

TEST REPORT

Rendered to:

FAIRWAY BUILDING PRODUCTS, LP

For:

Solutions Aluminum Handrail System

Report No: 89680.02-119-19
Report Date: 05/28/09

TEST REPORT

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May 28, 2009

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TEST REPORT

Rendered to:

FAIRWAY BUILDING PRODUCTS, LP
P.O. Box 37
53 Eby Chiques Road
Mount Joy, Pennsylvania 17552

Report No.: 89680.02-119-19
Test Date: 03/12/09
Through: 03/19/09
Report Date: 05/27/09

1.0 General Information

1.1 Product

Solutions Aluminum Handrail

1.2 Project Description

Architectural Testing was contracted by the manufacturer to conduct structural performance tests on *Solutions* aluminum handrail systems, consisting of 6 ft handrail sections, aluminum brackets, and support posts. This test report is a reissue of the original report 89680.01-119-19. This report is issued in the name of Fairway Building Products, LP through written authorization from the manufacturer. The systems were evaluated in accordance with the following ASTM standards:

ASTM E 935-00, *Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings*

ASTM E 985-00, *Standard Specification for Permanent Metal Railing Systems and Rails for Buildings*

1.3 Limitations

All tests performed were to evaluate structural performance of the handrail assembly to carry and transfer imposed loads to the supporting structure. The test specimens evaluated included the rails, rail brackets, and support posts. Anchorage of support posts to the supporting structure was not included in the scope of this testing and would need to be evaluated separately.

1.4 Product Description

The manufacturer provided the partially-assembled test specimens with the following details:

Handrail: 1.5 in OD by 0.12 in wall by 72 in long, 6005 aluminum extrusion, painted

Handrail Connector: 1.2 in OD by 0.11 in wall by 4 in long, 6005 aluminum, tubular extrusion, with one 0.06 in wide longitudinal slot, four 0.04 in high external longitudinal ribs, and three internal 0.04 in deep longitudinal scallops

Bracket Components:

- Quick Return Bracket - 1-1/2 in diameter by ninety degree bend, ADC 10 aluminum casting, see Drawing No. C201 in Appendix A for details
- Mid-Rail Bracket - 2.9 in long saddle by 3 in center to center distance, ADC 10 aluminum casting, see Drawing No. C200 in Appendix A for details
- Spacer Tube - 1-1/2 in OD by 1-15/16 in long, ADC 10 aluminum casting, see Drawing No. C206 in Appendix A for details
- Wall Mount Bracket - 3 in OD three-hole wall flange, ADC 10 aluminum casting, see Drawing No. C204 in Appendix A for details
- Small Post Adaptor - 2.4 in wide by 2-1/2 in high four-hole post flange, ADC 10 aluminum casting, see Drawing No. C202 in Appendix A for details
- Big Post Adaptor - 4 in wide by 2-1/2 in high four-hole post flange, ADC 10 aluminum casting, see Drawing No. C203 in Appendix A for details
- 3/8-16 x 2-1/2 in, pan head, hex socket drive, stainless steel cap screw and hex nut for attachment of quick return bracket to wall mount bracket or post adaptors, see drawing in Appendix A
- 3/8-16 x 3 in, flat-head, hex socket drive, stainless steel cap screw and hex nut for attachment of mid-rail bracket and spacer tube to wall mount bracket or post adaptors, see drawing in Appendix A

Structural Posts:

- 3 in OD by 0.13 in wall by 8 in long ASTM A 512 steel tube welded to a 5-1/2 in square by 5/16 in thick steel base plate with four 7/16 in by 9/16 in oval bolt holes on 4-3/8 in centers (for surface mounting), post-weld galvanized; with two 3 in ID by 3.31 in square by 1 in high extruded aluminum spacers, attached to top and bottom of tube with one #10 hex socket set screw each or one 1/8 in roll pin each
- 1-1/2 in OD by 3/16 in wall by 23 in long ASTM A 512 steel tube welded to a 4 in square by 5/16 in thick base plate with four 0.42 in by 0.50 in oval bolt holes on 2-7/8 in centers for surface mounting (for surface mounting), post-weld galvanized; with two 1.7 in square by 1-1/4 in high extruded aluminum spacers, attached to top and bottom of tube with one #10 hex socket set screw each or one 1/8 in roll pin each

1.4 Product Description (Continued)

Post Sleeves:

- 1-7/8 in square by 0.08 in wall, 6005-T5 aluminum, tubular extrusion, painted
- 3-1/2 in square by 0.08 in wall, 6005-T5 aluminum, tubular extrusion, painted
- 4-1/4 in square by 0.25 in wall, PVC / composite co-extrusion with 0.02 in cap-stock

Post to Sleeve Spacers: 1 in thick aluminum square spacer blocks at the top and bottom of post inserts, each attached to the tube with one 3/16 in roll pin - Post inserts for face mounting had a third spacer located 5 in above bottom of tube, also attached to the tube with one 3/16 in roll pin

Fasteners:

- #10 x 1 in pan-head, self-drilling, plated steel sheet metal screw
 - o One - Handrail to quick return bracket (1/8 in dia. predrill required)
 - o One - Mid-rail bracket to end of handrail and handrail connector (1/8 in diameter predrill required in handrail and handrail connector)
 - o Three - Wall mount bracket to composite post sleeve and 4x4 wood post
- #8 x 3/4in pan head, gimlet point, stainless steel, sheet metal screw
 - o Four - Big and small post adaptors to post sleeve

See drawings in Appendix A and photographs in Appendix B for additional details.

2.0 Structural Performance Testing

2.1 Scope

Three replicate specimens each of two configurations, each consisting of two handrail sections at 42 in height and three support posts, were tested according to the test methods described in ASTM E 935 in a laboratory set to maintain temperature in the range of $68 \pm 4^{\circ}\text{F}$ and humidity in the range of $50 \pm 5\%$ RH.

2.2 Test Configurations

Test configuration No. 1: 1-7/8 in end post with quick return bracket and small post adaptor, 6 ft rail (No.2), 1-7/8 in intermediate post with mid-rail bracket and small post adaptor, 6 ft rail (No. 1), and composite-sleeved wood 4x4 end post with quick return bracket.

Test configuration No. 2: 3-1/2 in end post with mid-rail bracket, 6 ft rail (No.2), 3-1/2 in intermediate post with mid-rail bracket, 6 ft rail (No. 1), and composite-sleeved wood 4x4 end post with mid-rail bracket.

2.3 Test Load Criteria

The test load criteria for rail and post members were 365 lb concentrated load and 60 plf uniformly distributed load as defined in ASTM E 985, Section 7.1.5. These are the worse case end-use category loadings defined in ASTM E 985.

By the following comparison of classic moment and deflection formulas for simply supported beams, it was determined that the 365 lb concentrated load was a worse case than the 60 plf load for both moment and deflection for the handrail.

For 6 ft rail to ASTM E 985, Section 7.1.5:

365 lb concentrated load -

$$S = M c / I = P L c / (4 I) = 365 \times 72 c / (4 I) = 6,570 c / I$$

$$\Delta = P L^3 / (48 E I) = 365 \times 72^3 / (48 E I) = 2,838,240 / (E I)$$

60 plf uniform load -

$$S = M c / I = P L c / (8 I) = (60 \times 6) 72 c / (8 I) = 3,240 c / I$$

$$\Delta = 5 P L^3 / (384 E I) = 5 (60 \times 6) 72^3 / (384 E I) = 1,749,600 / (E I)$$

∴ 365 lb concentrated load is worse case than 60 plf uniform load for stress (and moment) and deflection, for 8 ft and shorter rail lengths.

For the intermediate support posts, it was obvious that the 365 lb concentrated load is worse case than 60 plf times the 6 ft tributary rail length:

$$365 \text{ lb} > 60 \text{ plf} \times 6 \text{ ft}$$

$$365 \text{ lb} > 360 \text{ lb}$$

2.4 Test Setup

Each test specimen was inspected prior to testing to verify size and general condition of the materials, assembly and installation. No potentially compromising defects were observed prior to testing. Each specimen was approximately 12 ft long consisting of two 6 ft handrail sections, one intermediate post and two end posts. Anchorage of the structural posts to concrete was simulated by bolting them to rigid steel test fixtures with 5/16 in grade 8 hex head bolts with flat washers. Structural post anchorage (fasteners) was not within the scope of testing. The composite-sleeved wood 4x4 posts were secured in a rigid vertical stanchion. The composite-sleeved wood 4x4 posts were not within the scope of testing and were provided for anchorage of the wall mount bracket. Transducers mounted to independent reference frames were located to record handrail deflection at the point(s) of loading. See photographs in Appendix B for individual test setups.

2.5 Test Equipment

The handrail assemblies were tested on a self-contained rigid steel test fixture designed to accommodate anchorage of the test specimen assembly and application of the required test loads. The specimens were loaded using an electric winch mounted to a rigid steel test frame. High strength steel cables, load distribution plates, and spreader beams were used to impose test loads on the specimens. Applied load was measured using an electronic load cell located in-line with the loading system. Electronic linear displacement transducers were used to measure deflections. Deflections and load values were electronically recorded continuously throughout the loading process.

2.6 Test Procedure

Test procedures were conducted according to Test Method A - *Application of Horizontal Static Load to Top Rail* and Test Method B - *Application of Vertical Static Load to Top Rail* of ASTM E 985, and are further defined below.

2.6.1. Test Load Application

- A preload of 50% of test load was applied and then released
- A load of 25% of test load was applied and deflection readings were zeroed
- Load was increased to 40% of test load and maintained for at least 2 minutes
- Load was increased to 55% of test load and maintained for at least 2 minutes
- Load was increased to 70% of test load and maintained for at least 2 minutes
- Load was increased to 85% of test load and maintained for at least 2 minutes
- Load was increased to the full test load and maintained for at least 2 minutes
- Load was decreased to 25% of test load and deflections recorded
- Deflections were also recorded at the conclusion of each 2 minute hold period

2.6.2. Test Sequence

Test Specimen 1

Method B - Vertical concentrated load at mid-span of each handrail section

Method B - Vertical concentrated load at handrail ends adjacent to end brackets

Method A - Horizontal concentrated load at handrail ends adjacent to end brackets

Test Specimens 2 and 3

Method B - Vertical concentrated load at mid-span of each handrail section

Method B - Vertical concentrated load at handrail ends adjacent to end brackets

Method A - Horizontal concentrated load at mid-span of each handrail section

Note that for Specimens 2 and 3, Method A testing was applied at mid-span of *both* handrail sections per ASTM E 935, Section 13.1.

Note for Specimen 3, Method A testing is to be a repeat of the "weaker" of Specimen 1 or 2 per ASTM E 935, Section 13.1; which was determined by deflection results to be Specimen 2.

2.7 Test Results

The following tests were performed on the test specimens in accordance with the test load requirements of the referenced standards.

