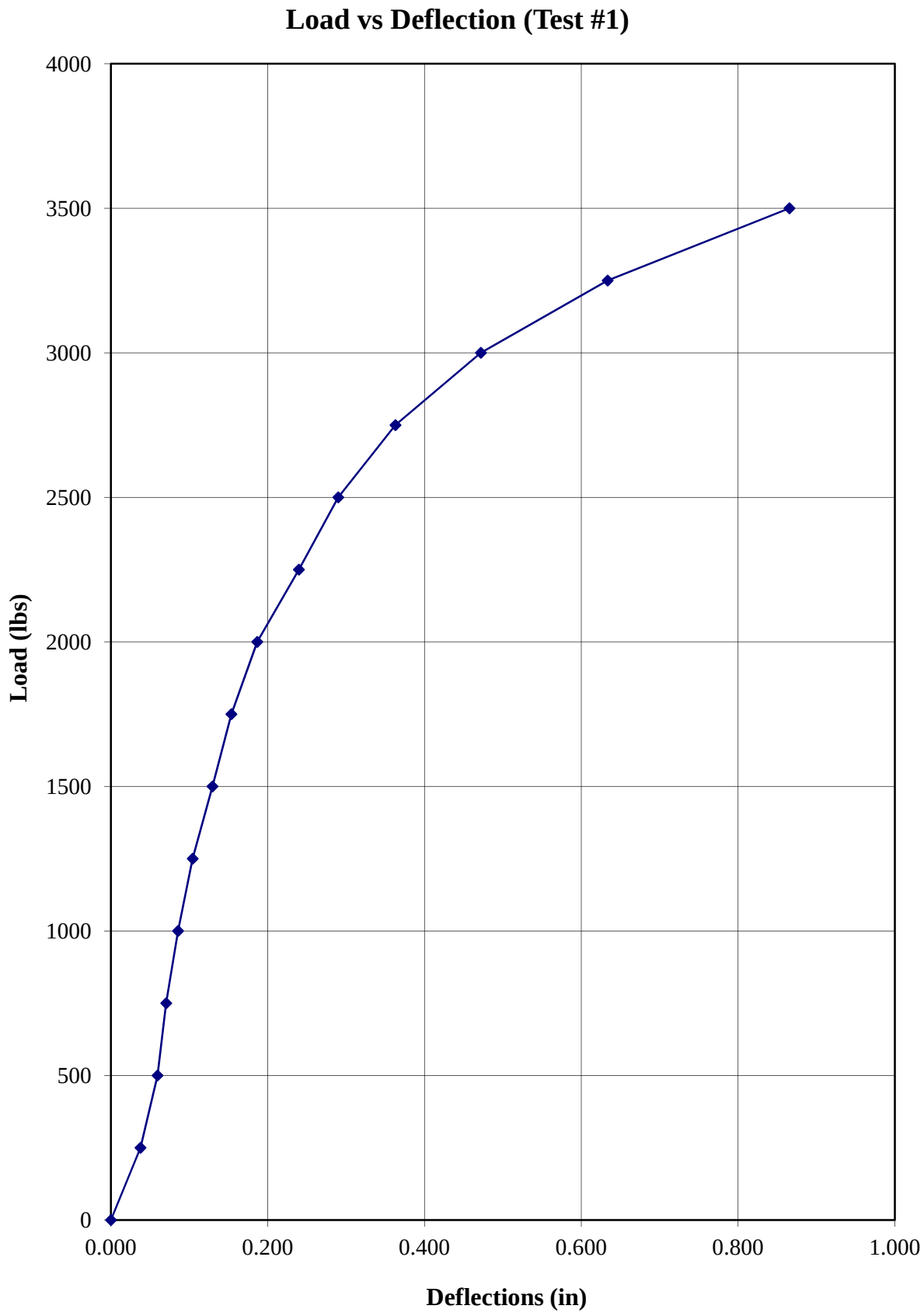
Test No:	1
Date:	1.16.13
Panel Type:	Panel-Loc Plus
Gauge:	29 ga.
Thickness:	0.0136"
Panel Width:	36"
Support Spacing:	4 spans @ 24" o.c.
Type of Structural Fastener:	#10 x 1.5" long Kwikseal II screws
Fastener Spacing at End Supports:	9" o.c.
Fastener Spacing at Interior Supports:	9" o.c.
Insulation	None
Type of Sidelap Fastener:	#12 x 3/4" long stitch screws
Sidelap Fastener Spacing	24" o.c
a = span length of diaphragm (ft):	8.33
b = depth of diaphragm (ft):	12.00

Load (lb)	Dial Indicator Reading (in)				Shear Deformation Δ (in)
	1	2	3	4	
0	0.000	0.000	0.000	0.000	0.000
250	0.006	0.008	0.054	0.006	0.038
500	0.029	0.044	0.136	0.018	0.059
750	0.056	0.076	0.211	0.037	0.070
1000	0.073	0.097	0.286	0.076	0.086
1250	0.090	0.116	0.350	0.097	0.104
1500	0.099	0.134	0.419	0.125	0.130
1750	0.107	0.139	0.471	0.150	0.154
2000	0.117	0.144	0.543	0.189	0.187
2250	0.136	0.159	0.650	0.226	0.240
2500	0.166	0.160	0.738	0.249	0.290
2750	0.204	0.161	0.855	0.273	0.363
3000	0.227	0.162	0.990	0.286	0.472
3250	0.258	0.175	1.198	0.303	0.634
3500	0.318	0.185	1.510	0.344	0.865

Failure Mode: Panel slotting at the fastener near roller and pinned corners

Duration of test: > 10 minutes

	Temperature (F)	Relative Humidity (%)
At construction:	66	26
At testing	66.2	26


Load vs Deflection (Test #1)
Load (lbs)
4000
3500
3000
2500
2000
1500
1000
500
0
0.000
0.200
0.400
0.600
0.800
1.000
Deflections (in)

