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LAND SEA AIR SPACE

TECHNICAL REPORT J128

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OCCUPANT RESTRAINT SYSTEM EVALUATION - PASSENGER CARS—SAE J128

SAE Information Report

Report of Occupant Restraint Systems Committee approved December 1969.

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1. INTRODUCTION

1.1 PURPOSE - The purpose of this SAE Information Report is to facilitate the development of restraint systems used in passenger cars to minimize occupant injury during collisions by:

(a) standardizing restraint system testing methods so that results from various facilities can be compared.

(b) serving as a guide in the design and development of effective restraint systems and in the preparation of detailed procedures for testing and evaluating specific types of restraint systems.

(c) providing an orientation for research in human tolerance to impact and for the development of improved human simulators.

The evaluation procedures discussed are lacking in some details at this time due to limitations in such areas as measurement systems, collision simulation, and data on human tolerance to impact; they will necessarily be subject to continuing review and improvement. Nevertheless, they are intended to form the basis for overall evaluation of any means by which a collision energy exchange between an occupant and his vehicle can be accomplished. Where present knowledge does not allow sound procedures and rigorous specifications consistent with this broad outlook, an attempt has been made to avoid arbitrary or restrictive statements. At the present state-of-the-art, judgment and experience must provide major guidance in restraint system testing.

1.2 SCOPE - This information report encompasses the significant factors which determine the effectiveness of the total occupant restraint system in all commonly encountered collision configurations. The total system includes all components which affect occupant injury by influencing the manner in which the collision energy exchange is performed. In addition to the elements that contribute to impact attenuation, consideration must be given to factors that encourage maximum use, such as comfort, reliability, appearance, and convenience. Hence, system evaluation necessarily involves consideration of the complete vehicle.

1.3 CONTENTS

2. DESIGN AND TESTING GUIDELINES

The following considerations form a minimum checklist for evaluating restraint system characteristics.

2.1 COLLISION CONSIDERATIONS

2.1.1 *Injury Attenuation* - A restraint system should perform in a manner which applies restraint forces to appropriate areas of the anatomy and which results in minimal occupant injury, with consideration of skeletal, internal organ, and soft tissue damage, including disfigurement.

In evaluating injury reduction, consideration should be given not only to the direct effects of restraining forces but also to the consequences of such phenomena as violent contact between occupants (for example, head bumping), excessive bodily deflection (for example, whiplash, spinal column buckling), and areas of load concentration on the human body (for example, loading of soft areas of the abdomen by such methods as submarining).

2.1.2 *Unusual Conditions* - While it is obviously desirable that a restraint system provide maximum protection for all occupants in all accident conditions, the statistical nature of collision casualties must be recognized. A system which provides generally good protection is not necessarily rendered unacceptable by inadequate performance under some extreme set of circumstances which will rarely be encountered.

2.1.3 *Ambient Conditions* - A restraint system should provide performance which remains acceptable throughout the range of ambient conditions under which it can reasonably be expected to be needed during its service life. Since it is not usually feasible to vary these conditions during crash tests, it may be necessary to conduct component tests which are supplementary to and more controllable than the complete system tests specified in paragraph 5.1.

2.1.4 *Durability* - Restraint system components should be subjected to such testing as will assure that acceptable performance will be maintained throughout their service life. This may require real time or accelerated exposure to such factors as aging, use, sunlight, corrosion, and dirt. (See SAE J4 for specific tests applicable to seat belt assemblies.)

2.1.5 *Component Installation* - Restraint system components should be installed in the vehicle in such a manner that they do not themselves constitute a significant impact hazard, including conditions of malfunction or improper usage.

2.1.6 *Deployment* - A restraint system or component which is stored remotely and moved rapidly into place immediately before or during an impact should not generate a serious hazard to the vehicle occupants or to service personnel. For example, it should not be excessively noisy, startle the driver into loss of control, or present a serious hazard from abrupt deployment or propellant discharge. It is not anticipated that such systems can be entirely free of hazard; their risks must be weighed against their merits.

2.1.7 *Egress* - The restraint system should contribute a minimum of difficulty or delay in exiting from the vehicle after a collision, with or without outside assistance. Particular heed should be paid to the user suspended in an overturned vehicle.

2.1.8 *Ejection* - Injury potential is generally increased when an occupant is completely or partially ejected from his vehicle during a crash. The relative ability of the restraints to retain the occupant within the body shell is therefore an important criterion of system performance.