Key to Test Results Tables:

Load Level: Target test load expressed as percent of test load criterion and test load (lb)

Applied Load: Actual applied load - Where more than one value is reported, the applied load was the range (min-max.) that was held during the time indicated for the test

Elapsed Time (E.T.): The length of time into the test with zero established at the beginning of the loading procedure - Where more than one value is reported, the time was the range (start-end) that the applied load was maintained

Displacement: Total specimen displacement measured at or adjacent to point of load unless noted otherwise

2.7 Test Results (Continued)

Test Configuration No. 1

Specimen 1 of 3

Test Method B				
Vertical Concentrated Load at Mid-Span of Each Handrail Section				
Test Date: 03/12/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	360	-----	-----	-----
25% (180 lb)	180	00:00	0.00	0.00
40% (290 lb)	288 - 294	04:58 - 09:28	0.12 - 0.14	0.12
55% (400 lb)	397 - 407	13:47 - 15:53	0.36 - 0.39	0.36 - 0.38
70% (510 lb)	500 - 525	17:59 - 20:53	0.63 - 0.68	0.64 - 0.69
85% (620 lb)	610 - 629	23:28 - 26:03	0.89 - 0.92	0.93 - 0.95
100% (730 lb)	712 - 735	29:31 - 32:02	1.14 - 1.17	1.20 - 1.22
25% (180 lb)	180	33:39	0.14	0.18

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 1 (Continued)

Specimen 1 of 3 (Continued)

Test Method B				
Vertical Concentrated Load at Rail Ends Adjacent to End Brackets				
Test Date: 03/12/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	412	-----	-----	-----
25% (180 lb)	180	00:00	0.00	0.00
40% (290 lb)	290 - 295	01:15 - 03:47	0.00	0.00
55% (400 lb)	400 - 407	05:46 - 08:39	0.01	0.01
70% (510 lb)	508 - 514	09:28 - 12:02	0.04	0.04 - 0.05
85% (620 lb)	616 - 614	13:43 - 16:32	0.07 - 0.08	0.08
100% (730 lb)	725 - 743	17:57 - 20:09	0.10 - 0.12	0.12
25% (180 lb)	180	21:29	0.01	0.04

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 1 (Continued)

Specimen 1 of 3 (Continued)

Test Method A				
Horizontal Concentrated Load at Rail Ends Adjacent to End Brackets				
Test Date: 03/12/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	----	----	----
50% (360 lb)	375	----	----	----
25% (180 lb)	180	00:00	0.00	0.00
40% (290 lb)	289 - 293	01:03 - 03:38	0.18 - 0.19	0.02
55% (400 lb)	396 - 406	05:16 - 07:34	0.40 - 0.42	0.05
70% (510 lb)	505 - 513	09:44 - 12:51	0.66 - 0.68	0.09
85% (620 lb)	618 - 627	14:16 - 16:57	0.94 - 0.97	0.14 - 0.15
100% (730 lb)	727 - 739	18:47 - :22:45	1.23 - 1.27	1.89 - 1.97
25% (180 lb)	180	24:38	0.12	0.00

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 1 (Continued)

Specimen 2 of 3

Test Method B				
Vertical Concentrated Load at Mid-Span of Each Handrail Section				
Test Date: 03/18/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	391	-----	-----	-----
25% (180 lb)	180	0.00	0.00	0.00
40% (290 lb)	287 - 293	02:12 - 05:45	0.16 - 0.17	0.13 - 0.14
55% (400 lb)	400 - 408	07:47 - 10:03	0.41 - 0.44	0.66 - 0.68
70% (510 lb)	502 - 514	11:03 - 13:38	1.03 - 1.05	0.97 - 0.99
85% (620 lb)	613 - 626	16:18 - 18:33	1.35 - 1.37	1.27 - 1.29
100% (730 lb)	724 - 738	19:18 - 21:43	1.33 - 1.37	1.33 - 1.37
25% (180 lb)	181	24:11	0.16	0.19

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 1 (Continued)

Specimen 2 of 3 (Continued)

Test Method B				
Vertical Concentrated Load at Rail Ends Adjacent to End Brackets				
Test Date: 03/18/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	370	-----	-----	-----
25% (180 lb)	180	0.00	0.00	0.00
40% (290 lb)	288 - 299	01:05 - 03:25	0.02	0.01
55% (400 lb)	394 - 411	04:32 - 07:12	0.05	0.04
70% (510 lb)	505 - 521	07:53 - 10:22	0.08	0.06 - 0.07
85% (620 lb)	615 - 628	11:34 - 14:04	0.12	0.09
100% (730 lb)	727 - 736	14:37 - 16:29	0.16	0.11 - 0.12
25% (180 lb)	182	19:08	0.04	0.02

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 1 (Continued)

Specimen 2 of 3 (Continued)

Test Method A				
Horizontal Concentrated Load at Mid-Span of Each Handrail Section				
Test Date: 03/18/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	360	-----	-----	-----
25% (180 lb)	181	00:00	00:00	00:00
40% (290 lb)	290 - 294	03:50 - 06:22	0.50 - 0.55	0.25 - 0.27
55% (400 lb)	400 - 411	08:15 - 11:52	1.10 - 1.18	0.61 - 0.68
70% (510 lb)	504 - 515	13:07 - 15:28	1.27 - 1.31	1.31 - 1.35
85% (620 lb)	618 - 654	16:11 - 20:38	1.82 - 2.02	1.73 - 1.90
100% (730 lb)	727 - 746	22:44 - 25:15	2.43 - 2.56	2.21 - 2.31
25% (180 lb)	182	27:02	0.21	0.50

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 1 (Continued)

Specimen 3 of 3

Test Method B				
Vertical Concentrated Load at Mid-Span of Each Handrail Section				
Test Date: 03/19/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	364	-----	-----	-----
25% (180 lb)	180	00:00	00:00	00:00
40% (290 lb)	290 - 295	02:04 - 04:44	0.19 - 0.21	0.15 - 0.16
55% (400 lb)	400 - 404	05:42 - 08:11	0.47 - 0.48	0.38 - 0.39
70% (510 lb)	504 - 513	09:18 - 11:24	0.77 - 0.78	0.64 - 0.65
85% (620 lb)	618 - 627	12:26 - 15:39	1.08 - 1.11	0.91 - 0.94
100% (730 lb)	727 - 737	16:20 - 19:21	1.39 - 1.42	1.18 - 1.21
25% (180 lb)	181	21:44	0.10	0.19

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 1 (Continued)

Specimen 3 of 3 (Continued)

Test Method B				
Vertical Concentrated Load at Rail Ends Adjacent to End Brackets				
Test Date: 03/19/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	369	-----	-----	-----
25% (180 lb)	180	00:00	00:00	00:00
40% (290 lb)	289 - 300	00:33 - 03:14	0.01 - 0.02	0.01 - 0.02
55% (400 lb)	399 - 408	03:44 - 05:56	0.04 - 0.05	0.04
70% (510 lb)	502 - 528	06:48 - 09:12	0.08 - 0.09	0.08
85% (620 lb)	612 - 631	09:38 - 12:09	0.12	0.11 - 0.12
100% (730 lb)	723 - 740	12:41 - 15:43	0.15 - 0.16	0.15
25% (180 lb)	181	20:54	0.02	0.02

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 1 (Continued)

Specimen 3 of 3 (Continued)

Test Method A				
Horizontal Concentrated Load at Mid-Span of Each Handrail Section				
Test Date: 03/19/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	360	-----	-----	-----
25% (180 lb)	180	00:00	00:00	00:00
40% (290 lb)	290 - 296	02:37 - 05:21	0.42 - 0.44	0.41 - 0.44
55% (400 lb)	399 - 404	05:45 - 08:20	0.88 - 0.92	0.82 - 0.85
70% (510 lb)	506 - 527	09:05 - 11:29	1.42 - 1.51	1.24 - 1.31
85% (620 lb)	618 - 629	11:44 - 13:08	1.96 - 2.05	1.66 - 1.72
100% (730 lb)	723 - 734	16:35 - 19:02	2.62 - 2.68	2.17 - 2.22
25% (180 lb)	184	21:54	0.38	0.30

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 2

Specimen 1 of 3

Test Method B				
Vertical Concentrated Load at Mid-Span of Each Handrail Section				
Test Date: 03/13/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	375	-----	-----	-----
25% (180 lb)	180	00:00	00:00	00:00
40% (290 lb)	289 - 292	02:14 - 04:30	0.14 - 0.15	0.12
55% (400 lb)	398 - 407	06:14 - 08:54	0.43 - 0.46	0.30 - 0.32
70% (510 lb)	503 - 514	12:28 - 14:38	0.78 - 0.81	0.54 - 0.55
85% (620 lb)	612 - 628	17:21 - 19:56	1.23 - 1.28	0.80 - 0.83
100% (730 lb)	722 - 741	23:50 - 26:07	1.62 - 1.67	1.03 - 1.06
25% (180 lb)	181	29:51	0.30	0.17

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 2 (Continued)

Specimen 1 of 3 (Continued)

Test Method B				
Vertical Concentrated Load at Rail Ends Adjacent to End Brackets				
Test Date: 03/13/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	365	-----	-----	-----
25% (180 lb)	180	00:00	00:00	00:00
40% (290 lb)	288 - 294	02:12 - 06:16	0.00	0.00
55% (400 lb)	391 - 408	07:50 - 11:55	0.03	0.03
70% (510 lb)	500 - 514	16:14 - 19:19	0.07	0.06 - 0.07
85% (620 lb)	612 - 629	22:34 - 26:17	0.11	0.10 - 0.11
100% (730 lb)	723 - 739	28:04 - 31:56	0.14 - 0.15	0.14 - 0.15
25% (180 lb)	182	34:35	0.02	0.05

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 2 (Continued)

Specimen 1 of 3 (Continued)

Test Method A				
Horizontal Concentrated Load at Rail Ends Adjacent to End Brackets				
Test Date: 03/13/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	----	----	----
50% (360 lb)	360	----	----	----
25% (180 lb)	180	00:00	00:00	00:00
40% (290 lb)	289 - 306	03:32 - 06:15	0.12 - 0.14	0.03 - 0.04
55% (400 lb)	401 - 414	08:36 - 11:02	0.29 - 0.33	0.08 - 0.11
70% (510 lb)	505 - 512	11:57 -14:17	0.55 - 0.58	0.13
85% (620 lb)	618 - 627	15:59 - 18:27	0.85 - 0.89	0.19 - 0.20
100% (730 lb)	728 - 740	19:41 - 23:06	1.16 - 1.23	0.26 - 0.27
25% (180 lb)	179	27:43	0.52	0.01

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 2 (Continued)

Specimen 2 of 3

Test Method B				
Vertical Concentrated Load at Mid-Span of Each Handrail Section				
Test Date: 03/19/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	361	-----	-----	-----
25% (180 lb)	183	00:00	00:00	00:00
40% (290 lb)	289 - 295	01:18 - 03:29	0.15 - 0.17	0.11 - 0.12
55% (400 lb)	395 - 410	05:10 - 07:57	0.39 - 0.42	0.33 - 0.36
70% (510 lb)	506 - 513	09:07 - 11:05	0.67 - 0.69	0.62 - 0.63
85% (620 lb)	614 - 626	12:13 - 14:27	0.98 - 1.01	0.85 - 0.87
100% (730 lb)	721 - 741	15:48 - 19:49	1.29 - 1.34	1.13 - 1.16
25% (180 lb)	181	21:09	0.16	0.19

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 2 (Continued)

Specimen 2 of 3 (Continued)

Test Method B				
Vertical Concentrated Load at Rail Ends Adjacent to End Brackets				
Test Date: 03/19/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	488	-----	-----	-----
25% (180 lb)	182	00:00	00:00	00:00
40% (290 lb)	290 - 296	00:59 - 03:31	0.01	0.01
55% (400 lb)	396 - 408	04:24 - 06:32	0.02	0.03
70% (510 lb)	505 - 515	07:11 - 09:50	0.05	0.06
85% (620 lb)	612 - 630	10:32 - 13:04	0.08	0.10 - 0.11
100% (730 lb)	724 - 742	13:20 - 16:00	0.11 - 0.12	0.13 - 0.15
25% (180 lb)	179	17:46	0.02	0.04

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 2 (Continued)

Specimen 2 of 3 (Continued)

