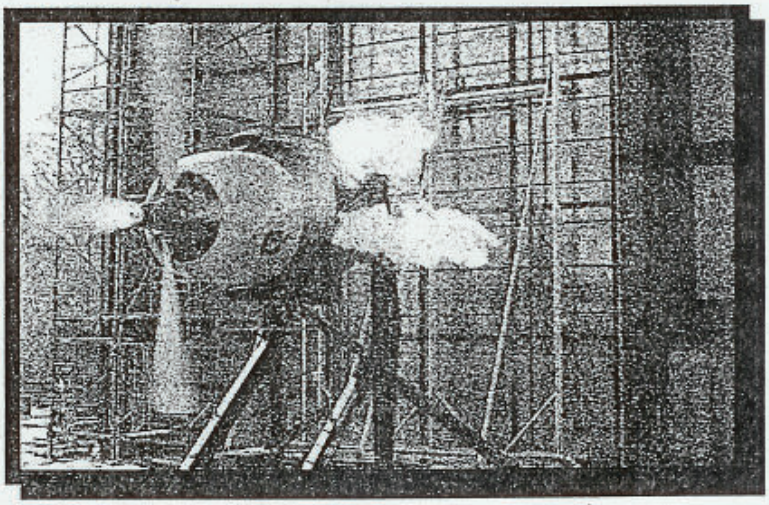
CONSTRUCTION CONSULTING LABORATORY, *INTERNATIONAL*



TEST REPORT:

US ALUMINUM
4500/4500SG CURTAIN WALL SYSTEM
REPORT # CCLI–99–014

November 19, 1999

Prepared for:

US ALUMINUM CORPORATION
200 Singleton Drive
Waxahachie, TX 75165

1601 Luna Road
Carrollton, Texas 75006

S- UNITED, INC.
A Quality Control Company

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CURTAIN WALL MOCK-UP TESTING REPORT
4500/4500SG CURTAIN WALL SYSTEM
REPORT # CCLI-99-014

1. PROJECT DATA

Project:	4500/4500SG Curtain Wall System Mock-Up Performance Testing
Test Completion:	September 29, 1999
Tested For:	United States Aluminum Corporation 200 Singleton Drive Waxahachie, TX 75165

Witnessed By: (All or Partial Viewing)

Jeff Lochenhour	U S Aluminum
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James Horton	Construction Consulting Laboratory, *International*
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Joseph P. Solinski	Construction Consulting Laboratory, *International*

2. MOCK- UP DESCRIPTION

The mock-up test specimen was identified as a combined specimen 4500/4500SG Curtain Wall. The combined mock-up specimen was approximately 29'-5" wide x 39'-1½ " high, **(Photograph 1).**

Both systems utilized 5" deep, extruded aluminum tubular vertical mullions. Various extruded aluminum shapes were utilized for the horizontal mullions. The system is an externally glazed system with vision glass units being 1" thick insulated units comprised of ¼" clear tempered glass on the exterior, with a ½" airspace, and a ¼" clear tempered glass on the interior side. The spandrel glass was ¼" clear tempered glass set into the frame using adapters that were buttered with Dow Corning 795 silicone at installation.

The 4500 system controls water internally with water deflectors and Dow Corning 795 silicone sealant. The sealant was buttered to all metal joints, screws, and the water deflectors. The glass on the interior was captured with straight cut gaskets that were set in Dow Corning 795 silicone sealant at the corners. On the exterior, gaskets installed on the face caps captured the glass. These caps were held to the frame with delin face clips spaced on 6" centers. The butt joints of the gaskets at the intersection between the horizontal and vertical caps were set in Dow Corning 795.

Drainage was provided by a $^{5}/_{16}$" weep hole located at the center of the horizontal face caps of both the vision and spandrel lites. Drainage of the system was completed at each face cap by drainage at the intersection with the vertical members.

The 4500 SG system utilized all the components as the 4500 system, but is a two-sided, vertical structural butt glazed system utilizing Dow Corning 795 silicone joints.

Reference, U S Aluminum, Drawing No. M98019 D, Titled "Mock-Up 4500/4500SG Curtainwall", **Appendix A.**

Drawing	Revision/Date
Sht 1 thru Sht 5	D/11-1-99

This report is not complete unless these drawings, stamped by this laboratory, are included.

