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SAE J972 DEC88

**Moving Rigid Barrier
Collision Tests**

SAE Recommended Practice
Revised December 1988

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Submitted for Recognition as
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HIGHWAY VEHICLE PRACTICE

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Ø MOVING RIGID BARRIER COLLISION TESTS

1. SCOPE AND PURPOSE:

Collision tests are conducted on automotive vehicles to obtain information of value in evaluation of structural integrity and in reducing occupant injuries. The deformation resulting from a moving rigid barrier impact is more severe at a given speed than that produced by using a crushable vehicle, but is more readily reproducible than that occurring during impacts of two vehicles. The purpose of this recommended practice is to establish sufficient standardization of such moving barriers and moving barrier collision methods so that results of tests conducted at different facilities may be compared.

Background information and a rationale for the test procedures described in this recommended practice are provided in the Appendix.

2. OBJECTIVES:

The primary objective of this recommended practice is to define test procedures for impacts which will result in a simulation of forces and deformations experienced during a vehicle crash. Standardized procedures allow proper evaluation of vehicle structural loads and deflections, occupant loads and dynamics, and photographic (or video) and postcollision observations of pertinent areas or events which are useful in establishing design criteria.

3. CRASH TEST FACILITY:

- 3.1 Test Site General: The test site shall be of sufficient area to provide accommodations for the test vehicle, various photographic equipment, a protected observer area, and provisions for accelerating the moving barrier to the desired velocity.

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- 3.1.1 The immediate crash site shall be level.
- 3.1.2 The approach road and the surface at the immediate crash site shall be paved.
- 3.1.3 Allowances for proper positioning of photographic equipment should be made.
- 3.1.4 Allowances should be made for after-impact skidding of both the test vehicle and the moving barrier.
- 3.2 **Approach:** The type of approach required depends upon the technique employed to obtain the desired impact velocity of the moving barrier. A practical approach is level, straight, and of sufficient length to permit the moving barrier to be towed along a rail guidance system with the impact occurring after the moving barrier is released from the tow force and released from guidance at the end of the rail.
- 3.3 **Barrier:** Two rigid impact surfaces are used: the flat surface described in 3.3.2 for rear impact tests and the contoured surface described in 3.3.3 for side impact tests. These two surfaces are attachable to the front end of a common carriage as shown in Fig. 1.