Test Method A				
Horizontal Concentrated Load at Mid-Span of Each Handrail Section				
Test Date: 03/19/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	360	-----	-----	-----
25% (180 lb)	182	00:00	00:00	00:00
40% (290 lb)	290 - 292	00:58 - 03:02	0.33 - 0.34	0.24 - 0.25
55% (400 lb)	395 - 403	04:04 - 06:36	0.76 - 0.81	0.56 - 0.58
70% (510 lb)	506 - 517	07:16 - 10:05	1.29 - 1.38	0.90 - 0.96
85% (620 lb)	618 - 629	11:27 - 13:57	1.90 - 1.99	1.32 - 1.37
100% (730 lb)	724 - 757	15:33 - 18:18	2.48 - 2.74	1.68 - 1.83
25% (180 lb)	183	19:59	0.76	0.40

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 2 (Continued)

Specimen 3 of 3

Test Method B				
Vertical Concentrated Load at Mid-Span of Each Handrail Section				
Test Date: 03/19/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	361	-----	-----	-----
25% (180 lb)	180	00:00	00:00	00:00
40% (290 lb)	287 - 292	00:39 - 03:18	0.13	0.10 - 0.11
55% (400 lb)	387 - 402	04:20 - 07:16	0.34 - 0.35	0.31 - 0.33
70% (510 lb)	498 - 514	10:05 - 13:32	0.60 - 0.61	0.56 - 0.58
85% (620 lb)	611 - 625	15:28 - 17:35	0.86 - 0.90	0.84 - 0.86
100% (730 lb)	727 - 738	20:23 - 22:40	1.15 - 1.17	1.15 - 1.17
25% (180 lb)	182	26:51	0.12	0.15

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 2 (Continued)

Specimen 3 of 3 (Continued)

Test Method B				
Vertical Concentrated Load at Rail Ends Adjacent to End Brackets				
Test Date: 03/19/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	-----	-----	-----
50% (360 lb)	377	-----	-----	-----
25% (180 lb)	180	00:00	00:00	00:00
40% (290 lb)	293 - 319	00:21 - 03:26	0.01 - 0.02	0.01
55% (400 lb)	397 - 414	04:44 - 07:45	0.03 - 0.04	0.04
70% (510 lb)	506 - 516	08:59 - 11:01	0.06	0.07 - 0.08
85% (620 lb)	612 - 624	12:38 - 14:42	0.09 - 0.10	0.12 - 0.13
100% (730 lb)	724 - 735	16:17 - 18:36	0.12	0.16
25% (180 lb)	181	22:25	0.02	0.04

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.7 Test Results (Continued)

Test Configuration No. 2 (Continued)

Specimen 3 of 3 (Continued)

Test Method A				
Horizontal Concentrated Load at Mid-Span of Each Handrail Section				
Test Date: 03/19/09				
Load Level ¹	Applied Load (lb)	E.T. (min:sec)	Displacement (in)	
			Rail No. 1	Rail No. 2
0% (0 lb)	0	----	----	----
50% (360 lb)	361	----	----	----
25% (180 lb)	180	00:00	00:00	00:00
40% (290 lb)	287 - 291	02:11 - 04:26	0.30 - 0.31	0.31 - 0.32
55% (400 lb)	400 - 406	07:10 - 10:33	0.69 - 0.74	0.68 - 0.72
70% (510 lb)	506 - 512	12:13 - 14:35	1.20 - 1.23	1.12 - 1.15
85% (620 lb)	618 - 628	16:28 - 19:01	1.73 - 1.80	1.61 - 1.67
100% (730 lb)	725 - 743	19:41 - 22:57	2.28 - 2.44	2.12 - 2.27
25% (180 lb)	183	25:12	0.67	0.52

¹ Load was imposed on both handrails simultaneously using a spreader beam; therefore, loads were doubled.

2.8 Summary and Conclusions

The 6 ft aluminum *Solutions* handrail system tested and reported herein met all of the load criteria of the referenced standards.

The test results obtained and reported herein are valid indefinitely and do not expire with the end of the service life of this report (see 3.0 Closing Statement).

3.0 Closing Statement

This report is issued in the name of Fairway Building Products, LP through written authorization from the manufacturer to whom the report was originally rendered. The original report number is 89680.01-119-19.

Detailed drawings, data sheets, representative samples of test specimens, a copy of this test report, and all other supporting evidence will be retained by Architectural Testing for a period of four years from the original test date. At the end of this retention period, said materials shall be discarded without notice, and the service life of this report by Architectural Testing shall expire. Results obtained are tested values and were secured using the designated test methods. This report neither constitutes certification of this product nor expresses an opinion or endorsement by this laboratory; it is the exclusive property of the client so named herein and relates only to the tested specimens. This report may not be reproduced, except in full, without the written approval of Architectural Testing.

For ARCHITECTURAL TESTING:

Keith A. Gurnee
Technician II
Structural Systems Testing

David H. Forney, P.E.
Senior Project Engineer
Structural Systems Testing

KAG:kag/alb

Attachments (pages): This report is complete only when all attachments listed are included.

Appendix A - Drawings (15)

Appendix B - Photographs (5)

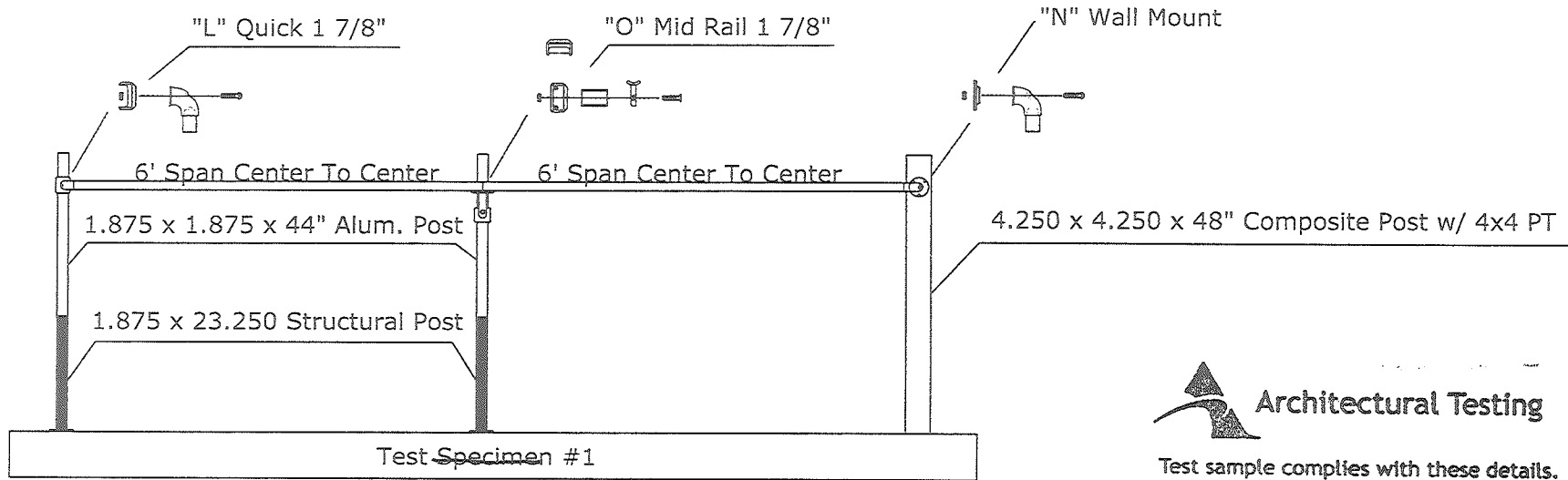
Revision Log

<u>Rev. #</u>	<u>Date</u>	<u>Page(s)</u>	<u>Revision(s)</u>
0	05/28/09	N/A	Original report issue

APPENDIX A

Drawings

Solutions ASTM E935 1.5" Handrail Testing



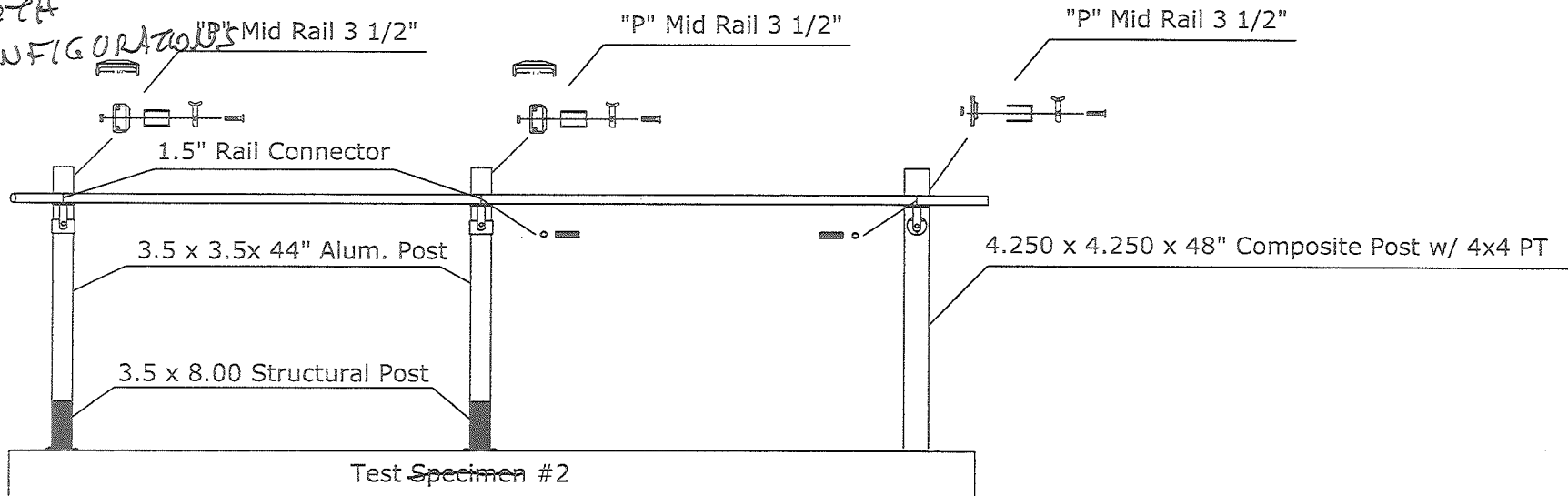
Test sample complies with these details.
Deviations are noted.