3. TEST EQUIPMENT

3.1 Test chamber consisted of structural steel beams, columns and bulkheads and was accessible through a bulkhead door.

3.2 Pressure differentials were created with reversible pumps for positive/negative loading.

3.3 Pressure differentials between the specimen interior and the atmosphere were measured with manometers.

3.4 Air infiltration was measured with a Merriam laminar flow element and a Dwyer inclined manometer.

3.5 Water was applied to the specimen from a spray rack equipped with swirl-type nozzles spaced two feet on center in vertical and horizontal directions, which, under controlled pressure, delivered a minimum of five gallons per square foot per hour on the specimen.

3.6 Dynamic winds were generated by a Curtis Wright 3350 Radial Aircraft Engine with a four (4) bladed propeller, 4.11 M (13'-6") diameter, which formulates typical and atypical wind conditions.

3.7 Structural variations were measured with dial indicator gauges with maximum movement hands located throughout the test specimen.

4. TESTING ALLOWABLES

4.1 AIR INFILTRATION: Total amount of air infiltration shall not exceed **.0017M^3 (.06 SCFM)** per square meter (M^3) (per square foot, psf) of the curtain wall area tested.

MAXIMUM ALLOWABLE **1.56 M^3/ min (55.0 SCFM) (Based upon a Calculated Area of 85.1 M^2 (916.1 sf)**

4.2 WATER PENETRATION: There shall be no water penetration during or at the conclusion of this test.

Note: "Uncontrolled water" is defined as any water that appears on any normally exposed interior surfaces, that is not contained or drained back to the exterior, or that can cause damage to adjacent materials or finishes. Water contained within drained flashings, gutters, and sills is not considered water leakage. The collection of up to one half (½) ounce of water (14.8 cc) in a fifteen (15) minute test period on top of any interior stop or stool integral with the wall system shall not be considered water leakage.

4.3 **DESIGN LOAD DEFLECTION:** There shall be no system failure and deflection of aluminum members at 100% of design load, and shall not exceed L/175 or 19.1 mm (0.75 inches), whichever is less:

Vertical Span: 3962.4 mm (156")/175 = 22.6 mm (0.89 inches)
Vertical Span Allowable = 19.1mm (0.75 inches)

Horizontal Span: 1466.9 mm (57.75")/175 = 8.4 mm (0.33 inches)
Horizontal Span Allowable = 8.4 mm (0.33 inches)

4.4 **PROOF LOAD RESIDUAL:** The permanent deformation of the aluminum members shall not exceed L/1000.

Vertical Span Residual: 3962.4 mm (156")/1000= 3.96 mm (0.16 inches)

Horizontal Span Residual: 1466.9 mm (57.75")/1000 = 1.47 mm (0.06 inches)

4.5 **SEISMIC DEFLECTION:** There shall be no breakage or fall-out of the glass or any wall components at the design displacement of .005 of the greater story height.

Design Displacement: 3962.4 mm (156") * .005 = 19.8 mm (0.78 inches)

5. TESTING SEQUENCE

As used throughout this report, positive pressure applied to the test specimen is considered to be **inward** acting and negative pressure is considered to be **outward** acting. All location references or comments are as viewing the test specimen from the interior (room side) of the test chamber and wall system.

The U S Aluminum drawings defined the design loads to be as follows:

Positive Design Load = +1.68 kPa (35 psf)
Negative Design Load = –1.68 kPa (35 psf)

	TEST	TEST STANDARD
1.	Preload @ 15.0 psf	ASTM E330-96
2.	Static Pressure Air Infiltration Test @ .30 kPa (6.24 psf)	ASTM E283-91
3.	Static Pressure Water Penetration Test @ .96 kPa (20 psf)	ASTM E331-93
4.	Dynamic Water Penetration @ 160.9 KMph (100 mph)	AAMA 501.1- 94
5.	Structural Performance by Static Pressure Test @ 50% & 100% Design Loads	ASTM E330-96
6.	Static Pressure Air Infiltration Test @ .30 kPa (6.24 psf)	ASTM E283-91
7.	Static Pressure Water Penetration Test @ .96 kPa (20.0 psf)	ASTM E331-93
8.	Dynamic Water Penetration @ 160.9 KMph (100 mph)	AAMA 501.1- 94
9.	Inter-story Differential Movement @ .005 of span	
10.	Static Pressure Air Infiltration Test @ .30 kPa (6.24 psf)	ASTM E283-91
11.	Static Pressure Water Penetration Test @ .96 kPa (20.0 psf)	ASTM E331-93
12.	Dynamic Water Penetration @ 160.9 KMph (100 mph)	AAMA 501.1- 94
13.	Structural Proof Load by Static Pressure Test @ 150% of Design Loads	ASTM E330-96
14.	Inter-story Differential Movement @ .010 of span	

