RACKING TEST EVALUATION OF EN-WALL 7250 UNITIZED CURTAIN WALL SYSTEM WITH 3M™ VHB™ STRUCTURAL GLAZING TAPE

Final Report

Submitted to:

3M Industrial Adhesives & Tapes Division
3M Center, Bldg. 220-5E-06
St. Paul, MN 55144-1000

by

Ali M. Memari, Ph.D., P.E., Professor
Kenrick Hartman, Former Graduate Student
Paul A. Kremer, Research Associate

Department of Architectural Engineering
The Pennsylvania State University
104 Engineering Unit A
University Park, PA 16802

March 15, 2011

Summary

Results of cyclic racking tests on two full-scale specimens of EN-WALL 7250 Unitized Curtain Wall Gasket Seal system (EN-WALL 7250 system) are presented. The objective of the study was to determine the performance of this type of curtain wall system under cyclic displacements and identify any type of failure that could occur under very large drifts. The test units (specimens) had overall dimensions of 180 in. wide by 156 in. high and were comprised of nine insulated glass panels bonded to aluminum framing with 3M™ VHB™ Structural Glazing Tape G23F. Racking tests followed the American Architectural Manufacturers Association (AAMA) 501.6 protocol to characterize the performance of the system. Tests were carried out in a step-wise manner in order to stop the test after each drift increment to inspect the specimen for any damage. Tests were carried out for unrestrained and restrained end boundary conditions. In summary, the full-scale specimens did not sustain any glass and 3M™ VHB™ Structural Glazing Tape G23F damage when subjected to AAMA 501.6 racking tests. Some framing derailment occurred under very high drifts when certain boundary conditions were imposed. A complete description of the unitized system design is presented along with racking test observations of potential serviceability issues. Air leakage tests were also performed to evaluate the serviceability performance with respect to air leakage after large drifts were experienced by the wall system.

Disclaimer

The material presented in this report is intended to provide a better understanding of the simulated seismic response of unitized curtain wall systems. The material in this report including the data and procedures shall not be relied upon under any circumstances for any specific application or actual projects without consultation by a licensed design professional experienced in the field of glazing systems design. Anyone using the material in this report assumes ALL liability resulting from such use, and the authors, Penn State University, 3M Industrial Adhesives & Tapes Division, or EN-WALL are not in any way liable for such use.

Table of Contents

1. Introduction

The use of structural sealant glazing (SSG) to adhere glass panes to glazing frames (Dow Corning 2006) as an alternative to dry glazing or capturing glass pane edges at mullion pockets with rubber gasketing has increased over the years. Furthermore, when glass is adhered to framing using SSG, the sealants will experience shear deformation if the curtain wall system is of stick-built type and goes through racking (Memari et al. 2006, 2010). In order to minimize the strains in the structural sealants and the opportunity to save on labor costs through shop glazing, unitized framing systems have become more common in recent years. In unitized systems, the glass is shop-glazed using SSG construction to avoid job site application of structural sealant for better quality control. Furthermore, the framing is isolated at each floor level from the framing above through a sliding joint known as a "stack joint." In such construction, the unitized curtain wall at each story can slide horizontally with respect to the curtain walls of adjacent stories and thus provide a form of seismic isolation against in-plane interstory drifts. In such cases, the wall panel is expected to "sway" and not actually "rack" as in the stick-built systems.

Unitized systems have traditionally employed structural silicone sealants to bond the glass lite to the frame, but double coated acrylic foam tapes have also been used as an alternative method of bonding the glass to the frame. Structural glazing tapes allow the use of framing systems that are very similar to those used for silicone sealants (3M 2008). According to the 3M™ VHB™ Structural Glazing Tape technical data sheet (3M 2006), "*3M™ VHB™ Structural Glazing Tape is a high performance double-coated pressure sensitive acrylic foam tape. It is used to attach glass to metal frames in glass curtain wall systems replacing commonly used mechanical fasteners, gaskets or structural silicone sealants. Application performance and test results* *demonstrate the outstanding durability, UV resistance and temperature performance of 3M™ VHB™ Tape acrylic foam chemistry.*" Few studies have been conducted to evaluate the seismic performance of unitized curtain wall systems, and this report represents one of the first full-scale experimental simulated seismic studies on this type of unitized systems with structural glazing tape. Testing for this pilot study consisted of cyclic racking tests on two EN-WALL 7250 unitized wall system specimens using 3M™ VHB™ Structural Glazing Tape G23F to form the structural seals. Racking tests followed the AAMA 501.6 test protocol (AAMA 2009), and were carried out in a step-wise manner to better characterize the performance of the system by allowing thorough inspection of the specimens for any damage between each step. Although the AAMA 501.6 protocol focuses on the occurrence of glass fallout, additional information related to seal damage and frame damage were also collected. The objective of the study was to determine the performance of this type of curtain wall system under imposed cyclic displacements and identify any type of failure that could occur under very large drifts. In this report, a complete description of the unitized system design is presented along with the racking test as well as air leakage test results.

2. Description of Test Specimens

The test specimen shown in Figure 1 was comprised of six (6) EN-WALL 7250 Curtain Wall Units (U1-U6) containing nine (9) glass lites positioned three panes high and three panes wide. The configuration simulated a story height in a typical commercial building with two spandrel areas and a section for vision glass. 3M Industrial and Adhesives and Tape Division (3M) has developed 3M™ VHB™ Structural Glazing Tape G23F as an alternative to wet and dry glazing. Rather than applying a thick liquid silicone sealant bead to the perimeter of the glass, 3M™ VHB™ Structural Glazing Tape G23F structural glazing tape performs like a peel and stick adhesive sealant, resulting in much cleaner and quicker assembly that does not rely as much on a worker's craftsmanship (3M 2008). This tape bonds on contact with no curing or drying time, making it an easier to apply with no mess or clean up and significantly less waste. Also, many two-part silicone glazing products require testing before application to verify mix ratio and cure time, but the 3M™ VHB™ Structural Glazing Tape G23F does not need to be tested each time as it is fully cured at the factory. For the study presented here, EN-WALL provided two curtain wall test specimens with outside dimensions of 180 in. wide by 156 in. high comprised of nine glass panels. Each specimen was made up of the EN-WALL 7250 Curtain Wall system that had 1-1/4 in. thick fully tempered insulating glass units consisting of fully tempered monolithic 1/4 in. thick inner and outer lites with a 3/4 in. air space. These glass panels varied in height and width according to the dimensions provided in Figure 1. 3M™ VHB™ Structural Glazing Tape G23F, a two-sided pressure sensitive acrylic foam tape, was used to form the structural seal bond between glass lites and aluminum extrusion surfaces within the specimens. Details of the specimens are shown in Appendix A.

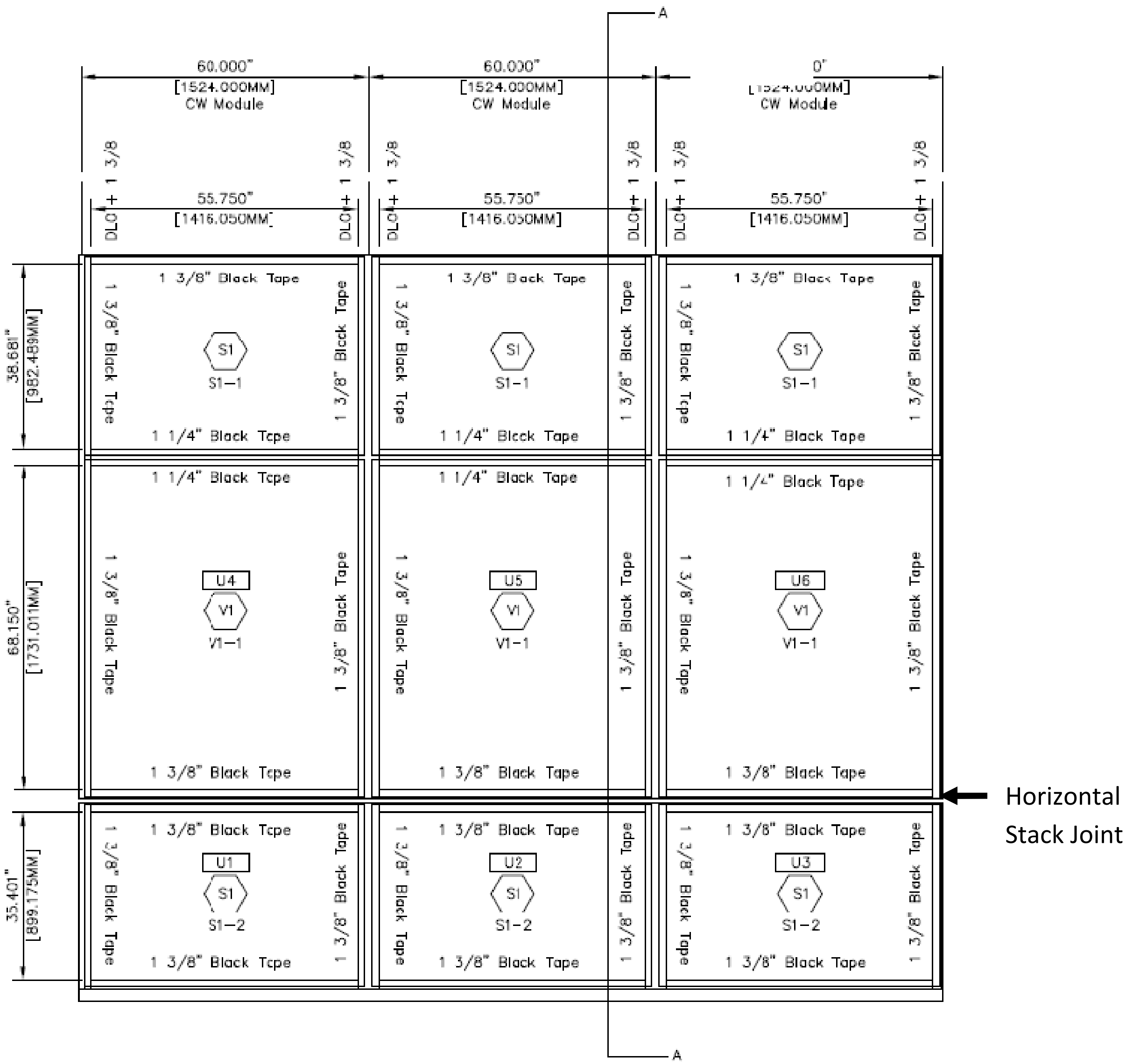


Figure 1- Unitized System (EN-WALL)

3. Testing Program

The racking test facility in the Building Envelope Research Laboratory at Penn State University was used for this study. Figure 2 shows a drawing of the racking test facility. The facility consists of two sliding steel tubes connected by a fulcrum arm. An actuator applies a given displacement to the bottom sliding tube, and through the fulcrum arm, the top tube moves an equal displacement in the opposite direction. This motion simulates the drift a single story may experience during an earthquake.

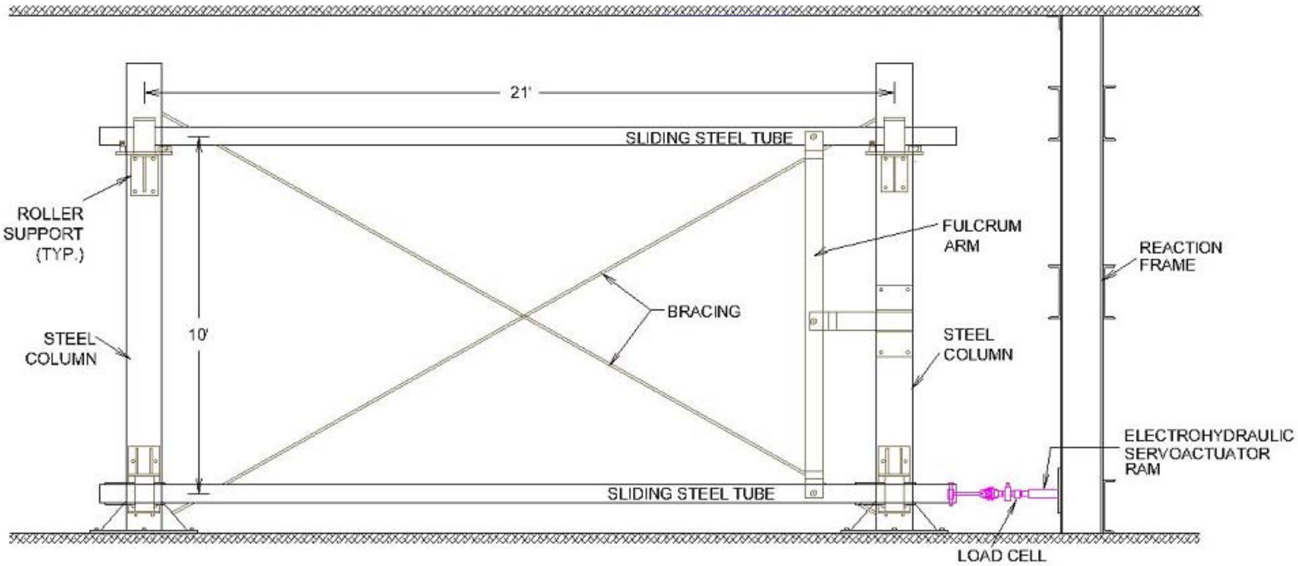
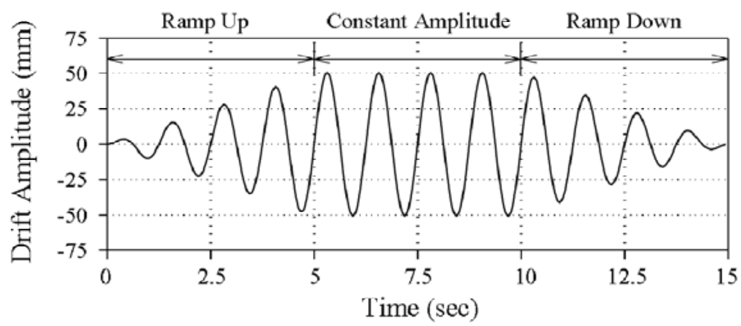
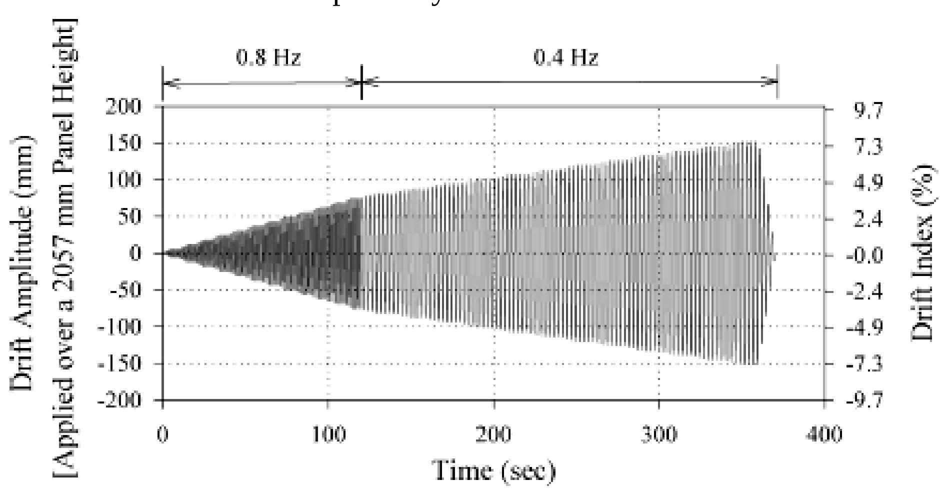


Figure 2 – Racking Facility

The specimens were tested according to the displacement-controlled racking protocol recommended in AAMA 501.6 (AAMA 2009). This test method is characterized by monotonically increasing-amplitude sinusoidal drift cycles that determines the serviceability and ultimate drift limits for architectural glass components subjected to cyclic, in-plane racking displacements. Recent experimental testing on the facility has utilized the test method in a "stepwise" fashion (rather than continuous) as a way of accurately recording the glass and glazing system serviceability performance parameters. The "stepwise" test method consists of a series of alternating "ramp up", "constant amplitude", and "ramp down" intervals, each comprised of four sinusoidal cycles where each step increases by 1/4 in. increments. Figure 3(a) depicts a typical racking step used in the stepwise crescendo racking tests, while Figure 3(b) shows the continuous time history of the crescendo test method when the steps are concatenated and the "ramp down" intervals removed.



(a) Typical racking Step (Step 8; 0.8 Hz; 2.5% drift% Drift Index.) for AAMA 501.6 stepwise dynamic crescendo tests



(b) Entire crescendo test

Figure 3. Drift Time Histories for Crescendo Test Method

The unitized specimens were mounted directly to the steel sliding tubes spaced at ten feet to simulate a typical floor height as shown in Figures 4 and 5. Frame-to-structure connections designed by EN-WALL for an actual installation of the unitized wall system on a building were used as shown in Figure 6. The connection used extruded aluminum anchor knuckles (clips) bolted on either side of vertical mullions to engage custom-formed steel angles attached to the racking facility (representing the building structure). Anti-walking clips were also mounted on the support angles on the outside of the knuckles. The facility was also modified with three 3/4 in. plates and a 16 ft long 8x6x1/2 angle that were mounted to the bottom sliding tube as shown in Figure 7. The bottom of the unitized system was then anchored to this angle.

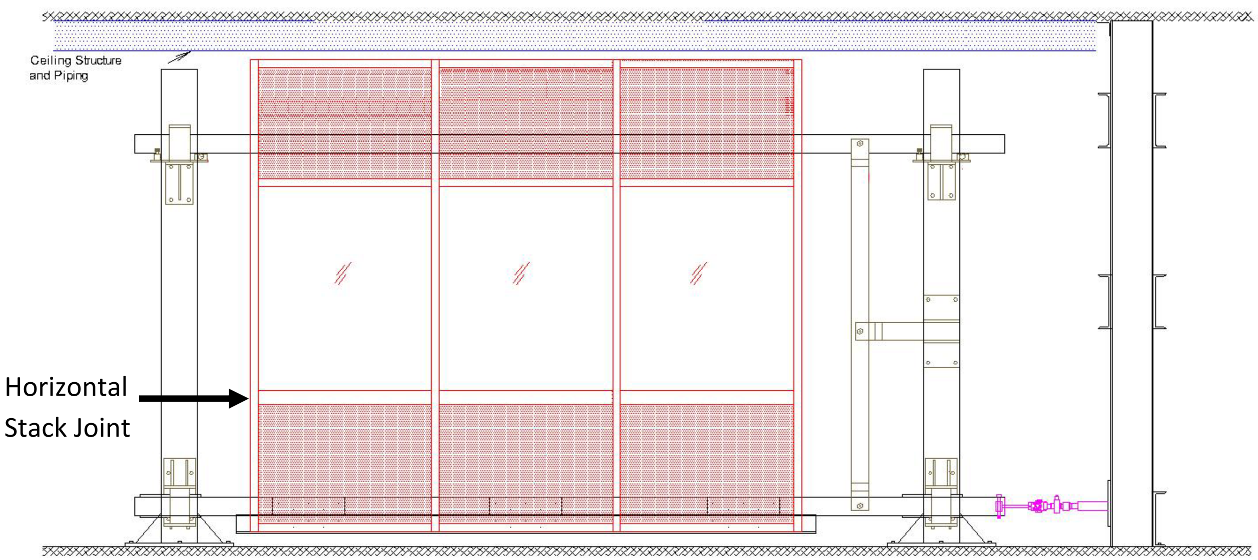


Figure 4- Unitized System Mounted to Facility

Figure 5- Photo of the Actual Specimen on the Facility

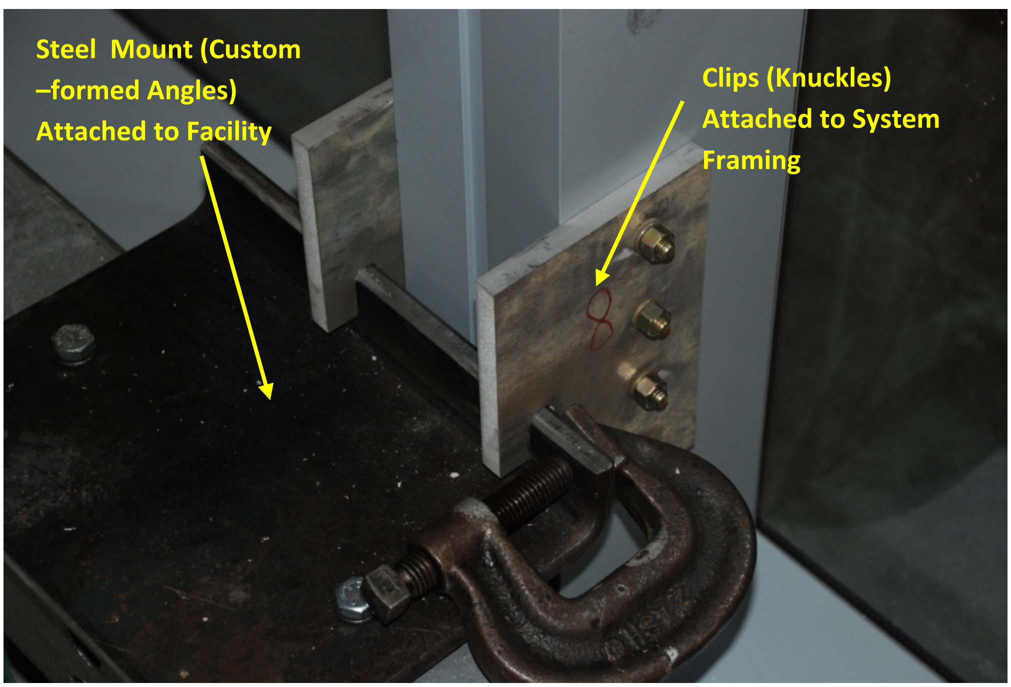


Figure 6- Additional Steel for Frame-to-Structure Connection

Figure 7- Attachment of the Bottom of the Specimen to the Facility

4. Test Setup and Specimen Assembly

The EN-WALL 7250 Curtain Wall units were fabricated and glazed by EN-WALL in a shop environment. The completed units were then shipped to the Building Envelope Research Laboratory in the Architectural Engineering Department at Penn State University. The panels were assembled in the Building Envelope Research Laboratory to construct the specimen on the racking facility. The unitized system was composed of 6 panels, 3 of which are considered larger panels with two lites of glass (shown laying on its side in Figure 8) and the other 3 are considered smaller panels that are each composed of one glass lite (shown in Figure 9)

Figure 8- Larger Unitized System Panel (Interior View)

Figure 9- Smaller Unitized System Panel (Exterior View)

Like panels were clipped together at their vertical joints to form a wall system. The panels were simply pushed together so that the male mullion (left side) of one curtain wall unit engages the female mullion (right side) of the adjoining curtain wall unit. The male mullion unit contained two (2) EPDM air seal gaskets. Two hooks on the left side of the panel connected to two more hooks on the right side forming a mechanical connection that holds the system together. The left and right sides (relative to an exterior view of the system) can be seen in Figures 10 and 11, respectively.

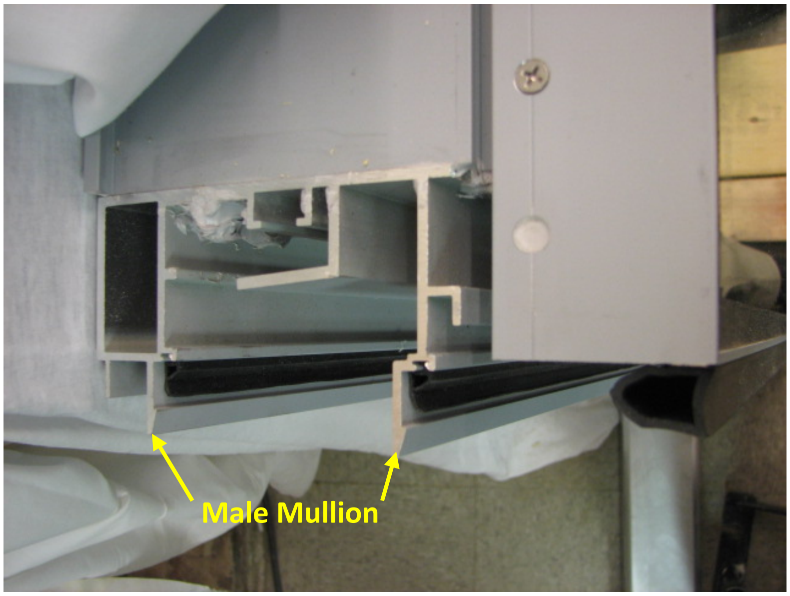


Figure 10- Left Side of Unitized System Panel (Male Mullion)

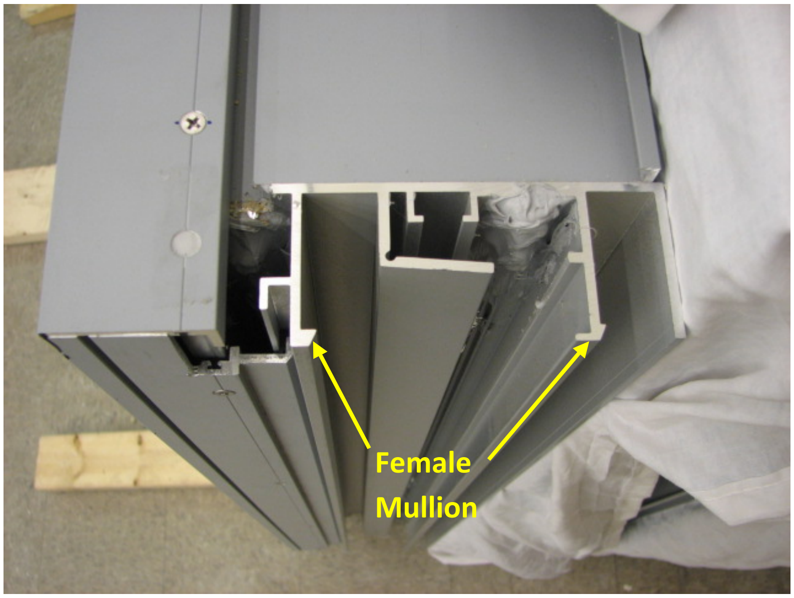


Figure 11- Right Side of Unitized System Panel (Female Mullion)

The taller panels were attached on top of the shorter panels through a continuous length horizontal stack joint that spanned all three panels where this joint connected to the top of the shorter panels and to the bottom of the taller panels. This stack joint was continuous across the width of all three panels. The stack joint attached to the lower panels can be seen in Figure 12 and the stack joint with the addition of the upper panels can be seen in Figure 13.