Report# 89680.02-119-19

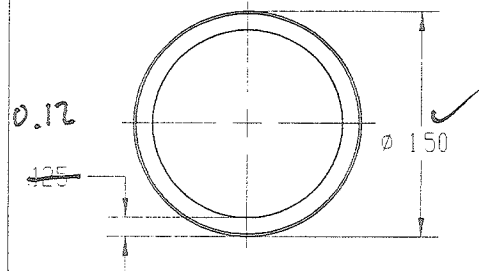
Date 4/30/09 Tech DTT

NOTE
MIRROR
IMAGES OF
BOTH
CONFIGURATIONS

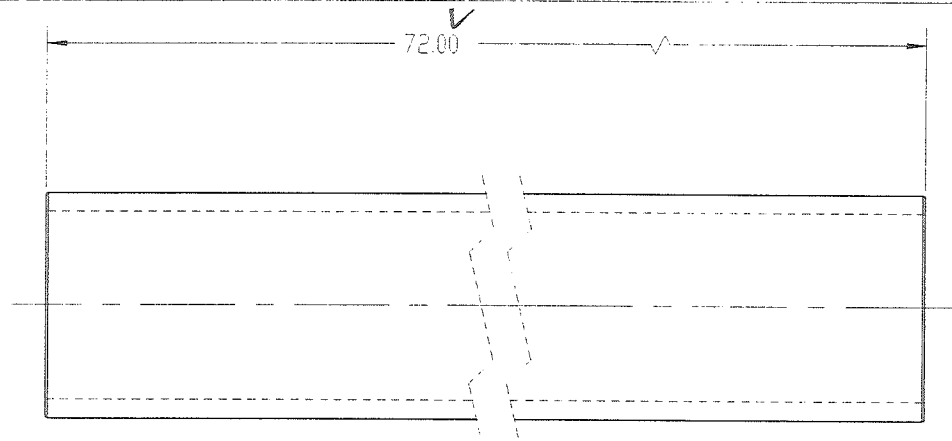
CONFIGURATION



CONFIGURATION



Full Scale



Full Scale

Material: 6005 Aluminum Alloy



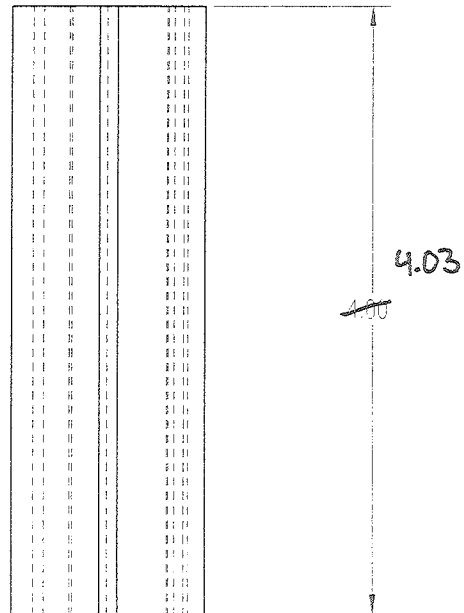
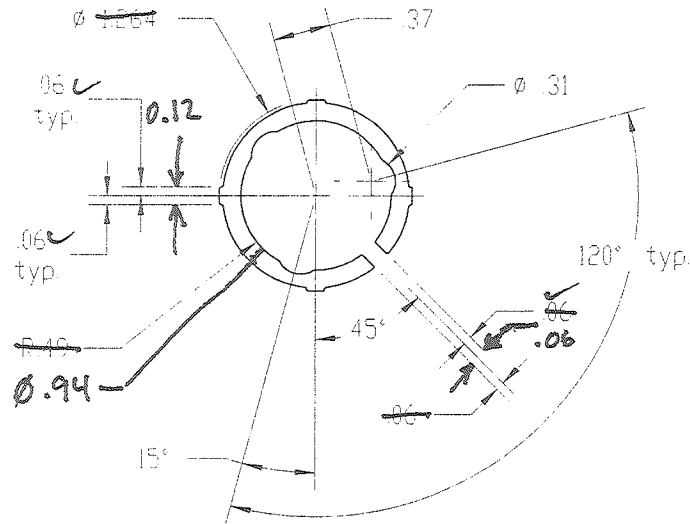
Architectural Testing

Test sample complies with these details.
Deviations are noted.

Report# 89680.02-119-19
Date 04-28-09 Tech KAG

TITLE: Solutions Handrail Straight Handrail		
DWG. NO.	WEIGHT	
1	✓	
SCALE 1/4"	SHEET	OF 1

1.25



Architectural Testing

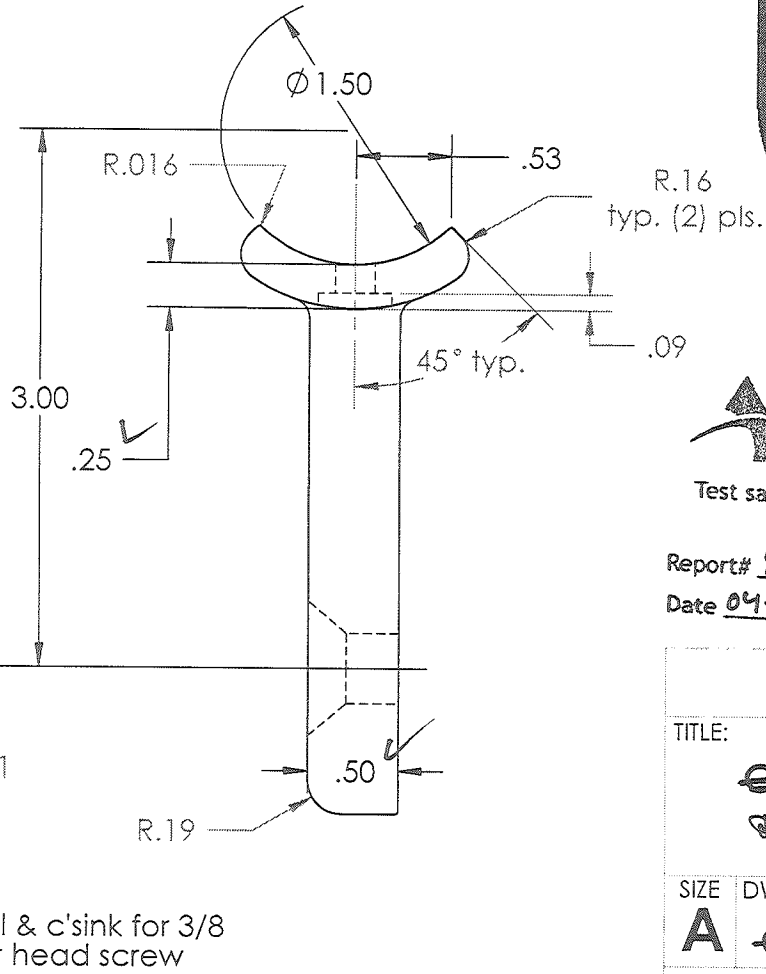
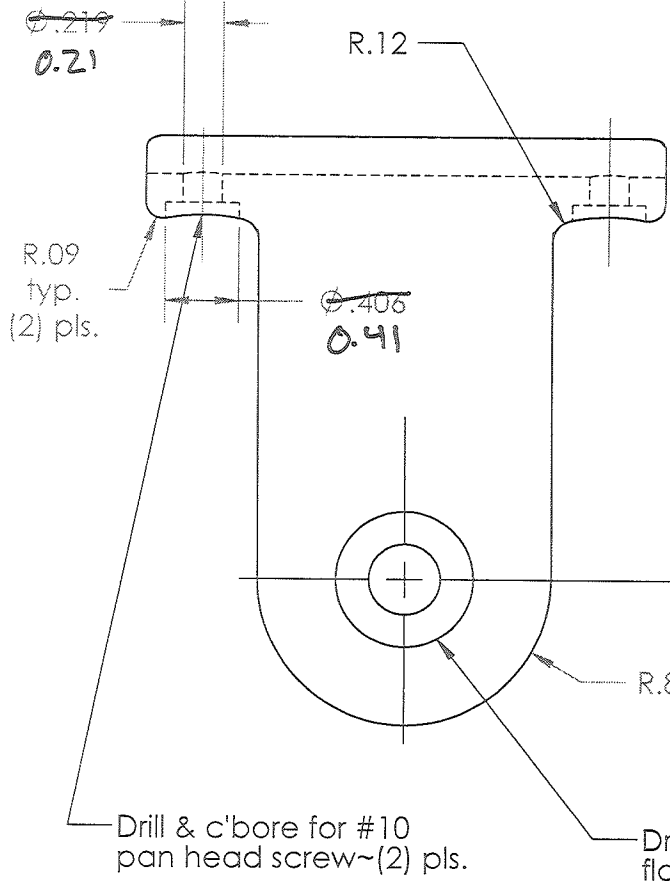
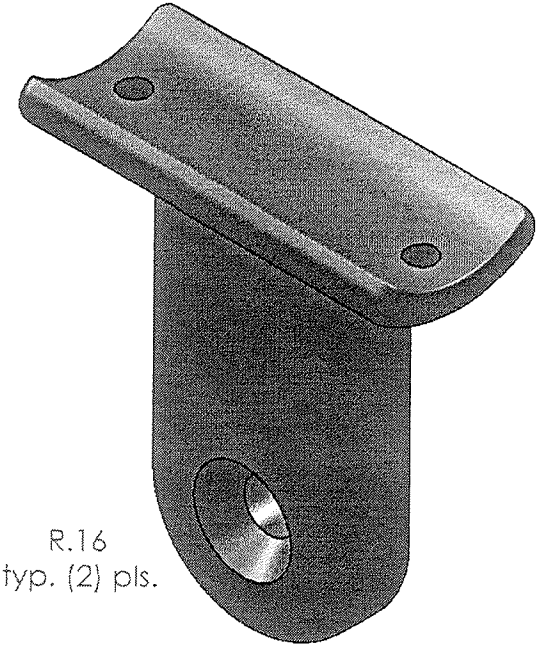
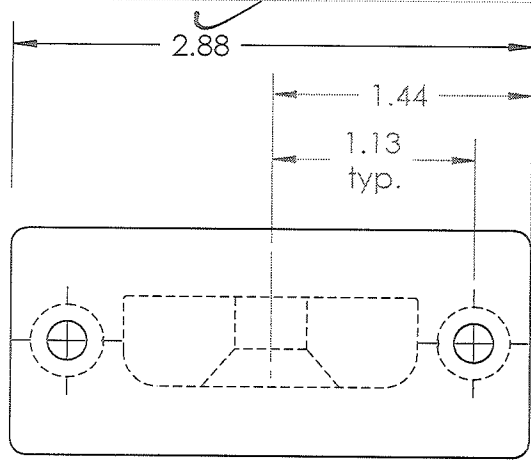
Test sample complies with these details.
Deviations are noted.

Report# 8968006-119-19

Date 4-28-09 Tech KAG/kff

Material: 6005 Aluminum Alloy

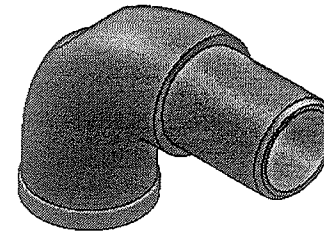
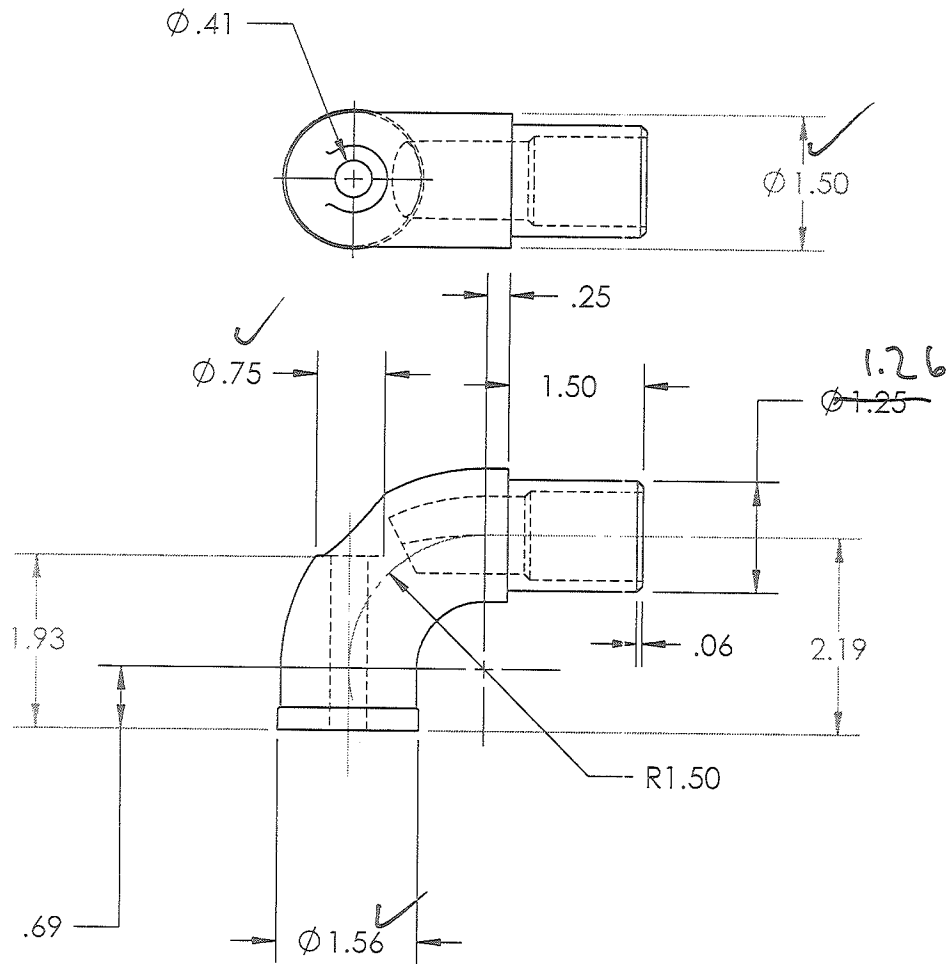
DRAWN		NAME	DATE	Solutions	
CHECKED		TITLE:			
ENG APPR		Straight Foil Connector			
MFG APPR					
D/A					
COMMENT					
SIZE	DWG	NO	REV		
A		0016			
					SHEET 1 OF 1



Architectural Testing
Test sample complies with these details.
Deviations are noted.

