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SURFACE VEHICLE INFORMATION REPORT

SAE J2052

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(R) TEST DEVICE HEAD CONTACT DURATION ANALYSIS

A technically equivalent version of SAE J2052 is included in ISO Technical Report 12351.

Foreword—A technique has been established for determining head impact contact duration called the "Force Difference Method." This technique allows calculation of Head Injury Criterion (HIC) only during head contact.

1. Scope—This methodology can be used for all calculations of HIC, with all test devices having an upper neck triaxial load cell mounted rigidly to the head, and head triaxial accelerometers.

1.1 Purpose—The purpose of this SAE Information Report is to describe a computer-adaptable technique for determining head engagement and disengagement times for use in the calculation of the HIC without reliance on contact switches or photography.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

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

SAE J211-1 MAR95—Instrumentation for Impact Test

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

FMVSS 49: 571-208—Occupant Crash Protection, revised as of April, 1997

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

ISO Technical Report 12351—Determination of head contact and duration in impact tests—ISO/TC22/SC12/WG3N355

3. *Definitions*

3.1 HIC—The HIC is one of the "injury criteria" prescribed by S6 of the Federal Motor Vehicle Safety Standard (FMVSS) 208. It is the maximum value calculable from the head c.g. resultant acceleration-time profile in accordance with Equation 1:

$$HIC = \left[\frac{1}{(t_2 - t_1)}\int_{t_1}^{t_2} a.dt\right]^{2.5} (t_2 - t_1) \qquad \text{(Eq. 1)}$$

where:

a is the resultant acceleration expressed as multiples of G (the acceleration of gravity), and t_1 and t_2 are any two points in time during the crash.

NOTE—Although a HIC window of 36 milliseconds maximum was subsequently mandated by NHTSA, it is not utilized with this document.

3.2 Contact HIC—HIC values calculated only during the periods of each head contact.

3.3 t_e, t_d—The head engagement and disengagement times, t_e and t_d respectively, are determined by the method given in Section 5. These are the starting and ending times, i.e., the windows for the iterative HIC calculations for each head contact.

NOTE—The maximum contact HIC for each t_e, t_d interval will have associated with it times t_1, t_2 which may be equal to, or less than the t_e, t_d interval.

3.4 Accelerometers (a_x, a_y, a_z)—The triaxial accelerometer(s) in the head of the test device will be referred to as an accelerometer, omitting the triaxial classification as defined in SAE J211-1; $+a_x$ is forward, $+a_y$ is to the right, and $+a_z$ is downward. These orientations are shown in Figure 1.

3.5 Load Cell—The triaxial force load cell (attached rigidly to the base of the skull portion of the test device to which the neck is attached) will be referred to as a load cell, omitting the triaxial and upper neck classification. Load cells with additional outputs can also be used.

3.6 Head Mass (M)—The mass of the head including the masses of the head accelerometers and mounting brackets and the mass of the load cell above the gage plane.

NOTE—Caution should be exercised to minimize the effect of elements external to the neck, such as neck skins or wires, which might carry load or modify the head mass.

3.7 Inertial Head Forces (Ma_x, Ma_y, Ma_z)—The inertial head forces are calculated from the triaxial accelerometers which are inside the head of the test device. The accelerations are multiplied by the M of the test device to determine the inertial head forces. The directions of these inertial forces are the same as the directions of their corresponding acceleration vectors.

3.8 Neck Forces (F_x, F_y, F_z)—The neck forces are determined directly from the load cell, per 3.5, which reads the forces acting on the neck at the location of the load cell (the base of the skull in this case). F_x is longitudinal shear, F_y is lateral shear, and F_z is axial force. Forces (F_x, F_y, F_z) are applied to the neck in this paper (see Figure 1). A positive F_x output from the load cell means head rearward motion relative to neck; positive F_y output is head left motion relative to neck; and positive F_z output is tensile force or head upward motion relative to the neck. Conventions are per SAE J211-1.

