Moderate Overlap Frontal Crashworthiness Evaluation

Guidelines for Rating Structural Performance (Version II)

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In the Insurance Institute for Highway Safety's frontal offset crash tests, injury measures recorded on a 50th percentile male Hybrid III driver dummy are used as one indicator of crashworthiness performance. These measures are not the only indicators, however, because although high dummy injury measures recorded in the offset test mean some people in similar real-world crashes would sustain significant injuries, the converse is not true. Low dummy injury measures do not necessarily mean there is no risk of significant injury to people in similar crashes. This is because the forces experienced by people of different sizes from the test dummy, or seated in different positions, can be quite different, especially when there is significant collapse of/intrusion into the occupant compartment. Major deformation or intrusion into the compartment is a good predictor of injury risk for people in similar crashes, even when dummy injury measures are low. For this reason, the Institute evaluates the structural integrity of the occupant compartment, or safety cage, during the offset test and uses this as an important additional indicator of crashworthiness performance. Specific measurements of intrusion into the occupant compartment are used to assess this aspect of performance.

Document Revision History

In December 2011, this document was revised to include criteria used to determine the integrity of fuel and high-voltage systems.

Measurements of Safety Cage Deformation

The measurements used by the Institute represent the residual movement (precrash/postcrash difference) of interior structures in front of the driver dummy. The movement of seven points on the vehicle interior plus the closing of the distance between the A- and B-pillars are the foundations of the Institute's structural ratings. Two of the interior measured points are located on the lower instrument panel, in front of the dummy's knees; four points are in the footwell area, three across the toepan and one on the driver's outboard footrest; the last measured point is on the brake pedal. The precrash and postcrash locations of these points are measured with respect to a coordinate system originating on the driver door striker. The measured movement of the interior seven points is adjusted to reflect movement toward the driver seat, which is represented by the locations of its attachment to the vehicle floor. Thus, movement of the driver seat with respect to the reference coordinate system is not reflected in evaluations of vehicle structure (this adjustment is not made for the A-to-B-pillar closure). A further adjustment may be made to the brake pedal intrusion in the event of pedals that "break away" or otherwise deform to limit intrusion. If a brake pedal is constructed so that it dangles loosely after the crash, the brake pedal is pushed straight forward against the toepan and held there to take the postcrash measurement. If the pedal drops away entirely, no postcrash measurement is taken.