Report# 89680.02-119-19
Date 04-02-09 Tech KAG

Solutions		
TITLE: Grab <u>Mid-Rail</u> Bracket <u>Bracket</u>		
SIZE <u>A</u>	DWG. NO. <u>C200</u>	Mat'l. <u>ADC10</u>
SCALE: 1:1		SHEET 1 OF 1



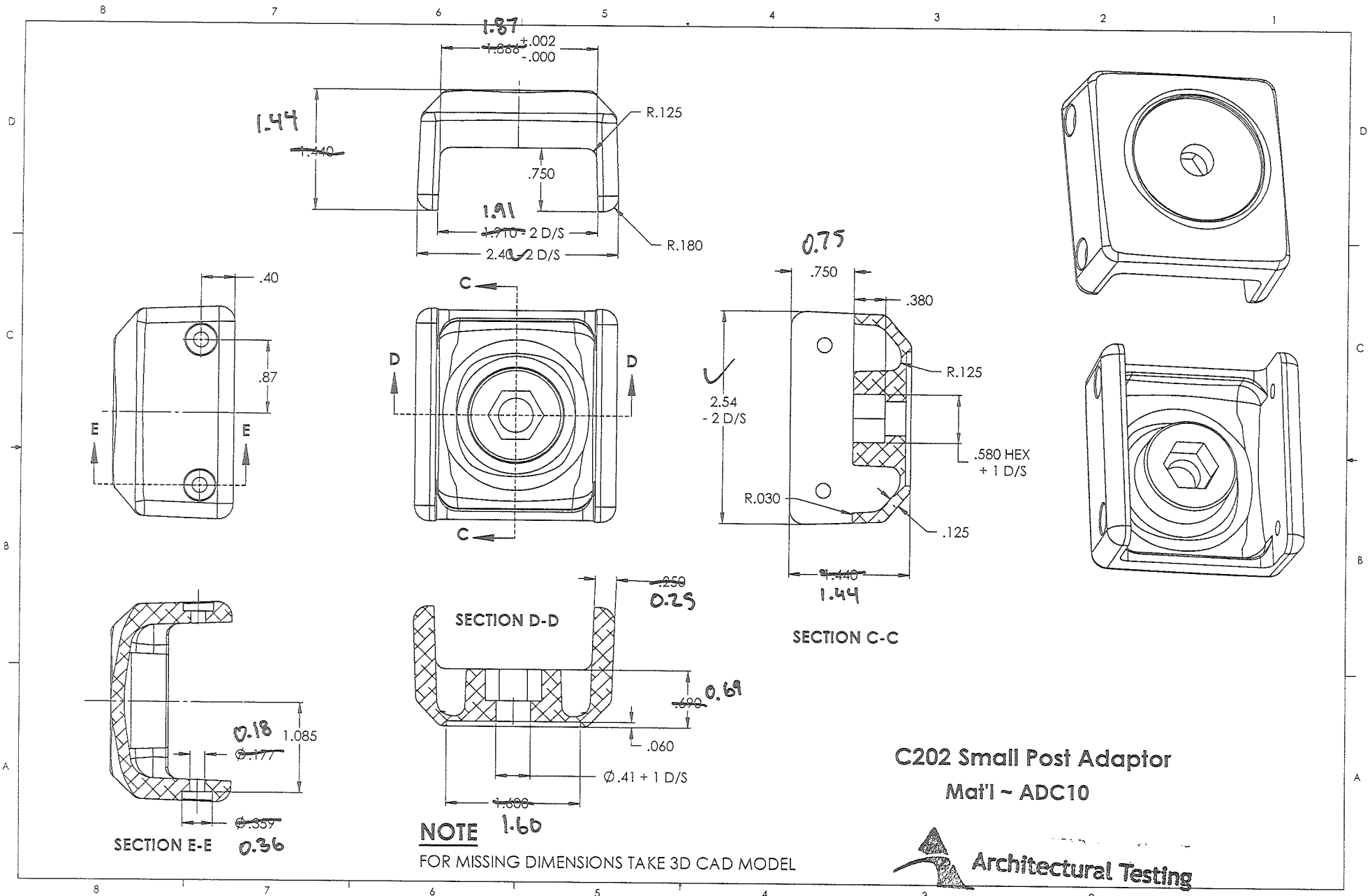
Architectural Testing

Test sample complies with these details.
Deviations are noted.

Report# 8968602-119-11

Date 04-02-09 Tech KAG

	NAME	DATE	
DRAWN			TITLE: Quick Return Bracket
CHECKED			
ENG APPR.			
MFG APPR.			
Q.A.			
COMMENTS:			SIZE DWG. NO. Mat'l. A C201 ADC10
			SHEET 1 OF 1



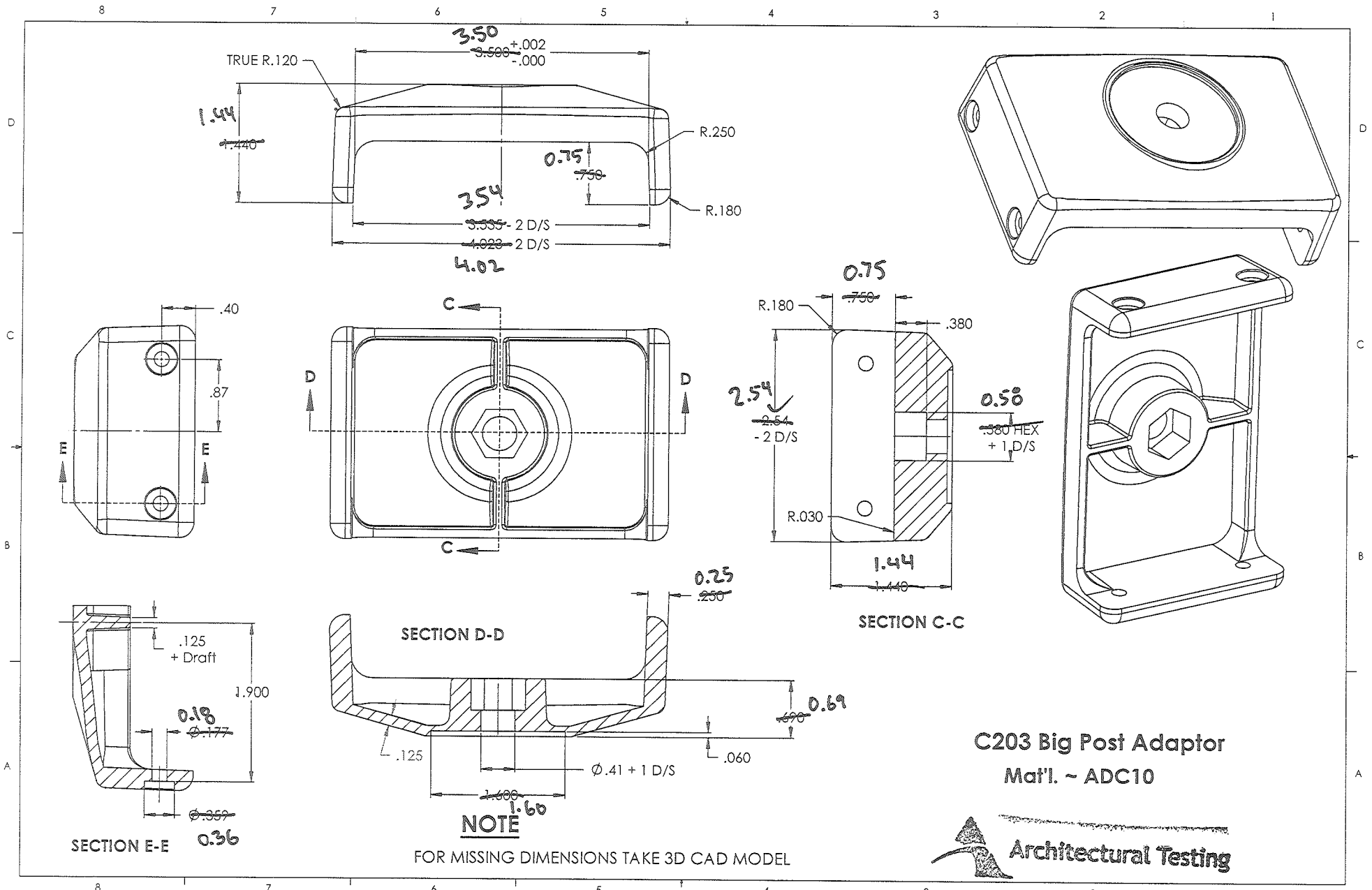
C202 Small Post Adaptor
Mat'l ~ ADC10

 Architectural Testing

Test sample complies with these details.
Deviations are noted.

Report# 89680.02-119-19
Date 04-02-09 Tech KYG

NOTE 1.60
FOR MISSING DIMENSIONS TAKE 3D CAD MODEL

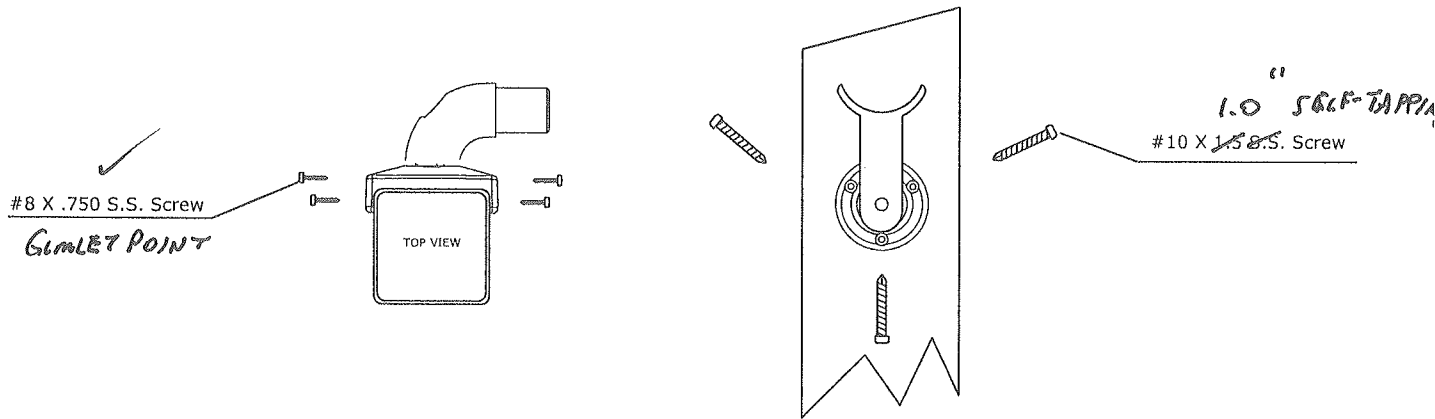


C203 Big Post Adaptor
 Mat'l. ~ ADC10



³ Test sample complies with these details.
² Deviations are noted.
 Report# 89680.02-119-19
 Date 04-02-09 Tech KAG

STEP #4 - Assemble Mounting Bracket. Place at Correct Height & Install Mounting Screws Into Mounting Flange.