6. TESTING and RESULTS

6.1 Preload to .72 kPa (15 psf) Positive Pressure per ASTM E330-96

Subject the test specimen to a static pressure differential of **.72 kPa (15.0 psf)**. This load was maintained for ten (10) seconds and released. An inspection was made to determine if any failure occurred.

Results: No visible differences were observed within the specimen or test chamber. All materials were intact.

6.2 Static Pressure Air Infiltration Test @ .30 kPa (6.24 psf) per ASTM E283-91

The specimen was completely covered with an impervious visqueen material and sealed at the perimeter with tape, thus allowing no movement of air through the specimen.

The exterior face of the specimen was then subjected to a positive pressure differential of **.30 kPa (6.24 psf)**. Air infiltration was measured and recorded, thus indicating the amount of infiltration through the chamber.

Chamber Reading: **3.09 M^3/min (109.1 SCFM)**

The visqueen material covering the specimen was removed and the exterior face of the specimen was subjected to a positive pressure differential of **.30 kPa (6.24 psf)**. Air infiltration was measured, thus indicating the amount of infiltration through the chamber and the specimen. Subtracting the previous reading (chamber only) from this reading yields the amount of infiltration through the specimen.

Chamber and Specimen Reading: **3.13 M^3/min (110.5 SCFM)**

Results:

CHAMBER	SPECIMEN & CHAMBER	SPECIMEN ONLY (YIELD)	ALLOWABLE (NOT TO EXCEED)
3.09 M^3/min 109.1 SCFM	3.13 M^3/min 110.5 SCFM	04 M^3/min 1.4 SCFM	1.56 M^3/min 55.0 SCFM

6.3 **Static Pressure Water Penetration Test @ .96 kPa (20.0 psf) per ASTM E331-93**

Water was applied to the exterior face of the specimen at a minimum rate of five (5) gallons per square foot per hour of wall area, in such a way as to completely and continuously cover the face of the specimen. Simultaneously, a positive **inward** differential static pressure of **.96 kPa (20.0 psf)** was applied against the face. The application of pressure and water was maintained for a period of fifteen (15) minutes, with observers inside the chamber checking for water penetration.

Results: No uncontrolled water penetration was observed.

6.4 **Dynamic Water Penetration @ 160.9 KMph (100 mph) Slipstream Velocity per AAMA 501.1-94**

Water was applied to the exterior face of the specimen at a minimum rate of five (5) gallons per square foot per hour of wall area, in such a way as to completely and continuously cover the face of the specimen.

Simultaneously, the wall was subjected to sufficient airflow from an aircraft engine with a four bladed propeller, approximately 4.11M (13' 6") in diameter,

approximately 6.10M (20' 0") in front of the specimen. The application of airflow and water was maintained for a period of fifteen (15) minutes, with observers inside the chamber checking for water penetration.

Results: No uncontrolled water penetration was observed.

6.5 **Uniform Structural Test @ 50% & 100% of Design Loads** per ASTM E330-96

Dial indicators were installed to measure deflection and residuals at end and midspan of typical horizontal and vertical members.

Test: With the specimen set in a positive mode, all indicators were set on zero. A positive pressure of **.84 kPa (17.5 psf) (inward)** equal to 50% of the design load was applied and held for ten (10) seconds, then released. The indicators were read and the data recorded.

Results: Refer to Structural Deflection Table #1.

Test: A positive pressure of **1.68 kPa (35.0 psf) (inward)** equal to 100% of the design load was applied and held for ten (10) seconds then released. The indicators were read and the data recorded.

Results: All the net midspan deflections were below the allowable of 0.75 inches for the verticals and 0.33 inches for the horizontals. Refer to Structural Deflection Table #1.

The vacuum/blower pumps were reversed and set to perform in a negative mode. The test specimen was subjected to a negative pressure of **–.84 kPa (–17.5 psf) (outward)** equal to 50% of design load. The pressure was held for ten (10) seconds and released.