3.3 TEST #2: 29 GA., 80 KSI PANEL-LOC PLUS AT FOUR EQUAL SPAN OF 2' 0"

Test No:	2
Date:	1.16.13
Panel Type:	Panel-Loc Plus
Gauge:	29 ga.
Thickness:	0.0136"
Panel Width:	36"
Support Spacing:	4 spans @ 24" o.c.
Type of Structural Fastener:	#10 x 1.5" long Kwikseal II screws
Fastener Spacing at End Supports:	9" o.c.
Fastener Spacing at Interior Supports:	9" o.c.
Insulation	None
Type of Sidelap Fastener:	#12 x 3/4" long stitch screws
Sidelap Fastener Spacing	24" o.c
a = span length of diaphragm (ft):	8.33
b = depth of diaphragm (ft):	12.00

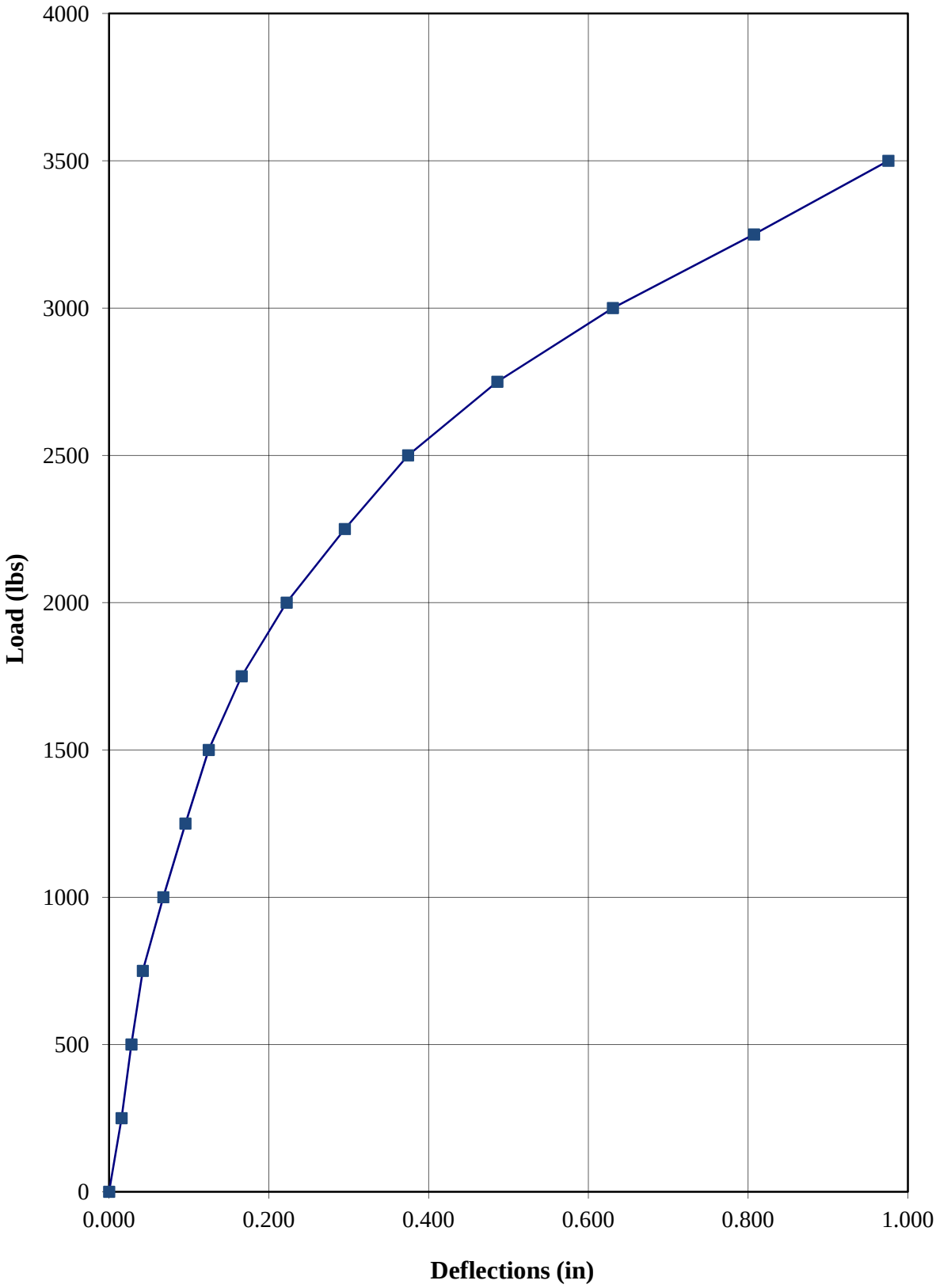
Load (lb)	Dial Indicator Reading (in)				Shear Deformation Δ (in)
	1	2	3	4	
0	0.000	0.000	0.000	0.000	0.000
250	0.010	-0.001	0.032	0.015	0.016
500	0.055	0.035	0.149	0.069	0.028
750	0.083	0.056	0.237	0.117	0.042
1000	0.097	0.066	0.306	0.151	0.068
1250	0.109	0.078	0.386	0.197	0.096
1500	0.112	0.094	0.454	0.227	0.125
1750	0.113	0.101	0.530	0.266	0.166
2000	0.113	0.106	0.617	0.303	0.222
2250	0.111	0.117	0.712	0.321	0.295
2500	0.114	0.123	0.818	0.348	0.374
2750	0.120	0.129	0.951	0.364	0.486
3000	0.122	0.135	1.112	0.377	0.631
3250	0.133	0.143	1.321	0.401	0.807
3500	0.142	0.152	1.526	0.432	0.976

Failure Mode: Panel slotting at the fastener near roller and pinned corners

Duration of test: > 10 minutes

	Temperature (F)	Relative Humidity (%)
At construction:	66.2	26
At testing	66.2	26

Load vs Deflection (Test #2)