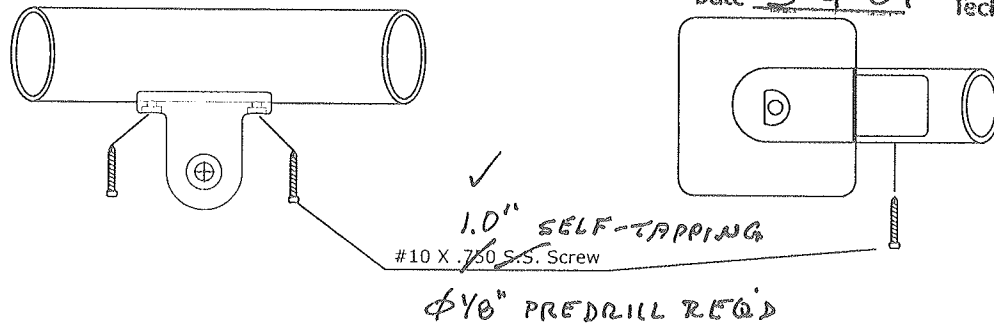


STEP #5 - Adjust Bracket To Correct Angle. Place Handrail On Mounting Bracket & Install Mounting Screws.

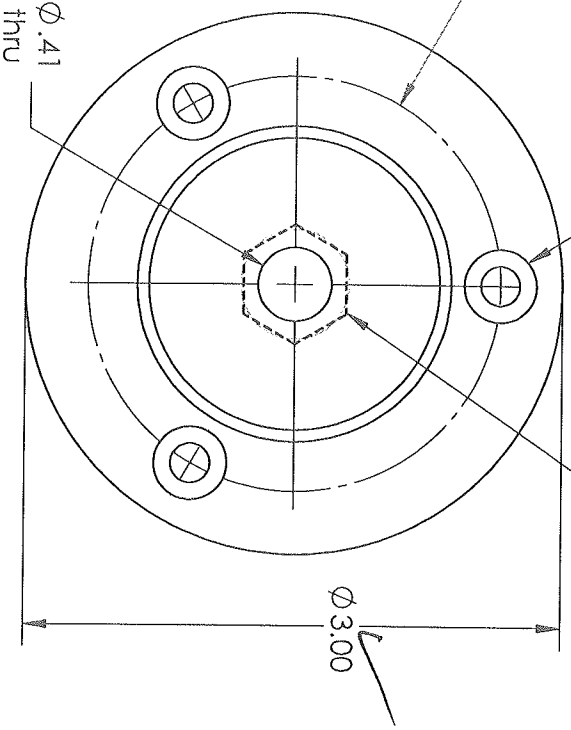
 Architectural Testing

Test sample complies with these details.
Deviations are noted.

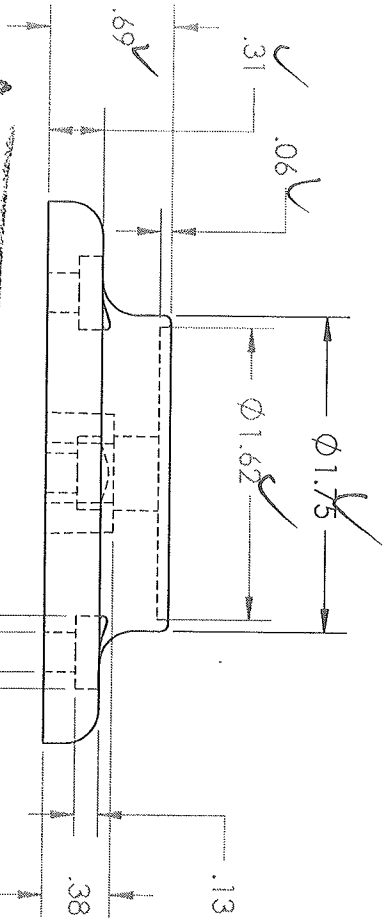
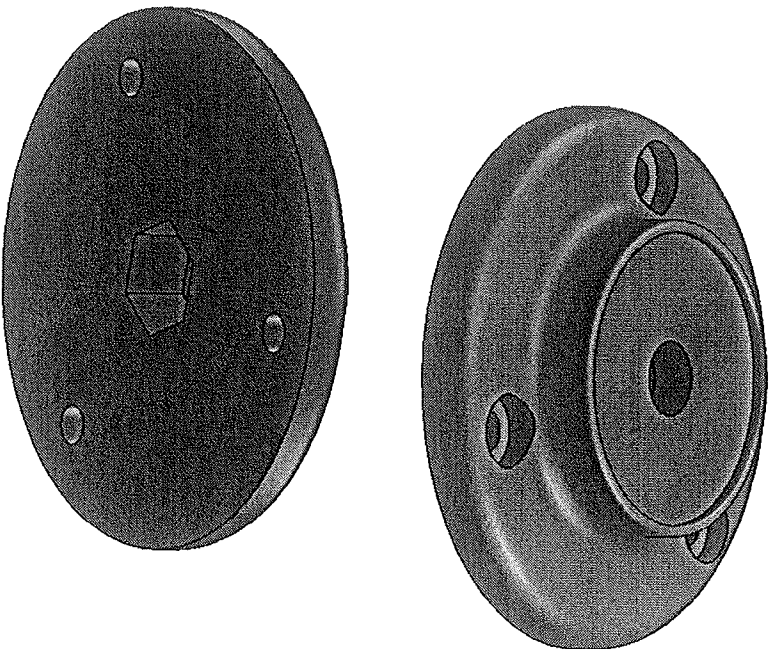
Report# 89680.06-119-19
Date 5-4-09 Tech SH



Drill & C'bore for #10
Pan Head Screw ~
(3) pls. ~ Equally spaced



Hex to fit 3/8 hex nut ~ .38 dp. from bottom side



Architectural Testing

Test sample complies with these details.
Deviations are noted.

Report# 89685 01-11-19
Date 01-02-09

Tech KAG

0.22
~~Ø.219~~

DRAWN	NAME	DATE
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE:

Wall Mount Bracket

SIZE DWG. NO.

A

C204

Mat'l.

ADC10

SHEET 1 OF 1

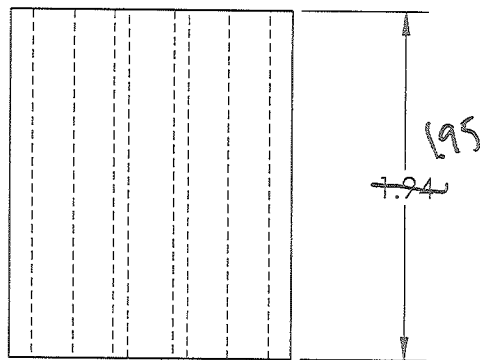
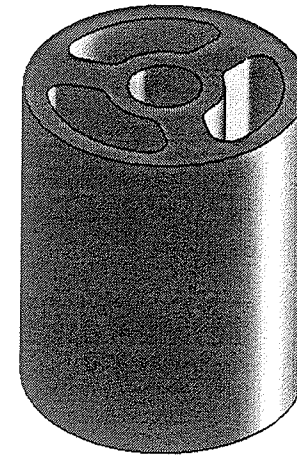
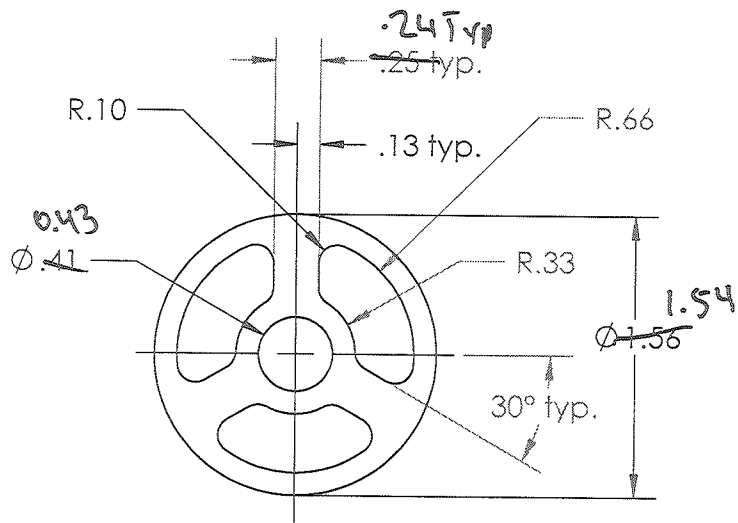
5

4

3

2

1



Architectural Testing

Test sample complies with these details.
Deviations are noted.

Report# 89680.02-119-19

Date 04-02-09 Tech KAG

Solutions

TITLE:

1.94"-Spacer Tube

SIZE	DWG. NO.	Mat'l.
A	C206	ADC10
SCALE: 1:1		SHEET 1 OF 1

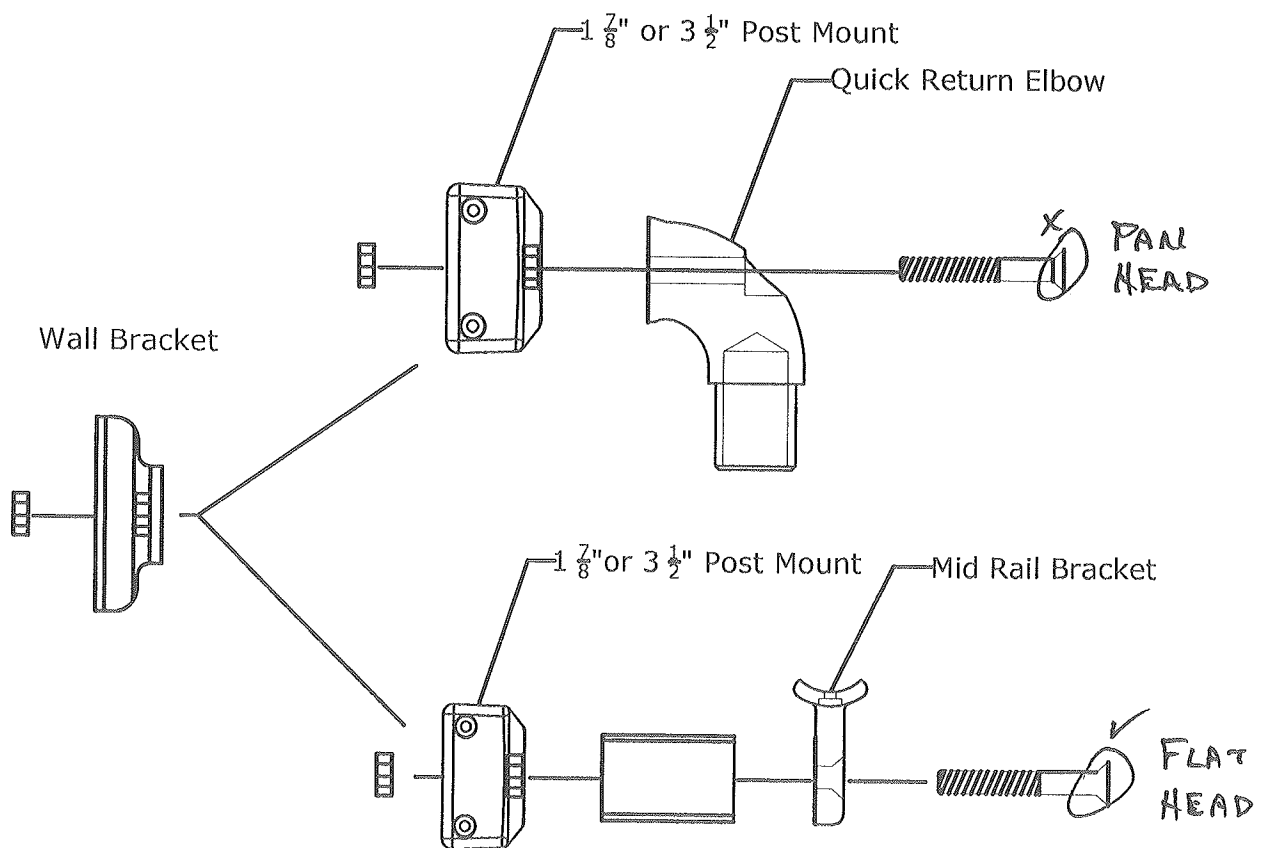
Assembling Mounting Brackets

A- Insert 3/8-16 S.S Hex Nut In Post/Wall Mount Plate.