2.2 ACCEPTABILITY CONSIDERATIONS - The following characteristics affect the probability of acceptance and proper use of the total restraint system so that its performance potential can be realized. These factors should therefore be weighed heavily in the overall evaluation of a system.

2.2.1 *Comfort* - The restraint system should embody as far as possible those features which contribute to occupant comfort. For those elements which usually contact the occupant, particular care should be paid to avoiding pressure points, rubbing, and similar sources of annoyance which discourage consistent and proper use.

2.2.2 *Convenience* - Restraint system convenience includes consideration of potential interference with normal driving functions as well as the use, removal, adjustment, and storage of components, particularly in darkness or without reference to written instructions. These needs are best met by minimizing occupant participation.

2.2.3 *Appearance* - The attractiveness of system components, both in use and stored, and their effect on occupant clothing should be carefully considered to encourage use.

2.2.4 *Durability* - In addition to the maintenance of system performance (paragraph 2.1.4), it is important to ascertain that the factors which influence acceptability will not deteriorate throughout the service life of the system to an extent which would constitute a significant deterent to maximum use.

2.2.5 *Maintenance* - The responsibility which the user is expected to accept in establishing and maintaining proper use should both be kept to a minimum and be documented in clear written instructions.

3. EQUIPMENT

3.1 ANTHROPOMORPHIC TEST DEVICES - For the impact tests specified in paragraph 5, restraint systems should be evaluated with the aid of an anthropomorphic test device which conforms to SAE J963. Other test devices which have not yet reached the degree of acceptance represented by SAE J963 may nevertheless be useful qualitative tools in reaching evaluation judgments. Attention is called to the following general considerations and limitations which apply to SAE J963 devices.

3.1.1 *Size* - Test devices conforming to SAE J963 are representative of the 50th percentile adult male. Good high-speed photographic coverage and instrumentation must be relied upon to interpret the applicability of results obtained with these test devices to larger or smaller occupants, and the restraint system should exhibit a sufficient margin of performance to assure comparable protection for the range of occupant sizes for which it is intended.

3.1.2 *Articulation* - Test devices conforming to SAE J963 provide a representative range of motion for the major body members, although the articulation is necessarily somewhat less sophisticated than that of the human being. In general, motions of the test device will be appropriate for severe impact conditions but less reliable for low-energy impacts, where such factors as muscular forces and internal damping can have a proportionately larger influence on the relative displacement of body elements during the collision event. Frictional forces between the test device and components of the vehicle can have important effects on relative motion of the test device. Body elements likely to be in substantial contact with the seat, vehicle interior, or restraining devices should therefore be clothed in material which will provide friction coefficients representative of typical occupant clothing; in the absence of special considerations, cotton is recommended. While it is recognized that loose, multiple-layer clothing can affect friction, form-fitting stretch garments are recommended to minimize interference with photographic analysis.

3.1.3 *Dynamic Compliance* - Correlation work is going on between SAE J963 test devices and human tolerance data of the type contained in SAE J885 as related to motor vehicle design (with revisions). However, it is not yet to the point where these test devices can be generally used to make quantitative predictions of human injury. There are many reasons for this, such as the multiplicity of conditions under which the human tolerance data have been obtained, the scarcity of such data, and the difficulty of developing mechanical parts which have the same dynamic properties as the human body. Basically, the SAE J963 device has little capability to measure simulated human physiological responses. Impact data measured by using such a test device can nevertheless be of considerable value in evaluating restraint systems because of considerations such as the following:

(a) Where possible, the evaluation desired should be relative to some similar restraint system whose performance with the same test device is known or can be determined. The relative performance is thus less likely to be obscured by differences between the test device and the human being.

(b) If typical crash loads are to be kept within human tolerance limits, the dynamic deflections of restraining elements will usually have to be quite large relative to the involved elements of the human body. Under these conditions, inaccuracies in the compliance rates of the test device will have only a relatively minor effect on the loads developed, since it is the stiffer element in the local impact.

It is, however, important to inspect test information closely in order to detect misleading results due to details of construction of the test device which are significantly different from

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those of the human body—for example, metal edges which might cut restraint devices.

3.2 TEST VEHICLE OR EQUIVALENT - The dynamic response of vehicles to a given impact can vary widely due to such factors as vehicle weight, structural design, body style, and engine size and location. These variations have significant effects on the performance of occupant restraining elements. It is, therefore, necessary to include the whole vehicle in the impact testing of a restraint system, or to verify the adequacy of any simulation of the complete vehicle. Exclusive of test devices and instrumentation, the vehicle should be tested at curb weight. While the weight of optional equipment should not be included, it is necessary to take into account any significant effects which such items might have on the structural crush characteristics of the vehicle. (Adjustment for the weight of any equipment required for this reason is covered in paragraph 4.2.1).

