

Low-Speed Crash Test Protocol

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Low-Speed Test Types

Four different low-speed crash tests, at a nominal 5 mi/h (8 km/h) impact speed, are performed 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 center 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 impact barrier face plate. The fixture includes a solid steel face plate measuring 214 cm wide, 92 cm high, and 4.5 cm thick. The entire face plate is covered with 2 cm-thick plywood. The angle barrier face plate is perpendicular to the floor, and the angle between the longitudinal centerline of the test vehicles and the plane of the face plate is 60 degrees (90 minus 30 degrees). If any vehicles have hoods or front fenders whose top leading edges are more than 92 cm above the floor, the entire angle barrier fixture is raised so that the bottom edge of the angle barrier face plate is 18 cm above the floor. Otherwise, the fixture is not raised.

For the rear-into-pole test, the test pole is made of 345 MPa yield solid steel measuring 152 cm long and 18 cm in diameter. The pole extends 92 cm above the floor surface and 60 cm below. The fixture retaining the test pole is designed so that with the test pole in place and a static load of 178 kN applied in a direction parallel to the test track centerline 51 cm above the floor, the fixture deflects no more than 2 mm at the floor. The fixture is also designed to withstand failure under a static load of at least 356 kN applied in a direction parallel to the track centerline 51 cm above the floor, again with the test pole in place.

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 windows are closed, except for one window on each side of the vehicle remaining slightly open to allow for instrumentation cable routing. 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 to 15 kg, so the vehicle's test weight exceeds its measured curb weight by no more than 25 kg.

Impact Test Procedures

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 125 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 placed in the "on" position, but the engine is not started. The transmission is placed in "neutral" and the parking brake is fully released.

The lateral offset to either side of the longitudinal centerline of the impacting vehicle does not exceed 7.5 cm from the specified target point. For the flat barrier impacts, this target point is located midway between the vertical edges of the impact barrier face plate. For the angle barrier impacts, the target point is offset 53 cm to the left of the vertical centerline of the angle barrier face plate. For pole impacts, the target point is the pole surface located in the tangent plane perpendicular to the track centerline.

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.

Photography

Following the completion of the tests, each vehicle is photographed using a 35 mm camera with color slide film 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 two floor-mounted Model 51 Locam II cameras using high-speed color motion picture film (100 frames per second) and a floor-mounted Arriflex 16 camera using the same film but at 24 frames per second (real time). 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 Audatex computerized system developed by Automatic Data Processing (ADP), Inc. The appraisers indicate "no damage" if (a) there is damage only to the external bumper surfaces and no other damage to the vehicle body or bumper, (b) localized dents are no more than 3/8 inch (0.95 cm) deep, and (c) 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 criteria were part of the federal requirements in effect from September 1, 1979 to July 6, 1982 for passenger car bumpers, under which minor cosmetic damage to exterior bumper surfaces was permitted after specified 5 mi/h (8 km/h) barrier and pendulum impacts and 3 mi/h (5 km/h) corner pendulum impacts (49 *CFR*, Part 581).

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 Audatex system, otherwise manually calculated by the appraisers).

Bumper Weights

Following the completion of the tests, the front and rear bumper assemblies of one vehicle of each model tested are removed and dismantled. Each bumper assembly and its individual major components including reinforcement bars, energy absorbers, and bumper covers are weighed using an A&D model FV-60KA1 platform scale. Additional bumpers are removed and dismantled (but not weighed) if the appraisers want to check for possible hidden damage.