B- Quick Return Elbow : Insert 3/8 x 2 3/4" S.S. Bolt
Through Elbow & thread into nut.

Mid-Rail Bracket : Insert 3/8 x 3" S.S. Bolt Through
Bracket, Spacer & Thread into nut.

✓
2 1/2" Lg

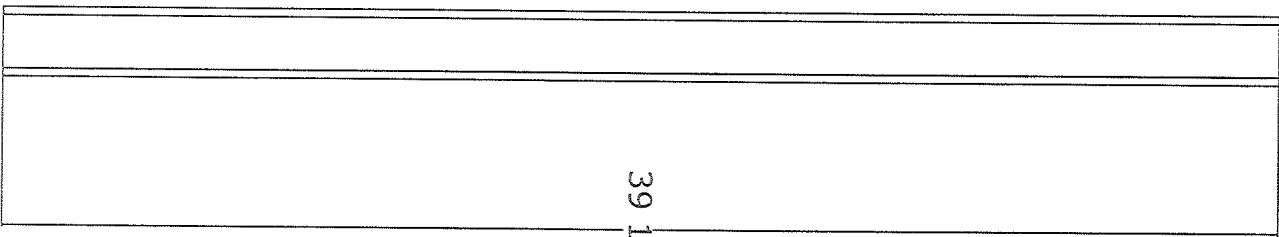
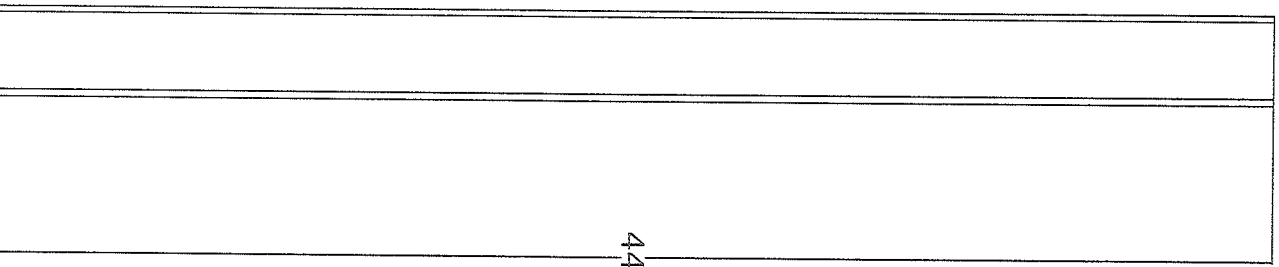
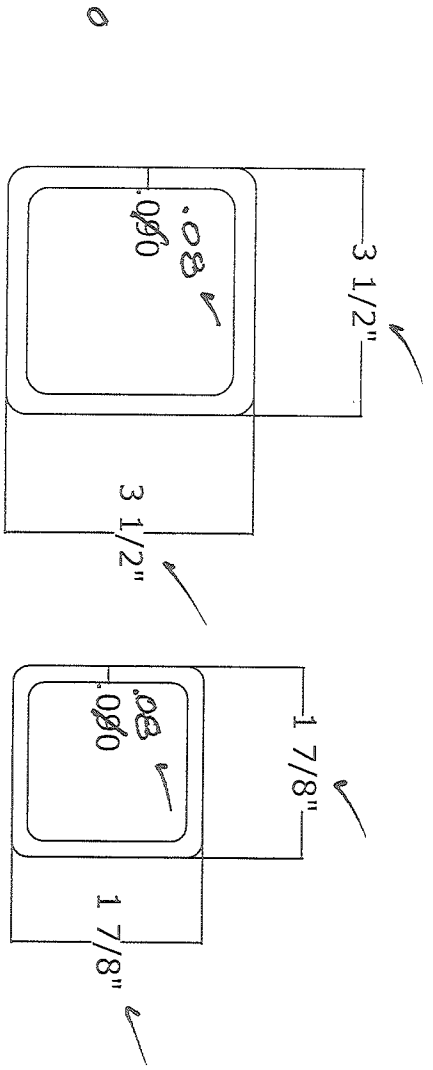


Test sample complies with these details.
Deviations are noted.

Report# B9680.02-119-19

Date 4-30-09 Tech DHF

Aluminum Post Sleeves

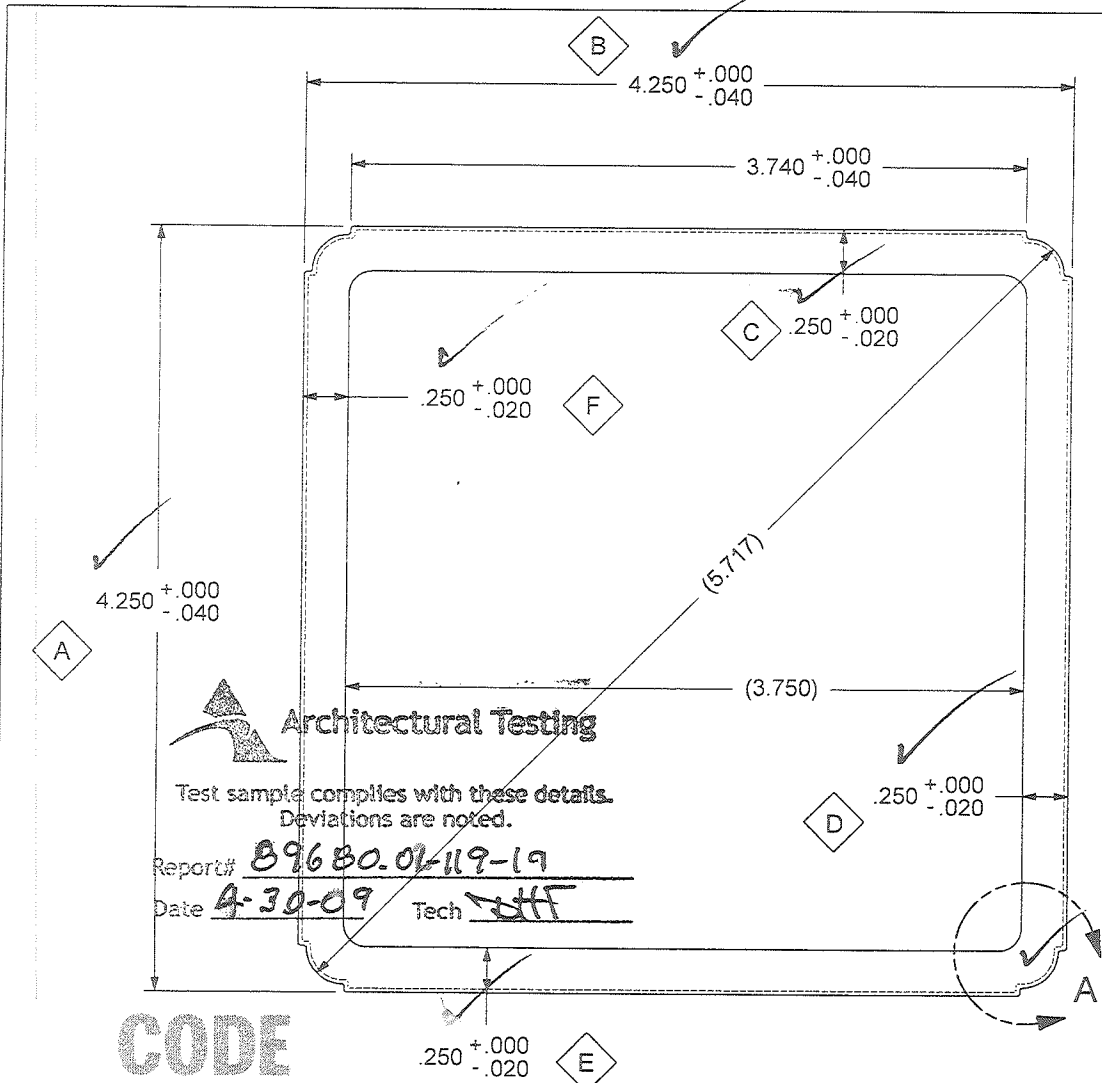


Architectural Testing

Test sample complies with these details.
Deviations are noted.

Report# B9680.01-119-19

Date 4-30-09 Tech DHF



Architectural Testing
 Test sample complies with these details.
 Deviations are noted.
 Report# 89680.01-119-19
 Date 4-30-09 Tech JHF

**CODE
 EVALUATED**

Total Volume	
Composite Volume	
Cap Stock Volume	
Comp. Weight Variable	
PVC Weight Variable	
Weight for Composite	
Weight for PVC	
PER FOOT COMBINED	

Do Not Scale Drawing
 Unless Otherwise Specified
 Dimensions are in inches

Tolerances
 .x ± .030 .xx ± .010 .xxx ± .005
 Angular ± 30' Fractions ± 1/16
 Break all Sharp Edges .003-.015
 Fillets .020 - .040
 Walls +.000 -.015



KROY BUILDING PRODUCTS INC.

