



# **Semi-Trailer Underride Evaluation Crash Test Protocol (Version I)**

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## SEMI-TRAILER UNDERRIDE EVALUATION CRASH TEST PROTOCOL (VERSION I)

Supporting documents for the Insurance Institute for Highway Safety (IIHS) crash test programs are available from the technical protocols section of the IIHS website (<http://www.iihs.org/ratings/protocols>).

### TEST CONDITIONS

Much of the pretest setup follows the *Moderate Overlap Frontal Crashworthiness Evaluation Crash Test Protocol (Version XVI)* (IIHS, 2016) with several deviations to account for the different test configuration. Most notably, in place of a deformable barrier face with slotted bumper, the test vehicle strikes the rear of a semi-trailer to test the ability of the trailer to prevent underride.

The IIHS underride test program has used a 2010 Chevrolet Malibu as the striking vehicle in each test. Each Malibu has been equipped with a 4-cylinder engine, typically the 1LS or 1LT trim level. If desired, a different midsize sedan of comparable size and weight could be utilized as the striking vehicle. Each vehicle is inspected for prior damage before being prepared for the test. A vehicle history report also is obtained (e.g., Carfax).

The semi-trailer is connected to a three axle tractor and is loaded with ballast totaling approximately 18,700 kg. The sliding rear axles of the trailer are placed in their middle positions, with a target of 185-195 cm clearance between the rear of the trailer and the rearmost surface of the rear tires. Prior to the test, the trailer's brakes are pressurized to 40 psi to simulate being stopped in traffic.

Pre-crash static measurements of the underride guard are recorded using a coordinate measurement machine (CMM). These same areas are measured again after the crash to determine deformation.

### Impact Speed and Overlaps

Semi-trailer underride crash tests are conducted at  $56.3 \pm 1$  km/h ( $35 \pm 0.6$  mi/h) and at three different vehicle-to-trailer overlaps: full-width,  $50 \pm 1$  percent overlap, and  $30 \pm 1$  percent overlap.

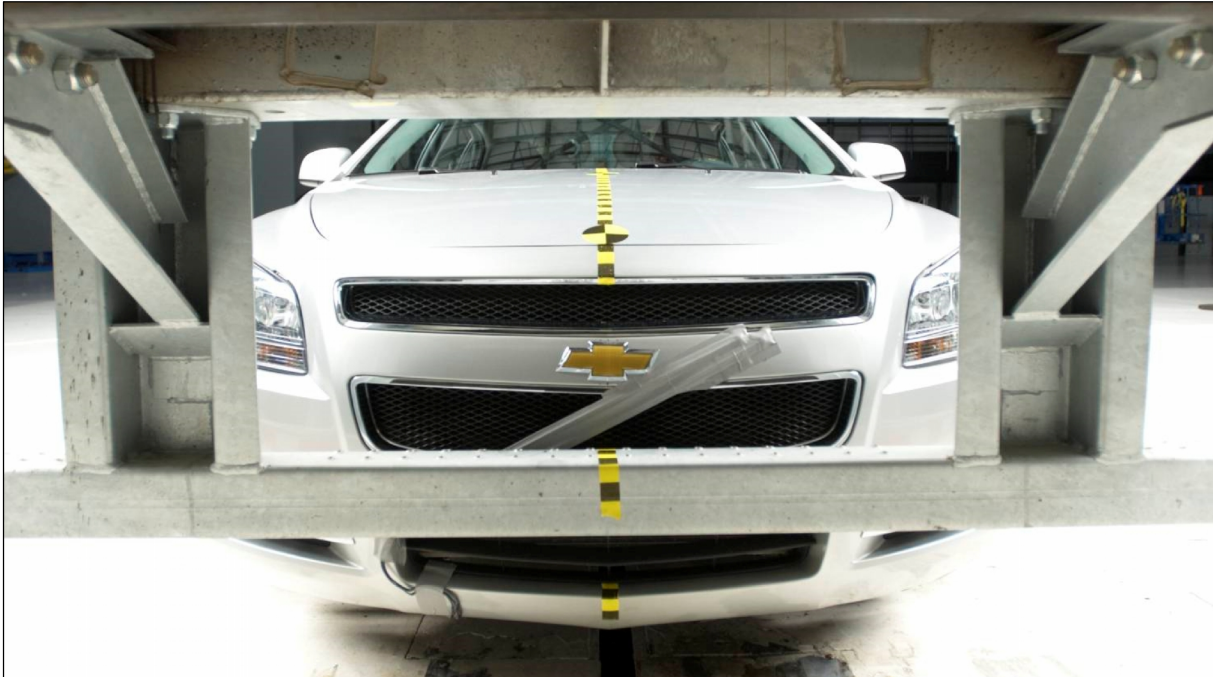
**Full-width:** The midsize car is aligned with the rear of the semi-trailer such that its lateral centerline is aligned with the centerline of the trailer's rear underride guard (Figure 1).

