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ROLL-OVER TESTS WITHOUT COLLISION—SAE J857 JUN80

SAE Recommended Practice

Report of the Automotive Safety Committee, approved June 1963, last revised October 1969, reaffirmed without change June 1980.

1. Scope—This SAE Recommended Practice is intended to establish guidelines for conducting passenger car roll-over tests so that data obtained by various test facilities may be more readily compared. A description is provided of the facilities and procedures for a curved rail-ramp technique, which has been found to be successful in producing roll-overs. Techniques and instrumentation for the study and evaluation of vehicle structure effects and occupant movement resulting from roll-overs produced by the curved rail-ramp system are also specified.

The curved rail-ramp procedure has been evolved from laboratory and field studies and tests which have sought to establish procedures which would provide realistic simulations of roll-over accidents without collision, and which would be reproducible among laboratories and between different types of

passenger cars. The original issue of SAE J857 described ground level and hill roll-over techniques. However, it was found that these procedures were not always successful in producing roll-overs and the results were never reproducible. Study of the deficiencies of the previous techniques led to the addition of a curved guide rail to the ramp method of ground level roll-over, described in the original version of J857. While reproducibility of results is still limited, the curved rail-ramp system has been found to achieve roll-overs consistently, a significant step forward in the study of the roll-over event.

Because there remains some general interest in the ground level and high roll-over techniques reported originally and for historical continuity, these techniques are reported in the Appendix to this recommended practice.

Procedures and equipment described will be subject to continuing review

and will be revised as experience and improvements in the technology warrant.

2. **Objectives**—The objective of this test procedure is to produce vehicle and occupant dynamics corresponding to accidental vehicle roll-over without collision and to provide a uniform evaluation of passenger compartment performance during roll-over. Data gathered should include measurements of, and means for, identifying occupant and vehicle dynamics and violation of the passenger compartment by structural deformation, as well as penetration and separation of the various components of the vehicle. The following occupant and vehicle criteria are desirable in evaluating vehicle performance:

- 2.1 **Triaxial Acceleration**
 - 2.1.1 Occupant
 - 2.1.2 Vehicle
- 2.2 **Occupant Movements**
 - 2.2.1 Conditions of restraint
 - 2.2.2 Restraint loadings
- 2.3 **Mechanisms of Accidental Door Unlatching**
- 2.4 **Physical Damage to Vehicle**
- 2.5 **Physical Damage to Occupants**

3. **Curved Rail-Ramp Roll-Over Test Method**

3.1 **Test Facilities and Equipment**

3.1.1 **TEST SITE**—The test site should encompass sufficient room for accelerating the test vehicle to the desired speed and accommodating the roll mechanism. The site should also provide space for photographic equipment and an observer area. Typical road lengths for a 50 mph test would be a total length of 1500 ft, allowing 1200 ft for accelerating and 300 ft for decelerating the tow car. Camera placement would require a width of 200 ft on the side toward the roll field and 100 ft on the side opposite the roll field.

3.1.2 **ROAD SURFACE**—The road surface should be smooth to retain control of the vehicle for direction and speed. To minimize gouging and to provide needed traction and consequent rolling moment, the outside front wheel curved path should be surfaced with Portland cement concrete coated with bonded aluminum oxide. The roll itself should take place on a smooth paved surface. Firm dirt or sod rolling surfaces may be used but may introduce undesirable variables.

3.1.3 **GUIDE SYSTEM**—The guide rail installed on the crown of the road should be straight for the required accelerating distance. A recommended curvature for the end of the rail, which has produced roll-overs consistently, is shown in Table 1 and Fig. 1. Fig. 1 illustrates a curvature to the right; however, a curvature to the left may be used, as well as curvature geometries other than that shown in Table 1. A roller guide shoe and lever (Fig. 2) should be attached to the vehicle along the centerline. The attachment of the lever is at the center by a pivot under the front frame cross member and at the rear to the steering center link. The guide shoe on the front of the steering lever will then steer the vehicle down the straightaway and through the curve. A ratchet is recommended to prevent steering recovery after the vehicle runs free of the guide rail. Other steering systems which will achieve equivalent results are acceptable.