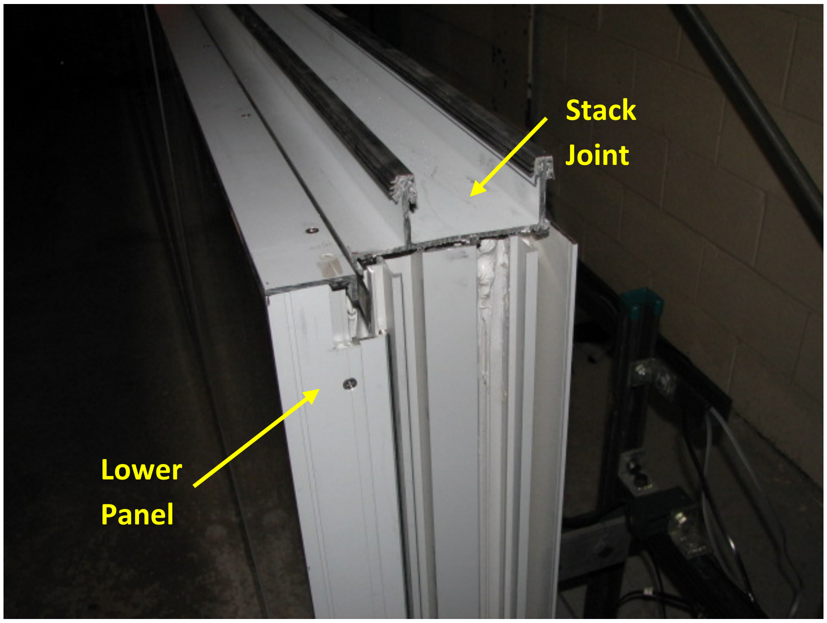


Figure 12- Horizontal Stack Joint Attached to Lower Panels

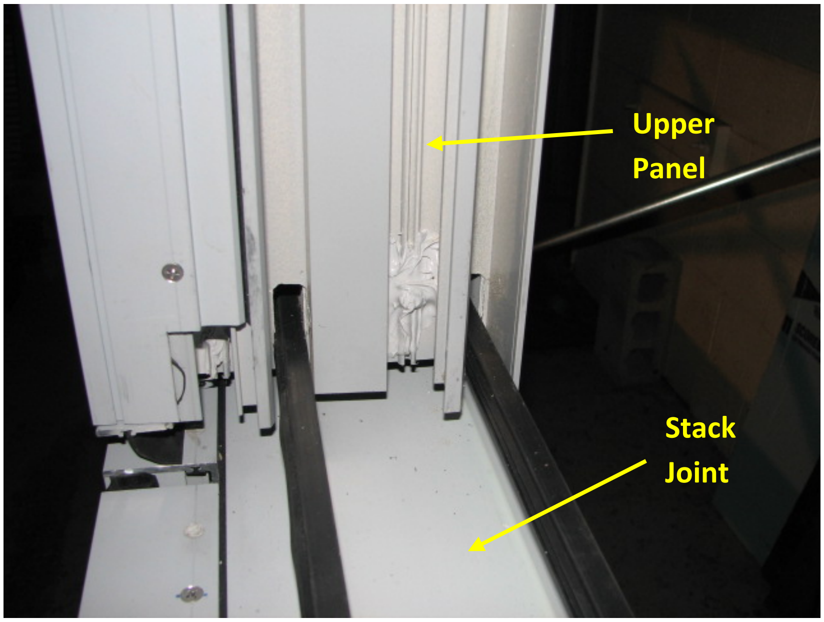


Figure 13- Horizontal Stack Joint Attached to both Lower and Upper Panels

The system was mounted to the racking facility through twelve dead load anchors or knuckles. Six of these anchors were attached to the framing (mullions) connecting the top three panels and six were attached to the bottom three panels. The anchors were attached to the unitized system using four bolts so that the anchors were butted against the inside face of the vertical mullions. These anchors then “sat” on custom-formed angles (steel plates) that were curved at 90° on one end. The plates were then bolted to the sliding tubes of the facility. The anchor setup can be seen in Figure 14. The holes in the mullions that were used to attach the dead load anchors were predrilled before shipment. However, additional holes had to be drilled for proper assembly of the specimens. Once the dead load anchors were installed and the specimen mounted to the facility, it was noticed that the prescribed clearance between the upper and lower panels at the horizontal stack detail was too large by approximately 1/4 in. This gap can be seen in Figure 15. To rectify the difference, the bearing surfaces of the dead load anchors were filed down to allow the upper panels sit lower and hence close the mentioned gap to the prescribed distance. Each dead load anchor was uniquely filed down as some anchors needed less adjustment than others.

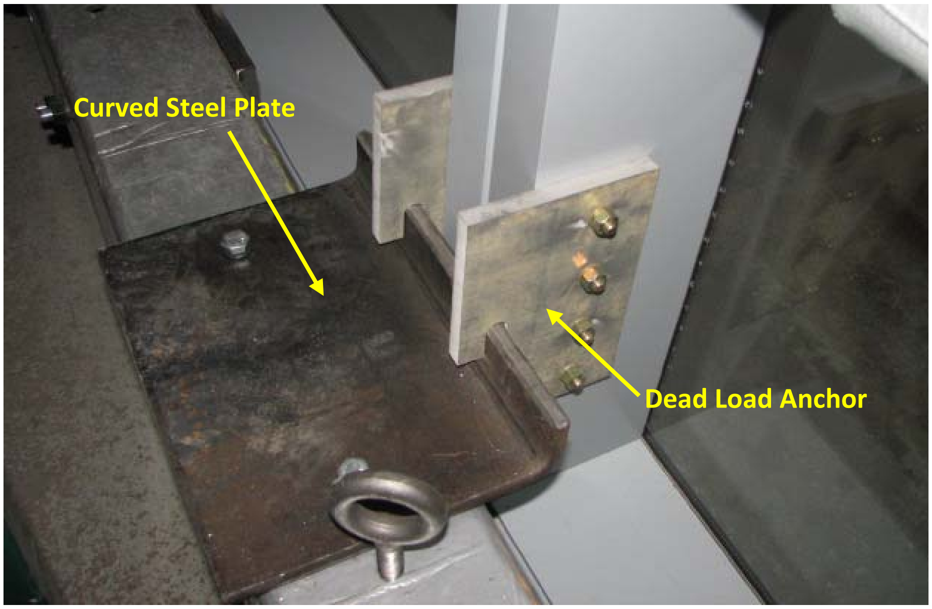


Figure 14- Dead Load Anchor Attachment

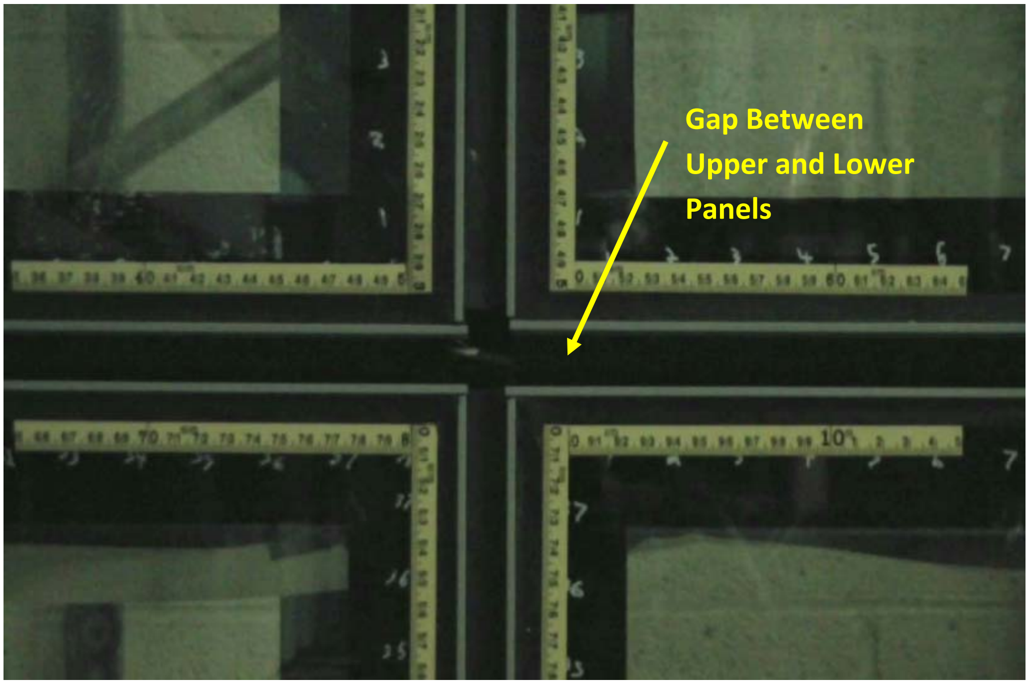


Figure 15- Gap between Upper and Lower Panels

To ensure the accuracy of testing, and also to acquire measured data in addition to visually monitored data, sensors were used on a number of glass panels. Sensors were attached to both the glass panels and to the racking facility itself. The upper and lower steel tubes had string potentiometers that were free to move in the vertical direction and thus measure pure horizontal motion. A direct current linear variable differential transformer (DC LVDT) was placed on the actuator to measure any displacement on the actuator plate. Also, the fulcrum arm had a direct current rotary variable differential transformer (DC RVDT) sensor that was mounted on a vertical and horizontal slide table to allow for free movement laterally. There were also two translation sensors mounted on the center panel (U5), the middle right panel (U6), and the lower right panel (U3), as shown in Figure 16. These sensors supplied data that measured the exact movement of glass and the relative movement of the respective glass panel with respect to the other panels and sensors. Also sensors were placed on the two dead load anchors to better determine if the dead load anchors were shifting relative to the facility. Table 1 summarizes the sensors that were used, and Figures 17 and 18 show photos of some of the sensors attached.

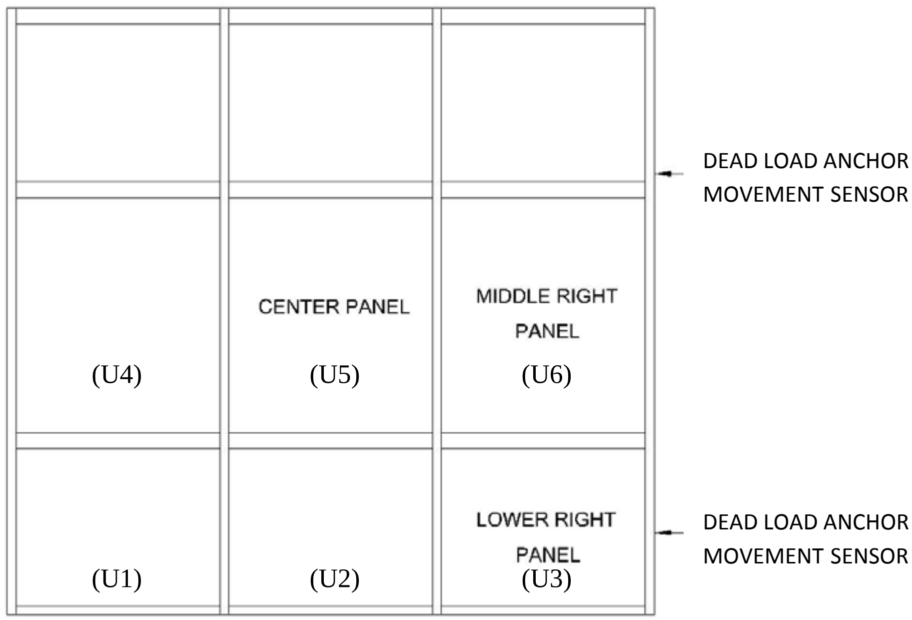


Figure 16- Unitized System Sensor Placement

Table 1- Sensor Summary

Item Measured	Sensor Type
Lower Tube Displacement	Linear Potentiometer
Upper Tube Displacement	Linear Potentiometer
Actuator Plate Displacement	DC LVDT
Fulcrum Arm Rotation	DC RVDT
Glass Panel Horizontal Translation (3 Panels)	Linear Potentiometer
Glass Panel Vertical Translation (3 Panels)	Linear Potentiometer
Glass Panel Rotation (3 Panels)	DC RVDT

Figure 17- Sensor on Dead Load Anchor

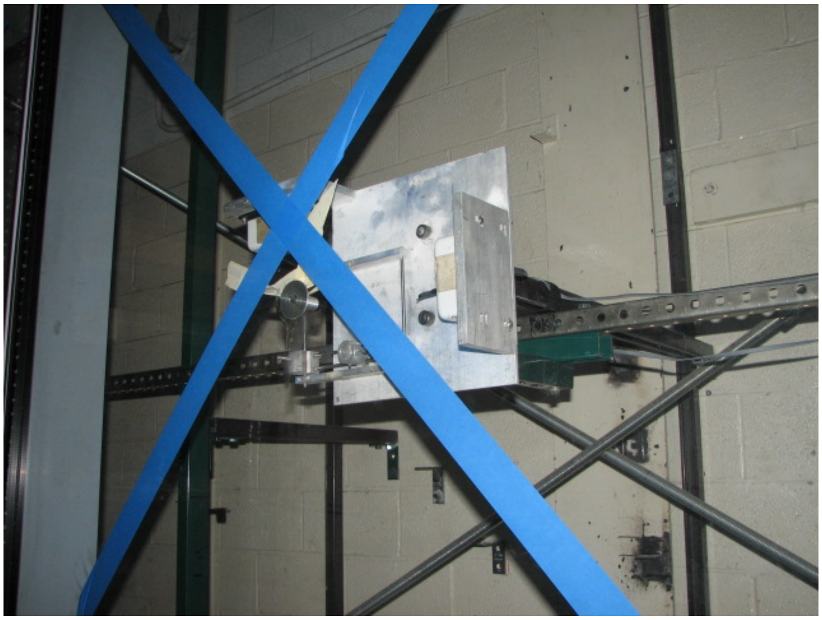


Figure 18- Photos of an Attached Sensor

The data collected from these sensors were used to evaluate the efficiency and flexibility of the racking system and determine the exact movement of a given glass panel. The sensors mounted on the top and bottom tubes experienced a series of peaks where the displacement is greatest in the positive and negative directions. The average of these values was taken and compared to the rotation that the fulcrum arm experienced. A displacement adjustment was used to account for the differences between the fulcrum arm rotation and the displacement of the upper and lower sliding tubes. A fully built specimen is shown in Figure 19.

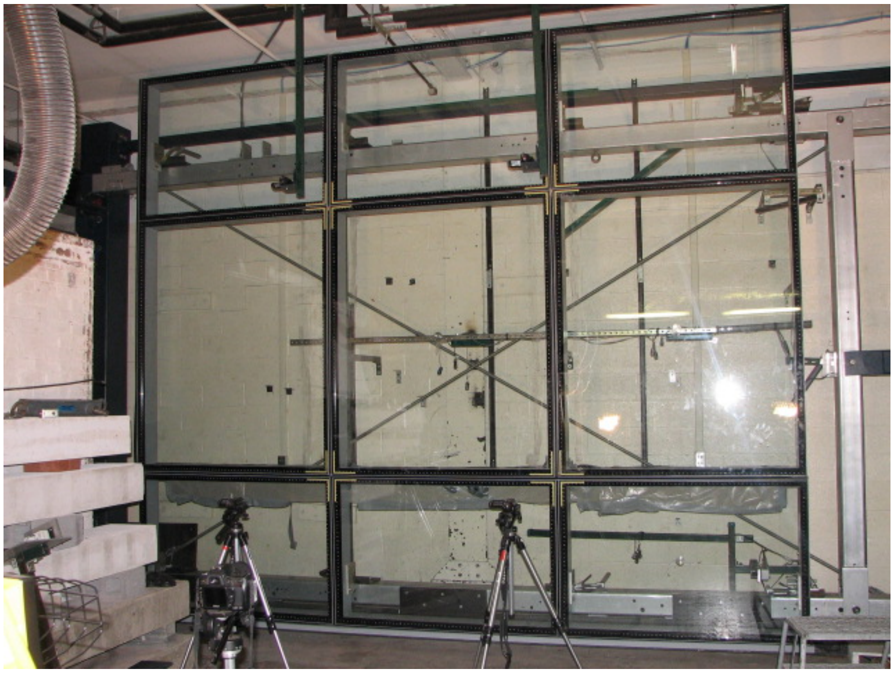


Figure 19- Fully Built Unitized System Test Specimen

5. Racking Tests of the Two Specimen

The main objective of the testing program was to evaluate the performance of the unitized system specimens with and without special end boundary conditions. In real-life construction, adjacent curtain wall panels are either planar (are along the same plane) or they intersect at corners (either interior or exterior corner). Furthermore, an end panel can be attached to a wall or column. In order to evaluate the performance of these planar specimens for corner or end wall/column boundary conditions, some artificial boundary conditions were created. The tests then included planar specimen test without and with some boundary restraint conditions. This section qualitatively reviews the results of the two unitized system specimens. The first specimen (Specimen 1) was tested twice, once without restraint at the stack joint and dead load anchors (Test 1), and once with restraints (Test 2). The second specimen (Specimen 2) had dead load anchor restraints and was tested three times, once without restraint at the stack joint (Test 1), and twice with two different types of restraints (Tests 2 and 3).

5.1 Specimen 1, Test 1

Racking tests were performed on the previously described unitized system. Because of the nature of inter-panel connections (at stack joint) it was expected that the system would be able to handle large drifts before the onset of any damage to the specimen. As expected, the first racking test on the first specimen (Specimen 1, Test 1) indicated that the horizontal stack joint was free to slide relative to the lower panels. This in turn translated very little force to the glass panels themselves. The rubber gaskets that connect to the upper panels were able to hold the upper panels in place, but the horizontal stack joint's connection to the lower panels provided little resistance against free translation. This movement can be seen in Figures 20 and 21.

Figure 20- Specimen 1. Test 1 before Racking Step

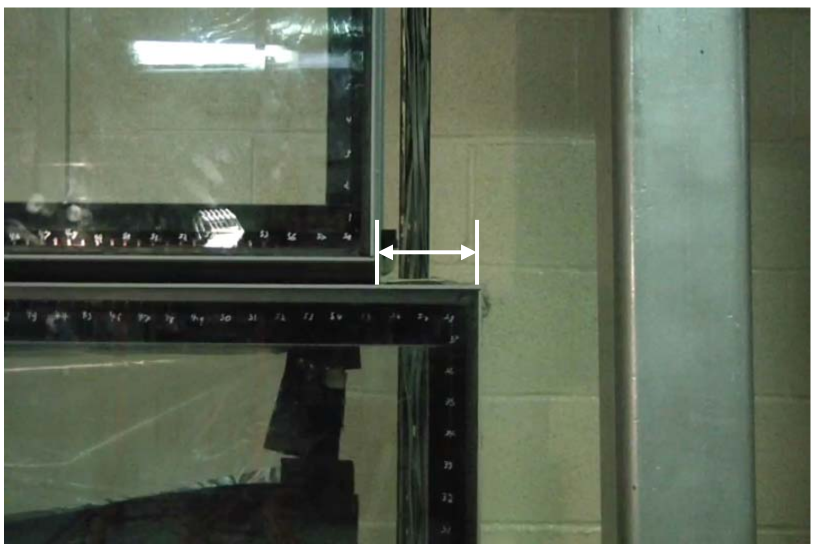


Figure 21- Specimen 1, Test 1 during Racking Step

The system also experienced permanent displacements similar to that shown in Figure 21. After the racking step of 1-3/4 in., the upper panels displaced 5/8 in. to the left relative to the lower panels. This displacement continued to grow. After a racking step of 2 in., this displacement grew to 1-7/16 in. Throughout the entire test, the three upper panels stayed connected to each other and the three lower panels stayed connected to each other. Glass panels did not rack and experienced very little load as a result of the sliding horizontal stack joint. However, upper panels exhibited permanent displacement, which increased as racking displacement increased, with respect to the upper sliding beams and therefore the lower panels because no anti-walking clips or clamps were installed. Stack wiper gasket and friction fit wedge spacer gasket pullout (Figure 22) was also observed during the racking test. Although these documented forms of gasket damage do not present a life-safety concern, they would lead to system maintenance to reset the panels and reinstall the dislodged gasketing. The wiper gasket is a rainscreen gasket, and the wedge gasket maintains spacing between framing components. Pullout didn't damage the gaskets, so they could be reused. Moreover, pullout of these gaskets does not represent a loss of primary seal within the system that could lead to unintended air leakage and moisture penetration through the system. However, potential seal loss related to permanent movement of the glass panels was not evaluated with this specimen.

The only "failure" that was observed was the sliding out of a wedge gasket that helped hold the horizontal stack joint to the lower panels and can be seen in Figure 22. Because of the relative movement between the horizontal stack joint and the lower panels the wedge gasket slowly worked its way out of the system. Because of the lack of glass damage to this specimen, a maximum displacement of 6 in. or a drift ratio of 5.0% was applied to the specimen multiple times, and after three racking steps at 6 in. the wedge gasket fully left the system. The test was considered completed after the first racking step of 6 in. without any damage to glass or 3M™ VHB™ Structural Glazing Tape G23F.

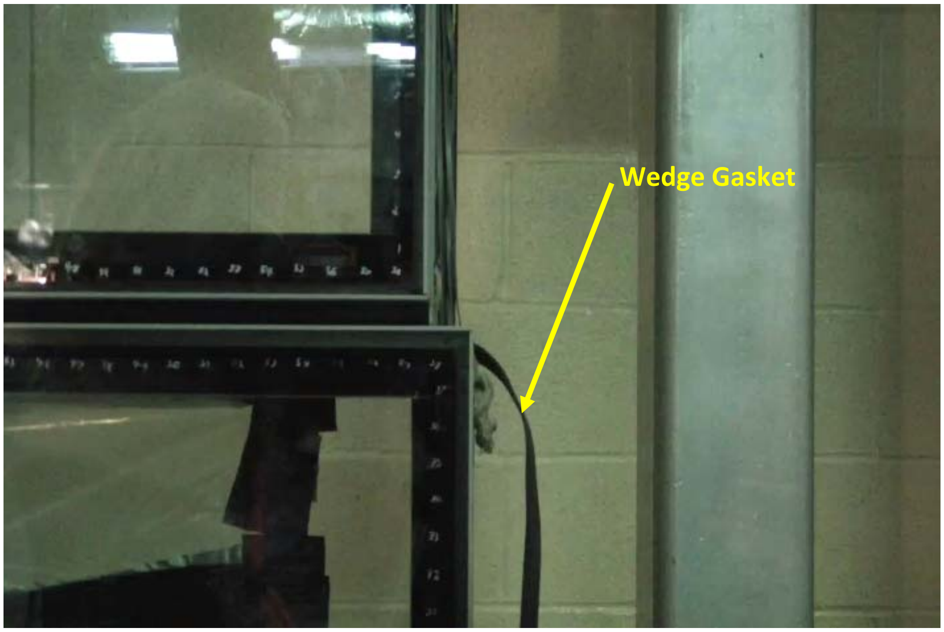


Figure 22- Wedge Gasket Leaving the System

The three primary damage states considered when testing glass systems consists of glass cracking, glass fallout, and gasket or seal degradation. While the wedge gasket shown in Figure 22 did leave the system after many racking cycles, the test resulted in no damaging stresses in the glass panels or any sealant damage, whether 3M™ VHB™ Structural Glazing Tape G23F or silicone sealant weatherseal. The glass was left undamaged even after reaching the displacement limits of the testing facility (6 in. actuator displacement (5.0% drift ratio)); hence, the cracking and fallout states were not reached. In other words, no such damage occurred under a maximum facility drift of 6 in. Gasket degradation usually refers to gaskets that surround the glass panel and not an internal gasket for the framing system. Observed stack joint and wedge gasket pullout may be avoided if the end condition was not open as was the case in testing. In a typical building installation, the right and left vertical sides that were exposed on the specimen would not be exposed. Instead, detailing such as an inside or outside corner connection or adaptation into another building wall system would most probably be present at the far boundaries of the wall system. The gasket may still pull out to some degree, but it would depend on restrictions presented by the boundary detailing. It is clear from this first test that the stack joint and anchor combination can minimize wall system component damage at large drifts because it does not restrict the panels from moving. During the initial test, the horizontal stack joint was allowed unlimited movement, while in an actual installation, detailing at the far boundaries would be expected to affect movement capacity and perhaps damage modes in a manner not evaluated in this initial test.

5.2 Specimen 1, Test 2

Test 2 of Specimen 1 was run using an end boundary condition to join the upper and lower panels. Because in practical applications of unitized systems on buildings some degree of restraint at the horizontal stack joint exists such as at corners of two perpendicular panels, it was desired to determine the behavior of the specimen if some form of restraint was used at the vertical edge. For this purpose, it was decided to first attach an aluminum bar to the vertical edge of the specimen to imitate the end detail shown in Figure 23 that shows the edge of the EN-Wall system anchored to the structure.