**50 percent overlap:** The midsize car is aligned with the rear of the semi-trailer such that its lateral centerline is aligned with the right edge of the trailer underride guard's horizontal member (Figure 2).

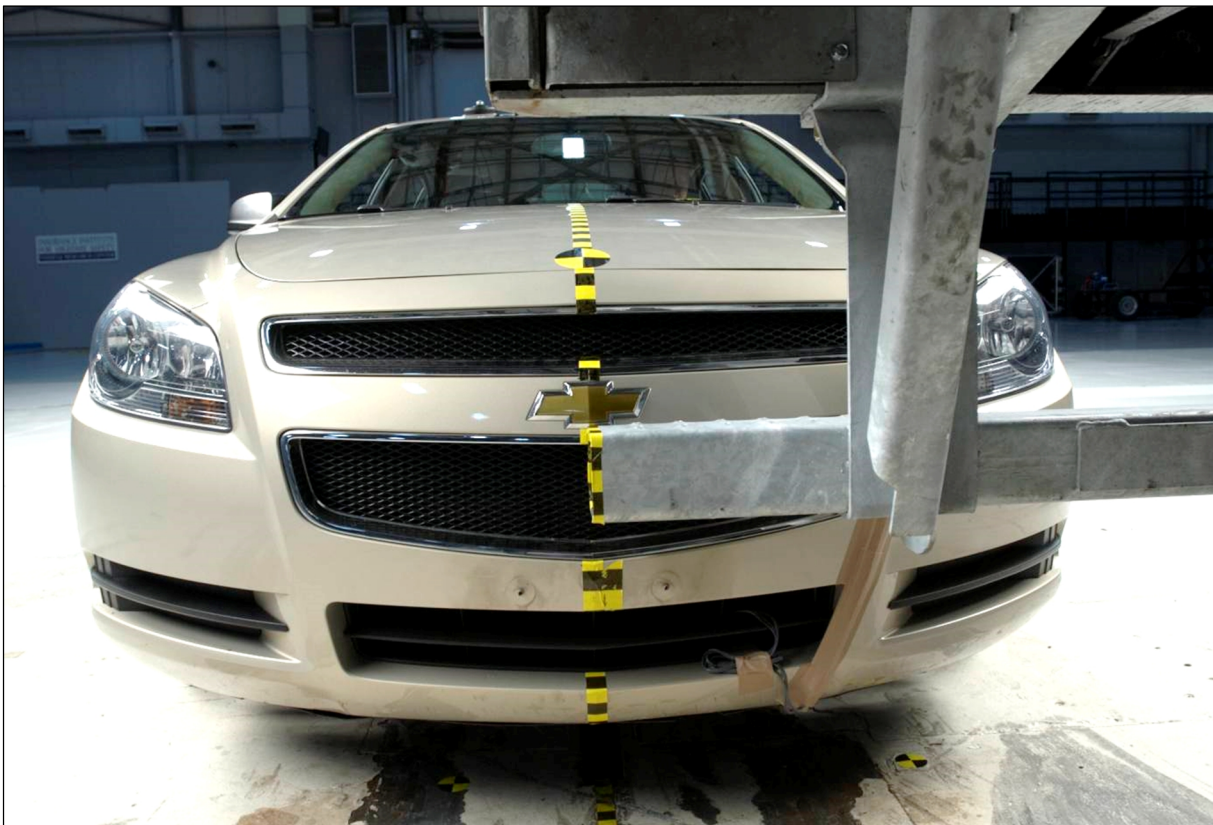
**30 percent overlap:** The midsize car is aligned with the rear of the semi-trailer such that the right edge of the trailer underride guard's horizontal member is offset to the left of the midsize car's centerline by 20 percent of the vehicle's overall width, resulting in a 30 percent vehicle overlap (Figure 3).