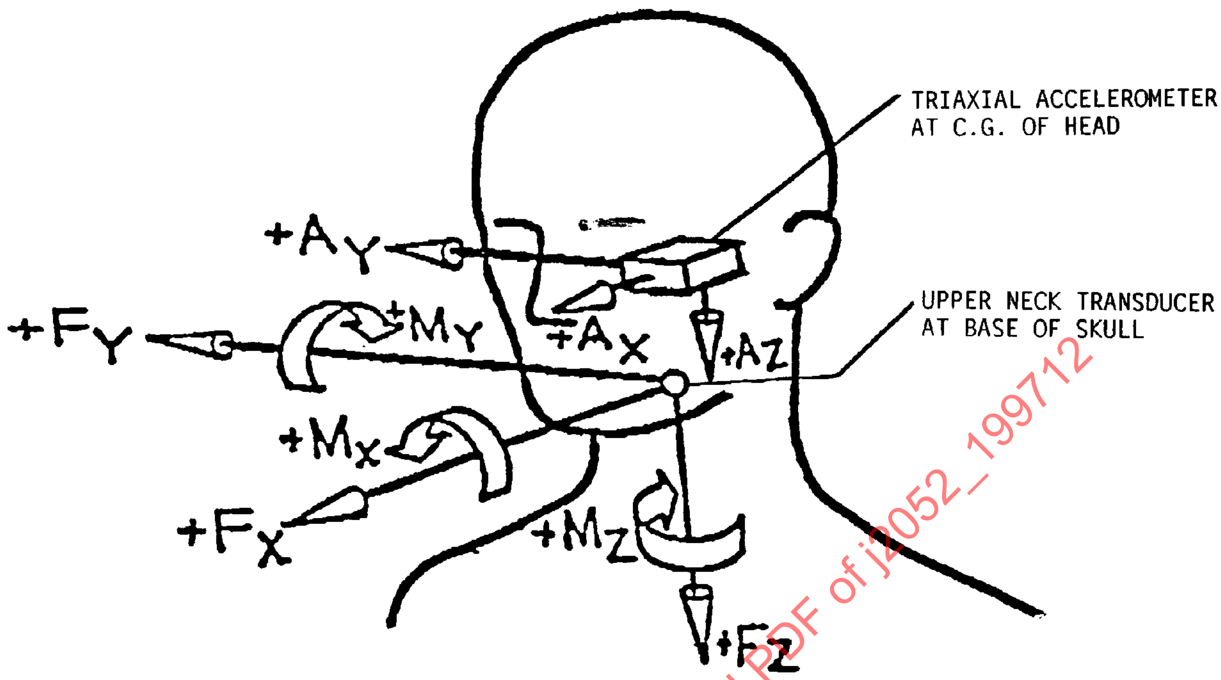

FIGURE 1—HEAD CONTACT DURATION ANALYSIS—ACCELERATION AND FORCE

3.9 Test Device—Any full, partial, or simulated anthropomorphic dummy equipped with head accelerometers and load cell per 3.4 and 3.5 is defined as the test device. For example, the 50th percentile male Hybrid III dummy specified in Part 571, subpart E, of FMVSS 208, can be used, as can any derivative of that dummy with proper instrumentation.

4. Data Acquisition And Processing System—The data acquisition and processing system must be capable of supplying transducer data per SAE J211-1 which recommends that both head acceleration and neck force utilize channel class 1000, and that any multiple recording devices are time-referenced per 4.4.2 of SAE J211-1.

5. Procedure For Determining Head Contact Duration (t_e, t_d)—The subject method uses Equation 2:

$$F = \sqrt{[(Ma_x - F_x)^2 + (Ma_y - F_y)^2 + (Ma_z - F_z)^2]} \qquad \text{(Eq. 2)}$$

The acceleration components (a_x, a_y, a_z) of the head are multiplied by the M to produce the components of inertial head force. Each neck force component (F_x, F_y, F_z) is subtracted from the corresponding calculated inertial head force component. The aforementioned subtractions produce three force-differences. The external resultant head force (F) is calculated by taking the root sum square of the force-differences, and is plotted as a function of time. This plot represents the resultant contact force acting on the head.

In order to establish consistent engagement (t_e) and disengagement (t_d) times for each contact, the following method is established: A contact is assumed to have occurred when the force level has reached 500 N. The t_e for this contact is obtained by tracing backwards in time from the 500 N point on the force versus time curve until 200 N is first reached. The t_d for this contact is determined by tracking forward in time until the curve crosses the 200 N force level.

A subsequent contact is assumed to have occurred when the force level again has reached 500 N after the first time t_d. The t_e and t_d for this second contact are determined in the same manner used for determining t_e and t_d in the previous contact. This process is repeated for each subsequent contact, and is illustrated in Figure 2.

