

**Low-Speed Crash Test Protocol
(Version IV)**

October 2001

**INSURANCE INSTITUTE
FOR HIGHWAY SAFETY**

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Low-Speed Test Configurations

Four different low-speed crash tests, at nominal 5 mi/h (8 km/h) impact speeds, are conducted on each vehicle model: front into full-width flat barrier, rear into full-width flat barrier, right front into 30 degree angle barrier, and rear into pole. The first two tests are patterned after the perpendicular barrier impacts required by federal regulations for passenger cars (49 *CFR* Part 581). The latter two tests are added to simulate a broader range of impacts occurring in actual on-the-road crashes. One vehicle of each model tested is used in the front-into-flat-barrier and rear-into-pole tests. A second vehicle is used in the front-into-angle-barrier and rear-into-flat-barrier tests.

Impact Barrier and Pole Specifications

For the front- and rear-into-flat-barrier tests, the impact barrier is an unyielding (rigid) block of reinforced concrete weighing 145,150 kg that is positioned perpendicular to both the crash hall floor and the longitudinal centerline of the test vehicles. The barrier is augmented with a solid steel face plate measuring 366 cm wide, 184 cm high, and 8 cm thick. The impact area of the face plate is covered with 2 cm-thick plywood.

For the front-into-angle-barrier test, a rigid steel fixture is bolted to the floor. The fixture includes a solid steel face plate measuring 214 cm wide, 92 cm high, and 4.5 cm thick. The entire angle barrier face plate is covered with 2 cm-thick plywood, and the bottom edge of the face plate is 18 cm above the floor (so that the top edge is 110 cm above the floor). The face plate is perpendicular to the floor, and the angle between the longitudinal centerline of the test vehicle and the plane of the face plate is 60 degrees (90 minus 30 degrees).

The rear-into-pole test is intended to assess how well the bumper system can protect the vehicle from damage in an impact with a narrow object. Normally, the longitudinal centerline of the vehicle will be aligned with the pole in these tests, but if some aspect of the bumper design (e.g., a trailer hitch) prevents a general assessment of this aspect of the bumper's performance, then the pole impact target point may be moved off-center (to the left or right) to the midpoint of the span from the vehicle centerline to the inboard edge of the rear frame sidemember end. The test pole is made of 345 MPa yield solid steel measuring 122 cm long and 18 cm in diameter. The pole extends 92 cm above the floor surface and is rigidly mounted. The actual impact point on the bumper will not be more than 7.5 cm either side of the target point.

Test Vehicle Preparation

Each vehicle is inspected upon arrival at the research center. The vehicles are checked for evidence of prior collision damage or repair. Previously damaged vehicles are not tested. Each vehicle is further examined to verify that it is in satisfactory operating condition and to note defects such as missing parts, maladjustments, or fluid leaks. If judged directly relevant to testing, such deficiencies are corrected or a replacement vehicle is procured.

Tires are inflated to the manufacturer recommendation for the lightly loaded condition if more than one recommendation is provided. The fuel tank is filled to at least 90 percent of capacity with unleaded gasoline or diesel fuel of the appropriate grade. All other fluid reservoirs are filled to at least their minimum indicated levels. Front and rear license plates, front license plate bracket (if provided), and all associated fasteners are removed. The rear license plate bracket (if present) is left in place unless it is bolted or riveted directly to the external face of the rear bumper, in which case both the bracket and fasteners are removed. Bolt-on trailer hitch reinforcement members that are supplied as optional equipment are removed, but their fasteners are reattached to the vehicle where possible.

The vehicle hood is closed. The trunk lid, liftgate, or tailgate is closed and not locked (if it can be closed without locking). The spare tire, jack, tools, and other equipment are secured with the manufacturer-supplied fasteners. Doors are closed but not locked, and the rear door childproof locks (if present) are not set. All side windows are fully open. The tilt steering wheel or column (if provided) is positioned to the middle of its adjustment range, and the telescoping wheel (if provided) is positioned fully forward.

Front seats are positioned to the nominal midpoint of their longitudinal adjustment range and fully lowered (if adjustable in height). Front seat backs are placed in their nominal upright position. All head restraints are fully lowered (if adjustable). All rear seats are left in place (if removable) and unfolded to accept occupants (if foldable). Integrated child seats (if present) are stowed. All lights, wipers, and climate control and sound systems are turned off (except daytime running lights).

Prior to placement of any instrumentation or propulsion system attachment hardware, each of the vehicles is weighed to determine its curb weight using an Intercomp model SW 8800 scale at each of the four wheels. Instrumentation weighs 10 kg, and propulsion system attachment hardware weighs 12-15 kg, so the vehicle's test weight exceeds its measured curb weight by no more than 25 kg. For the rear-into-flat-barrier test, an additional instrumentation package weighing 27 kg is placed onto the front passenger seat.

Each vehicle is attached to a cable that pulls it down a test track toward the barrier or pole using a stored gas propulsion system. The vehicle is released from the cable no more than 50 cm before impact, which allows the vehicle to travel under its own momentum into the barrier or pole at its normal running attitude. The vehicle's ignition switch is turned to its on position, but the engine is not started. The transmission is shifted into its neutral position, and the parking brake is fully released.