Test: With all indicators set on zero, the test specimen was subjected to a negative pressure of **–.84 kPa (–17.5 psf) (outward)** equal to 50% of design load. The pressure was held for ten (10) seconds and released. The indicators were read and data recorded.

Results: Refer to Structural Deflection Table #2.

Test: The test specimen was subjected to a negative pressure of **–1.68 kPa**

(–35.0 psf) (outward) equal to 100% of design load. The pressure was held for ten (10) seconds and released. The indicators were read and data recorded.

Results: All the net midspan deflections were below the allowable of 0.75 inches for the verticals and 0.33 inches for the horizontals. Refer to Structural Deflection Table #2.

6.6 Static Pressure Air Infiltration Test @ .30 kPa (6.24 psf) per ASTM E283-91

The exterior face of the specimen was subjected to a positive pressure differential of **.30 kPa (6.24 psf)**. Air infiltration was measured, thus indicating the amount of infiltration through the chamber and the specimen. Subtracting the previous reading (chamber only) from this reading yields the amount of infiltration through the specimen.

Chamber and Specimen Reading: **3.20M³/min (112.9 SCFM)**

Results:

CHAMBER	SPECIMEN & CHAMBER	SPECIMEN ONLY (YIELD)	ALLOWABLE (NOT TO EXCEED)
3.09M³/min 109.1 SCFM	3.20M³/min 112.9 SCFM	.11M³/min 3.8 SCFM	1.56M³/min 55.0 SCFM

6.7 Static Pressure Water Penetration Test @ .96 kPa (20.0 psf) per ASTM E331-93

Water was applied to the exterior face of the specimen at a minimum rate of five (5) gallons per square foot per hour of wall area, in such a way as to completely and continuously cover the face of the specimen. Simultaneously, a positive **inward** differential static pressure of **.96 kPa (20.0 psf)** was applied against the face. The application of pressure and water was maintained for a period of fifteen (15) minutes, with observers inside the chamber checking for water penetration.

Results: No uncontrolled water penetration was observed.

6.8 **Dynamic Water Penetration @ 160.9 KMph (100 mph) Slipstream Velocity per AAMA 501.1-94**

Water was applied to the exterior face of the specimen at a minimum rate of five (5) gallons per square foot per hour of wall area, in such a way as to completely and continuously cover the face of the specimen.

Simultaneously, the wall was subjected to sufficient airflow from an aircraft engine with a four bladed propeller, approximately 4.11M (13'-6") in diameter, approximately 6.10M (20'-0") in front of the specimen. The application of airflow and water was maintained for a period of fifteen (15) minutes, with observers inside the chamber checking for water penetration.

Results: No uncontrolled water penetration was observed.

6.9 **Inter-story Differential Movement @ the Design Displacement**

The mock-up was subjected to 3 full cycles of an inter-story movement equivalent to the design displacement of .005 of the floor span, 19.8 mm (0.78 inches).

Results: No broken or disengaged components were observed.

6.10 **Static Pressure Air Infiltration Test @ .30 kPa (6.24 psf) per ASTM E283-91**

Due to a problem with the chamber, the chamber tare was rerun at this point in the testing sequence. The specimen was completely covered with an impervious visqueen material and sealed at the perimeter with tape, thus allowing no movement of air through the specimen. The exterior face of the specimen was then subjected to a positive pressure differential of **.30 kPa (6.24 psf)**. Air infiltration was measured and recorded, thus indicating the amount of infiltration through the chamber.

Chamber Reading: **2.53M^3/min (89.4 SCFM)**

The exterior face of the specimen was subjected to a positive pressure differential of **.30 kPa (6.24 psf)**. Air infiltration was measured, thus indicating the amount of infiltration through the chamber and the specimen. Subtracting

the previous reading (chamber only) from this reading yields the amount of infiltration through the specimen.

Chamber and Specimen Reading: **2.65M³/min (93.8 SCFM)**

Results:

CHAMBER	SPECIMEN & CHAMBER	SPECIMEN ONLY (YIELD)	ALLOWABLE (NOT TO EXCEED)
2.65M³/min 93.8 SCFM	2.53M³/min 89.4 SCFM	.14M³/min 4.8 SCFM	1.56M³/min 55.0 SCFM

6.11 **Static Pressure Water Penetration Test @ .96 kPa (20.0 psf)** per ASTM E331-93

Water was applied to the exterior face of the specimen at a minimum rate of five (5) gallons per square foot per hour of wall area, in such a way as to completely and continuously cover the face of the specimen. Simultaneously, a positive **inward** differential static pressure of **.96 kPa (20.0 psf)** was applied against the face. The application of pressure and water was maintained for a period of fifteen (15) minutes, with observers inside the chamber checking for water penetration.