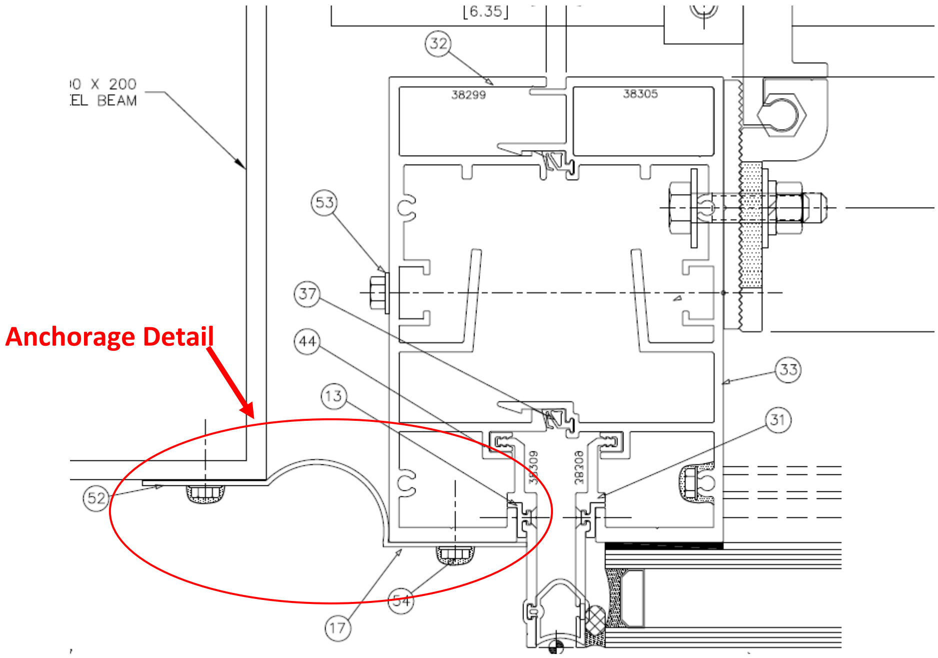


Figure 23- Side Anchorage Detail

The additional piece added was intended to help to tie the upper and lower panels (at the stack joint) together without over stiffening the mounted area. The added piece was only anchored to the top and bottom panels and not anchored to any part of the racking facility. It was shown through preliminary testing that the system did not see any damage if the top and bottom panels were tied together. In practical applications, the sliding movement (sway) at the horizontal stack joint would be restricted, and the added piece represented a more realistic condition compared to completely unrestrained situation. For this condition, a Kawneer 1600 pressure plate was used. This plate was chosen because of its stiffness properties as it was not overly stiff and was not expected to greatly restrict the systems inherent movement capacity if properly fastened to the edge. It was however stiff enough to appropriately limit movement in the system.

In addition, a combination of anti-walk clips and clamps shown in Figure 24 were mounted on both sides of the dead load anchors to restrict permanent displacements in both directions, and also to ensure that the dead load anchor knuckles did not slide off the curved steel plates completely. For ease of installation, multiple bar clamps were used and attached to the curved steel plate (custom-formed angle) so they were butted against the dead load anchors. Eight anchors were used, two at each corner panel, to restrict permanent movement of the system and also to ensure that the dead load anchors did not slide off the curved steel plates. An example of these bar clamps' orientation can be seen in Figure 25.

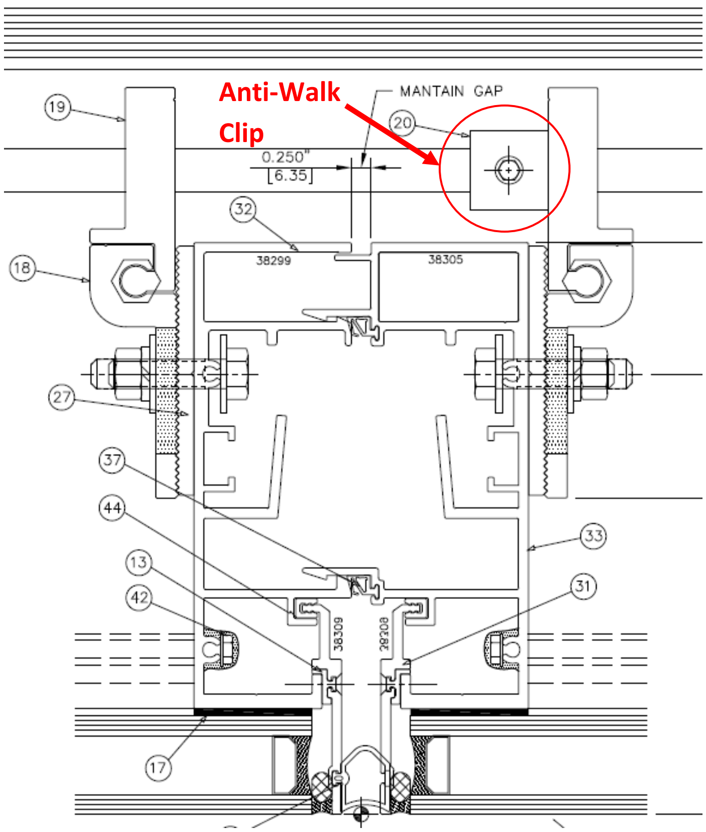


Figure 24- Anti-Walk Clips

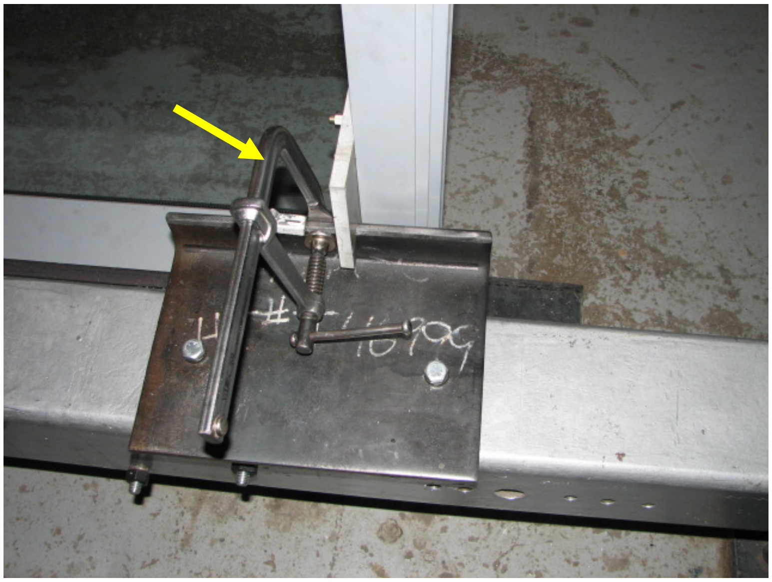


Figure 25- Bar Clamp Restraint

After the first racking test, the permanent drift observed was recorded by carefully realigning the lower and upper panels. The pressure plate was then attached to the right side of the unitized system using self-drilling (TEK) screws. Seven screws were spaced at 3 in. starting approximately 1 ft from the horizontal stack joint on both the upper and lower panels for a total of 14 TEK screws. It was predicted that screws that were placed close to the horizontal stack joint would easily pry out and thus the screws attached the plate at about 1 ft from the horizontal stack joint to allow deformation of the plate in this region. Figure 26 shows the pressure plate attached to the facility.

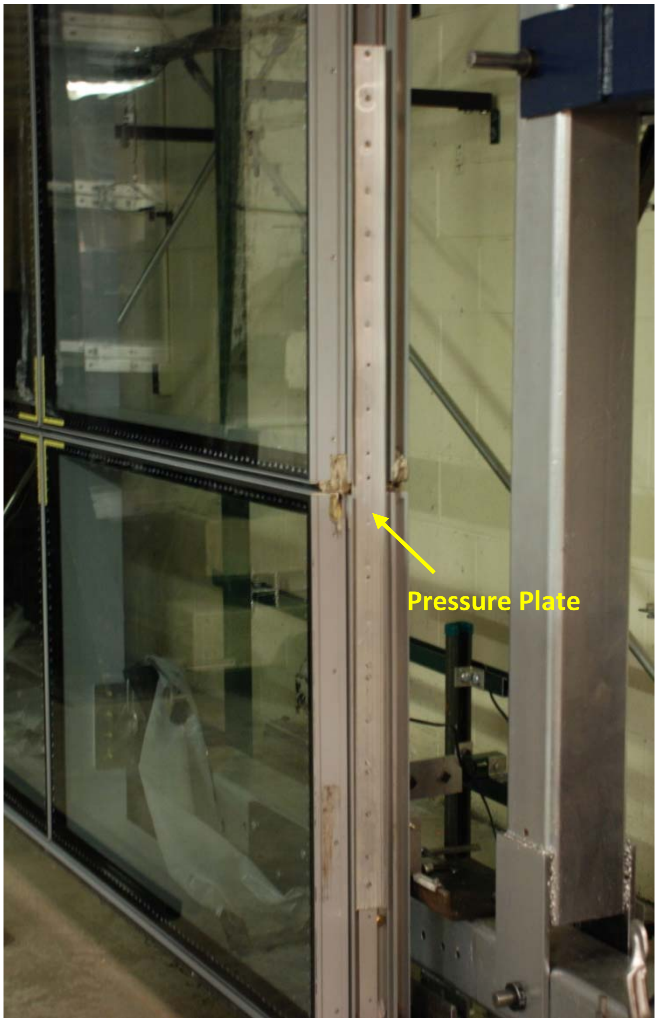


Figure 26- Pressure Plate Attached to First Specimen as an End Boundary Condition

After the installation of both the pressure plate end boundary and anti-walking clips and bar clamps around the anchor knuckles, Specimen 1 underwent a second round of AAMA 501.6 racking test (Test 2). The bar clamps worked as desired leaving the system with no permanent displacement after a given racking step. Prying action developed in the pressure plate during racking movement caused initiation of screw pull-out at the 2-1/4 in. racking step. Under smaller displacements, the screws remained engaged and the pressure plate bent and flexed with the racking movement. Once the displacement became large enough, the screws closest to the horizontal stack joint lost full engagement and began to pull out as shown in Figure 27. The screws that were placed farther away from the horizontal stack joint did not show signs of prying and stayed tightly fastened throughout the duration of the test. During larger displacements the pressure plate was observed to act solely as a tension member. Many screws were not subject to prying and therefore did not experience a large force in the direction of racking. These screws did, however, allow the pressure plate to carry the tensile loads created during racking movements. As the lower panels and upper panels move in opposite directions, the pressure plate was bent to meet this displacement. As a result, the pressure plate pulled the lower right panel towards the upper right panel (as shown in Figure 28). This does not represent a real world situation; however, the addition of this boundary condition induced some derailment. During the 5-3/4 in. racking step, the horizontal stack joint dislodged from the lower right panel. It is important to note that the wedge gasket could not be replaced before the second round of testing on this specimen (Specimen 1) and may have contributed to this behavior. The dislodged horizontal stack joint can been seen in Figure 29.

This damage mode may not occur in an actual installation because it does not fully represent the far boundaries used. Moreover, it may have little relevance because under such a large drift of 5.75 in. or a drift ratio of approximately 4.8%, the building structural system is severely damaged. According to the building code (ICC 2006, ASCE 2006), the maximum drift ratio allowed is 2.5%, which corresponds to a drift of 3.00 in. for the specimen, with the behavior as described above. More specifically, no damage was observed to the curtain wall at that drift level. However, because of the boundary condition imposed, loosening and pull-out of screws that attached the pressure plate end restraints were observed. Nonetheless, the objective of this second racking test was to investigate potential failure modes for more restrictive boundary conditions.

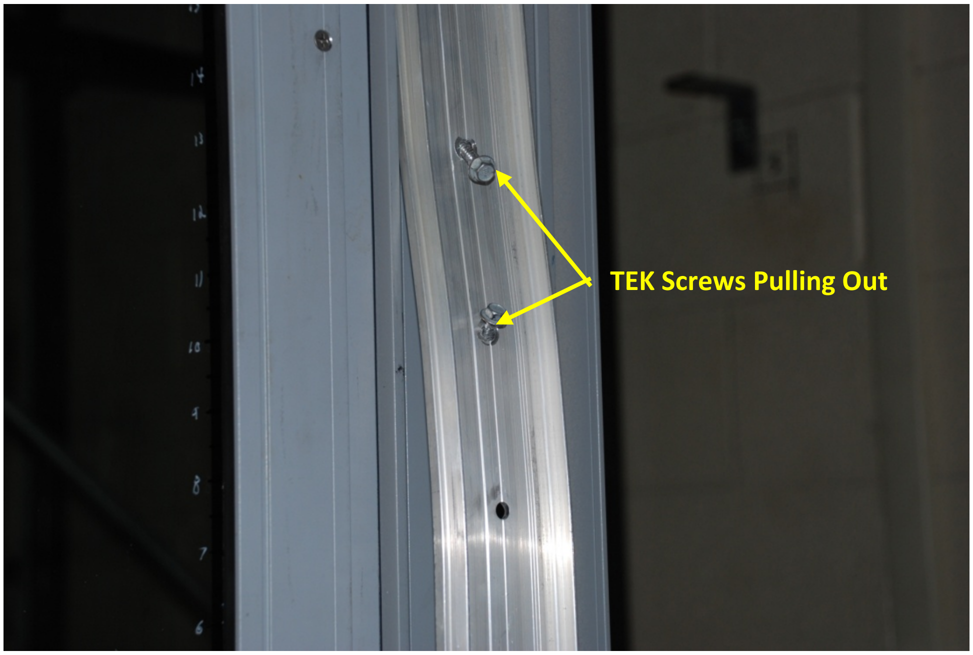


Figure 27- TEK Screws Pulling Out

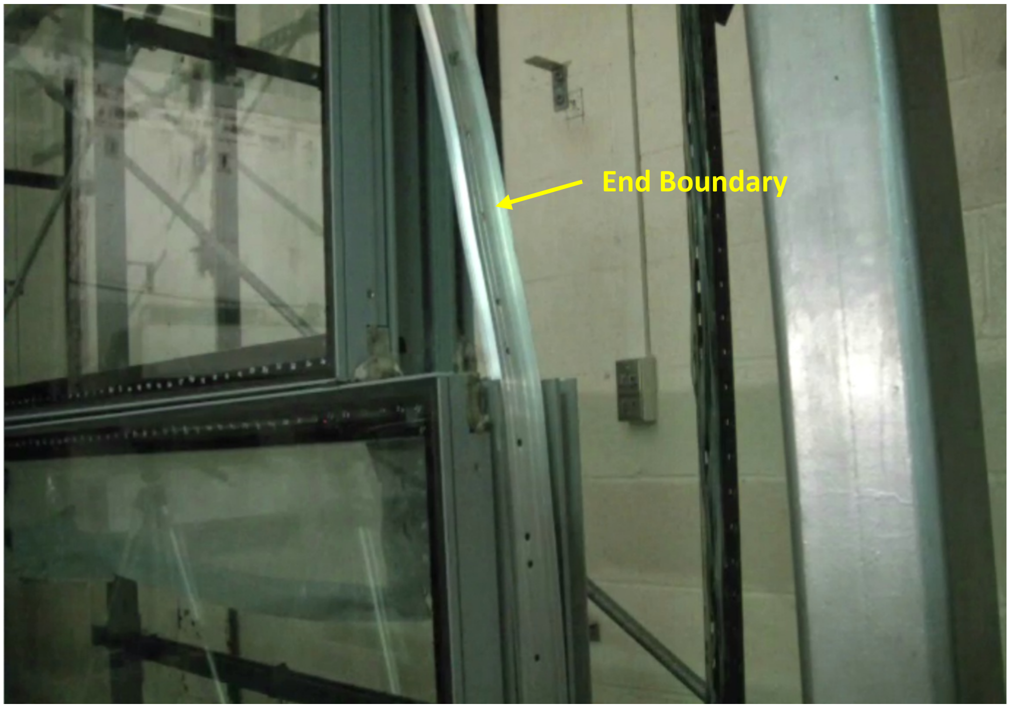


Figure 28- End Boundary Acting as a Tension Member

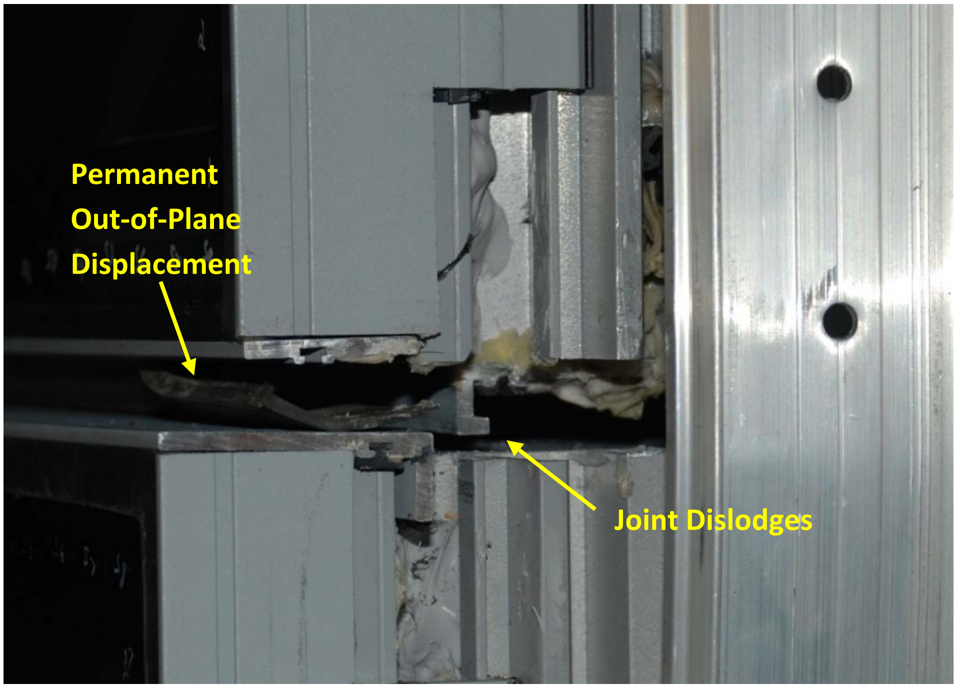


Figure 29- Dislodging of Horizontal Stack Joint and Lower Right Panel

As a result of the horizontal stack joint dislodging, the right panels were free to move out of plane as shown in Figure 29. Under such a boundary condition, this can potentially create a situation where an entire unitized panel or part of it has a greater chance of derailment at the stack joint. During possible subsequent additional racking, a panel's dead load anchors may slide off the curved steel plates (refer to Figure 15) or the racking motion may cause the dead load anchors (knuckles) to jump over the curved steel plate (custom-formed angles). This failure mode was not observed during testing, but the experiment shows the importance of sufficient dead load anchor design and its restraint.

It should be emphasized that the objective of adding the boundary conditions was indeed to impose a condition on the specimen to identify potential mode of failure if such a boundary condition is created as a result of building movement during an earthquake. Therefore, what this experiment showed is that the worst case scenario would be a potential derailment at stack joint. However, since the upper panel is supported by the bearing supports (curved steel plates (Figure 14), fallout of the panel as a whole is highly unlikely as a result of such derailment for properly designed and erected bearing supports, which the curtain wall designer would build into their respective systems.

5.3. Specimen 2, Test 1

A second unitized system (Specimen 2) was constructed in the same manner as the first specimen. This specimen was also subjected to three full, AAMA 501.6 racking test. The specimen was unrestrained during the first test (Test 1), and different end boundary conditions were employed for the second test (Test 2) and the third test (Test 3).

Although the Specimen 2, Test 1 did not use any type of restraint along the stack joint boundary between the upper and lower panels, bar clamps were installed around the knuckle anchors as previously described from beginning of the test to prevent translation of panels within the system. This test (Specimen 2, Test 1) did show some forms of damage. The vertical joints surrounding the upper center panel began to open up during the test. Inter-panel spacing between the center upper panel and the two neighboring upper panels were measured along the vertical joints at all four corners of the central upper panel throughout the test and are presented in Table 2. An example of racking-induced increases in the inter-panel spacing can be seen in Figure 30. Typical values for this joint dimension at the start of the test were about 0.6 in.

Table 2- Gap Between Upper Center Panel and Neighboring Upper Panels (in inches)

	Lower Left Corner	**Lower Right Corner**	**Upper Left Corner**	**Upper Right Corner**
After 1-3/4" Drift	0.92	0.61	0.61	0.58
After 2-1/2" Drift	1.06	0.61	0.59	0.62
After 2-3/4" Drift	1.18	0.61	0.58	0.62
After 3-1/4" Drift	1.21	0.61	0.58	0.61

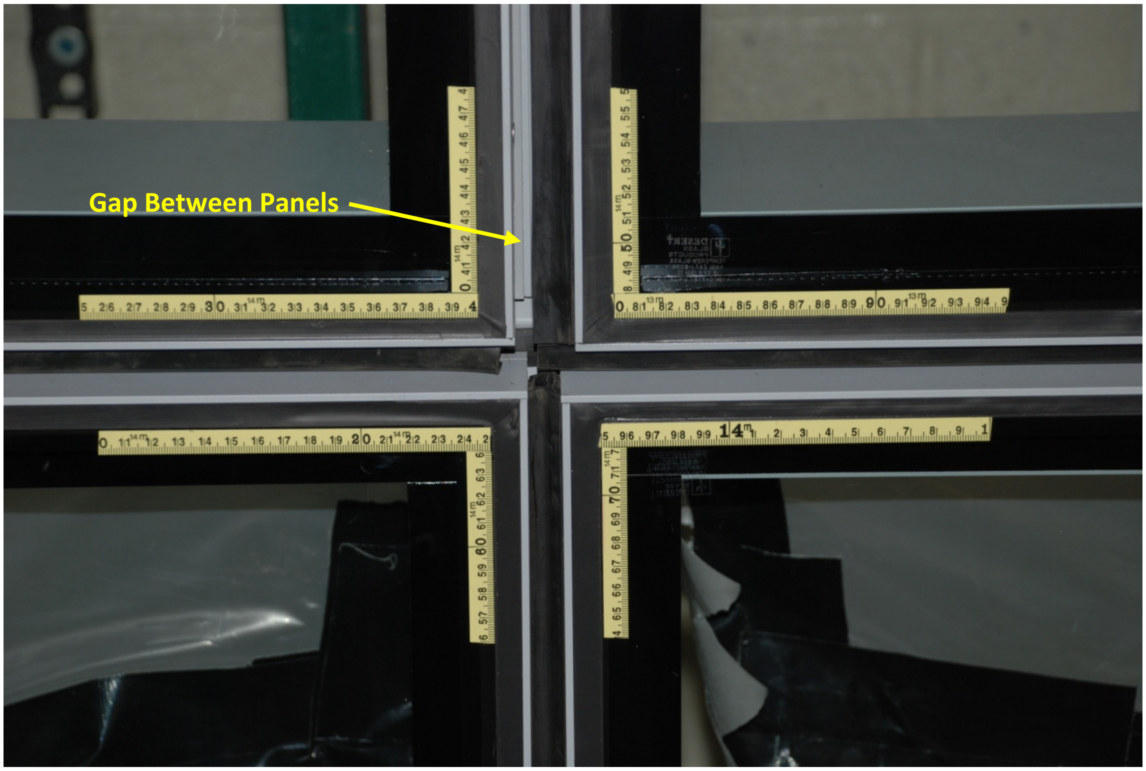


Figure 30- Gap between Center and Left Upper Panels

As shown in Table 2, the opening at the lower left corner of the upper center panel (shown in Figure 30) nearly doubled in magnitude from the start of the test (0.62 in. to 1.21 in.). This joint began to open up at a drift of 1.75 in. and continued to open until a drift of 3.25 in., beyond which the opening remained fixed. All other openings remained relatively constant throughout the test. This implies that, as an example, the upper left panel rotated clockwise and also translated slightly to the left to maintain a constant upper left corner inter-panel spacing. This form of damage is considered a serviceability failure because water and air would have a clear pathway through the system.

Wedge gasket that maintains spacing along the horizontal stack joint attachment to the lower panels pulled out at the lower left corner of the central panel. While the gasket was loose before it began pulling out, after the 4-1/4 in. racking step (3.5% drift ratio), the gasket protruded past the exterior face of the system. Figure 31 shows this after the 5-1/2 in. racking step (4.6% drift ratio) and also at the conclusion of this test. As noted for the second test of the first specimen (Specimen 1, Test 2), the high drift index associated with the onset of this gasket failure mode represents extreme conditions that would also likely be coincident with severe structural failure. As mentioned before, the objective of these tests was to develop a better understanding of how such a unitized system could fail under excessively large drifts. This behavior represents the curtain wall response under much more severe conditions than would be expected under building code design loading conditions.

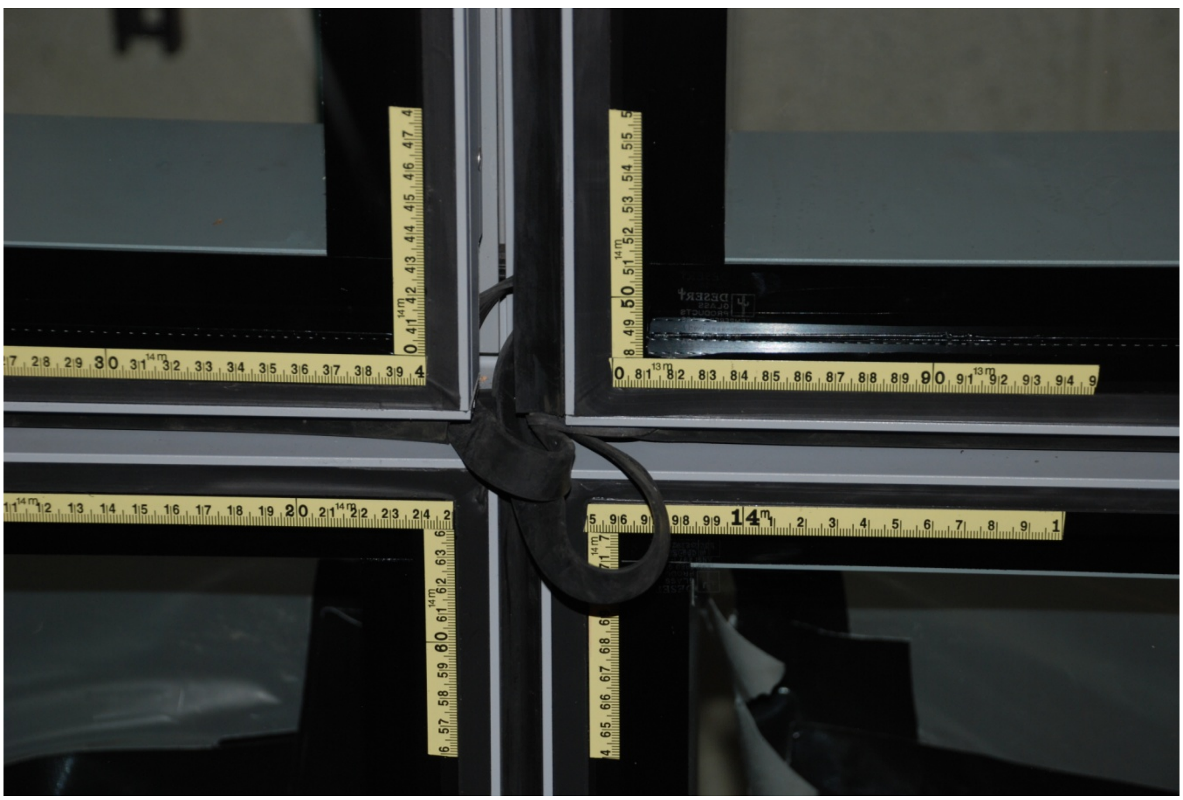


Figure 31- Wedge Gasket Pulling out at Gap between Panels

5.4 Specimen 2, Test 2

Because no permanent damage to the system was encountered during the first racking test, the second unitized system specimen was realigned and prepared for a second racking test (Specimen 2, Test 2). For this test, a new boundary condition was used in an effort to mitigate the amount of fastener pullout observed in the second test of the first specimen (Specimen1, Test 2) and to prevent the end boundary from acting as a tension member. It was observed that the fasteners used for the pressure plate boundary condition used in the first specimen test experienced significant prying. Also, once the fasteners closest to the horizontal stack joint pulled out, the pressure plate served mainly as a tension member. In an initial effort to create a more accurate boundary condition, two readily available aluminum angles and a slotted-hole aluminum connection piece were used. The aluminum angles were attached to the back side of the specimen at both ends so that the screws used for fastening were pointed out-of-plane (perpendicular) with respect to the racking plane. This orientation eliminated the prying action that occurred with the first boundary condition test. Also, the aluminum connection piece was made by milling slotted holes in the thin piece of aluminum bar used to link the two aluminum angle pieces together as shown in Figure 32. This slotted-hole aluminum angle boundary condition prevented the boundary condition from acting as a tension member.