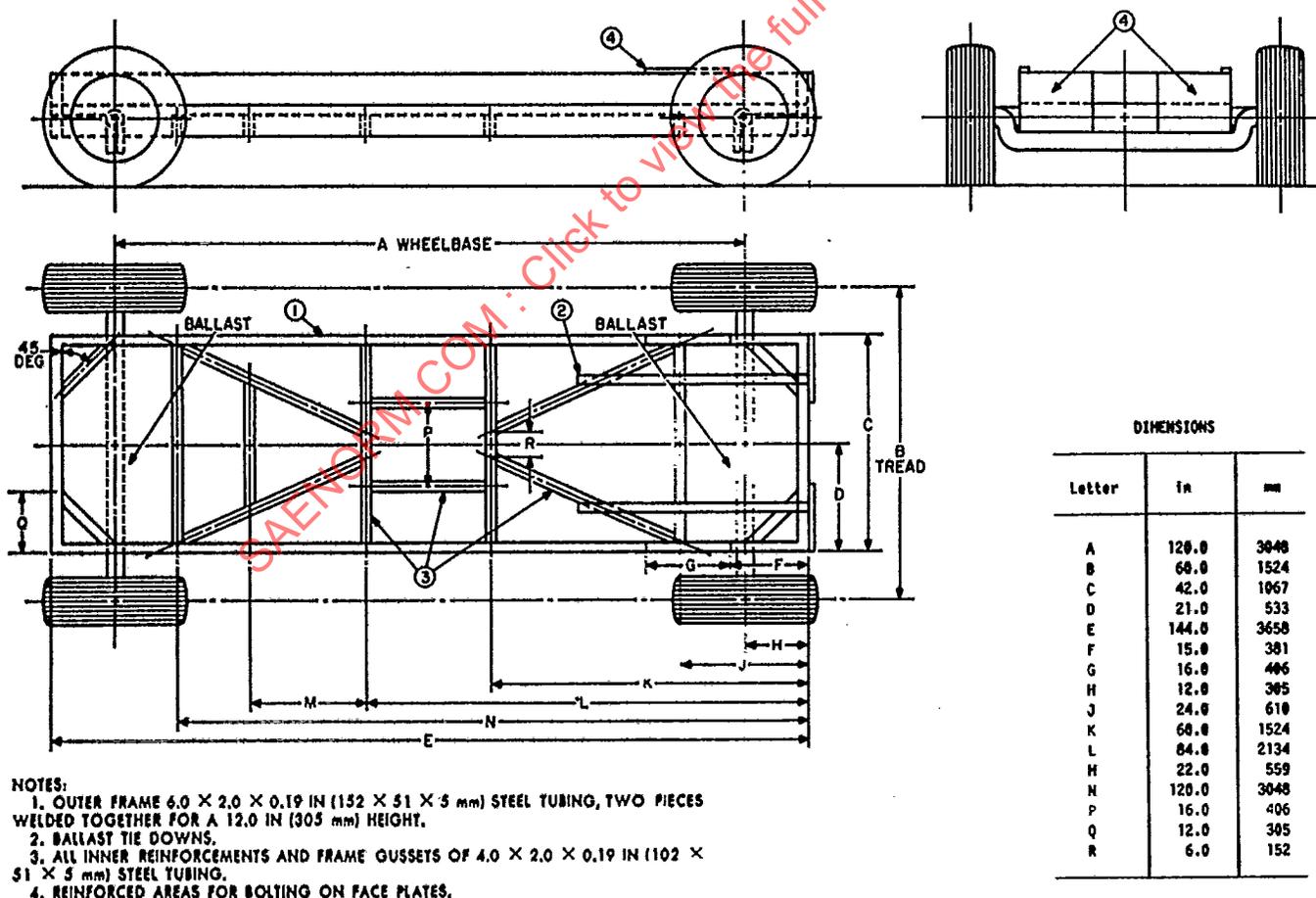
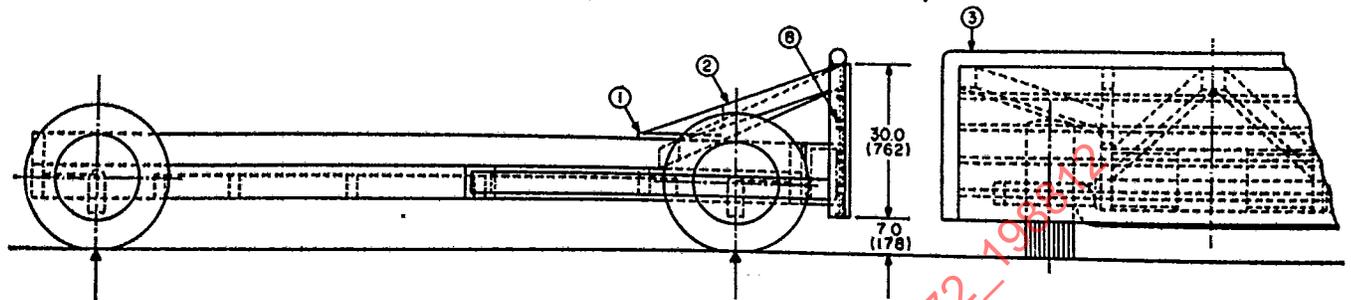