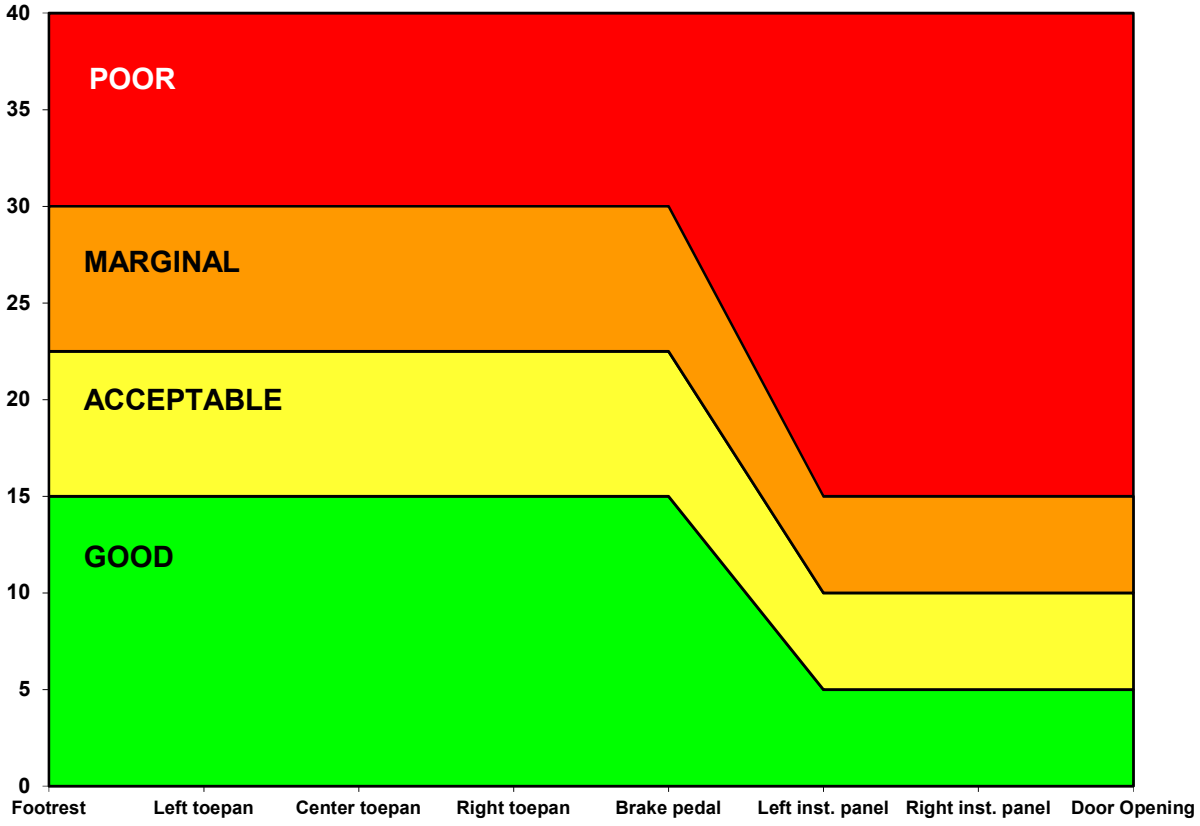
Evaluation of Intrusion Measurements

The initial structural rating is based on comparison of intrusion measurements with rating guidelines (Figure 1). This rating may then be modified (downgraded) on the basis of additional observations about the structural integrity of the safety cage.

The X-Y-Z vector resultant movements of the toepan, footrest, and brake pedal points are used for comparison with the rating guidelines. If the X movement is forward (away from the driver seat), then only the Y-Z vector resultant movement is used. Only the rearward movement (X) of the instrument panel is compared with the guidelines. Figure 1 shows the ranges for these measurements and associated structural ratings. Vehicle models with all intrusion measures falling in the area labeled good will receive

a good structural rating if no additional observations lead to a downgraded rating. Similarly, vehicle models with all intrusion measures falling into one of the other three zones shown in Figure 1 will receive an acceptable, marginal, or poor rating unless there are modifying observations.

Figure 1
Guidelines for Rating Occupant Compartment Intrusion (cm)



When intrusion measurements fall in different rating bands, the final rating generally reflects the band with the most measures. However, the final rating typically will not be more than one rating level better than the worst measurement. For example, a vehicle with a poor measurement for the left instrument panel would not score better than marginal for structure, even if all other measured values were good. Where there are ties, with half the measurements in one band and half in another, the final rating typically will be that of the worst band. Intrusion measurements falling on a boundary value will be considered to fall in the band that represents the better rating.

Qualitative Observations Leading to Downgraded Structure Rating

Some patterns of deformation are less desirable regardless of intrusion measurements. For example, a footwell that collapses in a way that traps the dummy's feet represents a greater injury risk than a footwell with similar intrusion measurements that does not trap the dummy's feet. Another example of a potentially modifying observation involves intrusion into the safety cage of some component or structure not captured by the eight measurement points. If a modifying observation is made, then the structural rating will be lowered one level from the rating suggested by the intrusion measurements (e.g., from acceptable to marginal).

Fuel and High-Voltage System Integrity Leading to Downgraded Rating

If a significant fuel leak or compromise of a high-voltage system (i.e., electric drivetrain) is observed during a test, both the structural and overall ratings may be downgraded to poor. Significant fuel leaks are those that exceed the leak rate allowed following tests conducted to assess fuel system integrity under U.S. Federal Motor Vehicle Safety Standard (FMVSS) No. 301.

High-voltage systems must meet the electrolyte spillage, battery retention, and electrical isolation requirements in FMVSS 305 to avoid downgrade. Additionally, the temperature of the high-voltage battery will be monitored both with a thermocouple and a thermal imaging camera, before and after a crash test. If an increase in temperature is detected, the vehicle will be moved immediately outdoors where continued monitoring will take place. The following summarizes these requirements:

- **Electrolyte spillage:** No more than 5 liters of electrolyte from propulsion batteries shall spill outside the passenger compartment and no visible trace of electrolyte shall spill into the passenger compartment.

- **Electric energy storage/conversion system retention:** Electric energy storage/conversion devices mounted outside the occupant compartment shall remain attached to the vehicle by at least one component anchorage, bracket, or any structure that transfers loads from the device to the vehicle structure, and shall not enter the occupant compartment.

- **Electrical isolation:** After the test, one of the following requirements must be met:
  - Electrical isolation between the high-voltage source and vehicle chassis must be greater than or equal to 500 ohms/volt for all high-voltage sources without continuous monitoring of electrical isolation. The isolation must be greater than or equal to 100 ohms/volt for all DC high-voltage sources with continuous monitoring of electrical isolation; or
  - The voltages from high-voltage sources measured according to the procedure specified in FMVSS 305 must be less than or equal to 30 VAC for AC components, or 60 VDC for DC components.

- **Temperature increase:** While postcrash activities commence, the battery temperature will be monitored with the onboard thermocouple for at least 4 hours. An increase in temperature from ambient laboratory temperature (20–22.2 degrees Celsius) will trigger an onboard temperature alarm at 25.5 degrees Celsius, resulting in the immediate evacuation of the vehicle from the facility. If over the next 2 hours of monitoring, both with the thermocouple and thermal imaging camera, the temperature begins to stabilize, and there are no visible signs of fire (i.e., smoke), postcrash activities can continue. A measured temperature above 25.5 degrees Celsius, or visible smoke or fire, will result in a poor overall vehicle rating.