DRAWN BY rhk	DATE 12/6/2004	4 1/4 x 4 1/4 Comp	
CHECKED BY rk	DATE 5/6/2005	Composite Post Dec Corner	
APPROVED BY rk	DATE 12/6/2004	REVISION NUMBER 4	CHANGE LETTER A

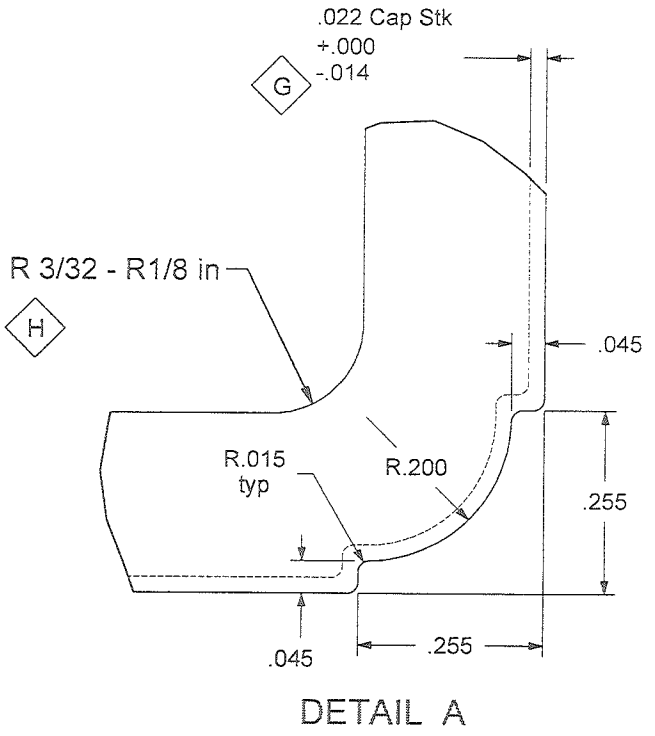
ISSUED FOR **Tooling/Production**

DRAWING NUMBER **po_cmp_4250_4250_250_xx_deccnr-coex.ipt**

MATERIAL **Composite Profile**

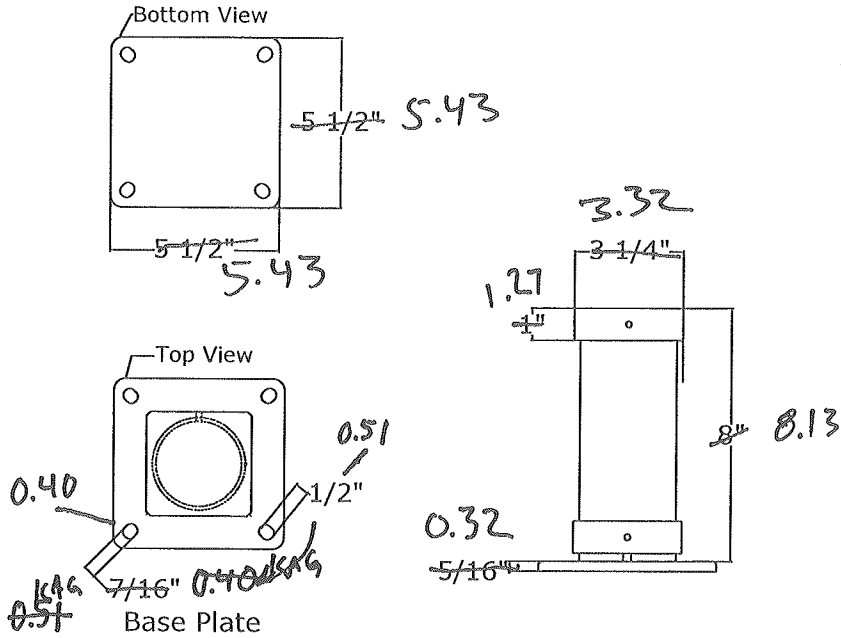
THE PART SHOWN HEREIN IS A PROPRIETARY PRODUCT OF KROY BUILDING PRODUCTS, INC. AND THIS DOCUMENT SHALL NOT BE RELEASED, USED, DUPLICATED, OR DISCLOSED IN WHOLE OR IN PART FOR ANY PURPOSE WITHOUT EXPRESS WRITTEN PERMISSION OF KROY BUILDING PRODUCTS, INC. WHERE SUCH PERMISSION IS GRANTED THIS LEGEND SHALL BE MARKED ON ANY REPRODUCTION HEREOF IN WHOLE OR IN PART. KROY BUILDING PRODUCTS, INC. RESERVES ALL RIGHTS TO THE DESIGN DISCLOSED HEREIN.

SHEET
1 OF 1



Part is Square
All Dimensions are typ
All Dimensions are Symmetrical

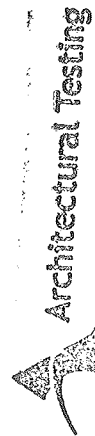
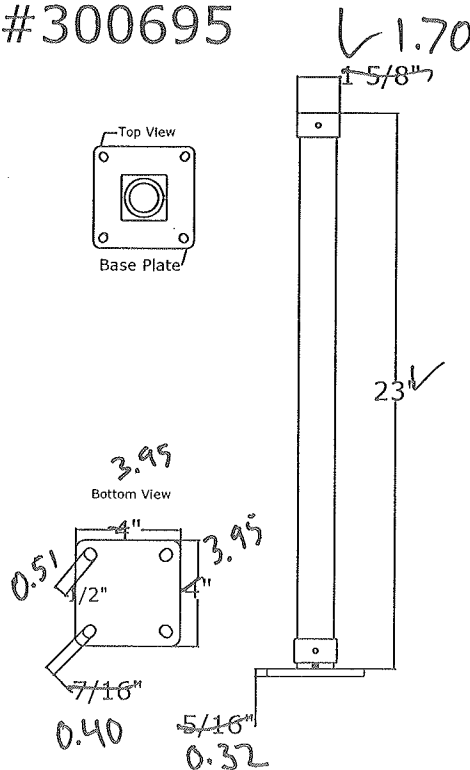
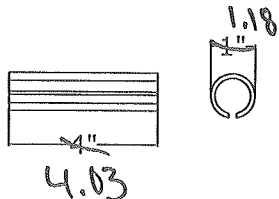
"H" 3 1/2" x 3 1/2" Structural Post #300700



"G" 1 7/8" x 1 7/8" x 23 1/4" Structural Post

#300695

1.5" Rail Connector



Test sample complies with these details.
Deviations are noted.

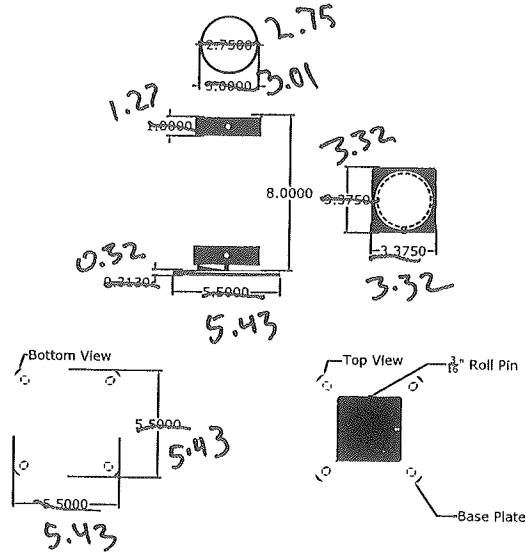
Report# 09680-02-119-19

Date 01-02-09 Tech KAG

Solutions Structural Mounting Post

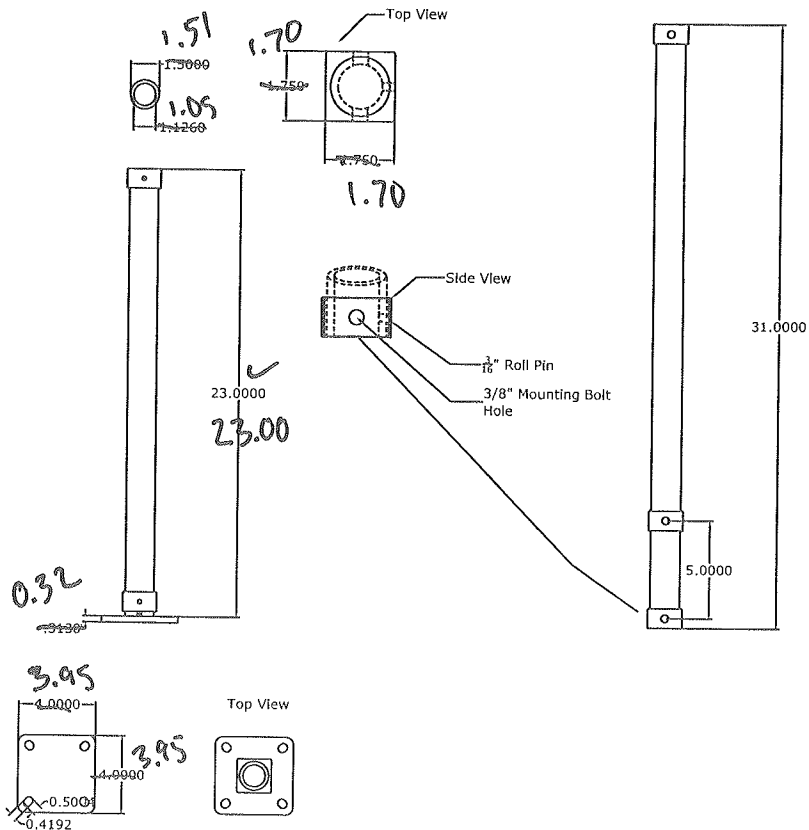
#A512 Steel Alloy

3.5" x 3.5" Structural Post



1.875 x 1.875 Structural Post

1.875 x 1.875 Side Mount Structural Post



Test sample complies with these details.
Deviations are noted.

Report# 89680.02-19-19
Date 04-02-09 Tech 1K16

APPENDIX B

Photographs



Photo No. 1

**Test Method B - Vertical Concentrated Load at Mid-Span of Each Handrail Section
Typical for all Specimens - Configuration No. 2 Depicted**



Photo No. 2

**Test Method B - Vertical Concentrated Load at Handrail Ends Adjacent to Brackets
Typical for all Specimens - Configuration No. 1 Depicted**



Photo No. 3
Test Method A - Horizontal Concentrated Load at Handrail Ends Adjacent to Brackets
Specimen 1 of Configuration No. 2 Depicted



Photo No. 4
Test Method A - Horizontal Concentrated Load at Mid-Span of Each Handrail Section
Typical for Specimens Two and Three - Configuration No. 1 Depicted

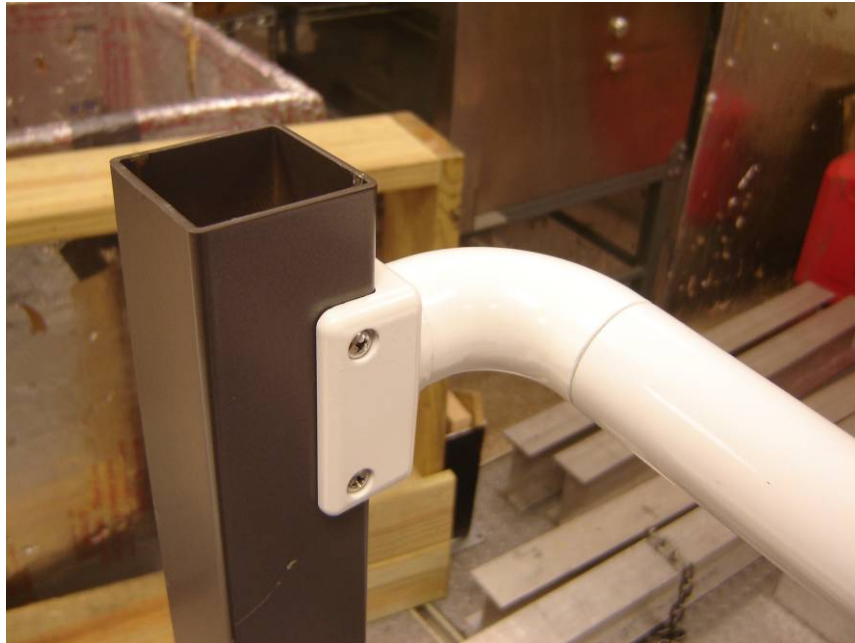


Photo No. 5
Quick Return Bracket and Big Post Adaptor



Photo No. 6
Mid-Rail Bracket, Spacer Tube, and Small Post Adaptor



Photo No. 7
Handrail Splice at Mid-Rail Bracket with Small Post Adaptor



Photo No. 8
Mid-Rail Bracket, Spacer Tube, and Wall Mount Bracket
Attached to Composite-Sleeved Wood Post



Photo No. 9
Quick Return Bracket and Wall Mount Bracket
Attached to Composite-Sleeved Wood Post



Photo No. 10
Mid-Rail Bracket, Spacer Tube, and Big Post Adaptor