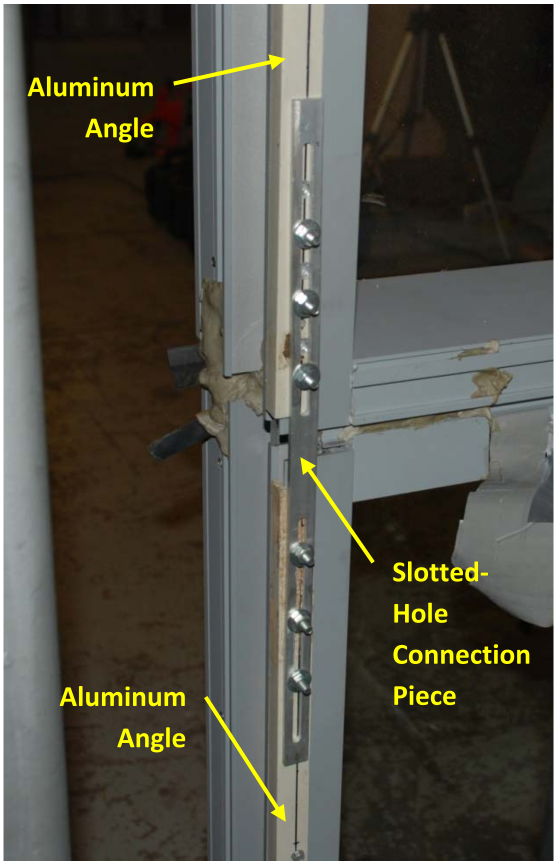


Figure 32- Slotted-Hole Aluminum Angle Boundary Condition

The slotted holes allowed for movement along the length of the piece so that the end boundary could resist considerable tensile loads in the connection detail. Early on in the racking test, the slotted-hole detail was observed to perform as desired, and allowed the free movement of the connection piece along its length. Ultimately, the piece did not perform as desired in the direction of racking due to the small cross section of the slotted-hole piece. It was observed that after the 1-3/4 inch racking step that the slotted-holes widened due to the in-plane racking forces. This widening of the holes can be seen in Figure 33.

Figure 33- Widening of Slotted-Holes

These holes continued to expand with racking, and at 2 ¼ in. drift the slotted holes effectively failed through widening and could not offer much restraint. Consequently beyond this point, the specimen behaved more like the first test of the second specimen with no boundary restraint. During the 2-1/4 in. racking step, the right boundary element failed and the slotted-hole connection piece was released from the system. The extent of the width of the slotted-holes can be seen in Figure 34. The test continued using only the left boundary element for two more racking steps and then the tests concluded when the right boundary element failed just as the left one did. Because of the lack of any effective boundary element, the system performed as an unrestrained system and of course no longer represented a realistic practical boundary condition. There was no failure in the unitized system during this test. It can be concluded that the boundary system used is not desirable for representing a corner condition found in typical unitized system construction. In this study, it was desired to select a boundary condition that created the worst case scenario while not unrealistically over stiffening the system. Also, part of the research was to investigate the effect of difference in the forms of boundary conditions on the response of the system.

Figure 34- Extent of Slotted-Hole Widening

5.5 Specimen 2, Test 3

Again, because no major damage was inflicted to the unitized system, the specimen was prepared for a third racking tests (Specimen 2, Test 3). A new boundary condition was used for this test that combined desired characteristics of the previous two boundary conditions tested. Two pressure plates, identical to the one used in the restrained test for the first specimen were attached to span both the right and left stack joint ends of the specimen using fasteners spaced at

6 in. Fastener holes through the pressure plate were also slotted to limit the development of significant tensile stresses within the boundary element. After application of the 1/2 in. racking step, it was noticed that the upper left panel separated from the upper center panel, much like in the second test of the first specimen. This time, the inter-panel spacing was affected along the entire vertical joint and increased significantly more than during the first specimen throughout the test. Table 3 shows the gap between the center panel and its neighboring panels after specific racking steps.

Table 3- Gap Between Upper Center Panel and Neighboring Upper Panels (in inches)

	Lower Left Corner	Lower Right Corner	Upper Left Corner	Upper Right Corner
Initial Gaps	0.66	0.58	0.56	0.61
After 1-3/4" Drift	1.08	0.62	0.56	0.61
After 3" Drift	1.38	0.62	0.85	0.62
After 4-3/4" Drift	1.46	0.63	1.16	0.62

The nature of these gaps differs slightly from those of the first specimen. The first specimen showed a gap only at the lower left corner, while the slotted-hole pressure plate end condition test showed a large gap at the top and bottom of the left vertical center panel edge. This slotted-hole pressure plate end boundary experienced a similar failure to that of the first restrained test (first and second specimens 1 test 2). During the 4-1/4 in. racking step, the horizontal stack joint dislodged from the lower left panel as shown in Figure 35. The lower left panel was pushed towards the exterior of the wall system relative to the upper left panel. Again, this represents a derailment potential noting that only the dead load anchors would be holding the upper left panel in place.

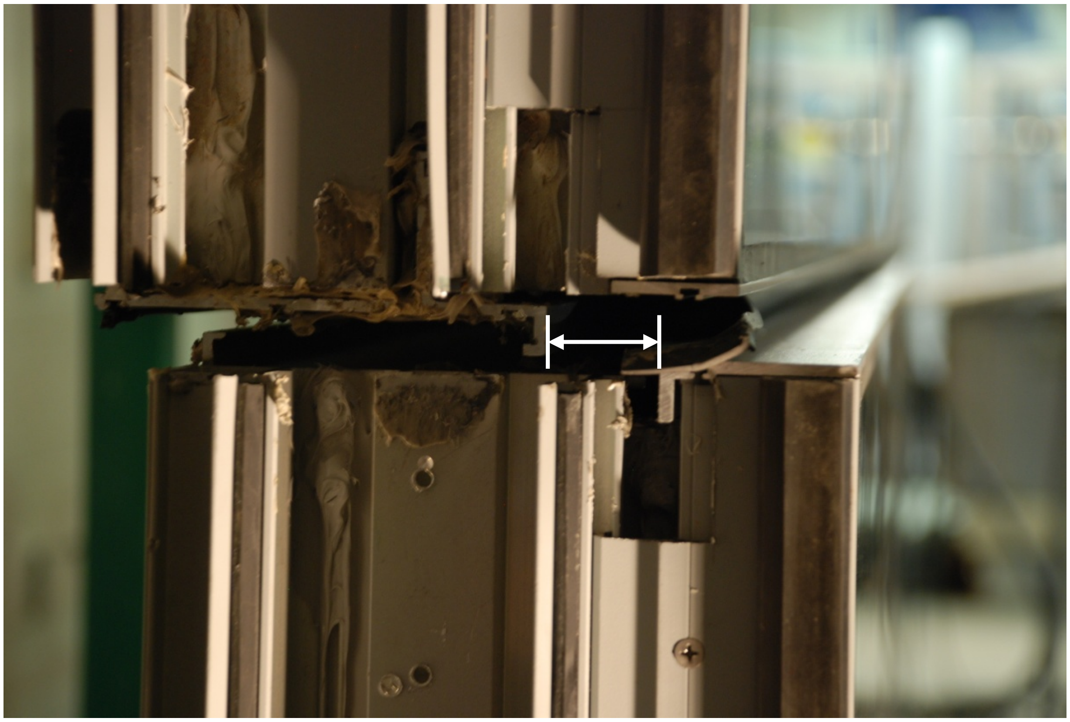


Figure 35- Horizontal Stack Joint Dislodges from Lower Left Panel

(Magnitude is shown by arrow)

During the subsequent two racking steps, the slotted-hole pressure plates sheared with the left boundary element shearing during the 4-1/2 in. racking step and the right boundary condition failing during the 4-3/4 in. racking step. By the time the boundary elements failed, the unitized system itself was thought to have reached a failure state (both vertical and horizontal joint dislodging). A sheared boundary element can be seen in Figure 36.

Figure 36- Sheared Boundary Element

6. Discussion of the Racking Test Results

Racking tests showed that this unitized system can accommodate a large amount of movement. The system by nature will slide or sway and adjust as needed to accommodate racking movements. The unrestrained racking test for the first specimen did not inflict any significant damage on the system. The unrestrained test with anti-walking means installed on the second specimen did cause a serviceability failure (air/water penetration) when the upper left and upper center panels separated along their mutual vertical joint. The separation was caused by the anti-walking restriction on the dead load anchors. Typically, a unitized panel is surrounded by other unitized panels either along the same plane or at intersecting planes with interior or exterior corners in an actual building installation. This was not the case in testing this specimen and it was left free to translate. In an effort to simulate an actual installation, end boundaries were added to the unitized system specimens for subsequent racking tests. The first boundary element used (a pressure plate) was attached to only the right side of the system and did not incorporate slotted-holes for the fasteners. The pressure plate proved to be flexible enough to allow some movement, but also created an end condition that did not allow unlimited movement. During testing with this detail, the unitized system did experience some serviceability damage when the horizontal stack joint released from the lower panels. The second end boundary installed was a slotted-hole angle connection. It was noticed during latter racking steps using the pressure plate end boundary element that the pressure plate acted as a tension member, which led to the use of slotted-holes. This end boundary, while good in concept, did not perform as desired. The third boundary element combined the two previously used elements to more accurately portray a real installation. A pressure plate was used with slotted-holes for fasteners to allow for movement along the vertical axis. The unitized system specimen tested with the slotted-hole pressure plate boundary element experienced a similar but more extensive failure exhibited by opening of the entire vertical joint between the upper left and upper center panels. Based on racking tests, weak points in the unitized system have been determined. Depending on the boundary conditions in real life situation, the stack wiper seal and the wedge gasket seals could be vulnerable to pullout to some degree. The horizontal stack joint is susceptible to dislodging from the lower panels under certain boundary conditions and very large racking displacements. Vertical inter-panel joints are also vulnerable to some separation, leaving a pathway for air and water penetration. The damage behavior reported occurred at drifts much larger than the maximum code allowable drifts.

A summary of results can be seen in Table 4 to help quantitatively compare the data. It is important to note that the first specimen did not experience any vertical joint dislodging in both unrestrained and restrained tests, while the second specimen did experience this limit state in both the unrestrained test and also the test using the slotted-hole pressure plate. Accordingly, this failure mode is perhaps dependent on the method of construction and not as dependent on system properties. Furthermore, it is possible that during the installation of the unitized panels of the second specimen, the gaskets lining the horizontal stack were compressed and during racking tests were allowed to return to their original position. Of course, this issue was not investigated sufficiently during this study, but should be considered further in follow-up studies.

Table 4- Summary of Unitized System Failure Drifts*

Description	Vertical Joint Dislodging			Horizontal Stack Joint Dislodging		
	in.	mm	Drift Index	in.	mm	Drift Index
First Specimen- Unrestrained	[a]	[a]	[a]	[a]	[a]	[a]
First Specimen- Pressure Plate End Boundary Condition	[a]	[a]	[a]	5.72	145.3	0.047
Second Specimen- Unrestrained	1.67	42.4	0.014	[a]	[a]	[a]
Second Specimen- Slotted Hole Pressure Plate End Boundary Condition	0.38	9.6	0.003	4.28	108.7	0.036

[a]Limit state was not reached by conclusion of test
*Note that the drift values have been adjusted for racking facility flexibility.

Overall, the EN-WALL 7250 system and the 3M™ VHB™ Structural Glazing Tape G23F performed very well during the racking tests. No failures were observed in the glass panels themselves, and the unitized system as a whole did not experience any permanent damage. The horizontal stack joint failure occurred at relatively high drifts, enhancing the system's seismic capacity.

7. Air Leakage Tests and Results

Air leakage tests were performed in accordance to the ASTM E 283-04 (ASTM 2004) standard. This standard calls for a sealed pressurized chamber to attach to the testing specimen making sure that the seal that binds the chamber and the specimen is air-tight. The chamber is pressurized to a given pressure. This pressure is targeted to be 75 pascals per ASTM E 283-04, but certain joints were unable to reach this pressure due to air leakage through the unitized system and thus a lower pressure was used (either 25 or 50 pascals), The test then measures the amount of air it takes to maintain the given pressure in the chamber, which is also the amount of air that is leaking through the specimen. The unitized system was tested along the four joints that surround the center glass panel. The bottom joint extended the width of the specimen as the horizontal stack joint was a continuous member and the entire joint needed to be tested. The joints tested can be seen in Figure 37.

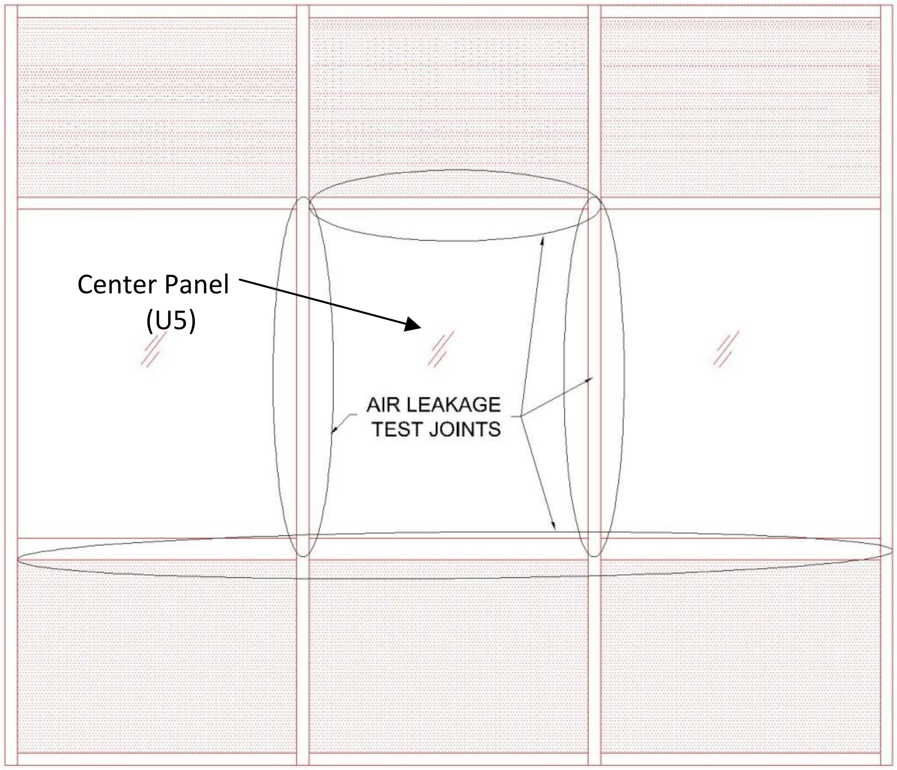


Figure 37- Air Leakage Test Joints

The joints are referred to as the left, right, top, and bottom joints (in the follow-up discussion) based on their orientation to the center panel from an exterior perspective. Plastic shrouds were made to serve as testing chambers. These shrouds were taped to the glass surrounding the joint of interest so that no air could escape. Then, the shroud was inflated to a desired pressure, as shown in Tables 5-11, and the air flow rate that it took to maintain that pressure was recorded. An example of a shroud used can be seen in Figure 38.

Figure 38- Typical Shroud for Air Leakage Tests

The specimens were designed only for racking tests. They did not include gaskets that are normally used for real world applications to protect against air leakage. Nonetheless, the air leakage tests were carried out to illustrate how air-tight the system would be if under seismic induced movement some gaskets sustain damage. The data generated should be used only to measure relative change from a baseline measurement taken prior to racking, which will signify if damage to the system during racking affects air leakage performance. Tables 5-11 show the values for different air leakage tests. Air leakage tests on the first specimen were performed before any racking steps. After the first test (unrestrained) no damage was observed and no further reading was taken. For the restrained test on the first specimen (second test of the first specimen), the dislodging of the horizontal stack joint allowed for a clear opening for air to pass through; therefore, no air leakage test was done after racking. Air leakage tests were performed on the second specimen at the start and conclusion of each racking test regardless of occurrence of damage to the unitized system. Certain values in Tables 5 and 11 are missing because the shroud was unable to be pressurized due to large gaps in the unitized system.

Table 5- Baseline Air Leakage for the First Specimen (Unrestrained)

Joint	Pressure Difference (inches H_2O)		Air Flow Rate (cfh)
	Target	Actual	
Top	0.300	0.300	12
Left	0.300	0.300	75
Right	0.300	0.300	150
Bottom	0.200	0.200	550

Table 6- Baseline Air Leakage for the Second Specimen (Unrestrained)

Joint	Pressure Difference (inches H_2O)		Air Flow Rate (cfh)
	Target	Actual	
Top	0.300	0.303	6
Left	0.300	0.082	650
Right	0.300	0.291	260
Bottom	0.100	0.100	540

Table 7- Air Leakage for the Second Specimen At Conclusion of Racking (Unrestrained)

Joint	Pressure Difference (inches H_2O)		Air Flow Rate (cfh)
	Target	Actual	
Top	0.300	0.300	9
Left	-	-	-
Right	0.302	0.302	260
Bottom	-	-	-

Table 8- Baseline Air Leakage for the Second Specimen (Slotted-Hole Angle Restraint)

Joint	Pressure Difference (inches H_2O)		Air Flow Rate (cfh)
	Target	Actual	
Top	0.300	0.300	17
Left	0.200	0.200	470
Right	0.300	0.298	390
Bottom	0.100	0.960	560

Table 9- Air Leakage for the Second Specimen at Conclusion of Racking (Slotted-Hole Angle Restraint)

Joint	Pressure Difference (inches H_2O)		Air Flow Rate (cfh)
	Target	Actual	
Top	0.300	0.297	16
Left	0.200	0.203	430
Right	0.300	0.302	270
Bottom	0.100	0.101	520

Table 10- Baseline Air Leakage for the Second Specimen (Slotted-Hole Pressure Plate Restraint)

Joint	Pressure Difference (inches H_2O)		Air Flow Rate (cfh)
	Target	Actual	
Top	0.300	0.300	14
Left	0.300	0.298	450
Right	0.300	0.299	180
Bottom	0.100	0.998	540

Table 11- Air Leakage for the Second Specimen at Conclusion of Racking (Slotted-Hole Pressure Plate Restraint)

Joint	Pressure Difference (inches H_2O)		Air Flow Rate (cfh)
	Target	Actual	
Top	0.300	0.302	15
Left	-	-	-
Right	0.200	0.188	560
Bottom	-	-	-

Tables 5-11 show the measured air flow rate needed to achieve a steady state condition for the pressure difference achieved for each joint. Certain joints were not able to reach the desired 0.300 in. of water pressure and thus needed to be scaled down to an achievable pressure. It is important to note that the values in Tables 5-11 were not adjusted for temperature and barometric pressure. To create accurate values, the air flow rate would need to be adjusted for outside factors. As mentioned before, the purpose of the air flow tests was to compare the air leakage prior to and after the racking test, and for this reason, the unadjusted values presented in the tables are sufficient. Air leakage is dependent on the seal created by the gaskets at a given panel's joints. The top joint did not vary in air leakage significantly while the left, right, and bottom joints varied due to the relative translation of the unitized panels.

8. Conclusions

The objective of this testing program was to evaluate the simulated seismic performance of EN-WALL 7250 unitized curtain wall system test specimens using 3M™ VHB™ Structural Glazing Tape G23F to form the structural seals. The evaluation was based on cyclic racking tests following the AAMA 501.6 test protocol. The goal was to identify any failure modes of the unitized wall system under very high drifts beyond what is expected during design earthquakes. The full-scale specimens were planar, but testing considered unrestrained planar and restrained boundary conditions to simulate corner or end boundary conditions. The racking tests of the planar specimens without any restraint at the stack joint showed no damage to glass, 3M™ VHB™ Structural Glazing Tape G23F or structural sealant weatherseal under the maximum racking facility drift capacity of 6 in. or a drift ratio of 5.0%, which is larger than what is expected during a design earthquake or the maximum building code drift ratio of 2.5%. However, there was some wedge gasket pullout starting when upper panels exhibited permanent displacement at the stack joint at the end of each cycle. Furthermore, there is also the potential for some vertical joint opening between panels when there are some boundary restraints, and this poses serviceability issues related to air leakage and moisture. When restraints were introduced at the stack joint, besides gasket pullout, the test results showed the possibility of vertical joint opening. At very large drift values (larger than 4.25 in. or 3.5% drift index) some derailment of the top panels with respect to the bottom panels at the stack joint is also possible. Maximum design drift index (ratio) for building structural design is 2.5%. Therefore, the drift corresponding to the potential derailment issue under special boundary restraint conditions is at least 40% higher than the maximum drift ratio allowed by the building code. Of course, the restraints introduced are expected to be more severe than in actual installations due to the corner conditions. The intention was to simulate worst case scenario performance.

Overall, the performance of this curtain wall system under the AAMA 501.6 testing protocol proved to be satisfactory for a planar system, and this study showed that the stack joint design can significantly enhance the seismic performance by creating a condition for the adjacent panels to sway or slide instead of being racked. The full scale unitized curtain wall specimens did not sustain any glass or 3M™ VHB™ Structural Glazing Tape damage when subjected to the AAMA 501.6 racking tests. The instrumentation employed for the testing program was not intended to measure the amount of strains experienced by the glass and 3M™ VHB™ Structural Glazing Tape (structural sealant) during these tests, and therefore, the resulting stresses were not determined. Based on the test results and lack of any observed damage to the glass and 3M™ VHB™ Structural Glazing Tape, however, one can conclude that due to the nature and design of the unitized curtain wall system, the amount of stress applied to the glass and 3M™ VHB™

Structural Glazing Tape has been small compared to their capacities. In other words, because the stack joint in effect creates a seismic isolation joint between adjacent vertical panels, the glass-to-mullion attachment is not expected to experience much in-plane shear during the unrestrained test cycles. However, the boundary restraint conditions would be expected to create some glass-to-mullion in-plane shear during the racking tests.

The authors recommend follow-up testing of this curtain wall system by adding a return panel to the main longitudinal segment in order to test the corner condition and evaluate the response of the sealants. This would allow the performance of the unitized curtain wall system and the bond of the structural sealant to be investigated when the wall system is forced to rack as opposed to the sway condition experienced in the current study.

9. References

3M (2008), *3M TM VHBTM Structural Glazing Tapes -- Technical Guide*, Industrial Adhesives and Tapes Division, St. Paul, MN.

3M (2006), http://multimedia.3m.com/mws/mediawebserver?33333LlQa7xJCOKkEo8pf OKTw MlHw7lQZMj3wMj3w333333--

AAMA (2009), *Recommended Dynamic Test Method for Determining the Seismic Drift Causing Glass Fallout from a Wall System*, Publication No. AAMA 501.6-09, American Architectural Manufacturers Association (AAMA), Des Plaines, IL.

ASCE (2006), *Minimum Design Loads for Buildings and Other Structures*, ASCE 7-05, American Society of Civil Engineers, Reston, VA.

ASTM (2004), Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Wall, and Doors Under Specified Differences Across the Specimen, ASTM E 283-04, ASTM International, West Conshohocken, PA.

Dow Corning (2006), *Structural Silicone Glazing from Dow Corning: Changing the Face of the World Cities*, Dow Corning Corporation, www.dowcorning.com, pp. 1-12.

International Code Council (ICC) (2006), *International Building Code (IBC)*, ICC, Falls Church, VA.

Memari, A.M., Chen, X., Kremer, P.A., and Behr, R.A. (2006), "Seismic Performance of Two-Side Structural Silicone Glazing Systems," *Journal of ASTM International*, Vol. 3 No. 10, pp. 1-10.

Memari, A. M., Kremer, P. A., and Behr, R. A., (2010), "Seismic Performance of Four-Side Structural Sealant Glazing System," *Journal of ASTM International*, Accepted for Publication.

