

Submitted for recognition as an American National Standard

## Dynamic Simulation Sled Testing

1. **Scope**—Dynamic simulation sled testing can represent various automotive collision conditions. Deceleration conditions during sled testing are readily reproducible and can be tuned to simulate collision events that occur during vehicle impacts with a fixed barrier or vehicle. Sled tests are conducted on automotive vehicle bodies or other structures to obtain valuable information. This information can be used to evaluate the dynamic performance of, but not limited to, vehicle restraint systems, vehicle seating systems, and body closure systems.
  - 1.1 **Purpose**—The purpose of this SAE Recommended Practice is to establish sufficient standardization of dynamic simulation sled testing methods so that results of similar tests conducted at different facilities can be compared. The dynamic simulation sled test device may be one of several types, which include an acceleration sled (Hyge) or a deceleration sled where the deceleration pulse is controlled.
  - 1.2 **Objectives**—The primary objective of this standard test method is to provide realistic simulation of the forces, which act on vehicle systems and occupants during vehicle collisions. This document also describes photographic documentation and measurements of occupant dynamics useful in evaluating restraint system designs.
2. **References**
  - 2.1 **Applicable Publications**—The following publications form a part of this specification to the extent specified herein. Unless otherwise specified, the latest issue of SAE publications shall apply.
    - 2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.
      - SAE J211-1—Instrumentation for Impact Test—Part 1—Electronic Instrumentation
      - SAE J211-2—Instrumentation for Impact Test—Part 2—Photographic Instrumentation
      - SAE J1980—Guidelines for Evaluating Out-of-Position Vehicle Occupant Interactions with Deploying Airbags
      - SAE EA-23—Owner's Manual for Hybrid III Dummy
      - SAE EA-25—Calibration Procedures—Hybrid III Small Female Dummy
      - SAE EA-26—Calibration Procedures—Hybrid III Large Male Test Dummy
      - SAE EA-27—User's Guide for the Twelve and Eighteen Month Old Infant Dummies (CRABI)
      - SAE EA-28—User's Guide for the Six Month Old Infant Dummy (CRABI)
      - SAE EA-29—User's Guide for the Hybrid III Six Year Old Child Dummy
      - SAE EA-31—User's Guide for the Hybrid III Three Year Old Child Dummy

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2.1.2 FEDERAL PUBLICATIONS—Available from the Superintendent of Documents, U. S. Government Printing Office, Mail Stop: SSOP, Washington, DC 20402-9320.

49 CFR Part 571—Federal Motor Vehicle Safety Standard (FMVSS)  
FMVSS 208—Occupant crash protection

**2.2 Related Publication**—The following publication is provided for information purposes only and is not a required part of this document.

2.2.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J1733—Sign Convention for Vehicle Crash Testing

### **3. Sled Test Facility**

**3.1 Sled Test Site, General**—The sled test site should encompass sufficient area to provide accommodations for a Hyge or similar sled, various photographic/video equipment, and a protected observation area.

3.1.1 Allowances for precise positioning of photographic/video equipment should be made, both on-board and off board.

**3.2 Dynamic Simulation Sled**—A sled test facility suitable for testing of passenger cars, light trucks, and vans should have the characteristics listed as follows:

3.2.1 A sled test facility should be able to reproduce a range of acceleration pulses in a repeatable manner. Several standardized pulses used in various test procedures are given in Appendix A.

3.2.2 The sled carriage shall be large enough to accommodate a full vehicle, a live body (an unreinforced vehicle body shell), any rigidized portion of a passenger compartment, photographic equipment, and instrumentation.

3.2.3 The effective mass of the sled module (passenger compartment, anthropomorphic test devices [ATD's], and on-board instrumentation) shall not exceed the limits of the Hyge or other similar sled facility. In cases where the load capacity of the sled facility may be exceeded, portions of the full vehicle, live body, or rigidized passenger compartment may be modified to reduce the mass, insomuch as it does not alter the response of the passenger compartment. In addition, instrumentation and/or photographic equipment considered non-essential might be eliminated. The final configuration is left to the discretion of the vehicle manufacturer or test engineer.

**3.3 Protective Measures**—Protective measures should be taken to ensure the safety of test personnel and observers.

### **4. Methodology**

**4.1** Dynamic simulation sled testing responses are complex by nature even during a relatively simple test. Careful control of the impact parameters must be exercised. As a standard evaluation procedure, a simulated impact speed of 48 km/h (30 mph) is recommended; however, other simulated impact speeds may be chosen for special studies.