3.4 TEST #3: 29 GA., 80 KSI PANEL-LOC PLUS AT THREE EQUAL SPAN OF 3' 0"

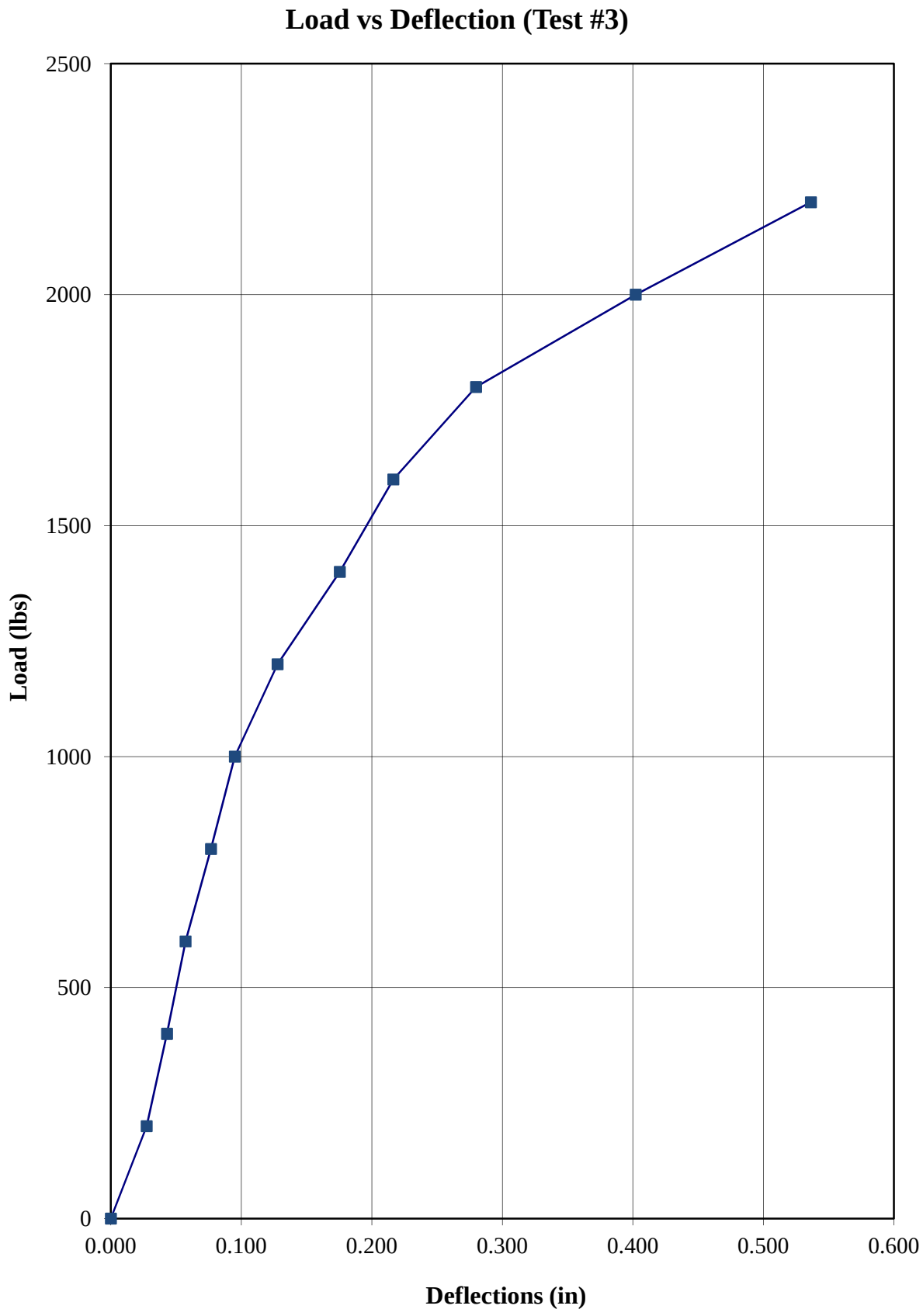
Test No:	3
Date:	1.18.13
Panel Type:	Panel-Loc Plus
Gauge:	29 ga.
Thickness:	0.0136"
Panel Width:	36"
Support Spacing:	3 spans @ 36" o.c.
Type of Structural Fastener:	#10 x 1.5" long Kwikseal II screws
Fastener Spacing at End Supports:	9" o.c.
Fastener Spacing at Interior Supports:	9" o.c.
Insulation	None
Type of Sidelap Fastener:	#12 x 3/4" long stitch screws
Sidelap Fastener Spacing	24" o.c
a = span length of diaphragm (ft):	9.33
b = depth of diaphragm (ft):	12.00

Load (lb)	Dial Indicator Reading (in)				Shear Deformation Δ (in)
	1	2	3	4	
0	0.000	0.000	0.000	0.000	0.000
200	0.013	0.018	0.075	0.025	0.027
400	0.040	0.087	0.200	0.050	0.043
600	0.054	0.134	0.297	0.082	0.057
800	0.067	0.156	0.375	0.116	0.077
1000	0.084	0.168	0.441	0.145	0.095
1200	0.098	0.187	0.534	0.184	0.128
1400	0.110	0.198	0.630	0.220	0.175
1600	0.130	0.207	0.715	0.245	0.216
1800	0.140	0.208	0.812	0.277	0.280
2000	0.146	0.216	0.975	0.313	0.402
2200	0.173	0.216	1.159	0.350	0.536

Failure Mode: Panel buckled near load corner

Duration of test: > 10 minutes

	Temperature (F)	Relative Humidity (%)
At construction:	66	27
At testing	66.2	27


Load vs Deflection (Test #3)
2500
2000
1500
1000
500
0
Load (lbs)
0.000
0.100
0.200
0.300
0.400
0.500
0.600
Deflections (in)

PHOTOGRAPHS

PHOTO 1 View of the structural and sidelap fasteners.
(DSCN0005)

PHOTO 2 View of the wood support layout for panel span of 2' 0".
(DSCN0009)

PHOTOGRAPHS

PHOTO 3 View of the panel fasteners at end and interior supports. (DSCN0011)

PHOTO 4 Overview of the diaphragm test setup of the Panel-Loc Plus at 2' 0" span. (DSCN0010)

PHOTO 5 View of panel slotting at fastener near the roller support in Test #1. (DSCN0015)

PHOTO 6 View of panel slotting at fastener near the pinned support in Test #2. (DSCN0021)