APPENDIX A

Unitized System Details

EN-WALL

5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702-834-9600
Fax: 702-533-0922
w w w . EN-WALL . com

Racking Load Testing of Unitized Curtain Wall Systems to Develop Failure Limit States and Fragility Information

Ali M. Memari, Ph.D.,P.E., Associate Professor
Department of Architectural Engineering, Penn State University, 104 Engineering Unit A, University Park, PA, 16802, Phone: 814-865-3367, Fax: 814-863-4789, E-mail: amm7@psu.edu

EN-WALL 7250 UNITIZED WALL SYSTEM FOR 1 1/4" GLASS

SEPT. 28, 2009

EN-WALL
5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702-834-9600
Fax: 702-533-0922

	REVISIONS
1	-
2	-
3	-
4	-

EN-WALL 7250 Unitized Wall
LAS VEGAS, NEVADA
Racking Load Testing of Unitized Curtain Wall
Penn State University

COVER

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039-20

0.00

ABBREVIATIONS

ALUM.	ALUMINUM	MECH	MECHANICAL
BD	BOARD	MET	METAL
BLDG	BUILDING	MINIMUM	MINIMUN
BLKG	BLOCKING	MISC	MISCELLANEOUS
BM	BEAM	BO	MASORY OPENING
BOT	BOTTOM	MOD	MODULE
CEM	CEMENT	MUL	MULLION
C	CENTERLINE	NIC	NOT IN CONTRACT
CLR	CLEAR	NO	NUMBER
COL	COLUMN	NTS	NOT TO SCALE
CONC	CONCRETE	OA	OVERALL
CONT	CONTINUOUS	OC	ON CENTER
CTSK	COUNTERSUNK	OPNG	OPENING
DET	DETAIL	OPP	OPPOSITE
DIA	DIAMETER	PL	PLATE
DIM	DIMENSION	PR	PAIR
DN	DOWN	RAD	RADIUS
DWG	DRAWING	REINF	REINFORCE
EA	EACH	REQ	REQUIRED
EL	ELEVATION	RM	ROOM
EP1	EXTERIOR PAINT 1	RO	ROUGH OPENING
EP2	EXTERIOR PAINT 2	SCHED	SCHEDULE
EQ	EQUAL	SHT	SHEET
EXP	EXPANSION	SIM	SIMILAR
EXT	EXTERIOR	STL	STEEL
EXIST	EXISTING	STRUC	STRUCTURAL
FFL	FINISH FLOOR LINE	TKH	THICK
FIN	FINISH	TOF	TOP OF FINISH
FL	FLOOR	TOP	TOP OF PARAPET
FLASH	FLASHING	TOPL	TOP OF PLATE
FM	FIELD MEASURE	TYP	TYPICAL
FOC	FACE OF CONCRETE	UON	UNLESS OTHERWISE NOTED
FOF	FACE OF FINISH		
FOG	FACE OF GLASS	VERT	VERTICAL
FT	FOOT/FEET	W/	WITH
FD	FRAME DIMENSION	W/O	WITHOUT
GA	GAUGE	WD	WOOD
GALV	GALVANIZED	WDO	WINDOW
GL	GLASS	WT	WEIGHT
GYP	GYPSUM	B.O.M	BOTTOM OF METAL
HDW	HARDWARE	T.O.M.	TOP OF METAL
HGT	HEIGHT	DLO	DAYLITE OPENING
HM	HOLLOW METAL	SMS	SHEET METAL SCREW
HORIZ	HORIZONTAL		
ID	INSIDE DIAMETER		
INSUL	INSULATION		
INT	INTERIOR		
IP	INTERIOR PAINT		
JT	JOINT		
LOC	LOCATION		
MAX	MAXIMUM		

GENERAL NOTES

1. THESE DRAWINGS., WHEN MARKED APPROVED OR REVIEWED SHALL BE DEEMED AS AN ACCURATE INTERPRETATION OF PROJECT REQUIREMENTS AND AS SUCH APPROVAL OR RETURN WITH OR WITHOUT COMMENTS UNLESS DISAPPROVED SHALL CONSTITUTE AN APPROVAL TO PROCEED WITH SHOP FABRICATION.
2. END-WALL ASSUMES NO RESPONSIBILITY FOR WORK OR ERRORS BY OTHER TRADES INCURRED THROUGH USE OF THESE SHOP DWGS.
3. ALL MATERIAL TO WHICH END-WALL FRAMING IS TO BE ANCHORED MUST BE STRUCTURALLY SOUND AND CAPABLE OF SUPPORTING MAXIMUM DESIGN LOADS IMPOSED BY OUR SYSTEM

LEGEND: SYMBOLS

WINDOW NUMBER — D3-01 — WINDOW # ARCH.

DETAIL NUMBER — 3 / 020 — DETAIL # SHEET #

PANEL TYPE — WORK POINT

AXIS LINE — 6.5 — GRID LINE

EXTERIOR ELEVATION — 1 / E.1 — ELEVATION # SHEET #

WINDOW SECTION — 2 / S-1 — SECTION # SHEET #

INTERIOR ELEVATION — 1, 2, 3, 4 / E.2 — ELEVATION # SHEET #

ROOM NUMBERS

FLOOR LEVEL

SEQUENTIAL NUMBER

EXECUTIVE ROOM — ROOM NAME

DOOR NUMBERS

DOOR W007 — SEQUENTIAL NUMBER

GLASS TYPE — GLASS TAG

ARCHITECTURAL DRAWINGS

SHEET INDEX	SHEET No.	DESCRIPTION
COVER SHEET	0.00	COVER SHEET
GENERAL	0.01	GENERAL NOTES
SCHEDULE	0.02	EN-WALL SCHEDULE
ELEVATION	2.01	CURTAINWALL ELEVATION
HORIZONTAL DETAILS	4.01	EN-WALL 7250 WALL SYSTEM (1 1/4" GLASS)
	4.02	EN-WALL 7250 WALL SYSTEM (1 1/4" GLASS)
	4.03	EN-WALL 7250 WALL SYSTEM (1 1/4" GLASS)
	4.03A	EN-WALL 7250 WALL SYSTEM (1 1/4" GLASS)
	4.04	EN-WALL 7250 WALL SYSTEM (1 1/4" GLASS)
	4.05	EN-WALL 7250 WALL SYSTEM (1 1/4" GLASS)
VERTICAL DETAIL	5.01	EN-WALL 7250 WALL SYSTEM (1 1/4" GLASS)
	5.02	EN-WALL 7250 WALL SYSTEM (1 1/4" GLASS)
	5.03	EN-WALL 7250 WALL SYSTEM (1 1/4" GLASS)
	5.04	EN-WALL 7250 WALL SYSTEM (1 1/4" GLASS)
	5.05	EN-WALL 7250 WALL SYSTEM (1 1/4" GLASS)
	5.06	EN-WALL 7250 WALL SYSTEM (1 1/4" GLASS)
	5.07	EN-WALL 7250 WALL SYSTEM (1 1/4" GLASS)

INSTALLERS NOTE:

1. Do not assume anything!! If there is a question or something is not fully explained, ask the question before work is fabricated or erection of the work begins. Contact the Project Manager for clarifications or additionaL information.

2. Review shop drawing before beginning work. Check to see that the Elevations, Sections and Details are not in conflict.

3. If conflicts or discrepancies are found inform the Project Manager.

4. Review dimensions shown on the Elevations before starting the installation. Compare the " Elevation Reference Points" with the existing Project conditions. Notify Project Manager of inconsistencies.

5. Horizontal caulking must be continuous with vertical caulking and with adjacent glazing system.

6. Exterior perimeter seal must marry into the building membrane behind the plaster area of wall. A flashing or others plaster accessory as needed.

7. Review and follow installation details.

GLASS SCHEDULE

S1
1 1/4" SPANDREL INSULATING UNITS
OUTBOARD – 1/4" CLEAR (FT)
3/4" AIRSPACE – BLACK FINISH SPACER
BLACK SILICONE
INBOARD – 1/4" CLEAR (FT)

V1
1 1/4" VISION INSULATING UNITS (FT/FT)
OUTBOARD – 1/4" CLEAR (FT)
3/4" AIRSPACE – BLACK FINISH SPACER
BLACK SILICONE
INBOARD – 1/4" CLEAR (FT)

FINISH SCHEDULE

– PPG FASHION GRAY KYNAR

SEALANT SCHEDULE

	SEALANT COLOR/TYPE
S1	DC 790 – GRAY
S2	DC 795 – BLACK
S3	TBD

SYSTEM DESCRIPTION

1 EN-WALL 7250 UNITIZED WALL SYSTEM

5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702-834-9600
Fax: 702-533-0922

REVISIONS

1	–
2	–
3	–
4	–

EN-WALL 7250 Unitized Wall

LAS VEGAS, NEVADA

Racking Load Testing of Unitized Curtain Wall

Penn State University

ALUM. EXTRUSIONS

DRAWN BY: SS

DATE: 7/8/09

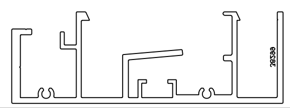
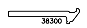
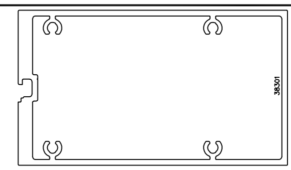
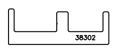
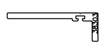
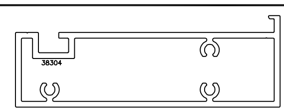
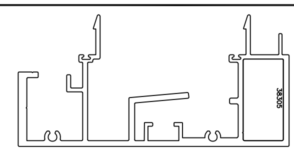
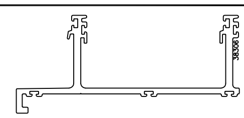
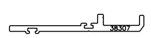
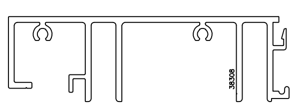
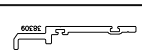
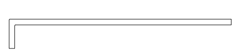
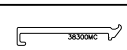
SCALE: N.T.S.

FILE: –

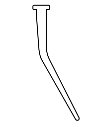
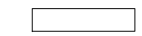
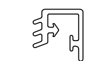
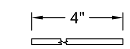
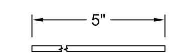
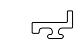
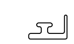
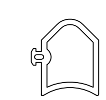
JOB NO.: 08039-20

0.01

EN-WALL ALUMINUM EXTRUSION SCHEDULE

EN-WALL #	PROFILE	DESCRIPTION	ALLOY	TEMPER
38299		FEMALE MULLION	6063	T5
38300		HORIZONTAL SHELF FIN	6063	T5
38301		CLOSED INTERMEDIATE HORIZONTAL	6063	T5
38302		LIFTING LUG	6061	T6
38303		LOWER STACK WEATHERSEAL FIN	6063	T5
38304		LOWER STACK	6063	T5
38305		MALE MULLION	6063	T5
38306		CONTINUOUS GUTTER	6063	T5
38307		UPPER STACK DEADLOAD FIN	6063	T5
38308		UPPER STACK	6063	T5
38309		VERTICAL WEATHERSEAL FIN	6063	T6
00000		.125" ALUMINUM FORMED ANGLE	-	-
00000		HORIZONTAL SHELF FIN MODIFIED	-	-

EN-WALL GASKET SCHEDULE

EN-WALL #	PROFILE	DESCRIPTION
4.01-05		70 Duro Peroxide EPDMThread-In Finger, Rainscreen
4.02-40		80 Duro Shore D, Rigid Clip @ Setting Chair Cut Length = 6"
4.01-08		80 Duro Silicone, Setting Block Cut Length = 4"
4.01-10		60 Duro EPDM, Continuous Gasket @ Chicken Head
4.01-11		40 Duro Translucent Silicone Sheet 4" Wide Cut Length = 12"
4.01-12		40 Duro Translucent Silicone Sheet 5" Wide Cut Length = 12"
4.01-13		85 Duro EPDM, Isolator # 1
4.01-28		85 Duro EPDM, Thermal Isolator
4.01-29		85 Duro EPDM, Thermal Isolator
4.01-30		60 Duro EPDM, Friction-Fit Spacer FC = .125
4.01-31		85 Duro EPDM, U Shapped Thermal Isolator
5.01-36		60 Duro EPDM, Air Seal @ Split Mullion
5.01-36		70 Duro Perox. EPDM, Joint Plug

EN-WALL

5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702-834-9600
Fax: 702-533-0922

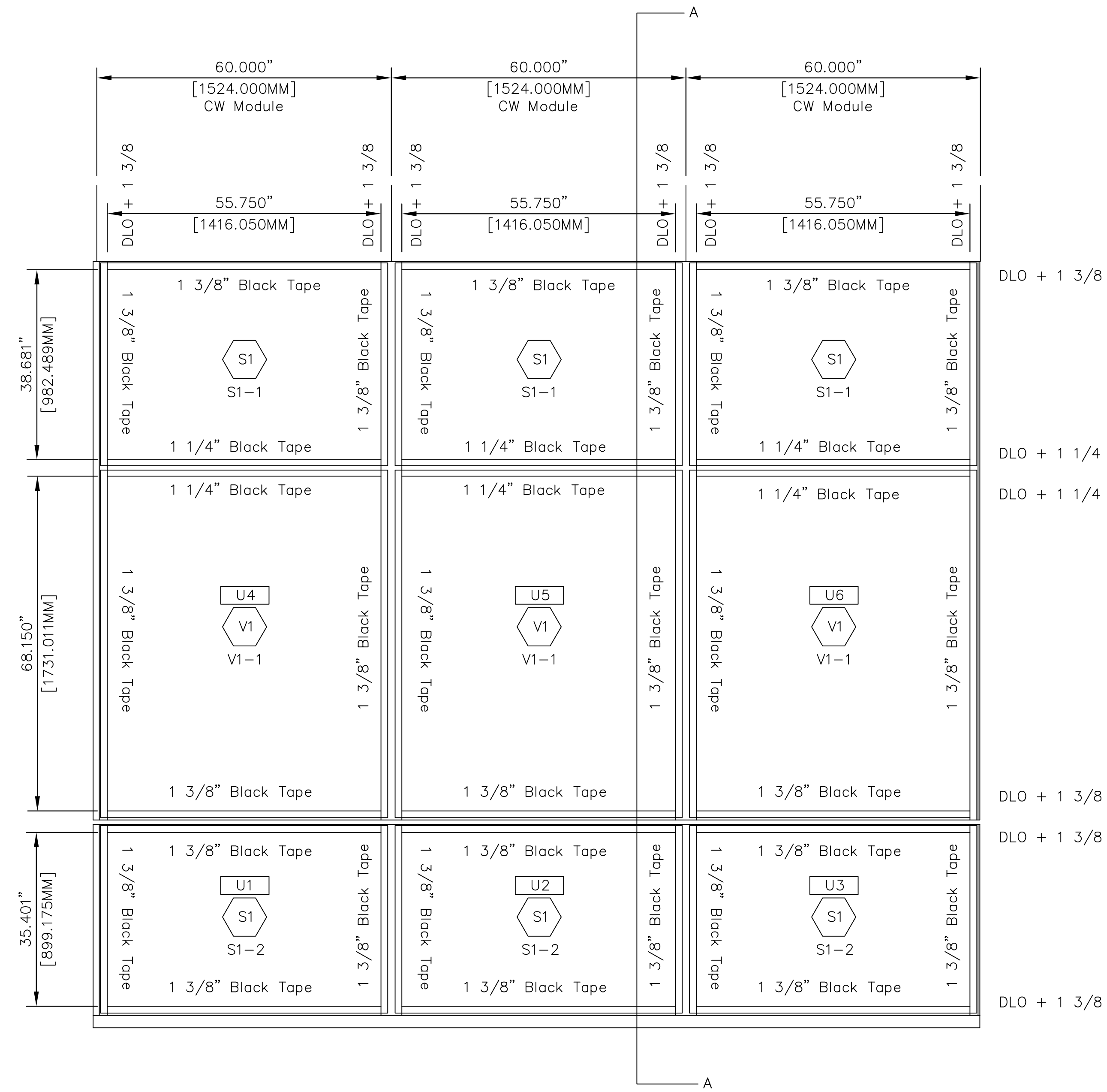
	REVISIONS
1	
2	-
3	-
4	-

EN-WALL 7250 Unitized Wall
LAS VEGAS, NEVADA
Racking Load Testing of Unitized Curtain Wall
Penn State University

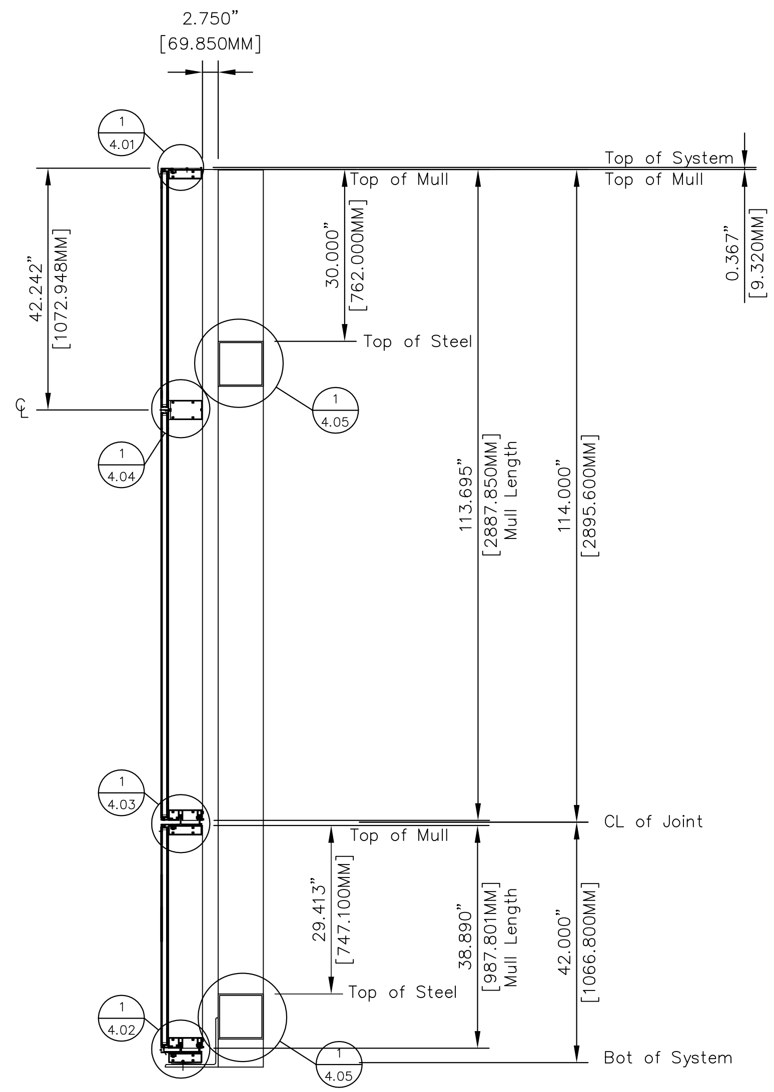
ALUM. EXTRUSIONS

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039-20-01

0.02



1 / 2.01 MOCK-UP ELEVATION
SCALE: None



A-A / 2.01 WALL SECTION
SCALE: None

EN-WALL
5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702-834-9600
Fax: 702-533-0922

REVISIONS

1	
2	-
3	-
4	-

EN-WALL 7250 Unitized Wall
LAS VEGAS, NEVADA

Racking Load Testing of Unitized Curtain Wall
Penn State University

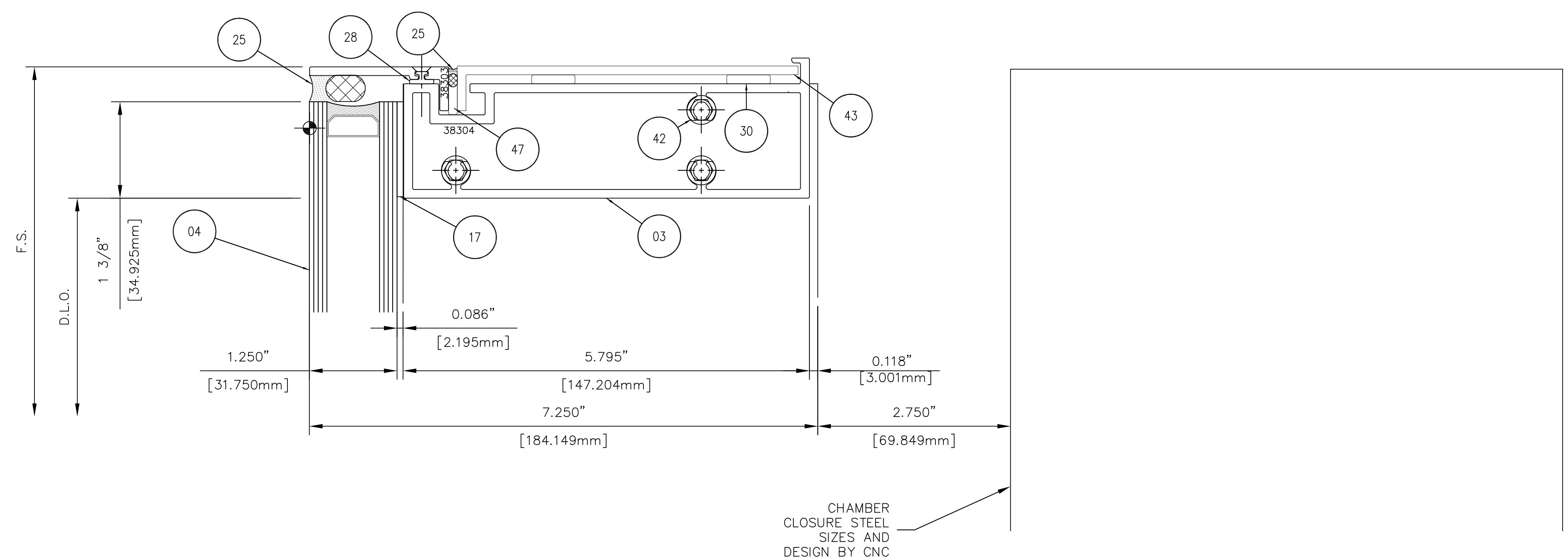
DETAIL

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	None
FILE:	2.01
JOB NO.:	-

2.01

LEGEND

00 Gasket
01 Upper Stack Extrusion
02 Continuous Gutter Extrusion
03 Lower Stack Extrusion
04 Glass
05 Stack Wiper Gasket
06 Upper Stack Deadload Fin
07 Lower Stack Weatherseal Fin
08 Setting Block
09 Closed Cell Baffle at Mullion
10 Continuous Chicken Head Gasket
11 12" Silicone Front Boot
12 12" Silicone Gutter Boot
13 Isolator Gasket #1
14 Extruded Aluminum Stool Trim
15 Stool Trim Wiper Gasket
16 Silicone Bedding
17 3M G23F Structural Glazing Tape
18 Extruded Anchor Knuckle
19 Extruded Anchor Hook
20 Extruded Anit-Walk Clip
21 Extruded U-Channel
22 –
23 Vertical Adjustment Screw
24 #10 x 1/2 FHPH
25 Silicone Weatherseal and Backer Rod
26 Halfen Anchor and Tee Bolt
27 Serrated Washer
28 Isolator Gasket #2
29 Isolator Gasket #3
30 Continuous Wedge Gasket
31 Vertical Weatherseal Fin
32 Female Mullion
33 Male Mullion
34 Retractable Lifting Lug
35 Silicone Seal
36 Pressure Equalizer Gasket
37 Vertical Weatherseal Gasket
38 Intermediate Horizontal
39 Horizontal Shelf Fin
40 Horizontal Fin Isolator
41 Chamber Steel
42 Assembly Screws
43 Aluminum Angle
44 Thermal Isolator
45 Neoprene Sponge @ Mull & Splice
46 5/16" Weep Hole @ 24" O.C.
47 Non-Continuous X 2" Wedge – 12" O.C.
48 1/2"-12-13 X 1 1/2" Grade 8 Hex Bolt
49 Pressure Equalization Access Hole
50 High Impact Plastic Shim
51 1/2" Type 'F' Bolt



1 –
4.01 –

HEAD HORIZONTAL DETAIL
SCALE: FULL SIZE

5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702-834-9600
Fax: 702-533-0922

REVISIONS

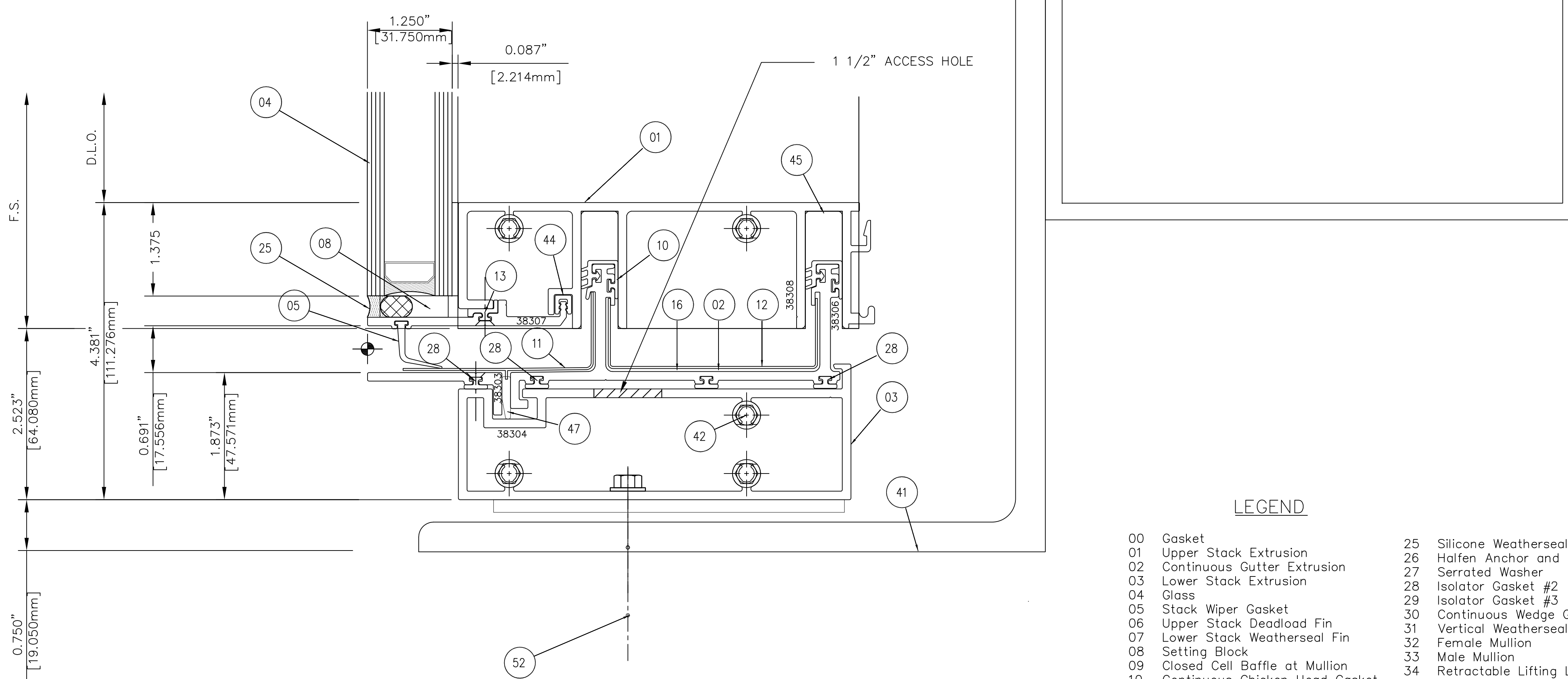
1	
2	-
3	-
4	-

EN-WALL 7250 Unitized Wall
LAS VEGAS, NEVADA
Racking Load Testing of Unitized Curtain Wall
Penn State University

HEAD HORIZONTAL

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039-20

4.01



1 | –
4.02 | –

SILL HORIZONTAL DETAIL AT SPLICE

SCALE: FULL SIZE

LEGEND

00 Gasket
01 Upper Stack Extrusion
02 Continuous Gutter Extrusion
03 Lower Stack Extrusion
04 Glass
05 Stack Wiper Gasket
06 Upper Stack Deadload Fin
07 Lower Stack Weatherseal Fin
08 Setting Block
09 Closed Cell Baffle at Mullion
10 Continuous Chicken Head Gasket
11 12" Silicone Front Boot
12 12" Silicone Gutter Boot
13 Isolator Gasket #1
14 Extruded Aluminum Stool Trim
15 Stool Trim Wiper Gasket
16 Silicone Bedding
17 3M G23F Structural Glazing Tape
18 Extruded Anchor Knuckle
19 Extruded Anchor Hook
20 Extruded Anit–Walk Clip
21 Extruded U–Channel
22 –
23 Vertical Adjustment Screw
24 #10 x 1/2 FHPH
25 Silicone Weatherseal and Backer Rod
26 Halfen Anchor and Tee Bolt
27 Serrated Washer
28 Isolator Gasket #2
29 Isolator Gasket #3
30 Continuous Wedge Gasket
31 Vertical Weatherseal Fin
32 Female Mullion
33 Male Mullion
34 Retractable Lifting Lug
35 Silicone Seal
36 Pressure Equalizer Gasket
37 Vertical Weatherseal Gasket
38 Intermediate Horizontal
39 Horizontal Shelf Fin
40 Horizontal Fin Isolator
41 Chamber Steel
42 Assembly Screws
43 Aluminum Angle
44 Thermal Isolator
45 Neoprene Sponge @ Mull & Splice
46 5/16" Weep Hole @ 24" O.C.
47 Non–Continuous X 2" Wedge – 12" O.C.
48 1/2"–12–13 X 1 1/2" Grade 8 Hex Bolt
49 Pressure Equalization Access Hole
50 High Impact Plastic Shim
51 1/2" Type 'F' Bolt
52 #14 X 3 HWH TEK 5 AT 12" O.C.