3.3 INSTRUMENTATION - Instrumentation appropriate for measuring accelerations, velocities, penetrations, distances, forces, and event timing is described in SAE J977. For correlation, acceleration data from the anthropomorphic test device should be recorded at 1000 Hz. However, to aid in the interpretation of results, it is recognized that some filtering of recorded data may be needed. Other appropriate instrumentation is listed in the SAE test procedures referenced in paragraph 5.1.

Complete high-speed photographic coverage is a very integral part of a restraint system test program. It will frequently be advisable to remove a door or other section of the vehicle body to permit better photographic coverage, in which case struts should be employed as needed to make the structural integrity representative of the complete vehicle and to restore equivalent lateral restraint.

4. TEST PREPARATION

4.1 INSTALLATION OF RESTRAINT SYSTEM COMPONENTS - Restraint system components should be installed, employed, and adjusted as they are intended to be used—for example, in accordance with the manufacturer's recommendations.

Where seat belts of the types covered by SAE J4 form a part of the restraint system, belts should be adjusted to a preload of approximately 5 lb per anchor. For shoulder belts, preload is obtained with a 3 × 3 × 3 in. block between the belt and the sternum, and the block is then removed before the test is run. If a locking type retractor is present, the tension that results from the retractor's internal spring should be used for a preload tension setting. Belts and test devices should be jostled about during the tightening process so as to minimize the efforts of friction on the preload reading.

4.2 INSTALLATION OF ANTHROPOMORPHIC TEST DEVICES

4.2.1 *Number of Occupants* - Occupant restraint conditions should be evaluated for each designated seating position. However, the dynamic response of a vehicle will vary with load and with the manner in which the load is restrained. In addition, a full complement of anthropomorphic test devices makes good photographic coverage quite difficult, and conditions of symmetry or previous experience may make it unnecessary to test all seating positions simultaneously.

With these and similar considerations in mind, the test vehicle should be loaded to 600 ±50 lb above curb weight (including all test devices, instrumentation, optional equipment, and ballast) for a vehicle with four, five, or six designated seating positions. This load should be reduced by 150 lb for vehicles with less than four seating positions and increased by 150 lb for vehicles with more than six seating positions.

4.2.2 *Occupant Placement* - With one anthropomorphic test device normally occupying the driver's position, the remaining devices should be located not only to demonstrate the restraint conditions at each unique seating position, but also to bring into play any interaction between occupants which could produce serious injury or significantly influence the behavior of the means of restraint. Adjustable seats should be at the mid-point of their travel; tests at the extremes of travel may also be required if seat postion has a significant effect on the manner in which the occupant engages the restraints.

4.2.3 *Posture* - Details of the restraint system and vehicle being tested should be considered in order to select from the range of normal seating postures and positions those which appear to be most appropriate in evaluating the system (that is, a driver seated against the door, a passenger in a reclining seat, etc.). The test results should then be examined carefully to assure that the system has exhibited a sufficient margin of performance to cover other reasonable postures and positions not specifically selected for testing.

In the absence of considerations specific to the particular vehicle and restraint system, the driver should be centered approximately 2 in. outboard of the center of the steering wheel with his hands on the wheel rim at the horizontal centerline. Where the spaces for other outboard occupants are similar to the driver's area, these test devices should be located approximately the same distance from the vehicle centerline as the driver. Test devices in center seats should be on the car centerline except that where the front seat footwell area is effectively divided into two compartments, both feet should be in the passenger's portion of the footwell. Passengers' arms should be placed on the lap with the hands overlapping.

4.2.4 *Joint Adjustment* - Friction at articulated joints of the anthropomorphic test devices should be adjusted to approximately 1 g at all points of articulation, using the torso as the reference base.

4.3 INSTALLATION OF INSTRUMENTATION - Major elements of the instrumentation load and any ballast required to reach the specified vehicle loading should be fixed securely to the vehicle structure in the normal cargo-carrying area. Alternate locations may sometimes be necessary to avoid damage to instrumentation during the crash.

Instrumentation applied to the test devices should not significantly alter the mass, center of gravity, or freedom of motion of each body member as specified in SAE J963. Similarly, the application of instrumentation to the vehicle/should not significantly affect its crush characteristics or the behavior of restraining elements. Guidance as to the specific measurements which should be made in evaluating a given restraint sys-

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