Requirements for acceptable photographic coverage include adequate lighting, and a clear background, which would preferably be of consistent texture and void of moving objects.

- 5. Instrumentation and Equipment**—To obtain meaningful information from a collision simulation sled test, it is important that adequate means be provided to observe and record test results. Inasmuch as the objectives of any one impact simulation are limited, the instrumentation to be used will need to be tailored to the type of instrumentation and equipment which can be employed to obtain desired data on the movements and loads experienced by the vehicle or sled buck, its components, or its occupants during a crash test simulation. It is essential that the recording system, including transducers and mounting systems, is not subject to resonant frequencies within the frequency response range of data of interest. The instrumentation and data acquisition system shall meet the requirements of the current SAE J211-1 and SAE J211-2. Data acquisition may begin at time zero=0.5 g or at a time or method specified by the test engineer.
- 5.1 Vehicle Accelerations Measurements**—Accelerations may be measured by accelerometers located on the sled buck itself (per FMVSS 208) or on the floor pan, frame, body sill, body components as required by the test engineer. Accelerometers intended to measure whole vehicle or sled buck accelerations should not be mounted in areas of localized resonant vibrations or distortion such as a seat belt anchorage. For data backup purposes, multiple installations of accelerometers on the vehicle or test buck are recommended.
- 5.2 Occupant Data**—ATD's are used to obtain data on restraint systems and occupant loading during tests. The Hybrid family of dummies which represent 3- and 6-year-old children, small female, mid-size male and large male adults, and the CRABI (child restraint air bag interaction) family of 6-, 12-, and 18-month-old infant dummies are recommended for use in frontal impact evaluation of restraint systems. Physical characteristics and response verification procedures for these dummies are given in SAE Engineering Aids 23, 25, 26, 27, 28, 29, and 31.
- 5.3 Loads on Occupant Restraint Devices**—Transducers may be used to measure the dynamic loads sustained by occupant restraint devices installed in the vehicle. The number of transducers used in each dynamic simulation should be sufficient to provide adequate recording of the loads imposed on these devices.
- 5.4 Contact Recordings and Documentation**—Electrically conductive surfaces may be installed on the head, chest, or knees of the appropriate dummies so that a time history of their contact with conducting surfaces can be recorded with respect to the onset of the simulated impact. Conductive surfaces could be placed on the sun visors/header, windshield, instrument panel, steering wheel, and knee bolsters. Contact-indicative paint may be used to visually display (post crash) areas of relative contact.
- 5.5 Impact Speed**—Provision, such as the use of velocity generators, should be utilized to record the speed of the sled buck during testing. Refer to current SAE J211-1.
- 5.6 Photographic Documentation**—It is desirable to provide comprehensive photographic coverage of each sled test. However, in cases where this is not possible, the following represent the recommended minimum coverage for meaningful information. Equivalent video equipment may be substituted. Refer to SAE J211-2
- 5.6.1 HIGH-SPEED CAMERAS**—A minimum of two high-speed cameras is recommended.
- 5.6.1.1 Broadside Cameras**—At least one high-speed camera should be located on each side of the crash simulation site. Locating axes for precise positioning of photographic equipment should be provided. These cameras should be positioned so that the field of view is large enough to include only the test sled buck and is perpendicular to the path of that sled buck at the onset of the simulated impact. Each camera should have provision for recording a timed pulse signal on the film and should have a framing rate sufficient to facilitate accurate micromotion analysis of the film. (Film frame rates of 200 to 1,000 frames per second are normally employed.) Suitable calibration and position reference targets, both stationary and on the vehicle or test buck and occupants, should be provided. Information obtained from this film through micromotion analysis includes total vehicle or test buck displacement, velocity, and deceleration. In addition, micromotion studies of the kinematics of the various occupants of the vehicle may be performed and compared to their transducer records.

5.6.1.2 *Overhead Cameras*—Cameras may also be placed directly above the test site. Film from these cameras can be used for motion analysis if provisions stated in 5.6.1.1 are included.

5.6.1.3 *Passenger Compartment*—Suitable acceleration resistant cameras may be installed on-board to view the passenger compartment of the test vehicle in order to record the kinematics of specific occupants.

5.6.2 STILL CAMERA(S)—Before- and after-test still photographs should be taken to document test conditions and results.

## 6. *Miscellaneous*

6.1 **Electronic and Photographic Instrumentation Coordination**—Provisions should be made for synchronizing electronic and photographic instrumentation.