The striking vehicle width is defined and measured as indicated in the Society of Automotive Engineers (SAE, 2009) *Surface Vehicle Recommended Practice J1100*, which states, "The maximum dimension measured between the widest part on the vehicle, excluding exterior mirrors, flexible mud flaps, and marker lamps, but including bumpers, moldings, sheet metal protrusions, or dual wheels, if standard equipment."

**Figure 1**  
**Full-Width Vehicle Overlap with Semi-Trailer**



**Figure 2**  
**50 Percent Vehicle Overlap with Semi-Trailer**



**Figure 3**  
**30 Percent Vehicle Overlap with Semi-Trailer**



The striking vehicle is accelerated by the propulsion system until it reaches the test speed and then is released from the propulsion system approximately 25 cm before impact with the semi-trailer. The onboard braking system, which applies the vehicle's service brakes on all four wheels, is activated 1.0 second after the vehicle is released from the propulsion system.

To verify test impact position, inch tape (1-inch increments alternating in black and yellow) is applied to both the semi-trailer underride guard's horizontal member and the striking vehicle's front bumper to highlight them for the overhead and under-trailer camera views.

### **Test Vehicle Preparation**

Preparation of the striking vehicle follows the "Test Vehicle Preparation" section of the *Moderate Overlap Frontal Crashworthiness Evaluation Crash Test Protocol (Version XVI)* (IIHS, 2016) with the following deviations. With the exception of vehicle mass, these steps are optional.

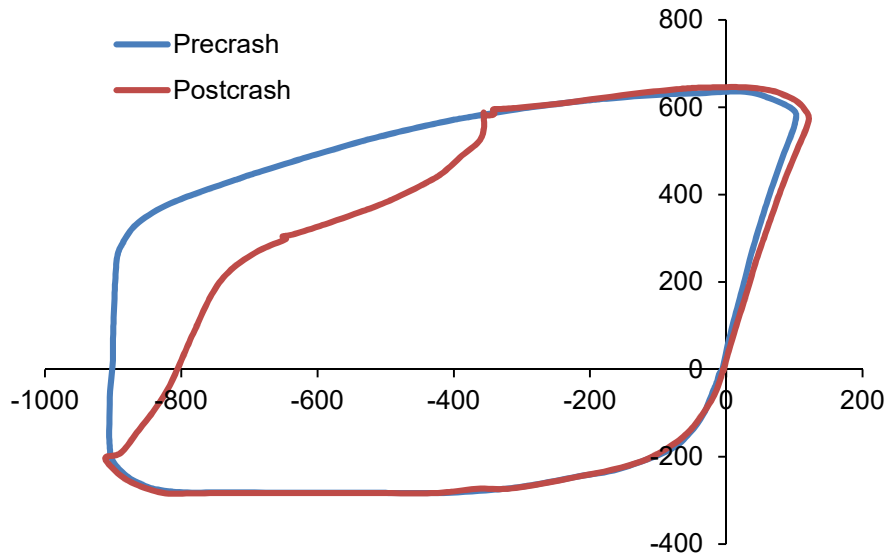
The weight of the striking vehicle is adjusted to a target mass, instead of 100-175 kg greater than the measured curb weight specified in the *Moderate Overlap Frontal Crashworthiness Evaluation Crash Test Protocol (Version XVI)* (IIHS, 2016). The target mass is  $1,811 \pm 20$  kg for the full-width test and  $1,709 \pm 16$  kg for the 50 and 30 percent overlap tests.