PHOTOGRAPHS

PHOTO 7 Overview of the diaphragm test setup of Panel-Loc Plus at 3' 0" span. (DSCN0027)

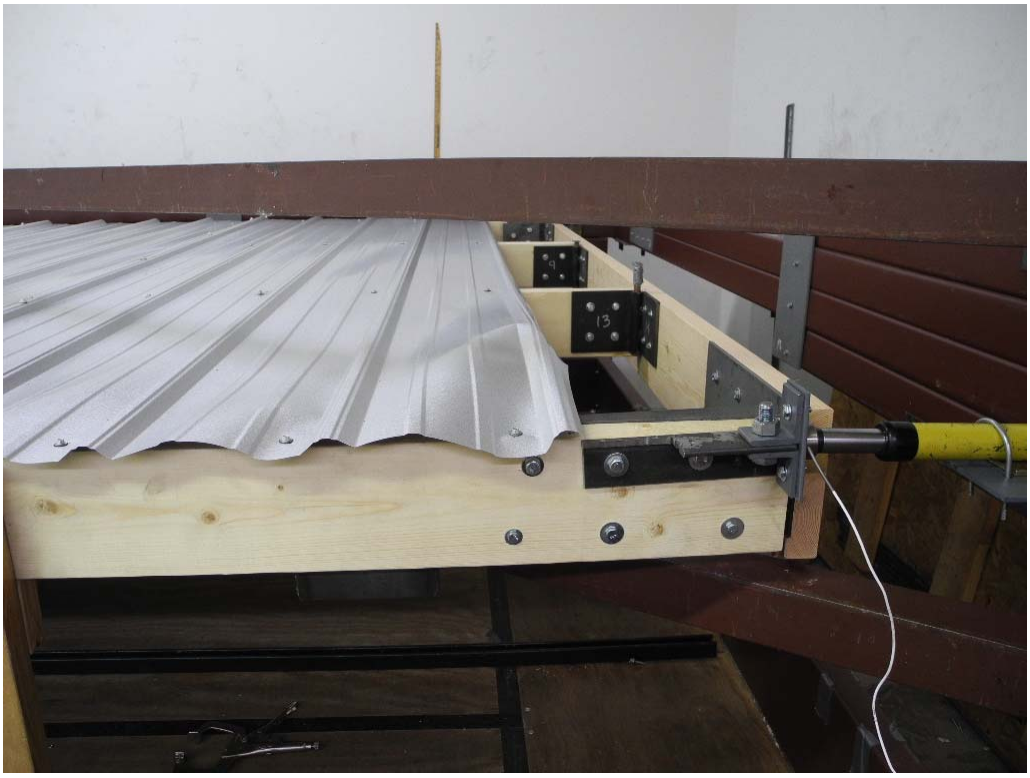
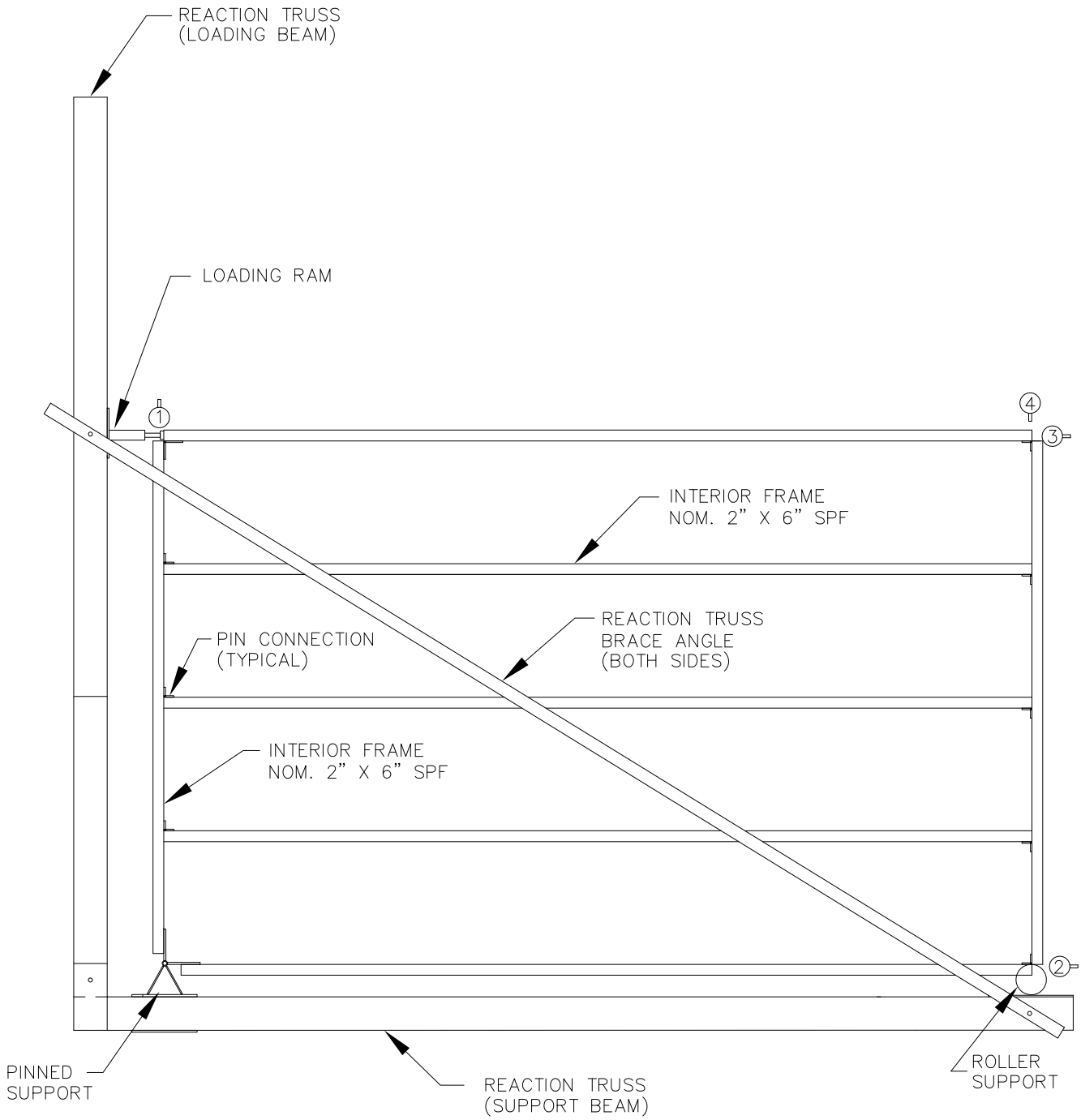