FIGURE 1 - Common Carriage for Moving Barriers

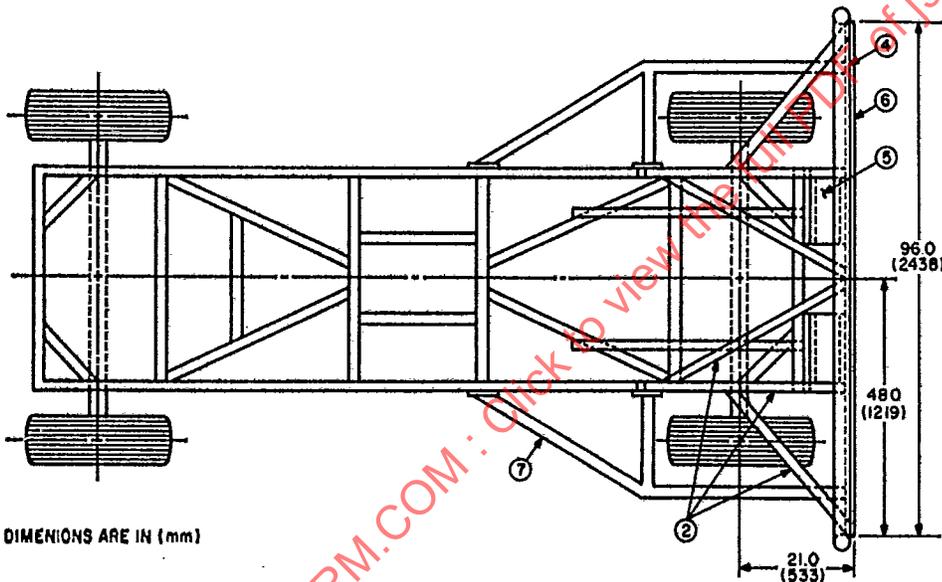
- 3.3.1 General: With either impact surface attached to the common carriage, the moving barrier assembly shall have the following characteristics:
- 3.3.1.1 The moving barrier shall be of rigid construction, symmetrical about a longitudinal-vertical plane, with a solid nonsteerable front axle and fixed rear axle attached directly to the frame rails with no spring nor other type suspension system on any wheel.
- 3.3.1.2 The total weight shall be 4000 ± 50 lb (1818 ± 22.8 kg). Weight distribution shall be 900 ± 25 lb (409 ± 11.4 kg) at each rear wheel and 1100 ± 25 lb (500 ± 11.4 kg) at each front wheel.
- 3.3.1.3 It shall have a braking device capable of stopping it.
- 3.3.1.4 Tread width of 60 ± 1 in (1524 ± 25 mm), front and rear axles.
- 3.3.1.5 Wheelbase of 120 ± 2 in (3048 ± 51 mm).
- 3.3.1.6 Pneumatic tires on all wheels, G78-15 or equivalent, inflated to 24 psi (165 kPa) minimum.
- 3.3.1.7 The center of gravity shall be located at:
 $\bar{X} = 54.0 \pm 1.5$ in (1372 ± 30 mm) rearward of the front wheel axis
 $\bar{Y} =$ at the longitudinal-vertical plane of symmetry
 $\bar{Z} = 15.8 \pm 0.5$ in (401 ± 13 mm) above ground
- 3.3.2 Rear Impact Testing: A flat impact surface 30 in (762 mm) high and 96 in (2438 mm) wide shall be used. It may be attached to the carriage as shown in Fig. 2. The impact surface is covered with 0.75 in (19 mm) thick plywood. Ground clearance to the lower edge of the impact surface shall be 7 ± 1 in (178 ± 25 mm).
- 3.3.3 Side Impact Testing: A contoured impact surface 24.75 in (629 mm) high and 78 in (1981 mm) wide shall be attached to the carriage as shown in Fig. 3. The impact surface is not covered with plywood. Ground clearance to the lower edge of the impact surface shall be 12.25 ± 0.5 in (311 ± 13 mm). This side-impact, moving-barrier assembly shall also have a moment of inertia about the center of gravity as follows:

$$I_x = 271 \pm 13.6 \text{ slug}\cdot\text{ft}^2 \text{ (367 } \pm \text{ 18.4 kg}\cdot\text{m}^2\text{)}$$

$$I_z = 3475 \pm 174 \text{ slug}\cdot\text{ft}^2 \text{ (4711 } \pm \text{ 236 kg}\cdot\text{m}^2\text{)}$$



TOTAL WEIGHT = 4000 ± 50LB (1814.4 ± 22.7 kg)

