

Mechanical Engineering Division
March 5, 2015

Trinity Highway Products
2525 Stemmons Freeway
Dallas, TX 75207

Subject: Post-Test Occupant Compartment Measurement Methodology for ET Plus® Test ET31-30

This letter provides a detailed description of the methodology used to measure post-test deformation of the vehicle used in Test ET31-30 under Southwest Research Institute (SwRI®) Project 18.20887. This letter is supplemental to SwRI Test Report 18.20887.05.100.FR4, Issue 1, “Full-Scale Crash Evaluation of the ET Plus® End Terminal with 4-inch Wide Guide Channel Installed with a Rail Height of 31 Inches,” and is not intended to be a stand-alone description of the test.

General Information

Test ET31-30 was conducted on January 27, 2015. Testing was conducted in accordance with Test 3-30 of National Cooperative Highway Research Program (NCHRP) Report 350. A summary of the test parameters for Test ET31-30 is provided below, and photographs of the vehicle pre- and post-test are provided in Figure 1 through Figure 3.

Table 1: Test Parameters

Test Identification	ET31-30	
Test Date	January 27, 2015	
Vehicle	1998 Geo Metro	
Vehicle Type	820C	
Test Inertial Mass	808.3 kg	1782 lb.
Target Speed	100±4 km/hr	62.1±2.5 mph
Test Speed	102.8 km/hr	63.9 mph
Target Impact Angle	0±1.5°	
Test Impact Angle	0.2°	
Extruder Head ID	5	
Rail Height	78.7 cm	31 in.



Figure 1: Vehicle Positioned for Test ET31-30, Pre-Test





Figure 2: Test ET31-30 Vehicle, Pre-Test



Figure 3: ET31-30 Test Vehicle Post-Test, Driver's Side Exterior

Post-Test Measurements

Following the completion of the test, the vehicle was thoroughly inspected and photographed in its post-test resting position. Still photographs as well as short videos were recorded from various angles. Measurements, both external and internal, were made to quantify the deformation to the vehicle resulting from the test. The processes used to make measurements are described below along with supporting photographs.

For both internal and external measurements, attention was focused on the front seat area of the vehicle. Reference marks were made on both sides of the vehicle starting at the B-Pillar as shown in Figure 4, and proceeding every 15.2 cm (6 in.) towards the A-Pillar at the front of the vehicle. In the area near the most significant damage, marks were made in 5.1 cm (2 in.) increments.



Figure 4: Exterior Reference Marks on Passenger Side Door, B-Pillar Forward

External Measurements

Before the vehicle was disturbed following the test, external deformation was measured relative to a string line that was positioned parallel to each side of the vehicle. The string was placed 122 cm (48 in.) from the centerline on both sides of the vehicle at a height of 45.7 cm (18 in.), and measurements were recorded from a vertical plane represented by the string line as shown in Figure 7 and Figure 8, and were made at each reference mark between the A-Pillar and B-Pillar. The measurements of external deformation are not used to determine compliance to NCHRP Report 350, and were recorded for reference only.