Instead of 14 points measured pretest for barrier crash tests, the driver door opening and vehicle windshield perimeter are recorded using a CMM. These same areas are measured again after the crash to view deformation (Figures 4-5).

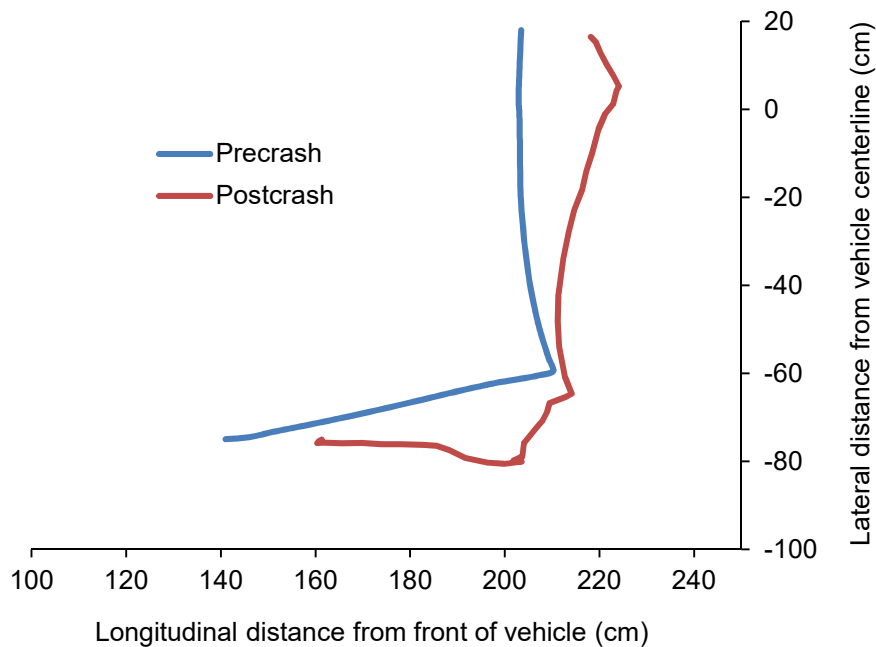
Two onboard cameras and LED lights are installed in the striking vehicle, along with their respective power supplies and control units.

A pressure-sensitive tape switch is applied to the vehicle such that it makes first contact with the semi-trailer's underride guard during the crash. Pressure applied to this tape completes an electrical circuit that signals the start of the crash (time-zero) for the data acquisition system.

**Figure 4**  
**Driver Door Opening Measure – Typical**



**Figure 5**  
**Windshield Perimeter, Overhead Measure – Typical**



## Crash Dummy Preparation and Setup

For the evaluation tests conducted at IIHS, test dummies are installed in the striking vehicle. However, because the dummy response is not used for evaluating the prevention of underride, 77 kg of ballast weight can be used in lieu of each dummy. The dummy/ballast weights are included in the target test mass of the vehicle given above.

For the full-width crash tests, 50th percentile male Hybrid III dummies are installed in the driver and right front passenger seats. For the 50 and 30 percent overlap tests, one dummy is installed in the driver seat. The driver dummies are positioned in the seat according to the *Guidelines for Using the UMTRI ATD Positioning Procedure for ATD and Seat Positioning (Version V)* (IIHS, 2004). The right front passenger seat is positioned to match the driver seat, and the passenger dummy's H-point is set to mirror that of the driver dummy.

## Test Results

To be considered a successful test (i.e., no underride), the semi-trailer's underride guard will prevent the trailer from intruding into the occupant compartment of the striking vehicle. The rear guard may deform, break, or collapse, but must not allow any portion of the trailer to intrude beyond the precrash position of the rear surface of either A-pillar.

## REFERENCES

Insurance Institute for Highway Safety. 2004. Guidelines for using the UMTRI ATD positioning procedure for ATD and seat positioning (version V). Arlington, VA.

Insurance Institute for Highway Safety. 2016. Moderate overlap frontal crashworthiness evaluation crash test protocol (version XVI). Arlington, VA.

Society of Automotive Engineers. 2009. Surface Vehicle Recommended Practice J1100; Motor vehicle dimensions. Warrendale, PA.