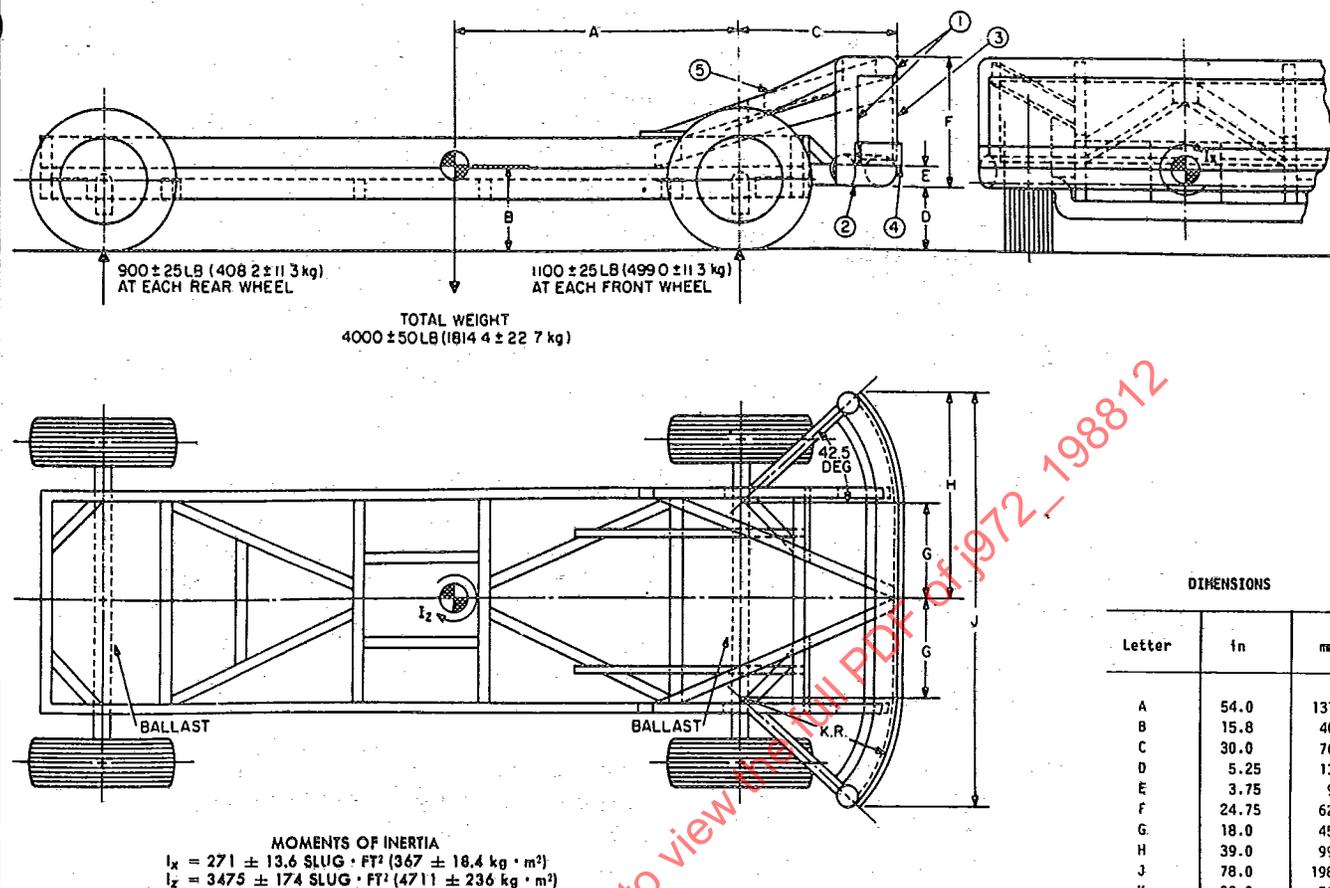


DIMENSIONS ARE IN (mm)

NOTES:

1. REINFORCED AREA FOR BOLTING ON FACE PLATE SUPPORTS.
2. UPPER FACE PLATE SUPPORTS 4.0 X 2.0 X 0.19 IN (102 X 51 X 5 mm) STEEL TUBING (SIX REQUIRED).
3. FACE PLATE FRAME 3.0 DIA X 0.19 IN (76 DIA X 5 mm) STEEL TUBING (THREE EDGES).
4. STEEL FACE PLATE 0.38 IN (10 mm) MINIMUM THICKNESS.
5. SPACER BETWEEN FACE PLATE AND CARRIAGE 6.9 IN (175 mm) THICK. BOX SECTION 1.0 IN (25.4 mm) WALLS.
6. PLYWOOD FACE 0.75 IN (19 mm) THICK, BOLTED TO FACE PLATE.
7. LOWER CORNER SUPPORTS FOR FACE PLATE, 4.0 X 2.0 X 0.19 IN (102 X 51 X 5 mm) STEEL TUBING.
8. FACE PLATE REINFORCEMENTS 5 X 15 X 0.25 IN (127 X 38 X 6.5 mm). STEEL U-CHANNEL, FIVE REQUIRED.