Results: No uncontrolled water penetration was observed.

6.12 **Dynamic Water Penetration @ 160.9 KMph (100 mph) Slipstream Velocity per AAMA 501.1-94**

Water was applied to the exterior face of the specimen at a minimum rate of five (5) gallons per square foot per hour of wall area, in such a way as to completely and continuously cover the face of the specimen.

Simultaneously, the wall was subjected to sufficient airflow from an aircraft engine with a four bladed propeller, approximately 4.11M (13'-6") in diameter, approximately 6.10M (20'-0") in front of the specimen. The application of airflow and water was maintained for a period of fifteen (15) minutes, with observers inside the chamber checking for water penetration.

Results: No uncontrolled water penetration was observed.

6.13 **Structural Proof Load Test @ 150% of Design Load** per ASTM E330-96

Dial indicators were installed to measure deflection and residuals at end and midspan of typical vertical and horizontal members. The test specimen was subjected to a positive pressure of **1.25 kPa (26.2 psf) (inward)** equal to 50% of design load to set the specimen in a positive mode. The pressure was held for ten (10) seconds and released.

Test: With the specimen set in a positive mode, all indicators were set on zero. A positive pressure of **2.51 kPa (52.5 psf) (inward)** equal to 150% of the design load was applied and held for ten (10) seconds, then released. The indicators were read and the data recorded.

Results: All of the measured midspan net residuals were below the allowable limits. Refer to Structural Deflection Table #3 for all the deflections and net residuals measured.

The vacuum/blower pumps were reversed and set to perform in a negative mode. The test specimen was subjected to a negative pressure of **–1.25 kPa (–26.2 psf) (outward)** equal to 50% of design load. The pressure was held for ten (10) seconds and released.

Test: With all indicators set on zero, the test specimen was subjected to a negative pressure of **–2.51 kPa (–52.5 psf), (outward)** equal to 150% of design load. The pressure was held for ten (10) seconds and released. The indicators were read and data recorded.

Results: All of the measured midspan residuals were below the allowable limits. Refer to Structural Deflection Table #4 for all the deflections and residuals measured.

6.14 **Inter-Story Differential Movement @ the Proof Displacement**

The mock-up was subjected to 3 full cycles of inter-story movement equivalent to .010 of the floor span, 39.6 mm (1.56 inches).

Results: No breakage or disengaged components were observed.

7. CONCLUSION

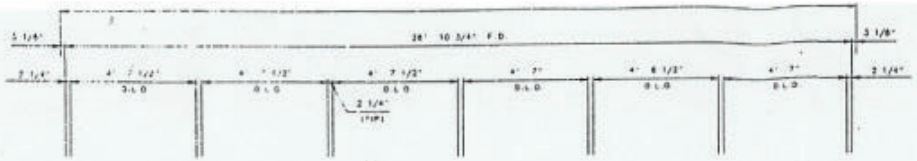
The tested specimen performed within the specified criteria.