EN-WALL
5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702–834–9600
Fax: 702–533–0922

REVISIONS	
1	–
2	–
3	–
4	–

EN–WALL 7250 Unitized Wall

LAS VEGAS, NEVADA

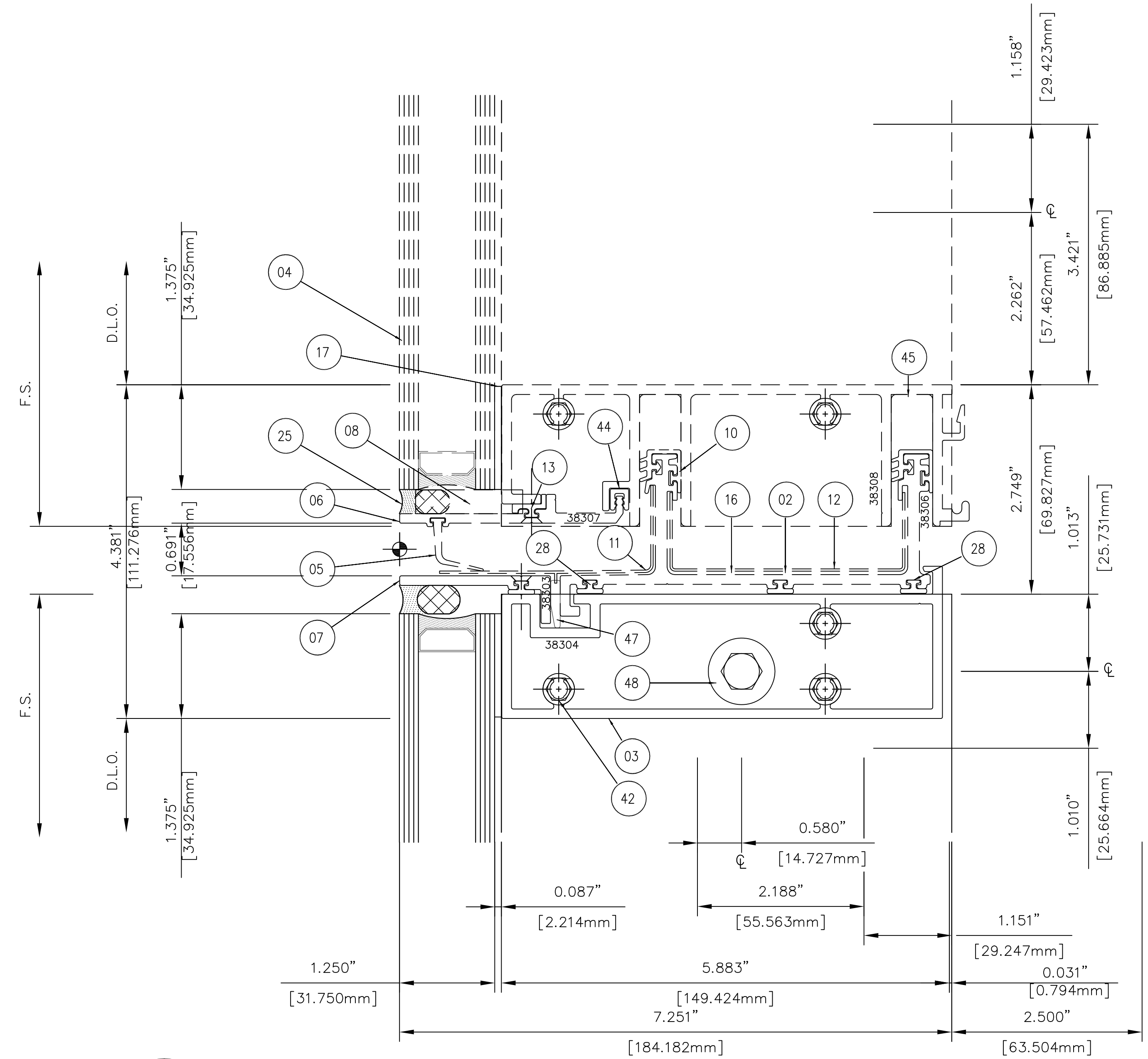
Racking Load Testing of Unitized Curtain Wall

Penn State University

SILL DETAIL

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039–20

4.02



1	–
4.03	–

STACK HORIZONTAL DETAIL – REFERENCE ONLY

SCALE: FULL SIZE

LEGEND

00 Gasket
01 Upper Stack Extrusion
02 Continuous Gutter Extrusion
03 Lower Stack Extrusion
04 Glass
05 Stack Wiper Gasket
06 Upper Stack Deadload Fin
07 Lower Stack Weatherseal Fin
08 Setting Block
09 Closed Cell Baffle at Mullion
10 Continuous Chicken Head Gasket
11 12" Silicone Front Boot
12 12" Silicone Gutter Boot
13 Isolator Gasket #1
14 Extruded Aluminum Stool Trim
15 Stool Trim Wiper Gasket
16 Silicone Bedding
17 3M G23F Structural Glazing Tape
18 Extruded Anchor Knuckle
19 Extruded Anchor Hook
20 Extruded Anit-Walk Clip
21 Extruded U-Channel
22 –
23 Vertical Adjustment Screw
24 #10 x 1/2 FHPH
25 Silicone Weatherseal and Backer Rod
26 Halfen Anchor and Tee Bolt
27 Serrated Washer
28 Isolator Gasket #2
29 Isolator Gasket #3
30 Continuous Wedge Gasket
31 Vertical Weatherseal Fin
32 Female Mullion
33 Male Mullion
34 Retractable Lifting Lug
35 Silicone Seal
36 Pressure Equalizer Gasket
37 Vertical Weatherseal Gasket
38 Intermediate Horizontal
39 Horizontal Shelf Fin
40 Horizontal Fin Isolator
41 Chamber Steel
42 Assembly Screws
43 Aluminum Angle
44 Thermal Isolator
45 Neoprene Sponge @ Mull & Splice
46 5/16" Weep Hole @ 24" O.C.
47 Non-Continuous X 2" Wedge – 12" O.C.
48 1/2"-12-13 X 1 1/2" Grade 8 Hex Bolt
49 Pressure Equalization Access Hole
50 High Impact Plastic Shim
51 1/2" Type 'F' Bolt

EN-WALL
5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702-834-9600
Fax: 702-533-0922

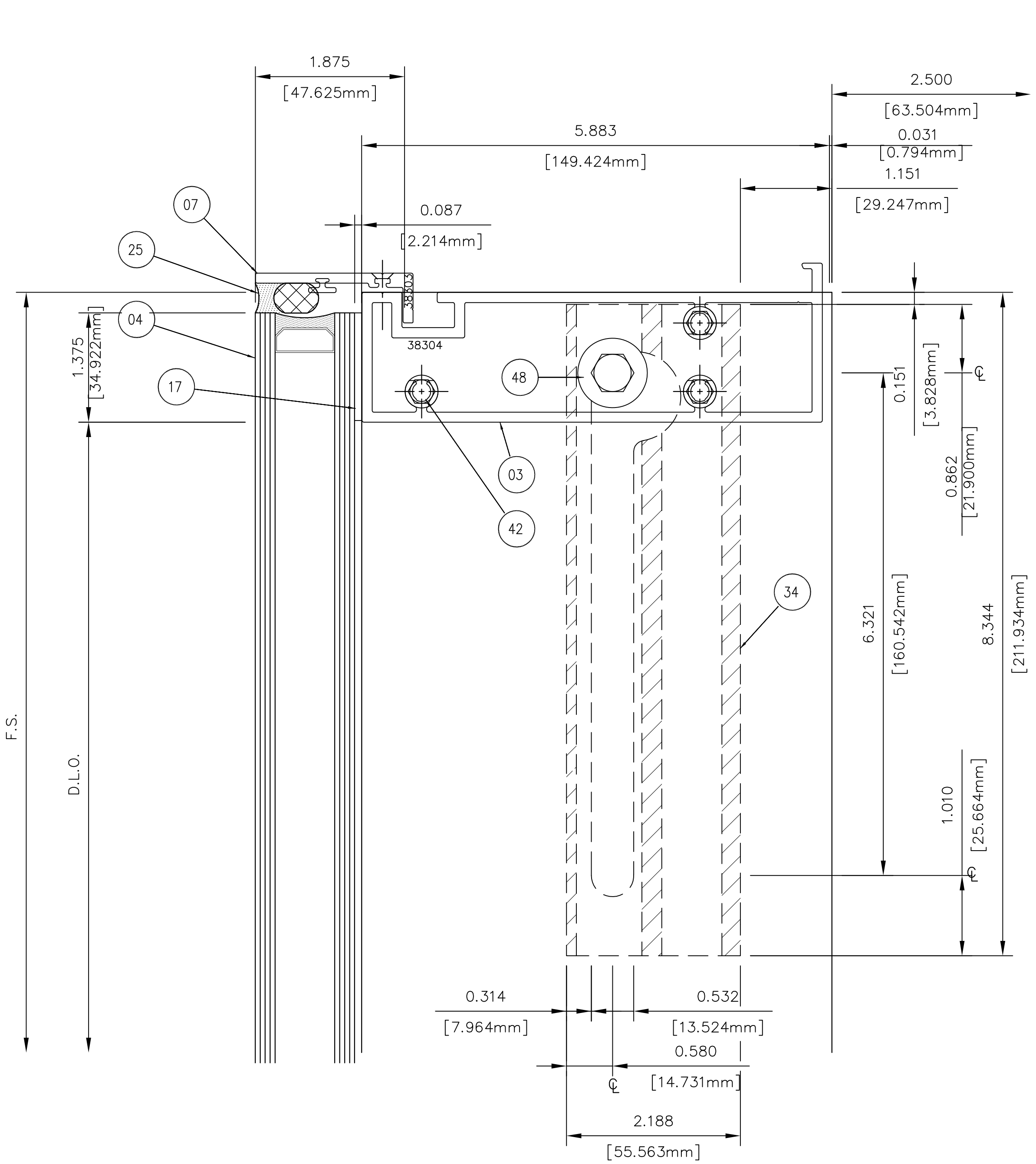
△	REVISIONS
1	-
2	-
3	-
4	-

EN-WALL 7250 Unitized Wall
LAS VEGAS, NEVADA
Racking Load Testing of Unitized Curtain Wall
Penn State University

STACK HORIZONTAL

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039-20

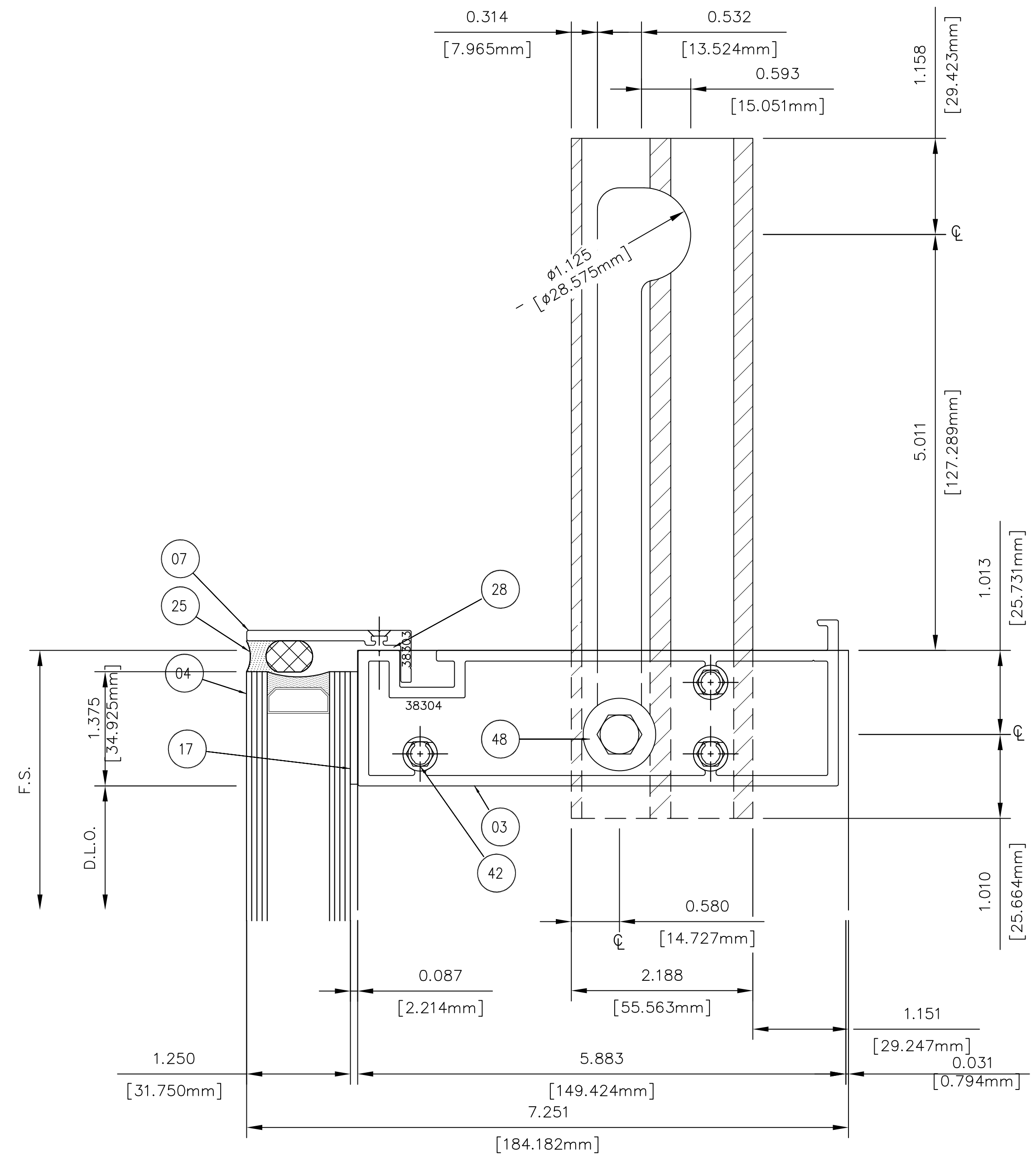
4.03



1 – 4.03A –

LOWER STACK HORIZONTAL DETAIL WITH LIFTING LUG RETRACTED

SCALE: FULL SIZE



2 – 4.03A –

LOWER STACK HORIZONTAL DETAIL WITH LIFTING LUG EXTENDED

SCALE: FULL SIZE

LEGEND

00 Gasket
01 Upper Stack Extrusion
02 Continuous Gutter Extrusion
03 Lower Stack Extrusion
04 Glass
05 Stack Wiper Gasket
06 Upper Stack Deadload Fin
07 Lower Stack Weatherseal Fin
08 Setting Block
09 Closed Cell Baffle at Mullion
10 Continuous Chicken Head Gasket
11 12" Silicone Front Boot
12 12" Silicone Gutter Boot
13 Isolator Gasket #1
14 Extruded Aluminum Stool Trim
15 Stool Trim Wiper Gasket
16 Silicone Bedding
17 3M G23F Structural Glazing Tape
18 Extruded Anchor Knuckle
19 Extruded Anchor Hook
20 Extruded Anit-Walk Clip
21 Extruded U-Channel
22 –
23 Vertical Adjustment Screw
24 #10 x 1/2 FHPH
25 Silicone Weatherseal and Backer Rod
26 Halfen Anchor and Tee Bolt
27 Serrated Washer
28 Isolator Gasket #2
29 Isolator Gasket #3
30 Continuous Wedge Gasket
31 Vertical Weatherseal Fin
32 Female Mullion
33 Male Mullion
34 Retractable Lifting Lug
35 Silicone Seal
36 Pressure Equalizer Gasket
37 Vertical Weatherseal Gasket
38 Intermediate Horizontal
39 Horizontal Shelf Fin
40 Horizontal Fin Isolator
41 Chamber Steel
42 Assembly Screws
43 Aluminum Angle
44 Thermal Isolator
45 Neoprene Sponge @ Mull & Splice
46 5/16" Weep Hole @ 24" O.C.
47 Non-Continuous X 2" Wedge – 12" O.C.
48 1/2"-12-13 X 1 1/2" Grade 8 Hex Bolt
49 Pressure Equalization Access Hole
50 High Impact Plastic Shim
51 1/2" Type 'F' Bolt

EN-WALL
5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702-834-9600
Fax: 702-533-0922

REVISIONS

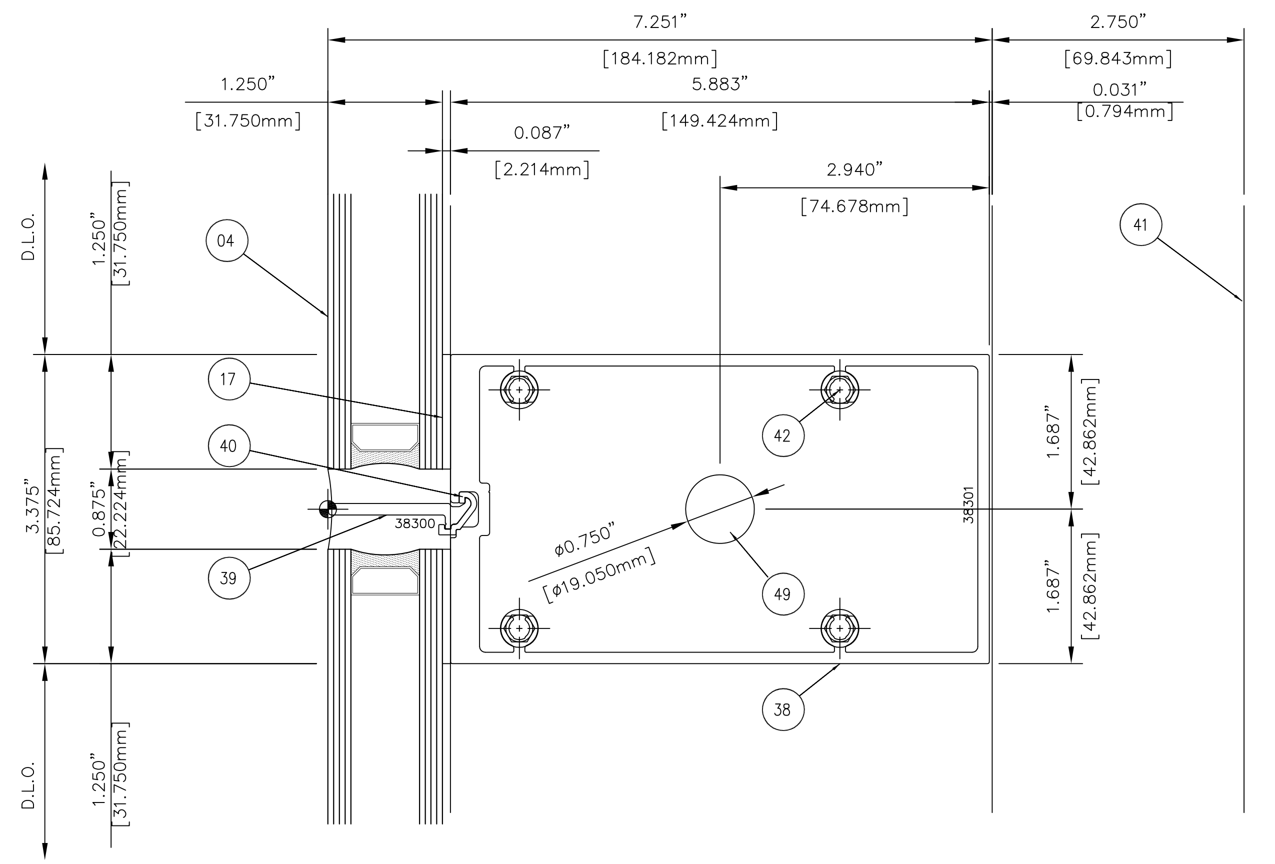
1	-
2	-
3	-
4	-

EN-WALL 7250 Unitized Wall
LAS VEGAS, NEVADA
Racking Load Testing of Unitized Curtain Wall
Penn State University

STACK HORIZONTAL

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039-20

4.03A



1 – 4.04 –

BUTT JOINT HORIZONTAL DETAIL

SCALE: FULL SIZE

LEGEND

00 Gasket
01 Upper Stack Extrusion
02 Continuous Gutter Extrusion
03 Lower Stack Extrusion
04 Glass
05 Stack Wiper Gasket
06 Upper Stack Deadload Fin
07 Lower Stack Weatherseal Fin
08 Setting Block
09 Closed Cell Baffle at Mullion
10 Continuous Chicken Head Gasket
11 12" Silicone Front Boot
12 12" Silicone Gutter Boot
13 Isolator Gasket #1
14 Extruded Aluminum Stool Trim
15 Stool Trim Wiper Gasket
16 Silicone Bedding
17 3M G23F Structural Glazing Tape
18 Extruded Anchor Knuckle
19 Extruded Anchor Hook
20 Extruded Anit–Walk Clip
21 Extruded U–Channel
22 –
23 Vertical Adjustment Screw
24 #10 x 1/2 FHPH
25 Silicone Weatherseal and Backer Rod
26 Halfen Anchor and Tee Bolt
27 Serrated Washer
28 Isolator Gasket #2
29 Isolator Gasket #3
30 Continuous Wedge Gasket
31 Vertical Weatherseal Fin
32 Female Mullion
33 Male Mullion
34 Retractable Lifting Lug
35 Silicone Seal
36 Pressure Equalizer Gasket
37 Vertical Weatherseal Gasket
38 Intermediate Horizontal
39 Horizontal Shelf Fin
40 Horizontal Fin Isolator
41 Chamber Steel
42 Assembly Screws
43 Aluminum Angle
44 Thermal Isolator
45 Neoprene Sponge @ Mull & Splice
46 5/16" Weep Hole @ 24" O.C.
47 Non–Continuous X 2" Wedge – 12" O.C.
48 1/2"–12–13 X 1 1/2" Grade 8 Hex Bolt
49 Pressure Equalization Access Hole
50 High Impact Plastic Shim
51 1/2" Type 'F' Bolt

EN-WALL
5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702–834–9600
Fax: 702–533–0922

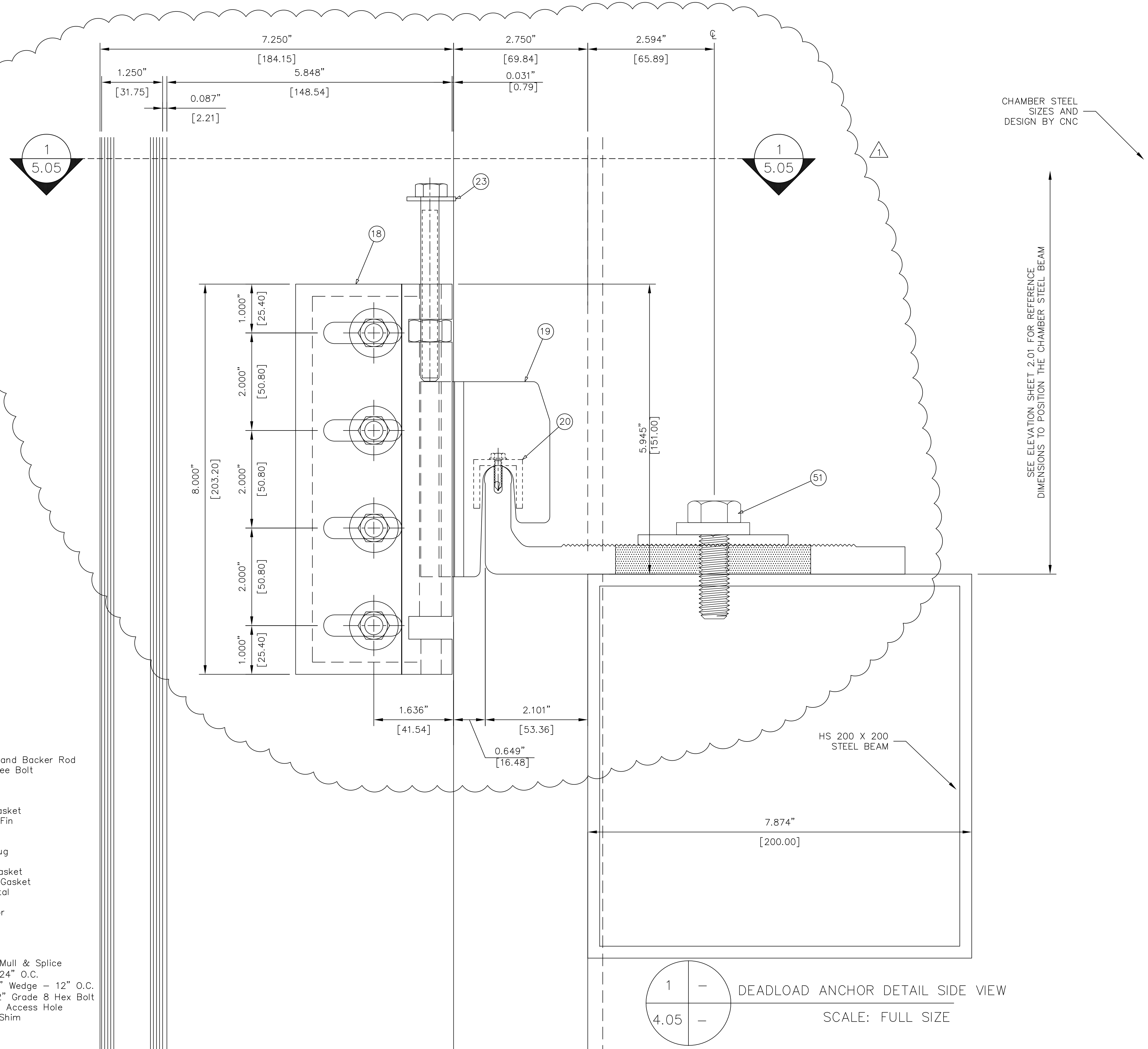
REVISIONS	
1	–
2	–
3	–
4	–

EN–WALL 7250 Unitized Wall
LAS VEGAS, NEVADA
Racking Load Testing of Unitized Curtain Wall
Penn State University

BUTT JOINT HORIZ.