6.2 **Vehicle Interior Deformation**—Any significant interior deformation, or energy-absorption device function, should be documented by measurement and/or photography.

6.3 **Vehicle Data and Definition**—Basic vehicle data should be recorded or photodocumented prior to conducting the dynamic simulation. These data should include, but not be limited to:

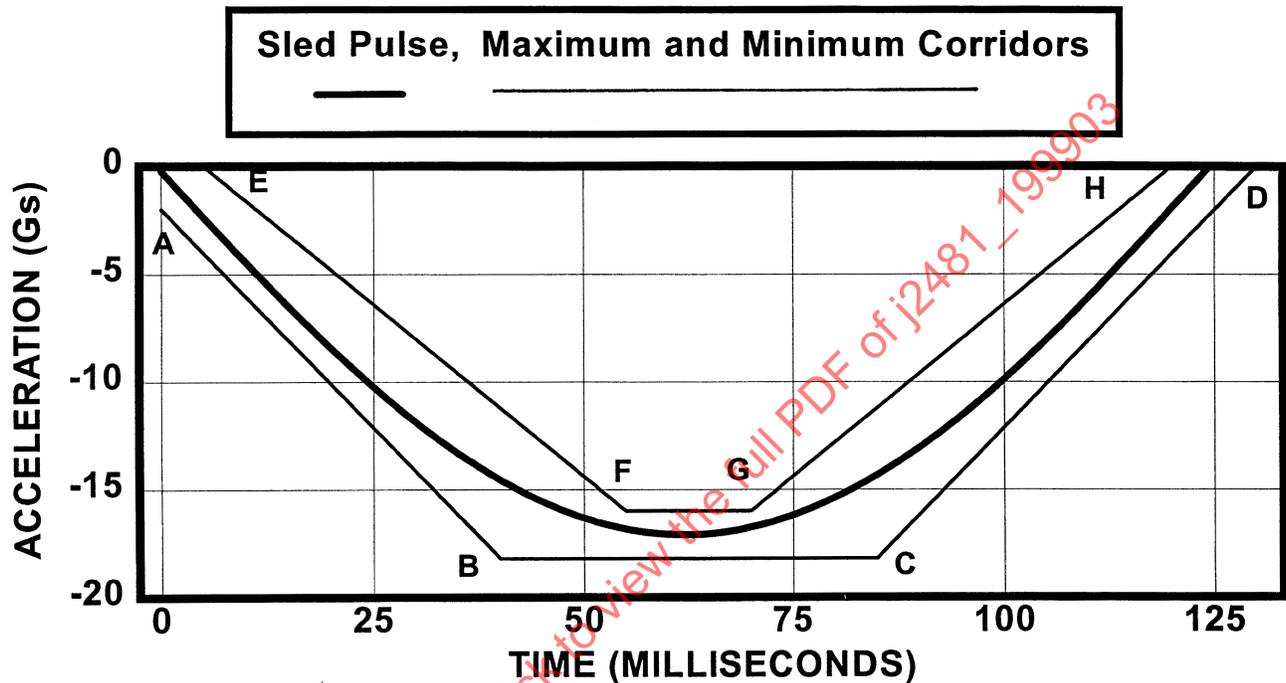
- a. Sled and test vehicle/buck mass
- b. Vehicle production identification (make, model, model year, trim level, etc.)
- c. Any significant variation from production conditions including corrosion, crash damage, or modifications to reinforce the sled buck.

PREPARED BY THE SAE IMPACT AND ROLLOVER TEST PROCEDURE STANDARDS COMMITTEE

## APPENDIX A

A.1 Figure A1 was taken directly from the revised portions of FMVSS 49 CFR Part 571, section 571.208.

An electronic version of the complete document (49 CFR Part 571 [Docket No. 74-14; Notice 114]) can be obtained via the World Wide Web at: <http://www.dot.gov/affairs/index.htm>.



Sled pulse acceleration, expressed in G's =  $17.2 \sin(t/125)$

for  $\Delta V = 30(+0,-2)$  mph

Reference point	t (ms)	Acceleration (G)
A	0	-2
B	40	-18.2
C	85	-18.2
D	130	0
E	5	0
F	55	-16
G	70	-16
H	120	0.00

FIGURE A1—SLED PULSE AND COORDINATES