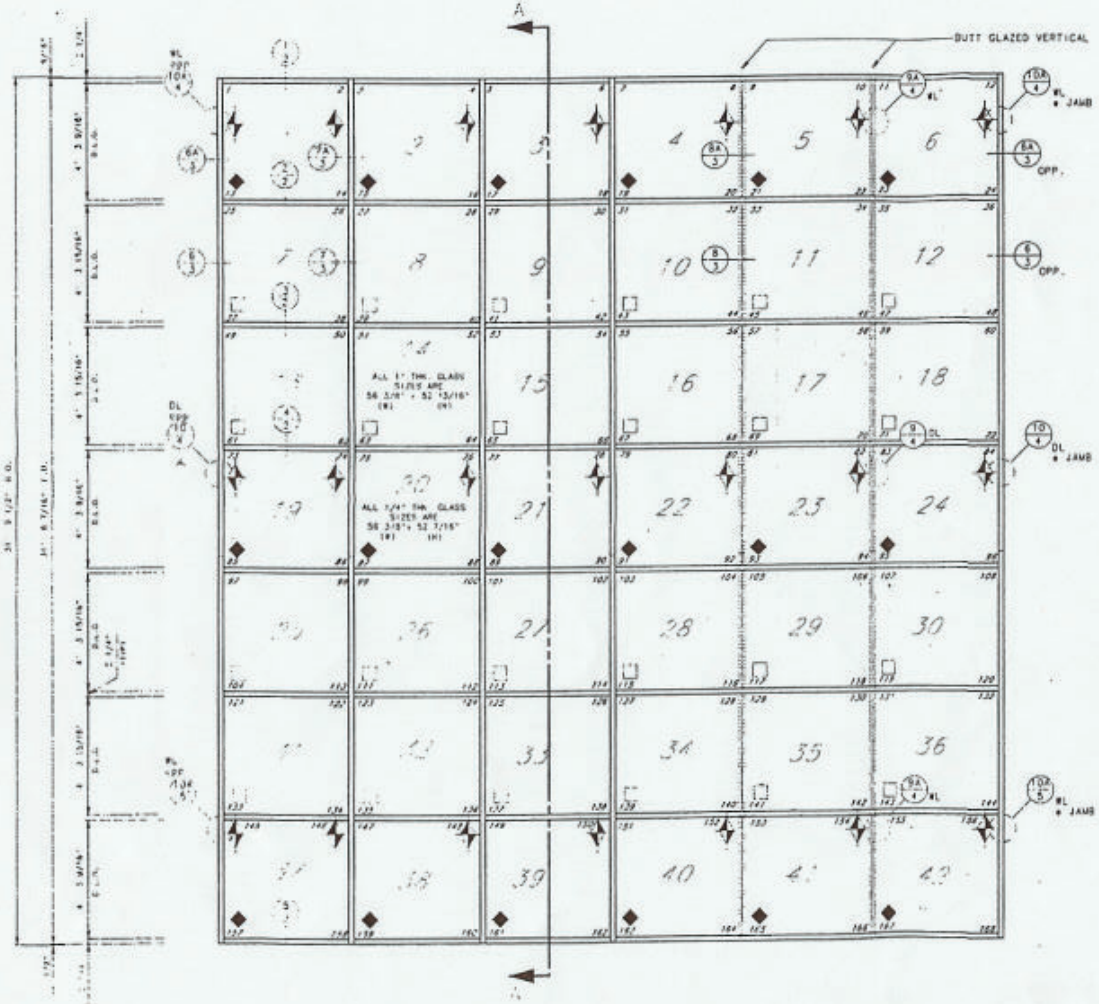
Respectfully submitted,

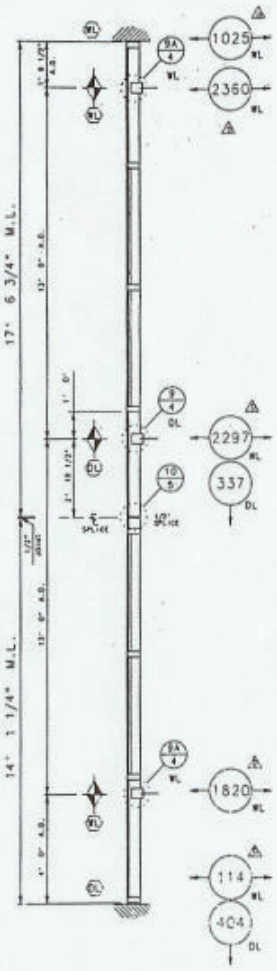
CONSTRUCTION CONSULTING LABORATORY, *INTERNATIONAL*

KENNETH H. LLOYD JR., P.E.
MANAGER

JOSEPH P. SOLINSKI
PRESIDENT







ELEVATION VIEW FROM EXTERIOR

WALL SECTION A-A

TEST REQUIREMENTS

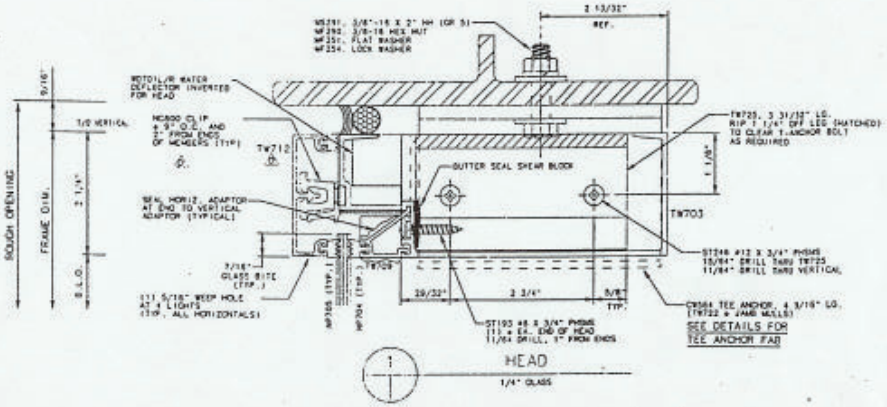
INFILL:	1" CLEAR IG UNIT, TEMPERED 1/4", CLEAR SPANDREL, TEMPERED
FINISH:	CLEAR ANODIZED
STRUCTURAL SILICONE:	DOW 795
PERIMETER SEAL:	DOW 795
SYSTEM SEAL:	DOW 795