Impact Speed Measurement

The crash test speed range is 4.95 ± 0.15 mi/h (7.96 ± 0.24 km/h). Impact speed is measured using two optical speed sensors mounted on each side of the vehicle that are aimed downward to detect retroreflective tape strips on the crash hall floor. Each sensor is connected to its own battery-powered timing module located inside the vehicle that displays the vehicle's speed in miles per hour. Speed is clocked over a 456 mm length of vehicle travel ending approximately

15 cm before the vehicle's impact with the barrier or pole. After the impact, speed measurements from the two timing modules are averaged to determine the recorded impact speed.

The propulsion system also has an optical speed measuring device that serves as a backup to the two speed sensors onboard the vehicle. This device measures the speed of the hardware attaching the vehicle to the propulsion system immediately prior to vehicle's release from the propulsion system before impact. The speed is clocked over a 100 cm length of vehicle travel ending 50 cm before the vehicle's release.

Photography

Following the completion of the tests, each vehicle is photographed with a digital still camera to document any resulting damage. Camera angles include views of the entire vehicle from the front, rear, and all four corners. Additional close-up photographs are taken of readily visible damage. Front-into-angle-barrier and rear-into-pole tests are recorded with one overhead and one floor-mounted Model 51 Locam II camera using high-speed color motion picture film (100 frames per second) and a floor-mounted real-time Sony Betacam video camera (30 frames per second). Rear-into-flat-barrier tests are recorded with one overhead Model 51 Locam II camera using high-speed film only if significant and readily visible damage such as glass breakage is anticipated.

Damage Estimates

Following the completion of the tests, damage estimates are written by two experienced appraisers. The appraisers collaborate in estimate preparation and use the PenPro computerized system developed by Automatic Data Processing (ADP), Inc. The estimating process is conducted as it would be done in a body shop; each bumper assembly is generally removed and dismantled to check for possible hidden damage.

For hourly labor rates indicated in the estimates, ADP supplies an average of labor rates for body repair and refinishing used in actual estimates by its clients across the country as of the most recent calendar year quarter. This average rate is rounded to the nearest dollar and used in calculating labor prices. Similarly, the cost for paint and related materials is based on the average rate used by ADP clients during the most recent quarter (rounded to the nearest dollar) and is directly proportional to the total refinishing time for each estimate.

For part replacement indicated in the estimates, new original equipment replacement parts at full list prices are specified (based primarily on the most recent ADP information, but secondarily on data from the appropriate *Mitchell Collision Estimating Guide*, *Motor Crash Estimating Guide* or vehicle manufacturers or dealers). No discounts, betterments, appearance allowances, insurance deductibles, taxes, or vehicle storage fees are applied. If vehicles have clear coat (two-stage clear over color) paint, all estimates requiring refinishing include the appropriate additional labor time (in most cases automatically computed by the PenPro system, otherwise manually calculated by the appraisers).

The front and rear bumper assemblies of one vehicle of each model tested and its individual major components including reinforcement bars, energy absorbers, and bumper covers are weighed.

Bumper Damage Criteria

The Institute recognizes that some cosmetic damage to exterior bumper surfaces may occur in low-speed collisions. When such damage is minor -- even if there is significant damage to other bumper parts -- repair costs are excluded from the final damage estimates. The criteria for minor cosmetic damage are as follows:

1. Damage is to the external bumper surfaces
2. Localized dents or deformation are no more than 3/8 inch (0.95 cm) deep
3. Overall bumper distortion or displacement is no more than 3/4 inch (1.9 cm) from the original contour, and there is no breakage of fasteners

These initial criteria were part of the federal performance requirements in effect from September 1, 1979 to July 6, 1982 for passenger car bumpers (49 *CFR* Part 581), which specified the maximum allowable damage to bumpers after 5 mi/h (8 km/h) barrier and pendulum impacts and 3 mi/h (5 km/h) corner pendulum impacts. The Institute has added analogous criteria to define minor cosmetic damage to plastic bumper covers, which were not in widespread use when the original criteria were made part of the bumper standard:

4. Larger localized dents, deformation, or distortion than indicated above if, in the opinion of the appraisers, the bumpers would meet the criteria after repairs to underlying damage such as replacement of reinforcement bars or foam absorbers
5. Tears or holes that penetrate completely through the cover material if they are no more than 1 cm in length or diameter and do not occur in critical areas such as openings for fasteners that secure the cover
6. Gouging or cracking partially into the cover material if its length or diameter is no more than 2 cm and is not located in critical areas
7. External paint or finish scuffing, delamination, wrinkling, and the like if there are no tears or holes completely through or cracks or gouges part way into the material as described above
8. Color lightening of molded-in-color (unpainted) covers

The criteria apply to all external parts attached to or judged by the test coordinator, appraisers, or crash estimating references to be part of the bumper system. Thus, minor damage to parts such as rub strips, bumper guards, moldings, valance panels, filler panels, and bumper outer extensions also are excluded from damage repair estimates if they can be reliably reattached to adjacent undamaged parts.

If any external part of the bumper system fails any of the above criteria for minor, cosmetic damage, then all repair, replacement, alignment, or refinishing operations recommended by the appraisers related to the failure will be included in the damage estimate. If all damage is within that specified in the criteria, the bumper is said to have "no damage."