Figure 5: String Line for External Deformation

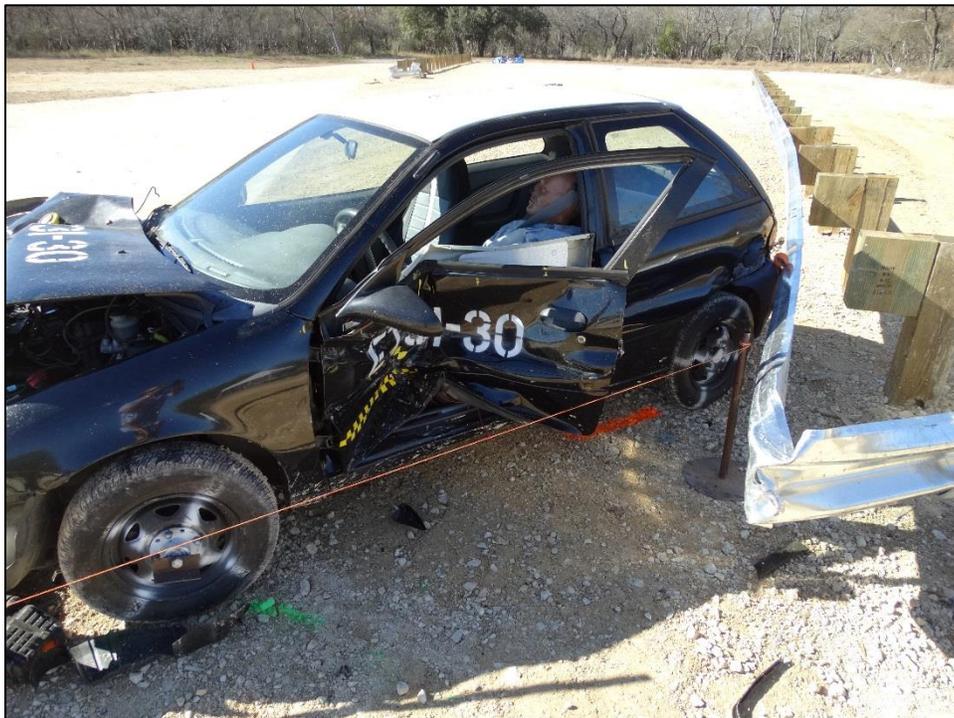


Figure 6: Reference String on Driver's Side



Figure 7: External Measurements - Driver's Side

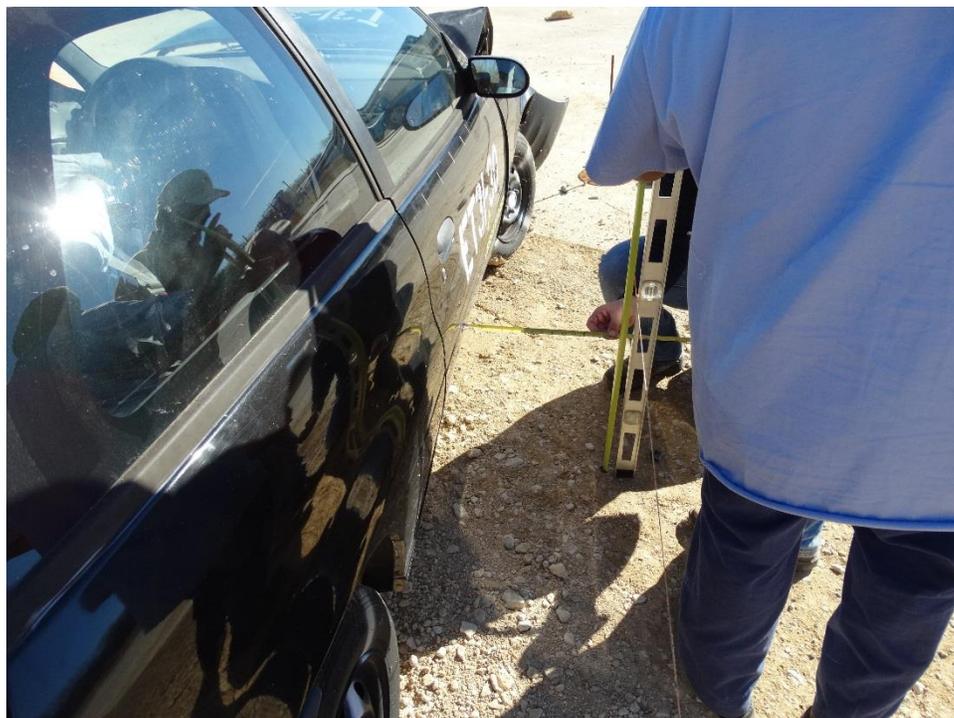


Figure 8: External Measurements - Passenger Side

Internal Measurements

Prior to taking interior deformation measurements, the anthropomorphic dummy was removed from the driver's seat of the vehicle through the passenger door to ensure minimal disturbance of the driver's side door. The reference marks shown in Figure 4 were transferred to the interior of the vehicle on the passenger side as shown in Figure 9, and then to the associated location on the driver's side door as shown in Figure 10. Measurements for both the driver and passenger side of the vehicle were made at each of these reference marks.



Figure 9: Reference Marks Transferred to Interior Passenger Side Door Panel



Figure 10: Corresponding Reference Marks on Driver's Side Door Panel

To facilitate comparative lateral measurements between the driver's side and passenger side of the vehicle, a string line was stretched between the radio console and the rear hatch latch in the center of the vehicle as shown in Figure 11. The lateral location of the centerline was verified by measuring surrogate vehicles of the same model with no internal damage, and was verified to be consistent within 0.5cm (3/16 in.). The vertical location of the string line was recorded by referencing it to the position of the onboard Electronic Data Recorder (EDR) mounting bracket shown in Figure 12, which could be related to the position of the center of gravity of the vehicle as follows:

- The string was located vertically 26.7 cm (10.5 in.) above the EDR mounting bracket.
- The vehicle's center of gravity was 13.6 cm (5.35 in.) above the center of the EDR unit, which places it 18.7 cm (7.35 in.) above the EDR mounting bracket.
- Subtraction locates the string 8 cm (3.15 in.) above the vehicle's center of gravity.