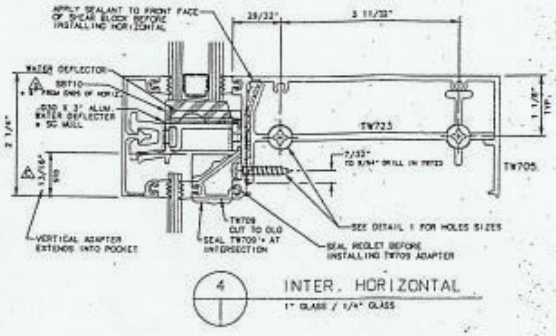
NOTES:
TEST COMPLETED 9/28/99 @ CONSTRUCTION CONSULTING LABORATORIES, CARROLLTON, TX

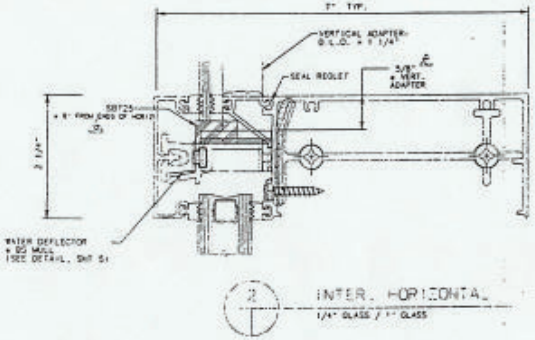
CONSTRUCTION CONSULTING LABORATORY, INTERNATIONAL
1601 Luna Road
Carrollton, Texas 75006
Phone (972) 242-0556

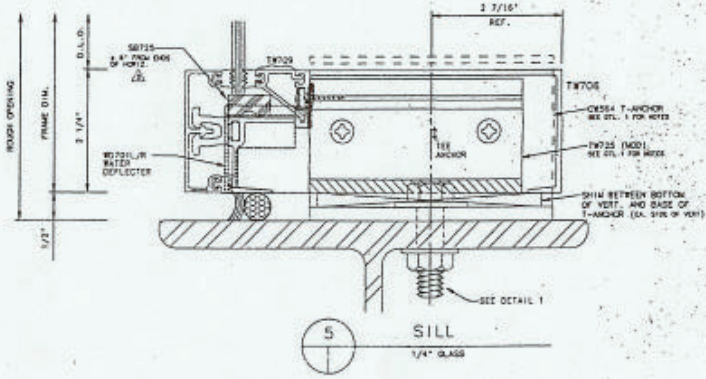
PATENT PENDING

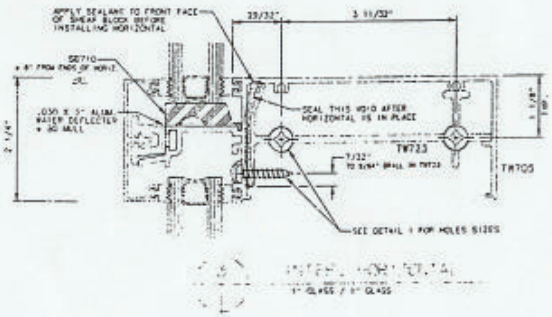
PROJECT: MOCK-UP
ARCHITECT:
CUSTOMER: UNITED STATES GYPSUM
UNITED STATES GYPSUM CORPORATION
DRAWN BY: G.HAGL
DATE: 1-8-99
DRAWING NO: W98019-D
SHEET: 1 OF 5