FIGURE 2 - Common Carriage With Flat Impact Surface Attached



NOTES:

- UPPER FRAME 4.0 IN DIA × 0.25 IN WALL (102 mm DIA × 6 mm WALL) STEEL TUBING (THREE SIDES).
- LOWER FRAME 6.0 IN DIA × 0.50 IN WALL (152 mm DIA × 13 mm WALL) STEEL TUBING.
- FACE PLATE 0.75 IN (19 mm) THICK COLD ROLLED STEEL.
- LEADING EDGE 1.0 × 4.0 IN (25 × 102 mm) STEEL BAND, SHARP EDGES BROKEN.
- ALL INNER REINFORCEMENTS 4.0 × 2.0 × 0.19 IN (102 × 51 × 5 mm) STEEL TUBING.

FIGURE 3 - Common Carriage With Contoured Impact Surface Attached

4. METHODOLOGY:

- 4.1 **General:** Even when simplified by using moving barriers, vehicle collisions are very complex and careful control of impact parameters must be exercised. Paragraphs 4.1.1-4.1.5 shall be followed for every moving barrier test, with the addition of those in 4.2 or 4.3 for the specific type of test under consideration.
- 4.1.1 The moving barrier shall impact the test vehicle while moving at essentially a constant velocity. The impact velocity chosen will depend upon the object of the test or the specific energy levels desired.
- 4.1.2 The moving barrier shall be braked following an initial separation from the impacted vehicle to preclude subsequent impacts.
- 4.1.3 The test vehicle shall be stationary, with its parking brake off and the transmission in neutral.

- 4.1.4 All doors on the test vehicle shall be closed and locked.
- 4.1.5 Position of windows during test is contingent on test objectives.
- 4.2 Rear Impact Tests: The flat impact surface shall be used.
- 4.2.1 The longitudinal-vertical plane of the moving barrier shall be at a 0 ± 3 deg angle relative to the longitudinal-vertical plane of the test vehicle.
- 4.2.2 The longitudinal-vertical plane at the centerline of the test vehicle and the moving barrier shall be in line within ± 3 in (± 76 mm) at the time of initial impact.
- 4.3 Side Impact Tests: The contoured impact surface shall be used.
- 4.3.1 All standard side components and door system components which may affect the strength or rigidity of the vehicle shall be installed. Steering wheel and seats shall be installed and in mid-position, if adjustable. After impacting one side of a vehicle, tests shall not be performed on the other side unless the frame, floor, and door opening remain essentially undistorted on that side.
- 4.3.2 The test shall be conducted with the moving barrier approaching from the left front or right front of the stationary test vehicle with the longitudinal-vertical plane of symmetry of the moving barrier at a 45 ± 3 deg angle relative to the longitudinal-vertical plane at the centerline of the test vehicle.
- 4.3.3 The moving barrier alignment shall be such that the lateral extremity of the contoured impact surface, when projected along a line parallel to the longitudinal-vertical plane of the moving barrier, is within 0-3 in (0-76 mm) of the "door opening reference" (DOR) point of the front door opening (Fig. 4). The DOR point is defined to be located at the front of the door opening and:
- (a) In a plane 4 in (100 mm) above the highest point on the door sill (Figs. 5 and 6).
 - (b) At that point on the rear edge of the hinge pillar where the hinge pillar structure is tangent to the 45 deg direction of impact (Fig. 7).

(The DOR point will typically be located on the hinge pillar, but not necessarily if the front door is not hinged forward of the door. The DOR point is then defined at the point of tangency to the 45 deg direction made by that door frame structure which is forward of the door. In either case, outer sheet metal is not used to define the DOR point location.)