PHOTO 8 View of panel buckling near the loaded corner in Test #3. (DSCN0030)

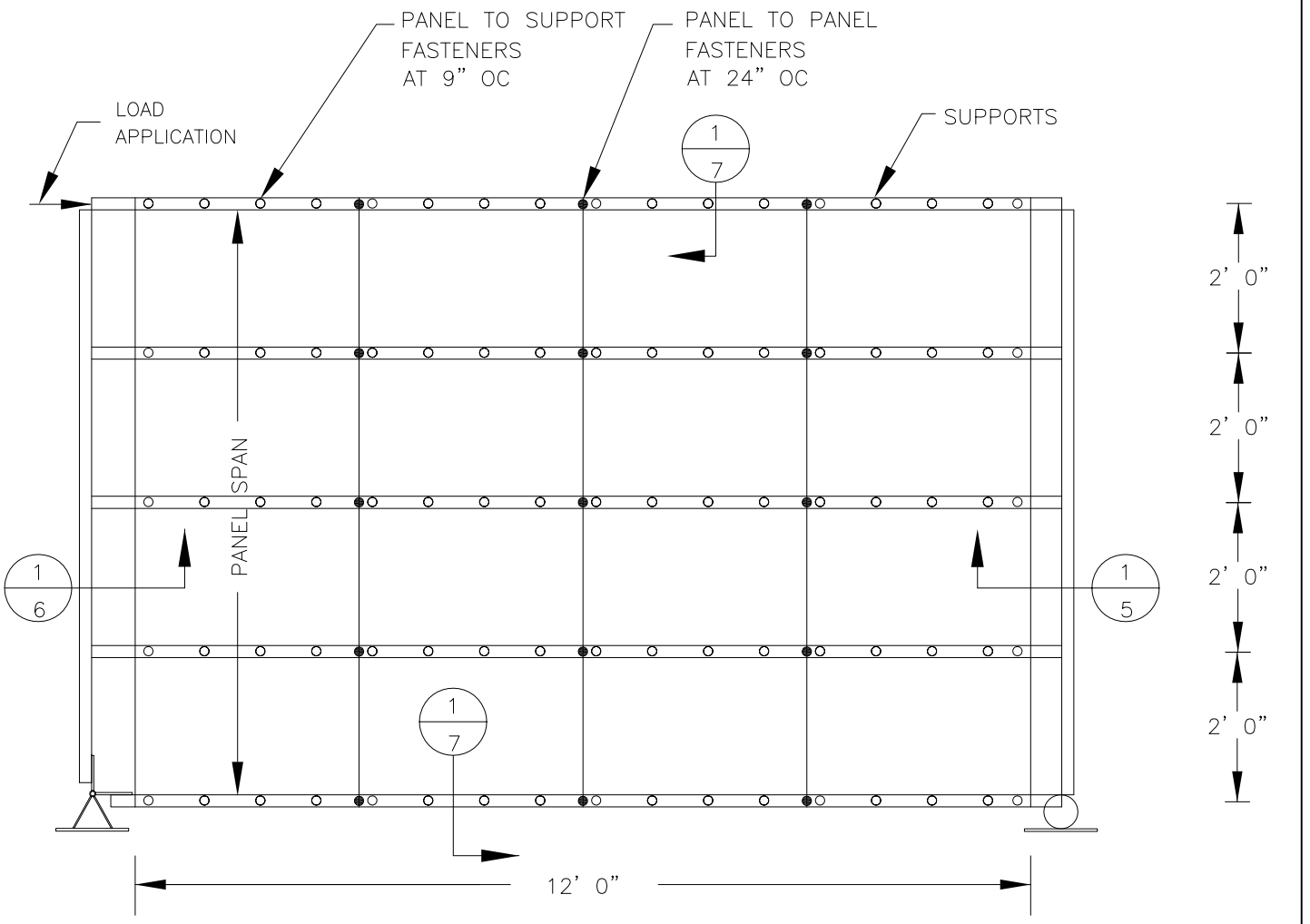
ENCON TECHNOLOGY, INC.	CENTRAL STATES PANEL–LOC PLUS DIAPHRAGM TEST SETUP	ASTM E455–11	17/25