3.1.4 **RAMP**—The severe turn usually will not produce enough of a rolling moment to cause the vehicle to roll over. A ramp (Fig. 1) placed to lift the inside front wheel will provide the additional rolling moment required. The rail curvature and ramp height are designed to produce a roll-over for current United States built passenger vehicles at speeds between 45 and 50 mph.

3.1.5 **ALLOWABLE DEVIATIONS**—The specifications for the test site described in paragraphs 3.1.2, 3.1.3, and 3.1.4 are typical of those which have been found to produce satisfactory test results. It is recognized that on occasion these specifications may be modified at the discretion of the testing facility in order to achieve desired results on specific vehicles.

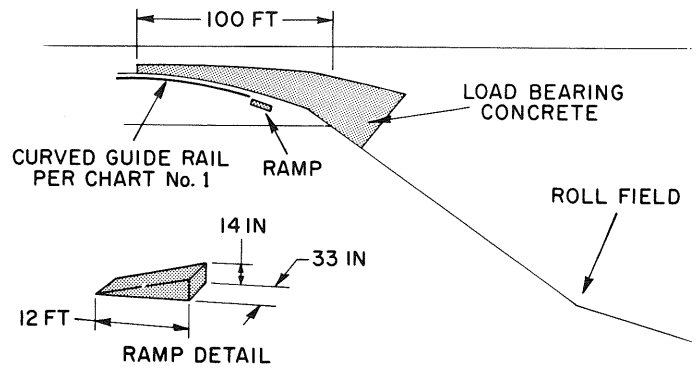


FIG. 1—ROLL-OVER TEST SITE

3.2 **Test Procedure**—The test vehicle may be self-propelled (using speed control devices) or towed to the required test speed. The test vehicle must be released from its tow cable, or its propelling force terminated, at the end of the straight guide rail. The final velocity should be measured just before the vehicle enters the curved rail section.

The front wheel on the outside of the curve will scuff hard and possibly allow rim scrape when the vehicle attains the first 75 deg of roll. The front tires should be inflated to 30 psi to minimize this rim contact.

A pawl and ratchet attached to the steering shaft will hold the front wheels in the turned position after departure from the rail. A remote brake abort system should be installed for test personnel safety.

If a self-powered test vehicle is desired, a speed control may be used to stabilize vehicle speed before the curved rail begins. When a tow vehicle is used, the test vehicle should be released at the end of the straight guide rail, allowing the test vehicle to coast through the curve.

4. **Instrumentation Equipment**—To obtain meaningful information from a roll-over test, it is important that adequate means be provided to observe and record test results. Because of the difficulty experienced in obtaining electrical impulse measurements in roll-over tests, documentation of test results is usually limited to high speed photography. For additional data, this section provides a guide to the type of instrumentation and equipment which can be employed to obtain desired data on the movements and loads experienced by the vehicle, its components, or its occupants.

4.1 **Vehicle Accelerations**—Overall vehicle accelerations may be measured triaxially by accelerometers located on the floor pan or the frame laterally in line with the floor seat belt anchor fittings. Caution should be exercised in selecting accelerometer mounting locations so that the data will not be influenced by local structural deformation or vibration.

4.2 **Occupant Dynamics**—To obtain data on occupant dynamic loading and movement during the test, anthropomorphic test devices can be used. These should be of a type that will closely represent the size, weight, and articulation characteristics of a human being in the seated position. Accelerometers may be placed in the head, chest, and, when possible, in the pelvic cavity to record acceleration at these points. Significant vertical and/or lateral accelerations accompany the movement of the rolling car; therefore, these accelerometers should be triaxial.

4.3 **Loadings on Occupant Restraint Devices**—Suitable transducers may be used to measure the dynamic forces occurring in occupant restraint devices installed in the vehicle. The number of transducers used in each crash test should be sufficient to provide adequate recording of these forces.

4.4 **Occupant Impact Areas**—Information on occupant impact areas can be obtained by internally mounted cameras as described in paragraph 4.5 and by applying various colors of chalk or paint to portions of the anthropomorphic test device. The chalk or paint will assist in identifying points within the vehicle contacted by the dummy.