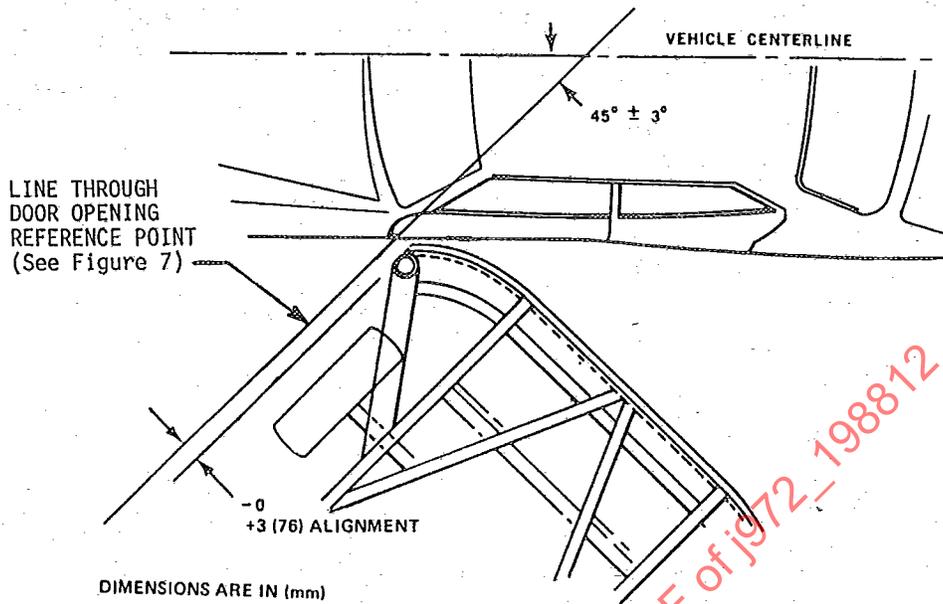


FIGURE 4 - Alignment at Impact

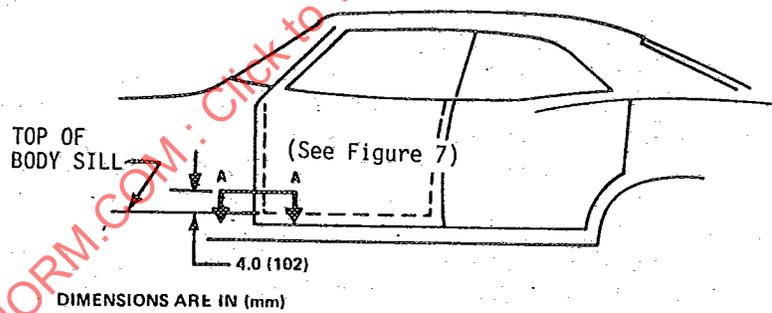


FIGURE 5 - Location of Area of DOR Point

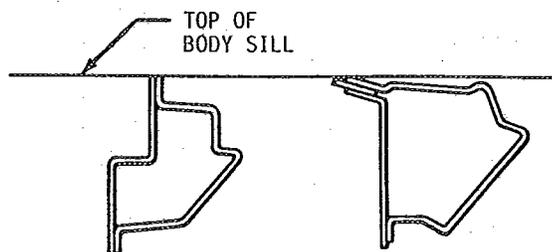


FIGURE 6 - Typical Cross Sections of Rocker Panels

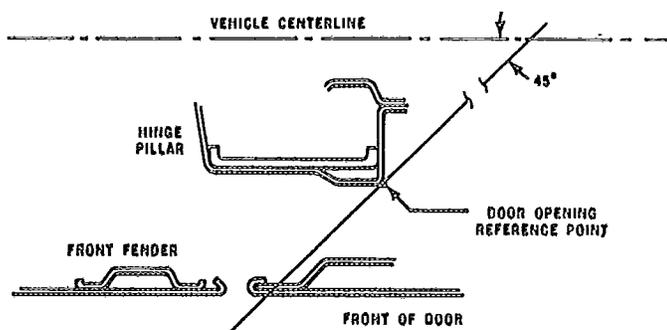


FIGURE 7 - Typical Section A-A Showing DOR Point With Hinge Pillar Tangent to 45 Deg Line

5. INSTRUMENTATION AND EQUIPMENT:

To obtain meaningful information from a moving barrier collision test, it is essential that adequate means be provided to observe and record the test results. Inasmuch as the objectives of any one impact test are limited, the instrumentation to be used will depend on the specific requirements of the test. The instrumentation systems should comply with SAE J211.