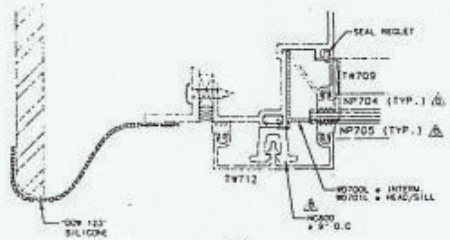




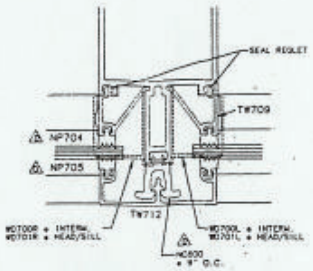
CONSTRUCTION CONSULTING LABORATORY, *INTERNATIONAL*
1601 Luna Road
Carrollton, Texas 75006
Phone (972) 242-0556

PATENT PENDING

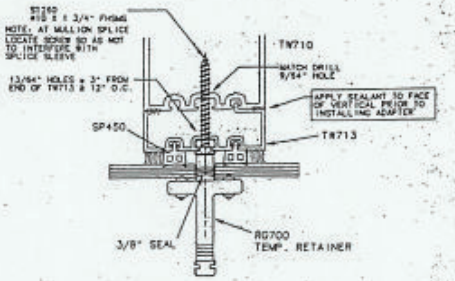
PROJECT: MOCK-UP
ARCHITECT:
CUSTOMER: UNITED SYSTEM ALUMINUM CORP.
DRAWN: G.HALL
DATE: 1-9-98
DRAWING NO: 498019.0
SHEET: 2 OF 5



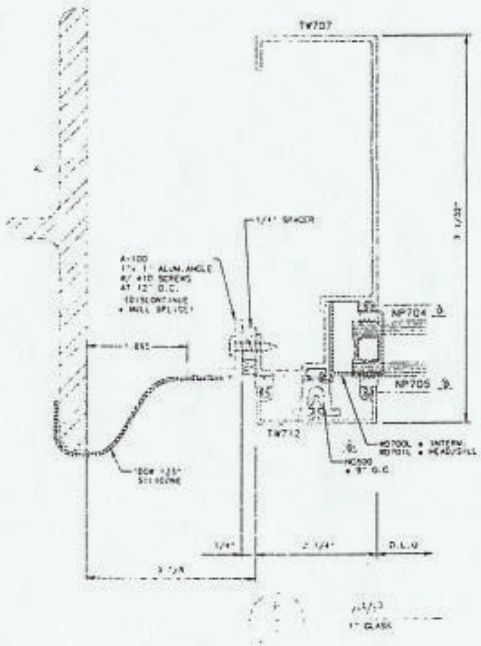
6A JAMB
1/4" GLASS



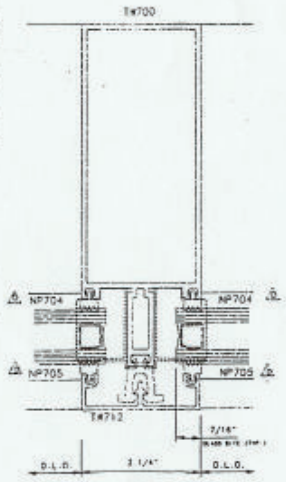
7A INTER. VERTICAL
1/4" GLASS



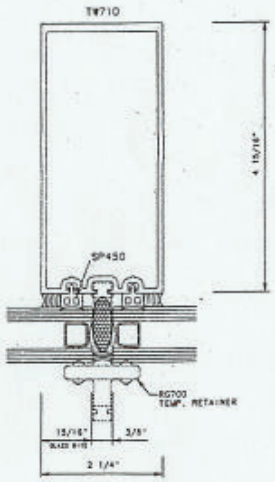
8A INTER. VERTICAL
1/4" GLASS



7 INTER. VERTICAL
1" GLASS



8 INTER. VERTICAL
1" GLASS



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PATENT PENDING

PROJECT: MOCK-UP
DRAWN BY: G. HALE
DATE: 1-8-09
DRAWING NO: M08019-D
SHEET: 5 OF 5