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039–20

4.04



1 | –
4.05 | –

DEADLOAD ANCHOR DETAIL SIDE VIEW

SCALE: FULL SIZE

LEGEND

00 Gasket
01 Upper Stack Extrusion
02 Continuous Gutter Extrusion
03 Lower Stack Extrusion
04 Glass
05 Stack Wiper Gasket
06 Upper Stack Deadload Fin
07 Lower Stack Weatherseal Fin
08 Setting Block
09 Closed Cell Baffle at Mullion
10 Continuous Chicken Head Gasket
11 12" Silicone Front Boot
12 12" Silicone Gutter Boot
13 Isolator Gasket #1
14 Extruded Aluminum Stool Trim
15 Stool Trim Wiper Gasket
16 Silicone Bedding
17 3M G23F Structural Glazing Tape
18 Extruded Anchor Knuckle
19 Extruded Anchor Hook
20 Extruded Anit-Walk Clip
21 Extruded U-Channel
22 –
23 Vertical Adjustment Screw
24 #10 x 1/2 FHPH
25 Silicone Weatherseal and Backer Rod
26 Halfen Anchor and Tee Bolt
27 Serrated Washer
28 Isolator Gasket #2
29 Isolator Gasket #3
30 Continuous Wedge Gasket
31 Vertical Weatherseal Fin
32 Female Mullion
33 Male Mullion
34 Retractable Lifting Lug
35 Silicone Seal
36 Pressure Equalizer Gasket
37 Vertical Weatherseal Gasket
38 Intermediate Horizontal
39 Horizontal Shelf Fin
40 Horizontal Fin Isolator
41 Chamber Steel
42 Assembly Screws
43 Aluminum Angle
44 Thermal Isolator
45 Neoprene Sponge @ Mull & Splice
46 5/16" Weep Hole @ 24" O.C.
47 Non-Continuous X 2" Wedge – 12" O.C.
48 1/2"-12-13 X 1 1/2" Grade 8 Hex Bolt
49 Pressure Equalization Access Hole
50 High Impact Plastic Shim
51 1/2" Type 'F' Bolt

EN-WALL
5340 W Robindale Road
Las Vegas, Nevada 89139
Tel.: 702-834-9600
Fax: 702-533-0922

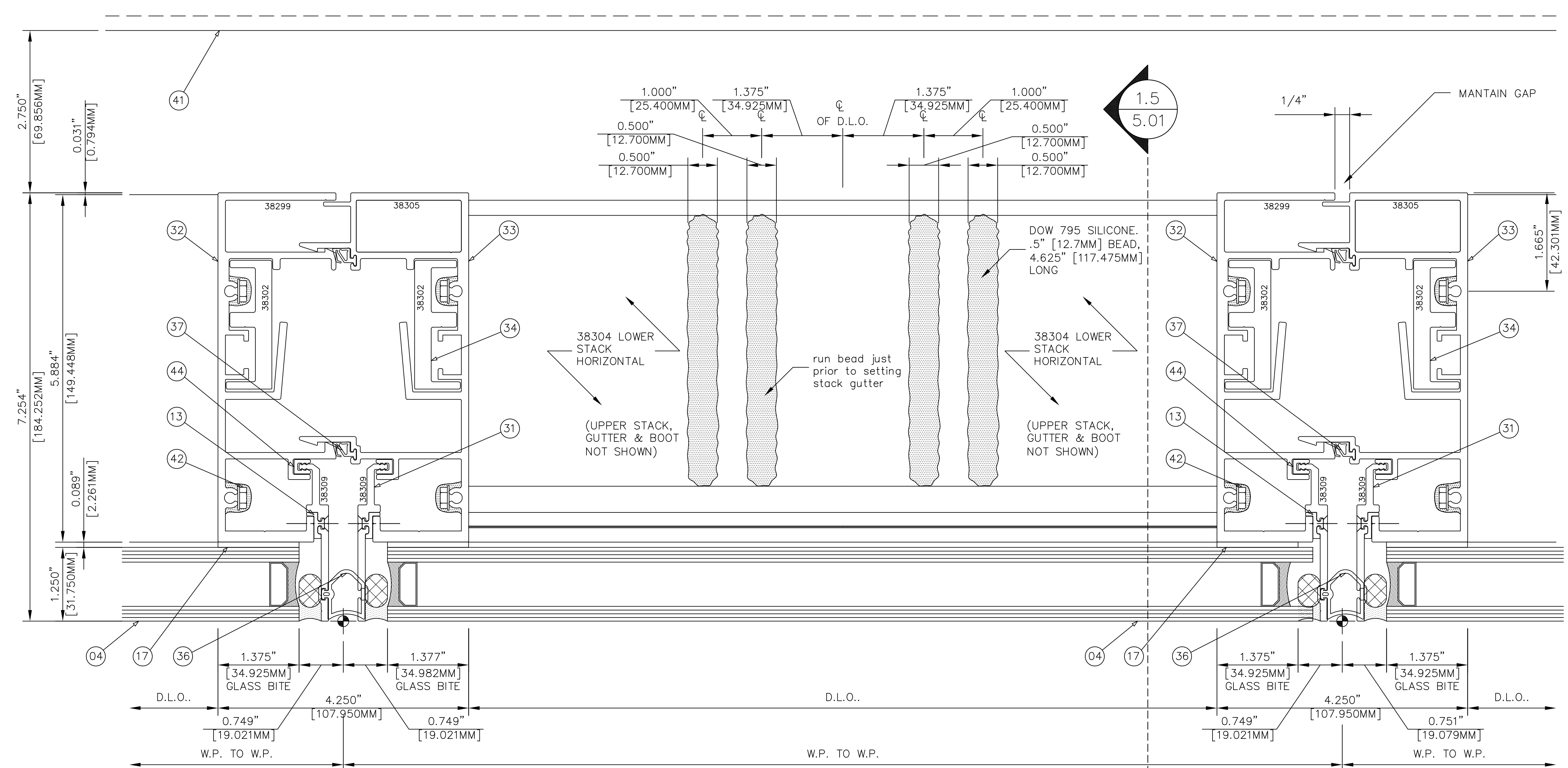
REVISIONS	
1	9/25/09 BY: KLS
2	-
3	-
4	-

EN-WALL 7250 Unitized Wall
LAS VEGAS, NEVADA
Racking Load Testing of Unitized Curtain Wall
Penn State University

DEADLOAD ANCHOR

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039-20-01

4.05

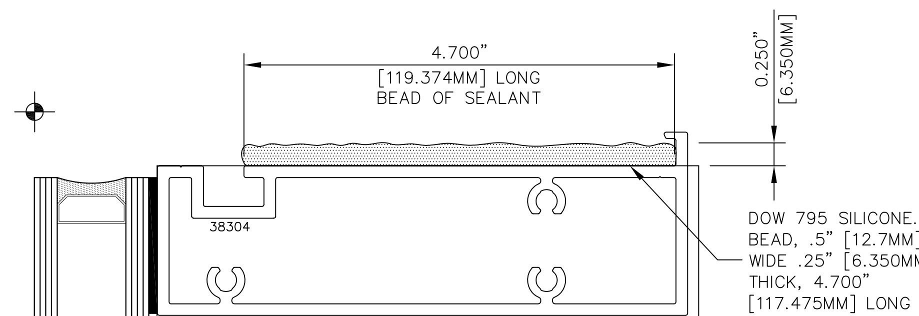


1 – 5.01 – INTERMEDIATE VERTICAL DETAIL

SCALE: FULL SIZE

LEGEND

00 Gasket
01 Upper Stack Extrusion
02 Continuous Gutter Extrusion
03 Lower Stack Extrusion
04 Glass
05 Stack Wiper Gasket
06 Upper Stack Deadload Fin
07 Lower Stack Weatherseal Fin
08 Setting Block
09 Closed Cell Baffle at Mullion
10 Continuous Chicken Head Gasket
11 12" Silicone Front Boot
12 12" Silicone Gutter Boot
13 Isolator Gasket #1
14 Extruded Aluminum Stool Trim
15 Stool Trim Wiper Gasket
16 Silicone Bedding
17 3M G23F Structural Glazing Tape
18 Extruded Anchor Knuckle
19 Extruded Anchor Hook
20 Extruded Anit-Walk Clip
21 Extruded U-Channel
22 –
23 Vertical Adjustment Screw
24 #10 x 1/2 FHPH
25 Silicone Weatherseal and Backer Rod
26 Halfen Anchor and Tee Bolt
27 Serrated Washer
28 Isolator Gasket #2
29 Isolator Gasket #3
30 Continuous Wedge Gasket
31 Vertical Weatherseal Fin
32 Female Mullion
33 Male Mullion
34 Retractable Lifting Lug
35 Silicone Seal
36 Pressure Equalizer Gasket
37 Vertical Weatherseal Gasket
38 Intermediate Horizontal
39 Horizontal Shelf Fin
40 Horizontal Fin Isolator
41 Chamber Steel
42 Assembly Screws
43 Aluminum Angle
44 Thermal Isolator
45 Neoprene Sponge @ Mull & Splice
46 5/16" Weep Hole @ 24" O.C.
47 Non–Continuous X 2" Wedge – 12" O.C.
48 1/2"–12–13 X 1 1/2" Grade 8 Hex Bolt
49 Pressure Equalization Access Hole
50 High Impact Plastic Shim
51 1/2" Type 'F' Bolt



1.5 – 5.01 – HORIZ SPLICE SECTION VIEW

SCALE: FULL SIZE

EN-WALL
5340 West Robindale Road
Las Vegas, Nevada 89139
Tel: 702–834–9600
Fax: 702–533–0922

REVISIONS

1	
2	-
3	-
4	-

EN–WALL 7250 Unitized Wall

LAS VEGAS, NEVADA

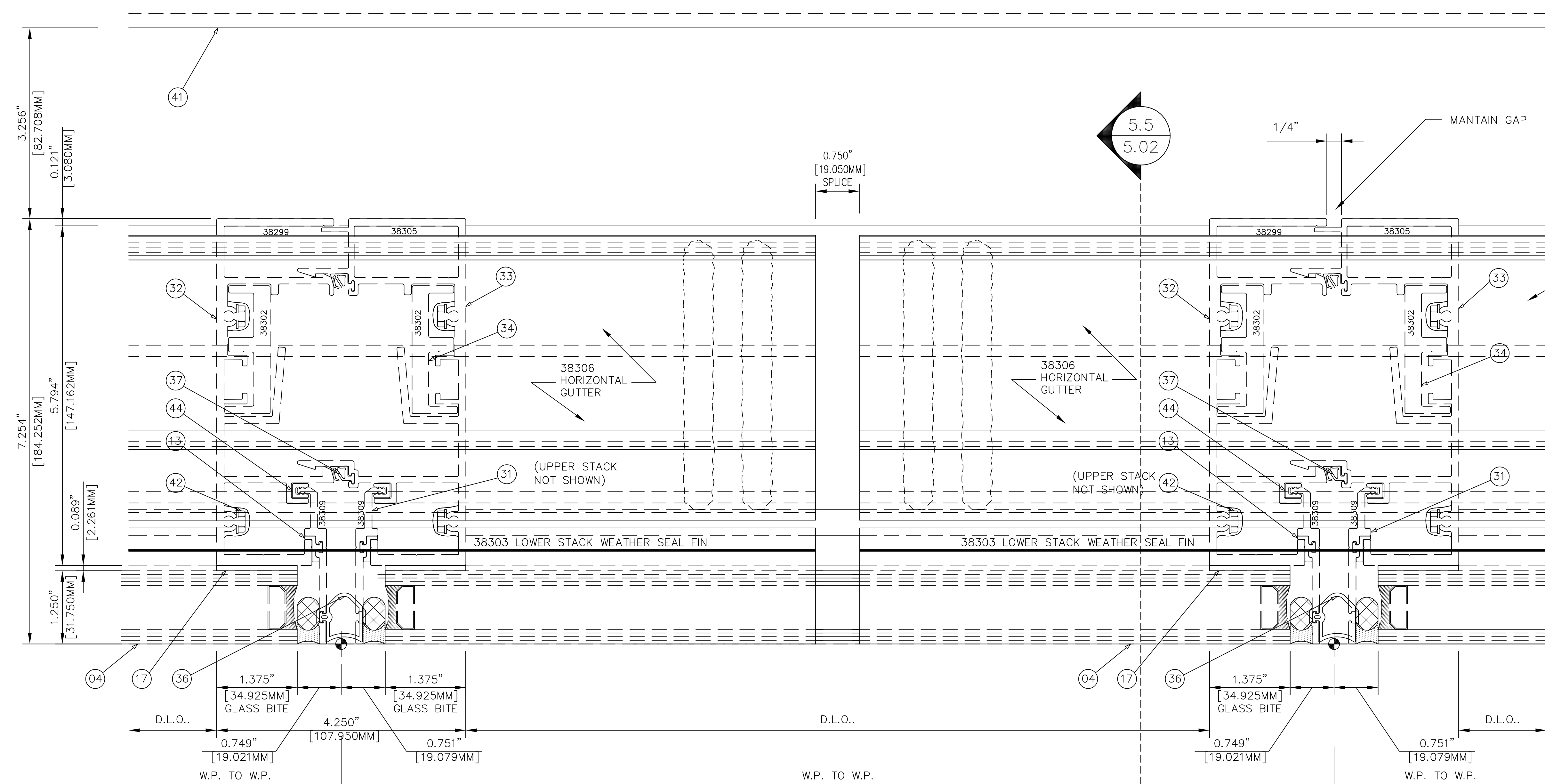
Racking Load Testing of Unitized Curtain Wall

Penn State University

INTERM. VERTICAL

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039–20

5.01

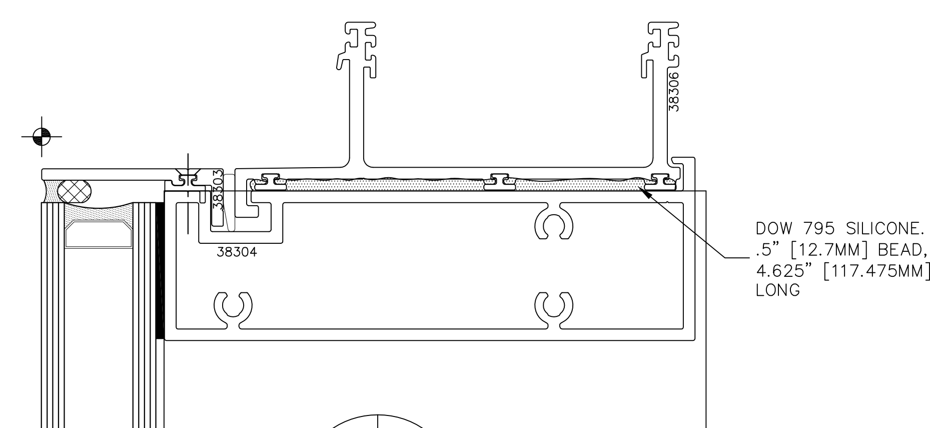


LEGEND

00 Gasket
01 Upper Stack Extrusion
02 Continuous Gutter Extrusion
03 Lower Stack Extrusion
04 Glass
05 Stack Wiper Gasket
06 Upper Stack Deadload Fin
07 Lower Stack Weatherseal Fin
08 Setting Block
09 Closed Cell Baffle at Mullion
10 Continuous Chicken Head Gasket
11 12" Silicone Front Boot
12 12" Silicone Gutter Boot
13 Isolator Gasket #1
14 Extruded Aluminum Stool Trim
15 Stool Trim Wiper Gasket
16 Silicone Bedding
17 3M G23F Structural Glazing Tape
18 Extruded Anchor Knuckle
19 Extruded Anchor Hook
20 Extruded Anit-Walk Clip
21 Extruded U-Channel
22 Anchor Deadload Rod
23 Vertical Adjustment Screw
24 #10 x 1/2 FHPH
25 Silicone Weatherseal and Backer Rod
26 Halfen Anchor and Tee Bolt
27 Serrated Washer
28 Isolator Gasket #2
29 Isolator Gasket #3
30 Continuous Wedge Gasket
31 Vertical Weatherseal Fin
32 Female Mullion
33 Male Mullion
34 Retractable Lifting Lug
35 Silicone Seal
36 Pressure Equalizer Gasket
37 Vertical Weatherseal Gasket
38 Intermediate Horizontal
39 Horizontal Shelf Fin
40 Horizontal Fin Isolator
41 Steel (Test Chamber)
42 Assembly Screws
43 Aluminum Angle
44 Thermal Isolator

1 – / 5.02 – INTERMEDIATE VERTICAL DETAIL

SCALE: FULL SIZE



1.5 – / 5.02 – HORIZ SPLICE SECTION VIEW

SCALE: FULL SIZE

EN-WALL

5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702-834-9600
Fax: 702-533-0922

REVISIONS

1	
2	-
3	-
4	-

EN-WALL 7250 Unitized Wall

LAS VEGAS, NEVADA

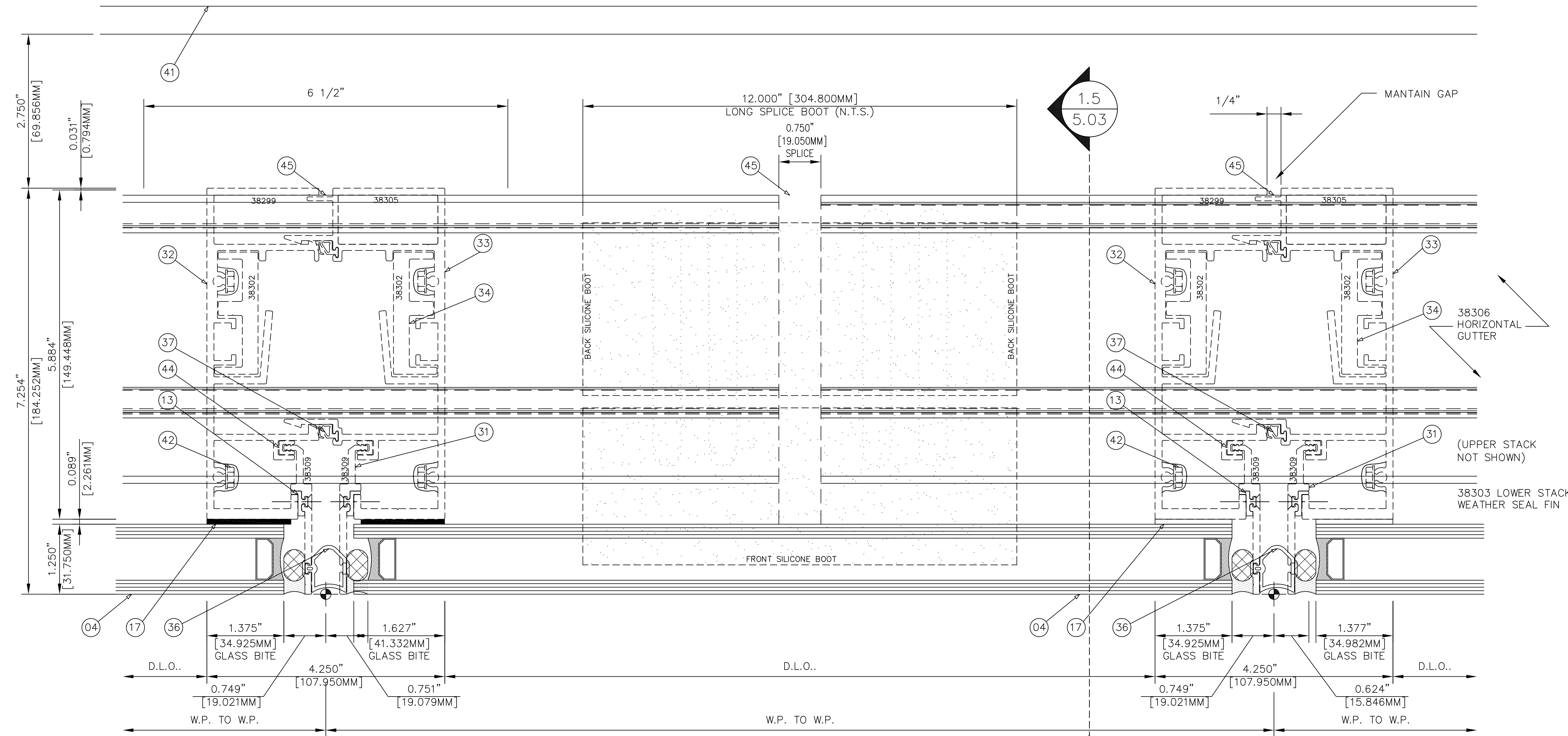
Racking Load Testing of Unitized Curtain Wall

Penn State University

INTERM. VERTICAL

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039-20

5.02

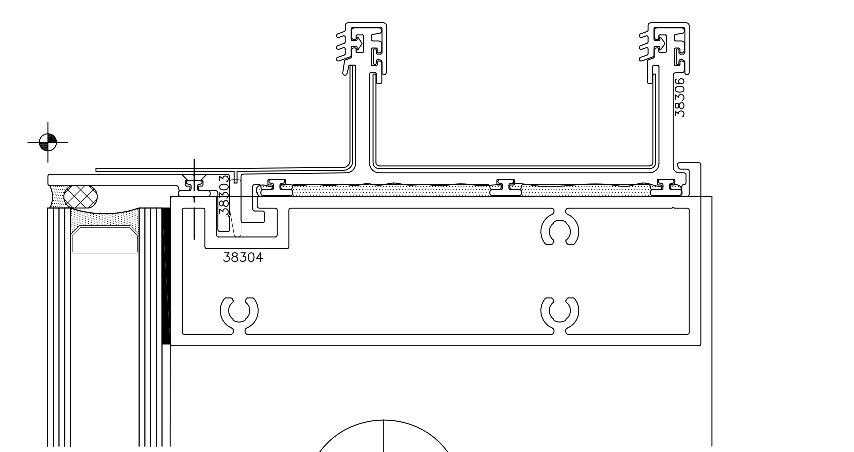


1 / 5.03 INTERMEDIATE VERTICAL DETAIL

SCALE: FULL SIZE

LEGEND

00 Gasket
01 Upper Stack Extrusion
02 Continuous Gutter Extrusion
03 Lower Stack Extrusion
04 Glass
05 Stack Wiper Gasket
06 Upper Stack Deadload Fin
07 Lower Stack Weatherseal Fin
08 Setting Block
09 Closed Cell Baffle at Mullion
10 Continuous Chicken Head Gasket
11 12" Silicone Front Boot
12 12" Silicone Gutter Boot
13 Isolator Gasket #1
14 Extruded Aluminum Stool Trim
15 Stool Trim Wiper Gasket
16 Silicone Bedding
17 3M G23F Structural Glazing Tape
18 Extruded Anchor Knuckle
19 Extruded Anchor Hook
20 Extruded Anit-Walk Clip
21 Extruded U-Channel
22 –
23 Vertical Adjustment Screw
24 #10 x 1/2 FHPH
25 Silicone Weatherseal and Backer Rod
26 Halfen Anchor and Tee Bolt
27 Serrated Washer
28 Isolator Gasket #2
29 Isolator Gasket #3
30 Continuous Wedge Gasket
31 Vertical Weatherseal Fin
32 Female Mullion
33 Male Mullion
34 Retractable Lifting Lug
35 Silicone Seal
36 Pressure Equalizer Gasket
37 Vertical Weatherseal Gasket
38 Intermediate Horizontal
39 Horizontal Shelf Fin
40 Horizontal Fin Isolator
41 Chamber Steel
42 Assembly Screws
43 Aluminum Angle
44 Thermal Isolator
45 Neoprene Sponge @ Mull & Splice
46 5/16" Weep Hole @ 24" O.C.
47 Non–Continuous X 2" Wedge – 12" O.C.
48 1/2"–12–13 X 1 1/2" Grade 8 Hex Bolt
49 Pressure Equalization Access Hole
50 High Impact Plastic Shim
51 1/2" Type 'F' Bolt
52 1/2" Anti Wack Bolt
53 1/2" Vertical Adjustment Screw –Start With Half Screw Spoused