4.5 **Photographic Instrumentation**—It is desirable to provide comprehensive photographic coverage of each test. Care should be taken to use lenses that will give a fairly tight field of view and an adequate depth of focus. Zoom type lenses are very useful for these tests. Shock resistant cameras with very wide angle lenses mounted within the test vehicle are helpful in observing occupant action. Comprehensive coverage for these types of tests should include both standard (24 frames/sec) and medium (125–500 frames/sec) speed cameras. These can be carried in the towing car and/or located at strategic points on both sides of the test site. Precautions should be taken for the safety of camera operators. Remotely operated cameras may be employed as necessary.

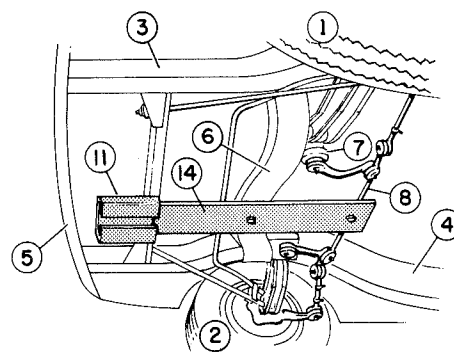
4.6 **Miscellaneous**

4.6.1 **ELECTRONIC AND PHOTOGRAPHIC INSTRUMENTATION COORDINATION**—Provision should be made for synchronizing electronic and photographic instrumentation.

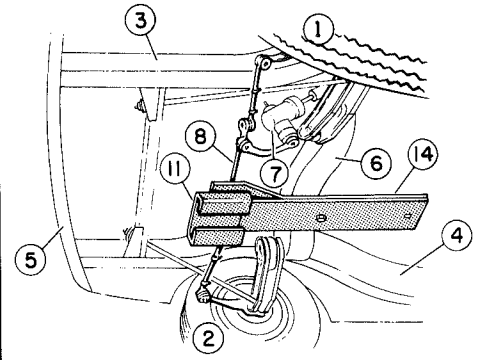
TABLE 1—CURVATURE OF ROLL-OVER GUIDE RAIL

Tangent, ft	Offset, in.	Tangent, ft	Offset, in.	Tangent, ft	Offset, in.
0	0	21	3-1/2	41	12-1/2
1	3/32	22	4	42	14
2	3/16	23	4-3/16	43	15
3	5/16	24	4-3/8	44	16-1/4
4	7/16	25	4-1/2	45	17-7/8
5	5/8	26	4-7/8	46	19-1/2
6	13/16	27	5	47	21-1/8
7	1	28	5-3/8	48	23
8	1-3/16	29	5-1/2	49	24-3/4
9	1-3/8	30	6	50	26-3/4
10	1-1/2	31	6-1/8	51	28-3/4
11	1-5/8	32	6-3/16	52	30-3/4
12	1-7/8	33	6-1/2	53	33-1/4
13	2-1/8	34	6-3/4	54	35-1/4
14	2-1/4	35	7-1/2	55	37-3/4
15	2-1/2	36	8-1/8	56	40
16	2-11/16	37	8-3/4	57	42-5/8
17	2-7/8	38	9-3/4	58	45-1/4
18	3	39	10-1/2	59	48
19	3-1/4	40	11-1/2	59 ft, 8-1/2 in.	48
20	3-7/16				50

- LEGEND
- ① LEFT FRONT WHEEL
 - ② RIGHT FRONT WHEEL
 - ③ LEFT FRAME LONGITUDINAL
 - ④ RIGHT FRAME LONGITUDINAL
 - ⑤ FRONT BUMPER
 - ⑥ SUSPENSION CROSSMEMBER
 - ⑦ STEERING GEAR
 - ⑧ STEERING CENTER LINK
 - ⑨ 5/8 IN. PIVOT PIN WELDED UNDER ⑥
 - ⑩ 5/8 IN. STUD WELDED TO ⑧
 - ⑪ ROLLER GUIDE SHOE
 - ⑫ 3/4 IN. x 2-1/2 IN. SLOT
 - ⑬ 3/4 IN. BOLT
 - ⑭ STEERING LEVER



STEERING LINKAGE REAR OF AXLE



STEERING LINKAGE FORWARD OF AXLE

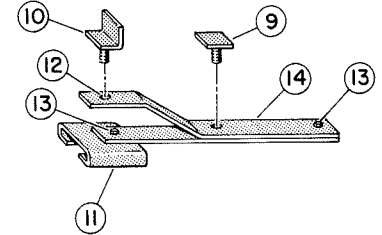
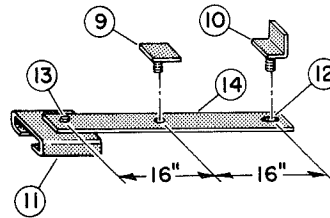


FIG. 2—ROLL-OVER STEERING LEVER AND ROLLER GUIDE SHOE

4.6.2 VEHICLE DEFORMATION—Measurements should be made before and after the test to determine the location, nature, and extent of significant permanent deformation.