These dimensions were later used to relate the location of maximum deformation to the vehicle's center of gravity.



Figure 11: Centerline Strung from Radio Panel to Rear Hatch Latch



Figure 12: Vertical Location of Centerline Relative to EDR Bracket

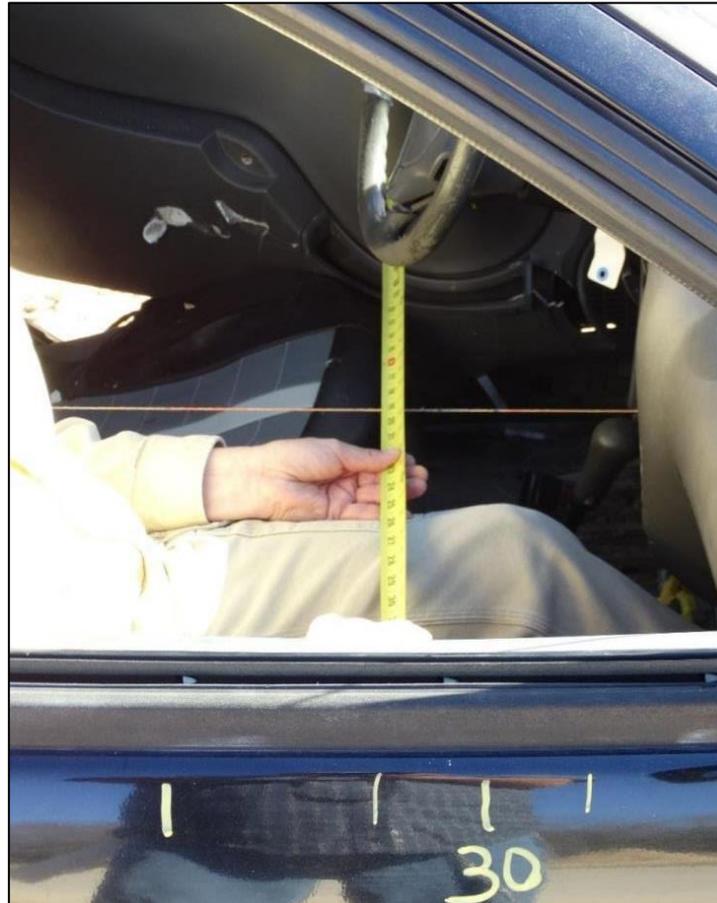


Figure 13: Representative Measurement of Driver's Side Compartment to Centerline



Figure 14: Representative Measurement of Passenger Side Compartment to Centerline

Following the test, internal measurements were made at each of the longitudinal reference marks between the A-Pillar and B-Pillar, and the maximum relative reduction was noted at the lower front corner of the map pocket on the driver's side door, shown in Figure 15. To measure the relative deformation at this location, the top edge of the loose trim on the map pocket was pressed against the door panel as shown in Figure 16, and the resulting measurement to the centerline was compared to the measurement for the corresponding corner of the map pocket on the passenger door. The maximum post-test occupant compartment deformation at the point of maximum compartment reduction was measured to be approximately 17.1 cm (6.75 in.) at a point located approximately 2.2 cm (0.85 in.) below the center of gravity and approximately 5.1 cm (2 in.) aft of the radio panel, roughly even with the height of the front edge of the seat. This measurement equated to a reduction in the width of the occupant compartment of 14% and an Occupant Compartment Deformation Index¹ (OCDI) rating of LF0000200. Note that all measurements with the exception of the location of maximum reduction were made at the height of the centerline string.

¹ The OCDI rating was computed in accordance with NCHRP Report 350, Appendix E.



Figure 15: Location of Maximum Occupant Compartment Deformation



Figure 16: Top Corner of Map Pocket Trim Held against Door Panel for Measurement

If you have any additional questions concerning the vehicle measurements described above, please contact me.

Sincerely,

A handwritten signature in blue ink that reads "Jenny Ferren". The signature is fluid and cursive, with a long horizontal stroke extending to the right.

Jenny Ferren, Manager
Structural Engineering and Product Assurance