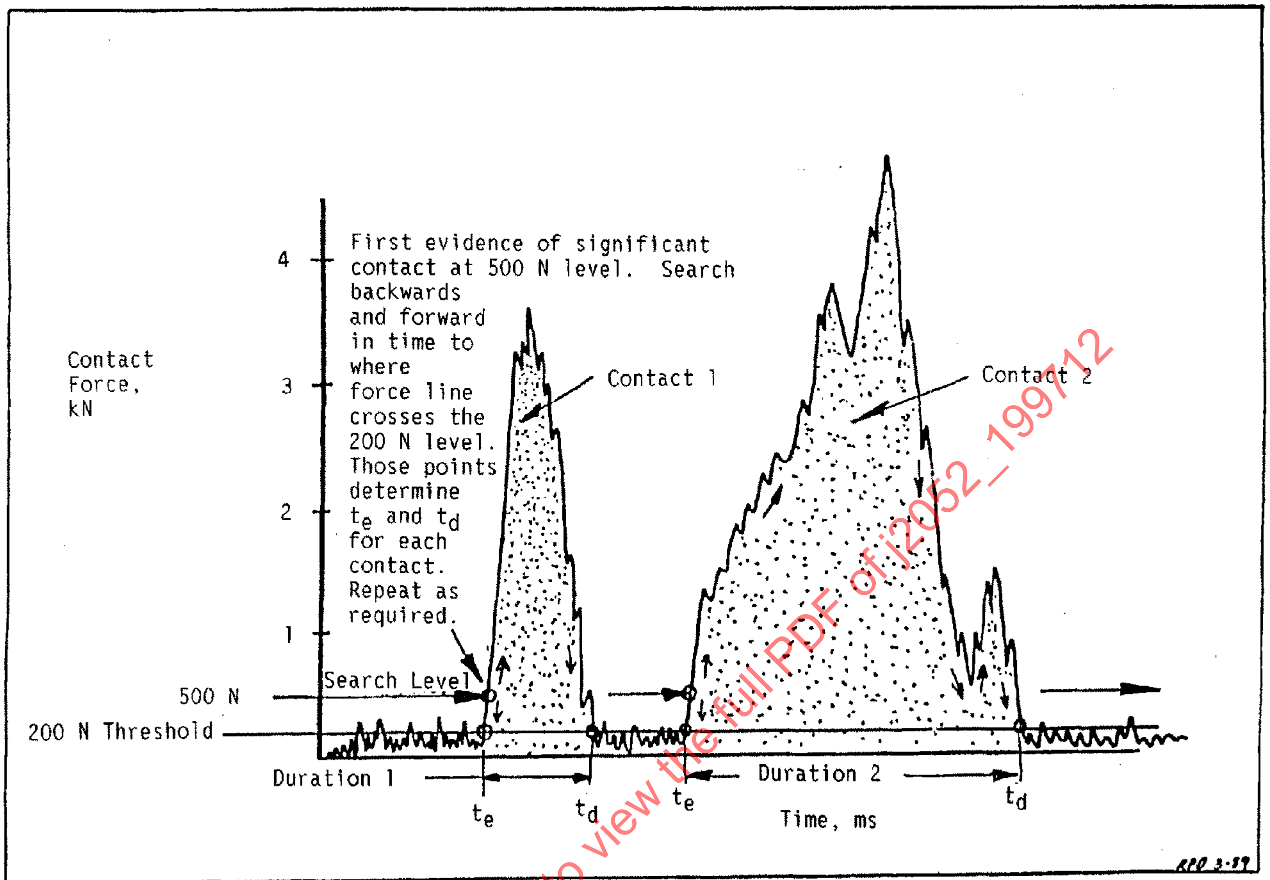

FIGURE 2—DETERMINATION OF CONTACT DURATIONS FROM CONTACT FORCE-TIME CURVE

6. Other Information

6.1 Maximum Contact HIC—The HIC is calculated for each contact interval determined in Section 5. The HIC t_1 and t_2 values for each contact interval may be equal to, or within the corresponding t_e, t_d interval. The maximum contact HIC is the largest HIC value from all the contacts.

6.2 Resultant External Contact Force, F, and Its Direction (θ_x, θ_y, θ_z)—The procedure in Section 5 allows the calculation of the actual contact force (which is the peak force shown in Figure 2). The direction of that force can be obtained by Equations 3 through 5:

$$\theta_x = \cos^{-1}\left[\frac{Ma_x - F_x}{F}\right] \quad \text{(Eq. 3)}$$

$$\theta_y = \cos^{-1}\left[\frac{Ma_y - F_y}{F}\right] \quad \text{(Eq. 4)}$$

$$\theta_z = \cos^{-1}\left[\frac{Ma_z - F_z}{F}\right] \quad \text{(Eq. 5)}$$