APPENDIX

The following roll-over test procedures are reported as a matter of general engineering information:

1. Ground Level Roll-Over—In ground level roll-overs, a linear velocity is applied to the test vehicle and the roll is induced by a turning maneuver, or a combination of a turning maneuver and an external force supplied by a ramp, or other means.

This level road technique produces an apparently realistic roll-over but one which is difficult to reproduce. Lack of reproducibility can be traced to such factors as variations in vehicle design and variations associated with different test sites.

2. Hill Roll-Over—In a hill roll-over, the vehicle is rolled sideways down a steep (approximately 60%) slope. This technique is relatively simple but it is somewhat unrealistic in that it does not provide the forward component of velocity normally encountered in roll-over accidents.

Ground Level Roll-Over—The test site should encompass sufficient room for accelerating the test vehicle to the desired speed and for accommodating the roll mechanism. The site should also provide space for photographic equipment and an observer area.

The approach and surface at the roll mechanism should be smooth enough

to retain control of the vehicle for direction and speed. The roll itself should take place on a smooth, firm dirt or sod surface. This may be a downgrade to prolong rolling.

The modern passenger vehicle, with its low center of gravity and wide tread, is very difficult to roll-over by a full turn broadside on a typical road surface. Therefore, it is necessary to introduce an additional overturning moment by broadsliding on turf or by passing the inside wheels of the test vehicle over a specially designed ramp. In both cases, several attempts may have to be made to determine the technique that will produce the desired number of rolls (2-3). Speeds in the order of 30 to 60 mph are generally used.

Broadslide Method—(See Fig. 3.) The vehicle is generally towed to the desired speed along the approach path. The test vehicle is released from the towing vehicle and the front wheels are turned to the fully locked position as rapidly as possible at such a point that the vehicle will go into a broadslide across the roll area. Best results have been obtained with a 6 on 1 (17%) downgrade. As the vehicle broadslides across this area, the ground will apply a resisting force which produces a rolling moment. The magnitude of this force is determined by the condition and nature of the ground. It has been found that a dry sod turf will produce forces sufficient to initiate roll-over on most passenger vehicles.

One of the drawbacks of this method is the difficulty in reproducing ground surface conditions at different locations and under different weather conditions.

Ramp Method—The ramp roll-over method is similar to the broadslide

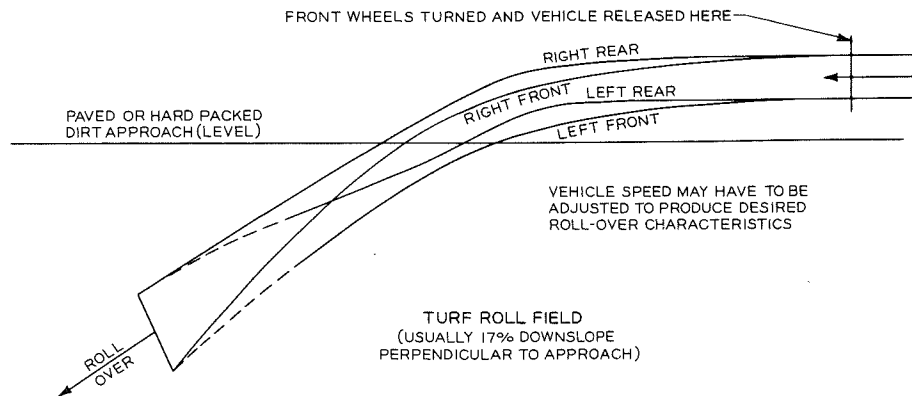


FIG. 3—BROADSLIDE METHOD