1.5 / 5.03 HORIZ SPLICE SECTION VIEW

SCALE: FULL SIZE

EN-WALL
5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702–834–9600
Fax: 702–533–0922

REVISIONS

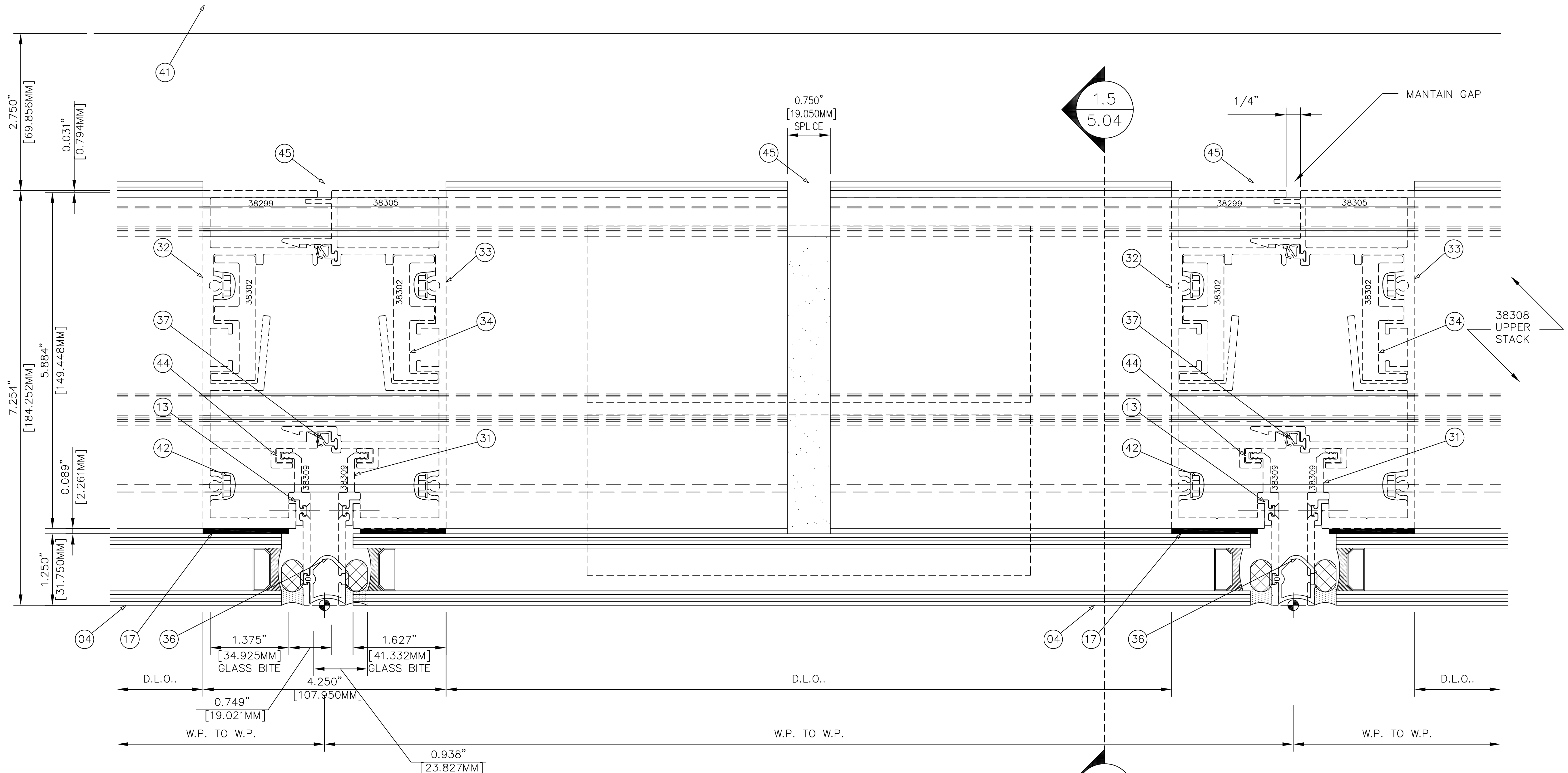
1	
2	-
3	-
4	-

EN–WALL 7250 Unitized Wall
LAS VEGAS, NEVADA
Racking Load Testing of Unitized Curtain Wall
Penn State University

INTERM. VERTICAL

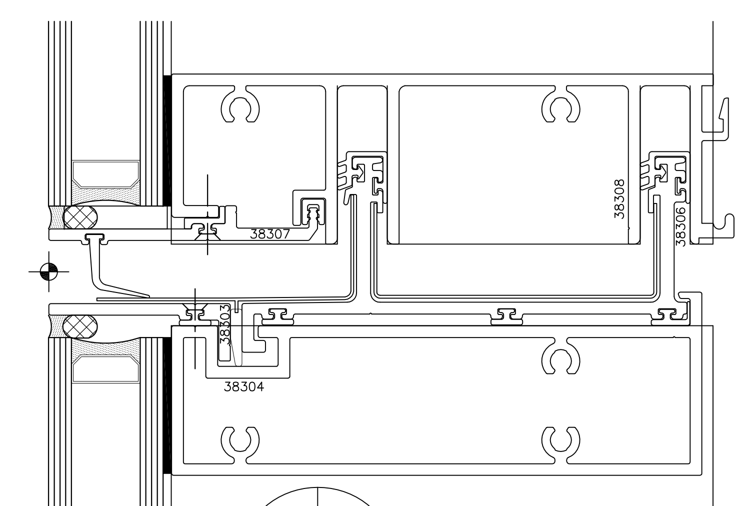
DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039–20

5.03



1 – 5.04 – INTERMEDIATE VERTICAL DETAIL

SCALE: FULL SIZE



1.5 – 5.04 – HORIZ SPLICE SECTION VIEW

SCALE: FULL SIZE

LEGEND

00 Gasket
01 Upper Stack Extrusion
02 Continuous Gutter Extrusion
03 Lower Stack Extrusion
04 Glass
05 Stack Wiper Gasket
06 Upper Stack Deadload Fin
07 Lower Stack Weatherseal Fin
08 Setting Block
09 Closed Cell Baffle at Mullion
10 Continuous Chicken Head Gasket
11 12" Silicone Front Boot
12 12" Silicone Gutter Boot
13 Isolator Gasket #1
14 Extruded Aluminum Stool Trim
15 Stool Trim Wiper Gasket
16 Silicone Bedding
17 3M G23F Structural Glazing Tape
18 Extruded Anchor Knuckle
19 Extruded Anchor Hook
20 Extruded Anit–Walk Clip
21 Extruded U–Channel
22 –
23 Vertical Adjustment Screw
24 #10 x 1/2 FHPH
25 Silicone Weatherseal and Backer Rod
26 Halfen Anchor and Tee Bolt
27 Serrated Washer
28 Isolator Gasket #2
29 Isolator Gasket #3
30 Continuous Wedge Gasket
31 Vertical Weatherseal Fin
32 Female Mullion
33 Male Mullion
34 Retractable Lifting Lug
35 Silicone Seal
36 Pressure Equalizer Gasket
37 Vertical Weatherseal Gasket
38 Intermediate Horizontal
39 Horizontal Shelf Fin
40 Horizontal Fin Isolator
41 Chamber Steel
42 Assembly Screws
43 Aluminum Angle
44 Thermal Isolator
45 Neoprene Sponge @ Mull & Splice
46 5/16" Weep Hole @ 24" O.C.
47 Non–Continuous X 2" Wedge – 12" O.C.
48 1/2"–12–13 X 1 1/2" Grade 8 Hex Bolt
49 Pressure Equalization Access Hole
50 High Impact Plastic Shim
51 1/2" Type 'F' Bolt

EN-WALL
5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702–834–9600
Fax: 702–533–0922

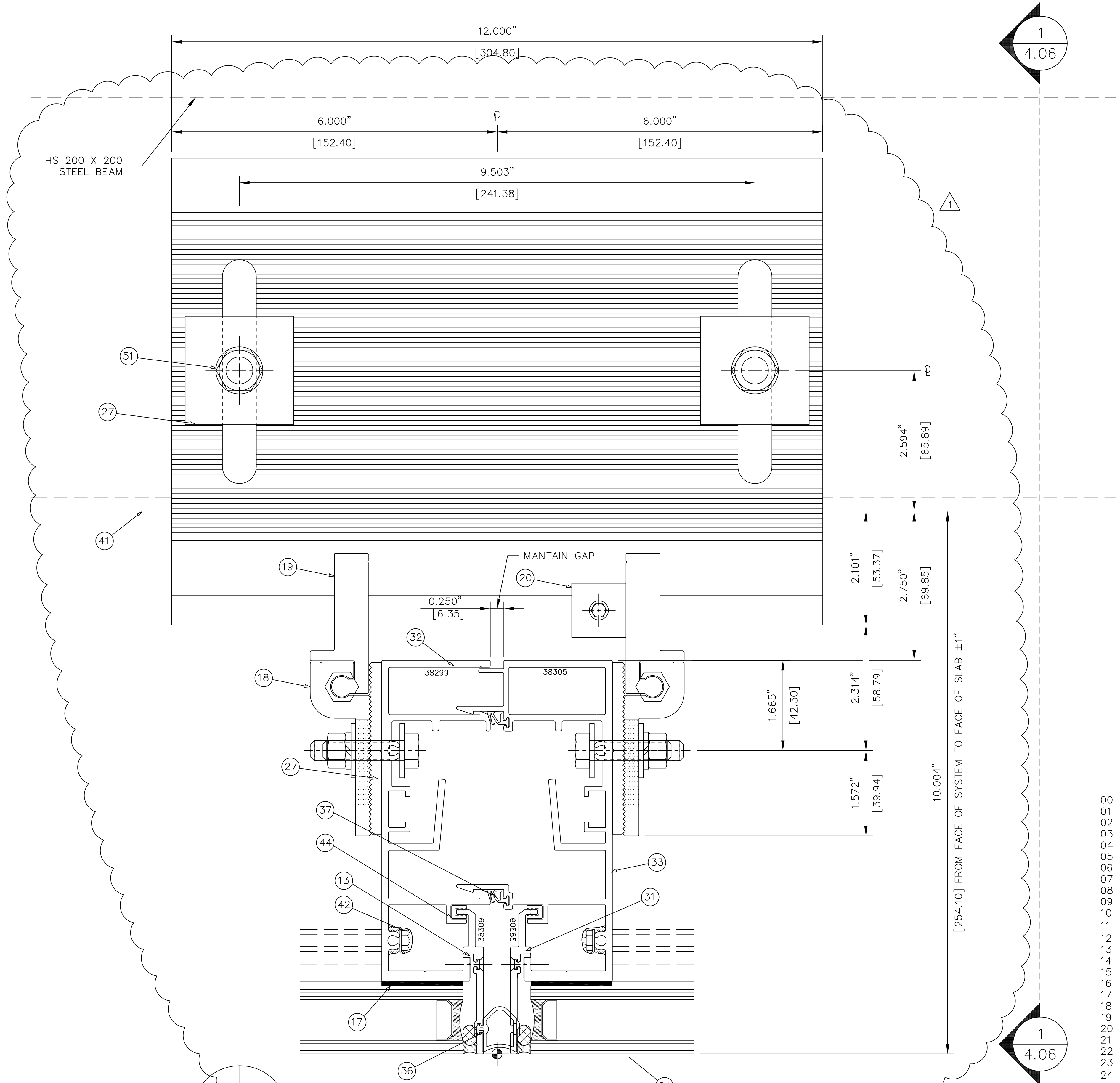
REVISIONS

1	
2	-
3	-
4	-

EN–WALL 7250 Unitized Wall
LAS VEGAS, NEVADA
Racking Load Testing of Unitized Curtain Wall
Penn State University

INTERM. VERTICAL

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039–20



DEADLOAD ANCHOR DETAIL TOP VIEW

SCALE: FULL SIZE

1 / 5.05

LEGEND

00	Gasket	25	Silicone Weatherseal and Backer Rod
01	Upper Stack Extrusion	26	Halfen Anchor and Tee Bolt
02	Continuous Gutter Extrusion	27	Serrated Washer
03	Lower Stack Extrusion	28	Isolator Gasket #2
04	Glass	29	Isolator Gasket #3
05	Stack Wiper Gasket	30	Continuous Wedge Gasket
06	Upper Stack Deadload Fin	31	Vertical Weatherseal Fin
07	Lower Stack Weatherseal Fin	32	Female Mullion
08	Setting Block	33	Male Mullion
09	Closed Cell Baffle at Mullion	34	Retractable Lifting Lug
10	Continuous Chicken Head Gasket	35	Silicone Seal
11	12" Silicone Front Boot	36	Pressure Equalizer Gasket
12	12" Silicone Gutter Boot	37	Vertical Weatherseal Gasket
13	Isolator Gasket #1	38	Intermediate Horizontal
14	Extruded Aluminum Stool Trim	39	Horizontal Shelf Fin
15	Stool Trim Wiper Gasket	40	Horizontal Fin Isolator
16	Silicone Bedding	41	Chamber Steel
17	3M G23F Structural Glazing Tape	42	Assembly Screws
18	Extruded Anchor Knuckle	43	Aluminum Angle
19	Extruded Anchor Hook	44	Thermal Isolator
20	Extruded Anit-Walk Clip	45	Neoprene Sponge @ Mull & Splice
21	Extruded U-Channel	46	5/16" Weep Hole @ 24" O.C.
22	–	47	Non-Continuous X 2" Wedge – 12" O.C.
23	Vertical Adjustment Screw	48	1/2"-12-13 X 1 1/2" Grade 8 Hex Bolt
24	#10 x 1/2 FHPH	49	Pressure Equalization Access Hole
		50	High Impact Plastic Shim
		51	1/2" Type 'F' Bolt

EN-WALL
5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702-834-9600
Fax: 702-533-0922

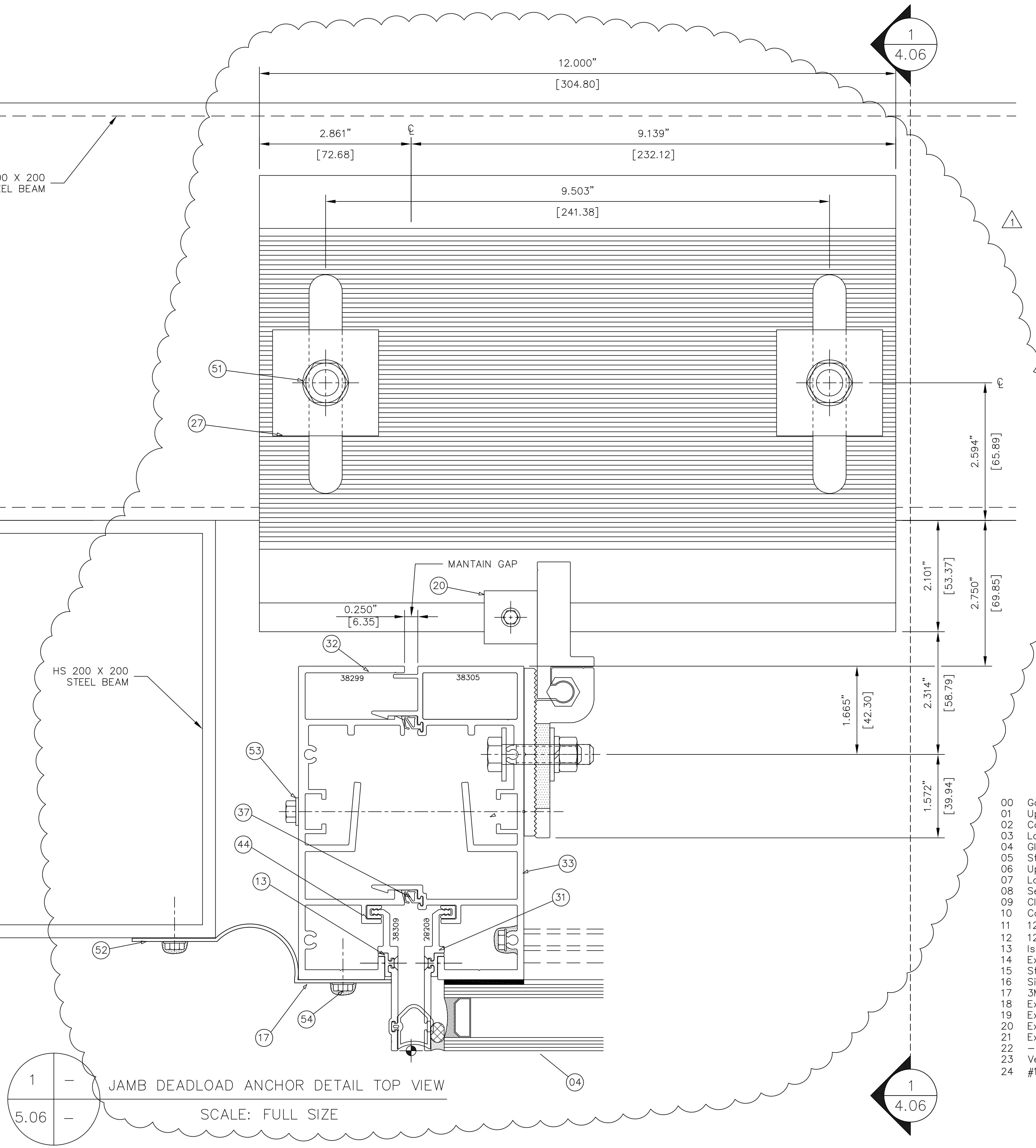
REVISIONS

1	9/25/09 BY: KLS
2	-
3	-
4	-

EN-WALL 7250 Unitized Wall
LAS VEGAS, NEVADA
Racking Load Testing of Unitized Curtain Wall
Penn State University

DEADLOAD ANCHOR

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039-20-01



LEGEND

00	Gasket	25	Silicone Weatherseal and Backer Rod
01	Upper Stack Extrusion	26	Halfen Anchor and Tee Bolt
02	Continuous Gutter Extrusion	27	Serrated Washer
03	Lower Stack Extrusion	28	Isolator Gasket #2
04	Glass	29	Isolator Gasket #3
05	Stack Wiper Gasket	30	Continuous Wedge Gasket
06	Upper Stack Deadload Fin	31	Vertical Weatherseal Fin
07	Lower Stack Weatherseal Fin	32	Female Mullion
08	Setting Block	33	Male Mullion
09	Closed Cell Baffle at Mullion	34	Retractable Lifting Lug
10	Continuous Chicken Head Gasket	35	Silicone Seal
11	12" Silicone Front Boot	36	Pressure Equalizer Gasket
12	12" Silicone Gutter Boot	37	Vertical Weatherseal Gasket
13	Isolator Gasket #1	38	Intermediate Horizontal
14	Extruded Aluminum Stool Trim	39	Horizontal Shelf Fin
15	Stool Trim Wiper Gasket	40	Horizontal Fin Isolator
16	Silicone Bedding	41	Chamber Steel
17	3M G23F Structural Glazing Tape	42	Assembly Screws
18	Extruded Anchor Knuckle	43	Aluminum Angle
19	Extruded Anchor Hook	44	Thermal Isolator
20	Extruded Anit-Walk Clip	45	Neoprene Sponge @ Mull & Splice
21	Extruded U-Channel	46	5/16" Weep Hole @ 24" O.C.
22	–	47	Non-Continuous X 2" Wedge – 12" O.C.
23	Vertical Adjustment Screw	48	1/2"-12-13 X 1 1/2" Grade 8 Hex Bolt
24	#10 x 1/2 FHPH	49	Pressure Equalization Access Hole
		50	High Impact Plastic Shim
		51	1/2" Type 'F' Bolt

EN-WALL
5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702-834-9600
Fax: 702-533-0922

REVISIONS

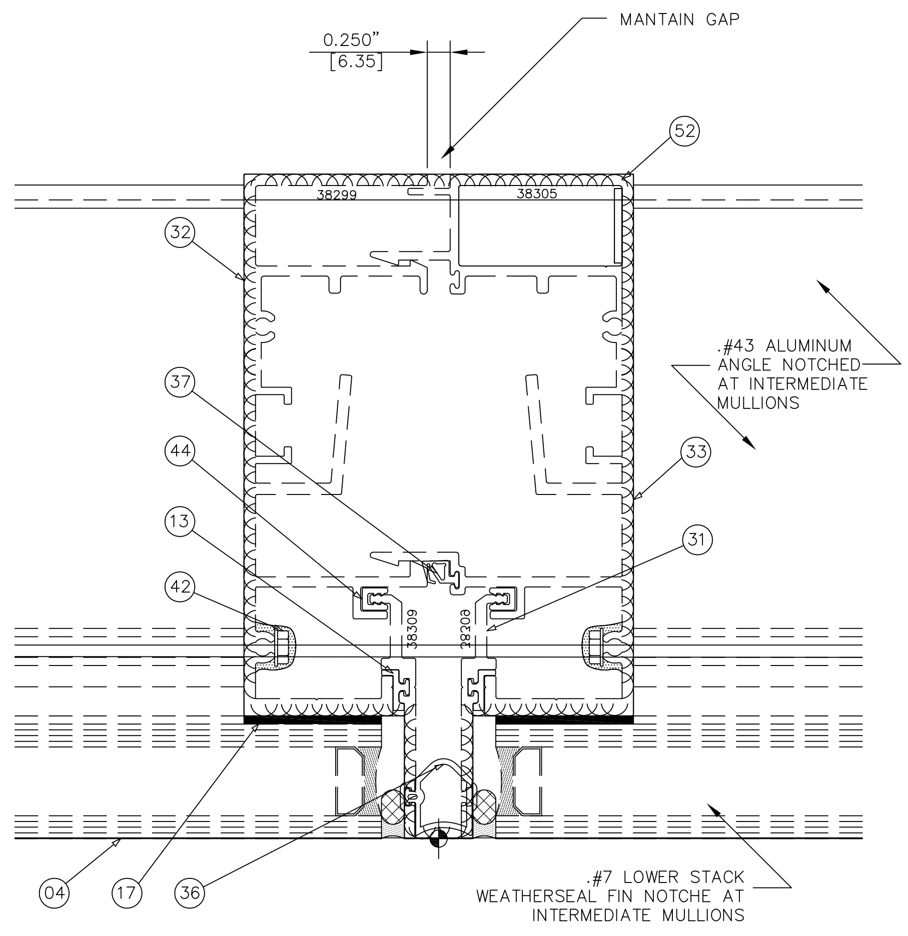
1	9/25/09 BY: KLS
2	-
3	-
4	-

EN-WALL 7250 Unitized Wall
LAS VEGAS, NEVADA
Racking Load Testing of Unitized Curtain Wall
Penn State University

DEADLOAD ANCHOR

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039-20-01

5.06



1 | –
5.07 | –

TOP OF INTERMEDIATE MULLION DETAIL

SCALE: FULL SIZE

LEGEND

00 Gasket
01 Upper Stack Extrusion
02 Continuous Gutter Extrusion
03 Lower Stack Extrusion
04 Glass
05 Stack Wiper Gasket
06 Upper Stack Deadload Fin
07 Lower Stack Weatherseal Fin
08 Setting Block
09 Closed Cell Baffle at Mullion
10 Continuous Chicken Head Gasket
11 12" Silicone Front Boot
12 12" Silicone Gutter Boot
13 Isolator Gasket #1
14 Extruded Aluminum Stool Trim
15 Stool Trim Wiper Gasket
16 Silicone Bedding
17 3M G23F Structural Glazing Tape
18 Extruded Anchor Knuckle
19 Extruded Anchor Hook
20 Extruded Anit–Walk Clip
21 Extruded U–Channel
22 –
23 Vertical Adjustment Screw
24 #10 x 1/2 FHPH
25 Silicone Weatherseal and Backer Rod
26 Halfen Anchor and Tee Bolt
27 Serrated Washer
28 Isolator Gasket #2
29 Isolator Gasket #3
30 Continuous Wedge Gasket
31 Vertical Weatherseal Fin
32 Female Mullion
33 Male Mullion
34 Retractable Lifting Lug
35 Silicone Seal
36 Pressure Equalizer Gasket
37 Vertical Weatherseal Gasket
38 Intermediate Horizontal
39 Horizontal Shelf Fin
40 Horizontal Fin Isolator
41 Chamber Steel
42 Assembly Screws
43 Aluminum Angle
44 Thermal Isolator
45 Neoprene Sponge @ Mull & Splice
46 5/16" Weep Hole @ 24" O.C.
47 Non–Continuous X 2" Wedge – 12" O.C.
48 1/2"–12–13 X 1 1/2" Grade 8 Hex Bolt
49 Pressure Equalization Access Hole
50 High Impact Plastic Shim
51 1/2" Type 'F' Bolt
52 ALUMINUM PLATE SET IN D.C. 795 BED OF SEALANT

EN-WALL
5340 West Robindale Road
Las Vegas, Nevada 89139
Tel.: 702–834–9600
Fax: 702–533–0922

REVISIONS	
1	
2	-
3	-
4	-

EN–WALL 7250 Unitized Wall
LAS VEGAS, NEVADA
Racking Load Testing of Unitized Curtain Wall
Penn State University

DEADLOAD ANCHOR

DRAWN BY:	SS
DATE:	7/8/09
SCALE:	N.T.S.
FILE:	–
JOB NO.:	08039–20–01