- 5.1 Vehicle Accelerations: Test vehicle accelerations may be measured by accelerometers located on the floor pan and/or the frame. Accelerometers may also be placed on the moving barrier to record its acceleration during the test.
- 5.2 Photographic Instrumentation: Comprehensive photographic coverage is desired; therefore, still photographs and a minimum of two high-speed motion picture cameras should be used. The field of view of these cameras will depend upon the specific test objective. Adequate lighting and locating axes for precise positioning of photographic equipment should be provided. The cameras should have a timed pulse signal on the film so that an accurate film speed and time base can be determined for subsequent measurement of displacement and velocity data from analysis of the film. Suitable calibration and position reference targets, both stationary and on the vehicle and moving barrier, should be provided. An overhead camera centered at the point of impact with a field of view large enough to include the test vehicle and the moving barrier is useful for studying side impact tests. A pit for underbody camera views is also useful for studying rear impact tests. Suitable shock-resistant cameras may be rigidly mounted on the test vehicle to view the passenger compartment to record the kinematics of any anthropomorphic test device which may be seated in the vehicle. Equivalent video equipment may be substituted.
- 5.3 Vehicle Deformation: Measurements shall be made before and after the test to determine the total permanent deformation.
- 5.3.1 For rear impact tests, the specific measurements of the vehicle deformation will vary according to the individual objectives of the test.

5.3.2 For side impact tests with the contoured face moving barrier, a post-test measurement is recommended of the maximum inward lateral displacement of the inner door panel in that area adjacent to any outboard designated seating position which is bounded by a horizontal plane 4 in (102 mm) below the seating reference point, the beltline, and vertical-transverse planes 8 in (203 mm) forward and 2 in (51 mm) rearward of the seating reference point. The measurement shall be made in a lateral direction relative to an undisturbed vertical-longitudinal reference plane on the vehicle side opposite the impacted area. The measurement shall be made to the inner sheet metal panel.

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The phi (\emptyset) symbol is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.

APPENDIX
MOVING BARRIER COLLISION TEST PROCEDURE
BACKGROUND INFORMATION AND RATIONALE

Background Information: The test procedures outlined in this SAE Recommended Practice are the results of preliminary testing undertaken to evolve a comparable and repeatable procedure for evaluating the effect of side and rear collisions. Car-to-car and rigid moving barrier-to-car tests and the passenger car door system crush test procedure (SAE J367) were the approaches considered. It was readily recognized that while car-to-car tests are realistic, the numerous variables which are introduced make repeatability very difficult. The door system crush test will give repeatable results, but requires correlation with this contoured moving barrier test and car-to-car impacts to establish realism and relevance. Recognizing the limitations of dynamic full-scale tests, the door system crush test procedure was developed before the contoured barrier shape for side impact was evolved.

Rationale: Vehicle-to-vehicle tests have been conducted by various agencies to evaluate the crashworthiness of the vehicles. When series of tests and comparative tests are conducted with two vehicles, each test agency must pick an available model to use as an impacting vehicle. They must use this same model for all tests in the series in order to eliminate, to the best of their ability, the effects of the impacting vehicle as a variable in the program to evaluate the impacted vehicle. This same impacting vehicle model may not be available to another agency or may be out of production before additional tests may be conducted; therefore, future correlation and consistency are jeopardized. To avoid the problems of individual test agencies selecting their own impacting vehicles, and to provide consistency over time, the rigid moving barrier has been developed. This development process has evolved to the selection of two moving barriers.

This choice of two moving barriers of different shapes was based on observations and studies of available accident and crush test data covering a broad range of vehicles and conditions. These data indicated two basic shapes of deformation of the impacting vehicle: first, along a relatively flat plane on the front and rear of the vehicle (typical of head-on and front-to-rear crashes), and second, a deformation contour which tends to round one of the vehicle fenders (typical of cornering impacts or angle impacts). Therefore, the moving barrier for rear impacts was designed with a flat face that was high enough, wide enough, and low enough to insure that the entire rear structure of most car lines would be exposed to the impact surface without overlapping the edges. Following this moving barrier was the contoured face moving barrier which was designed with the deformation considerations and observations of a wide range of side impacts from a wide range of types of vehicles.

The 45 deg angle of impact recommended in this procedure for a side impact by the contoured moving barrier into a stationary test vehicle represents a very severe impact condition. The selection of this angle is a first trial at a worst-case condition in relation to structural deformation, based on available data. Because the deformation shapes of impacting vehicles may tend to change over time (with changes in strengths of the various front, side, and rear structures), we anticipate that there will be further evolution of this test procedure, particularly the development of a standardized, deformably-faced, moving barrier test vehicle.