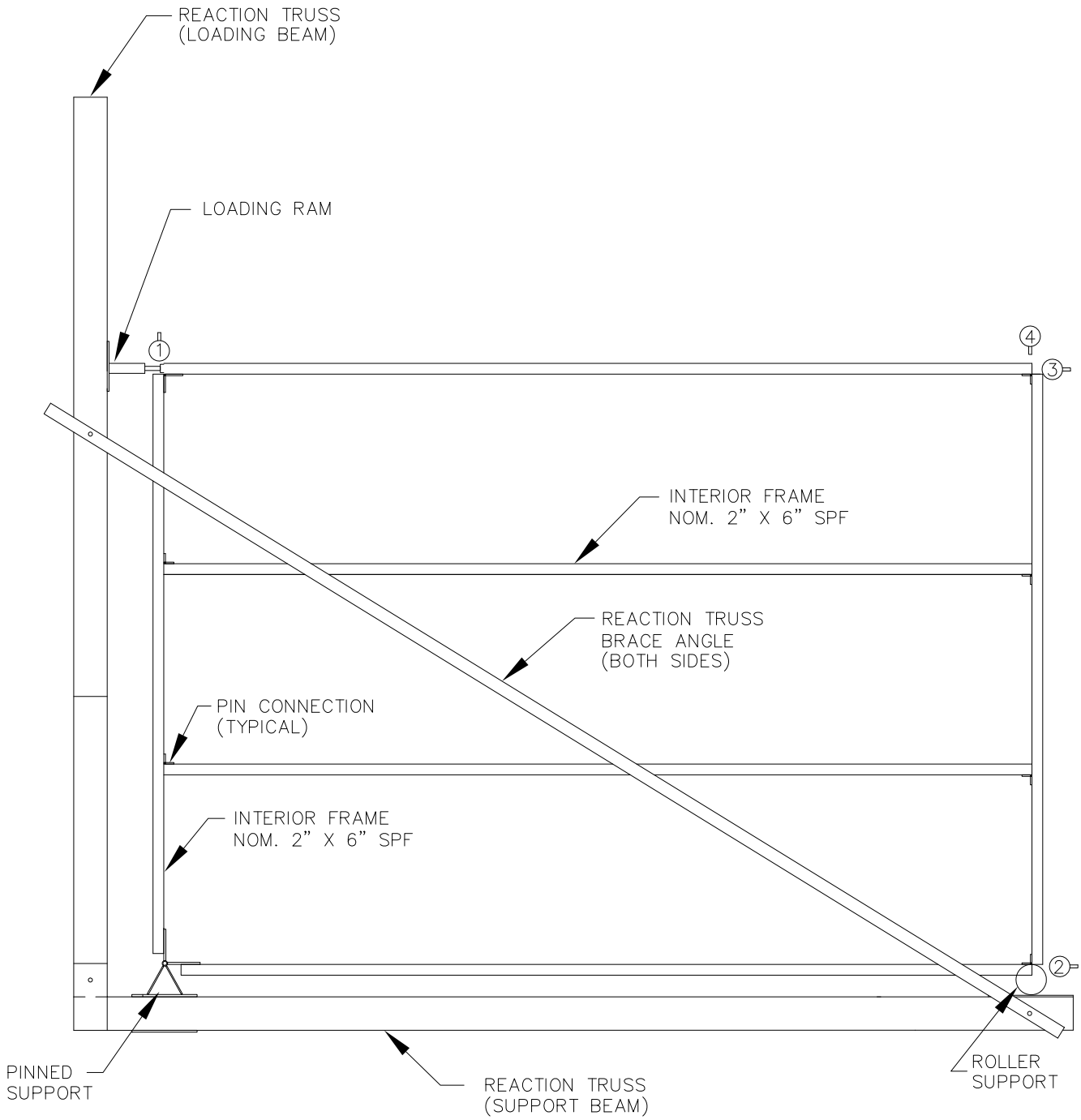
1/1 TEST SETUP PLAN VIEW

NOTES:

① DIAL INDICATOR LOCATION



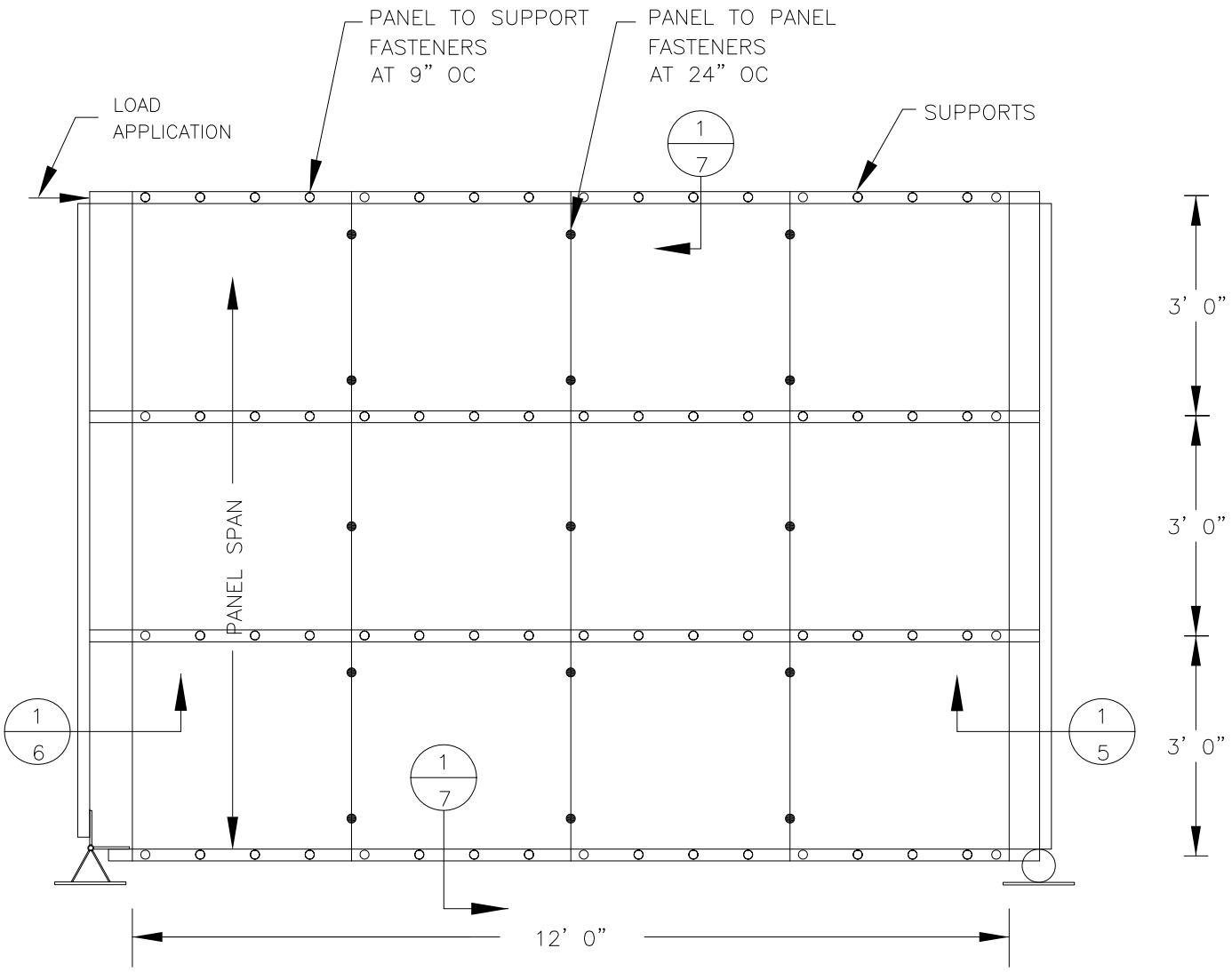
1/2 PLAN VIEW OF TEST PANEL SETUP



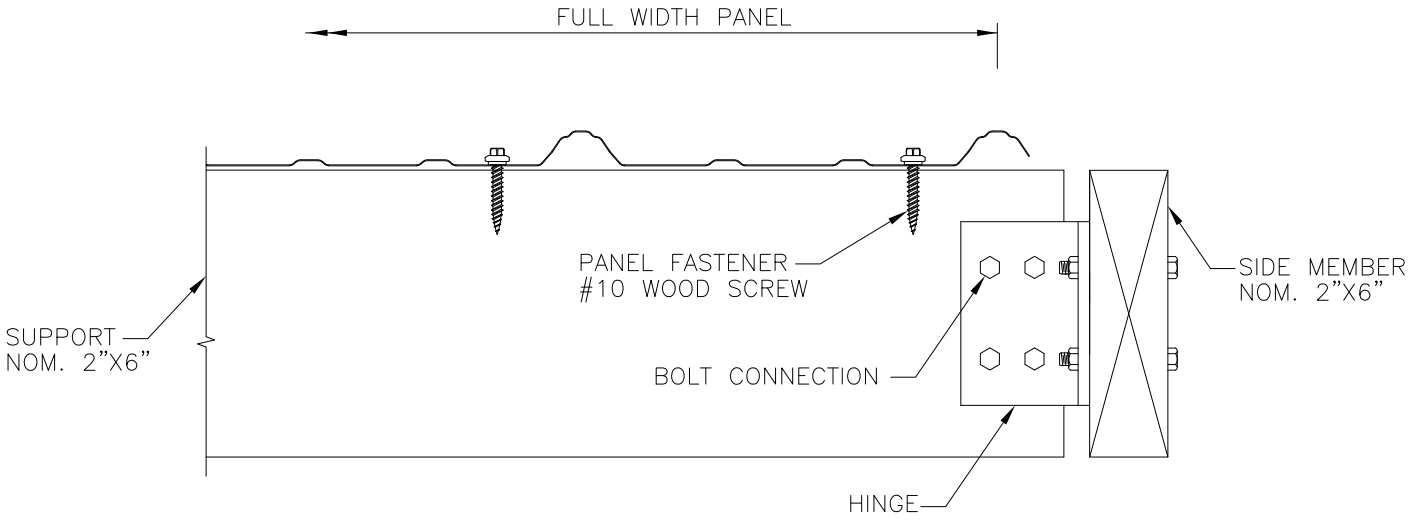
1/3 TEST SETUP PLAN VIEW

NOTES:

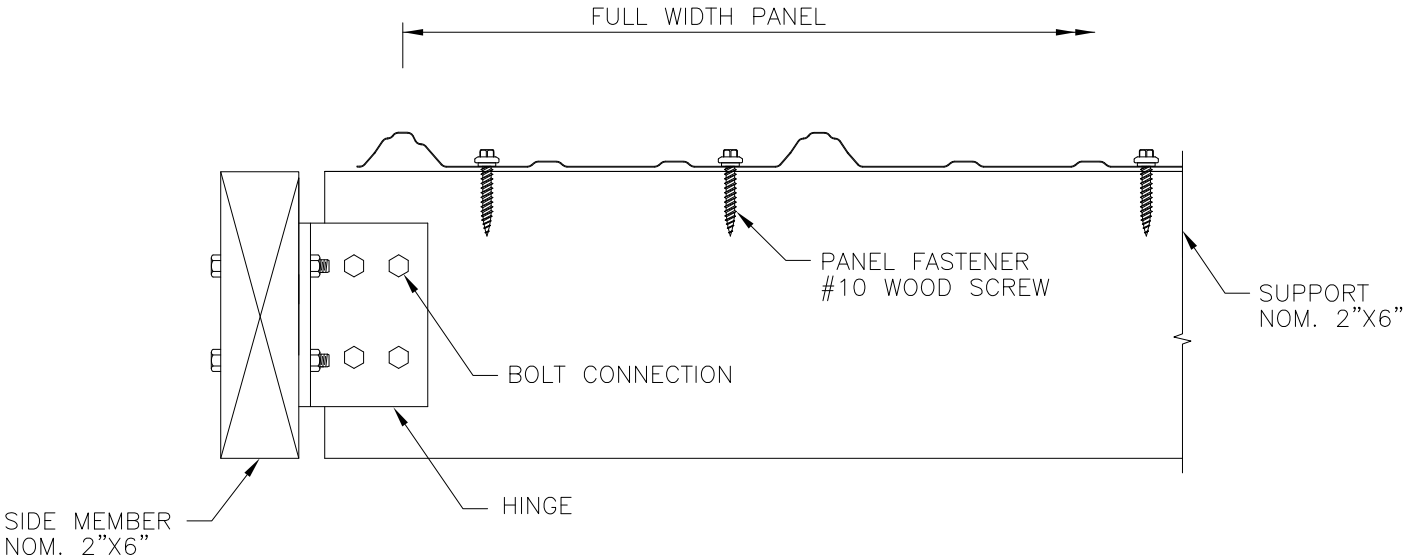
① DIAL INDICATOR LOCATION



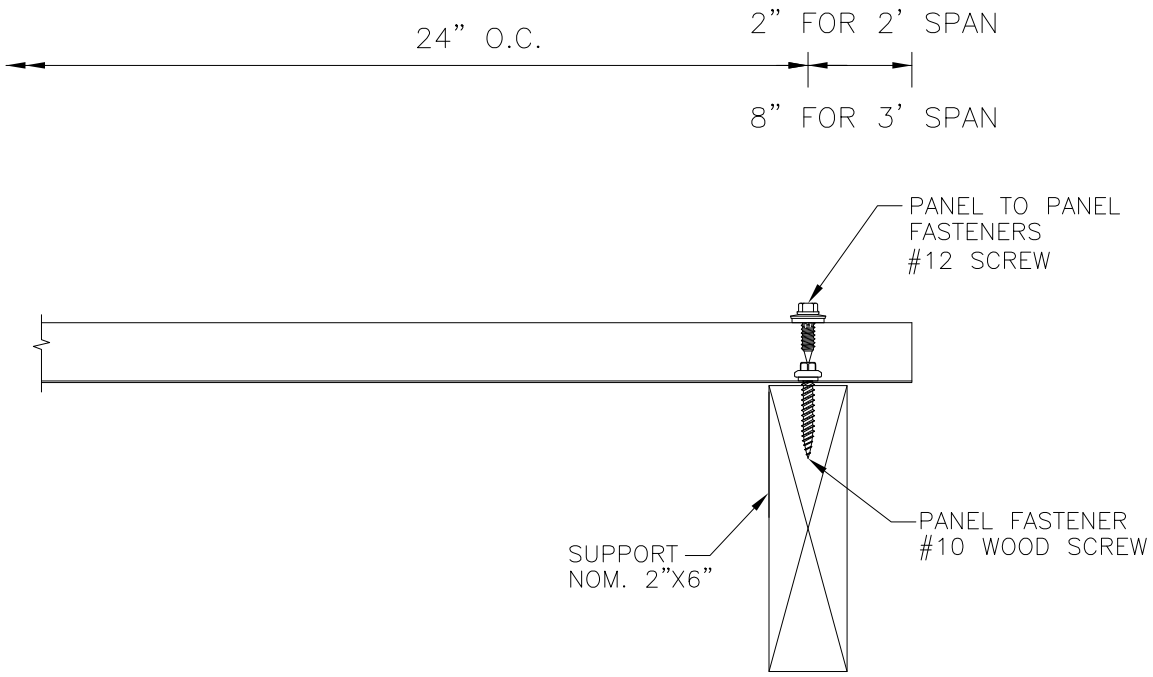
1/4 PLAN VIEW OF TEST PANEL SETUP



1/5 DETAILS OF "STARTER RAKE" OF TEST ROOF



1/6 DETAILS OF "FINISHED RAKE" OF TEST ROOF



1/7 DETAILS OF "END SUPPORTS" OF TEST ROOF

SHERRY LABORATORIES

TESTING TODAY, PROTECTING TOMORROW

WWW.SHERRYLABS.COM

Western Materials, SEG, & Nonmetallics
3100 North Hemlock Circle
Broken Arrow, OK 74012-1115

Tel: 918-258-6066
800-982-8378
Fax: 918-258-1154

LABORATORY REPORT

Attn: **Bala Sockalingam**

ENCON Technology, Inc.
1216 N. Lansing Ave.
Suite C
Tulsa, OK 74106 United States

Report No: **B13011033**
Date Reported: **1/23/2013**
P.O. No: **Verbal**

Material: **Steel**

Description: **(1) Panel-Loc Plus 29 ga., Sample No.: 1**

Room Temperature Tensile Testing ASTM E8/E8M-11, Parallel to Length of the Specimen, As Received

Width, Initial, in	Thickness, Initial, in	Tensile Strength, psi	Yield (0.2% Offset), psi	Elongation (4W), %	Location of Fracture
0.504	0.0136	106600	100000	2	Outside Middle Half of Gage

Approved by:

Tim Jones
Mechanical Testing Technician

APPENDIX

5.3 TEST CONDITIONS

A. OWNERSHIP OF ENCON WORK PRODUCT

All test results developed as a part of this work shall be CUSTOMER's property. All samples submitted to ENCON for testing shall become the property of ENCON. CUSTOMER understands that any test program including procedures and test machines incorporated as a part of this work is a result of continuing long-term research and development by ENCON and because of this all ENCON test procedures, test drawings and other intellectual property relating to this work is and shall remain the property of ENCON. Test samples were disposed of shortly after completion of the tests unless other arrangements were agreed to in writing prior to the test.

ENCON will use its normal procedures to retain copies of the information developed as a part of this test for a period of three years from the date the work was done. This material may be routinely destroyed thereafter.

B. ENCON GUARANTEE

ENCON guarantees it used its best effort to accomplish this test work. Work done by ENCON was carefully completed by personnel believed to be competent. ENCON tests were based on what was currently believed to be good engineering practices in use at the time of the test.

The safety factors used are generally accepted as suitable to produce safe results. However, good engineering practices and applicable codes and insurance requirements must be taken into consideration in determining if a test procedure is satisfactory for a specific end use. Applicable specifications, good engineering practices and applicable safety factors may change in the future. CUSTOMER should be alert to these changes.

The information and test results presented by ENCON in this test report are offered in good faith based on information ENCON believes to be reliable. This information is offered as a guide to assist CUSTOMER in CUSTOMER's endeavors and does not contain any warranties as to fitness by ENCON. No REPRESENTATION OF WARRANTIES, EXPRESS OR IMPLIED, INCLUDING THOSE OF MERCHANTABILITY AND OF FITNESS FOR A PARTICULAR PURPOSE are made by ENCON, and more specifically, ENCON hereby expressly disclaim such. In no event shall ENCON be liable for ANY CONSEQUENTIAL, INCIDENTAL OR SPECIAL DAMAGES, including, without limitation, labor, transportation, loss of use, loss of profits, harm, personnel injury and damage to property.

If any doubt exists as to the proper means of interpreting or using the test results contained herein, contact ENCON for clarification. CUSTOMER should assure themselves through careful evaluations that test results are suitable for those end uses to which CUSTOMER intends to put them.

APPENDIX

Information and material provided by CUSTOMER to ENCON was reviewed by an ENCON executive. However, ENCON does not accept the responsibility for accuracy or verification of CUSTOMER's information or the suitability of CUSTOMER materials. Materials supplied by CUSTOMER were tested as received and were not evaluated for code or insurance compliance. CUSTOMER is expected to review the ENCON drawings, tables, test results and other information provided by ENCON to CUSTOMER critically so as to assure CUSTOMER that these presentations, formulas, drawings and other information are accurate and meaningful for the purpose intended.

No other warranties or guarantees shall be issued, implied, delivered or otherwise construed to be issued, implied or delivered.