Instrumentation For Impact
Test — SAE J211b

SAE RECOMMENDED PRACTICE

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SOCIETY OF AUTOMOTIVE ENGINEERS, INC.
400 COMMONWEALTH DRIVE, WARRENDALE, PA. 15096

INSTRUMENTATION FOR
IMPACT TEST - SAE J211b   SAE Recommended Practice

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1. SCOPE-The purpose of this SAE Recommended Practice is to provide guidelines for instrumentation used in automotive safety impact tests. The aim is to achieve uniformity in instrumentation practice and in reporting test results, without imposing undue restrictions on the performance characteristics of the individual elements in an instrumentation or data analysis system. Use of this recommended practice will provide a basis for meaningful comparisons of test results from different sources.

2. DEFINITIONS

2.1 DATA CHANNEL-All of the instrumentation from and including a single transducer (or multiple transducers whose outputs are combined in some specified way) up to and including any analysis procedures that may alter the data.

2.2 SCALE FACTOR-The intended ratio of real-to- analog values (for example, g/in (cm) of trace deflection, lb (g)/V of tape recorder signal.

2.3 STATIC ACCURACY-For d-c channels, the deviation from the channel scale factor at zero frequency. For a-c channels, the deviation from the channel scale factor at a designated frequency between f_l and f_h of Fig. 1.

2.4 DYNAMIC ACCURACY-The change in scale factor as a function of input frequency.

2.5 FULL SCALE-The maximum usable linear range of an instrument.

2.6 DATA CHANNEL FULL SCALE-That value of a data channel determined by the instrument in the channel with the lowest full-scale level. This is expressed in terms of the measured variable (input). For example . F.S.=50 g, 1000 lb, 500 g, 100 cm/s, etc.
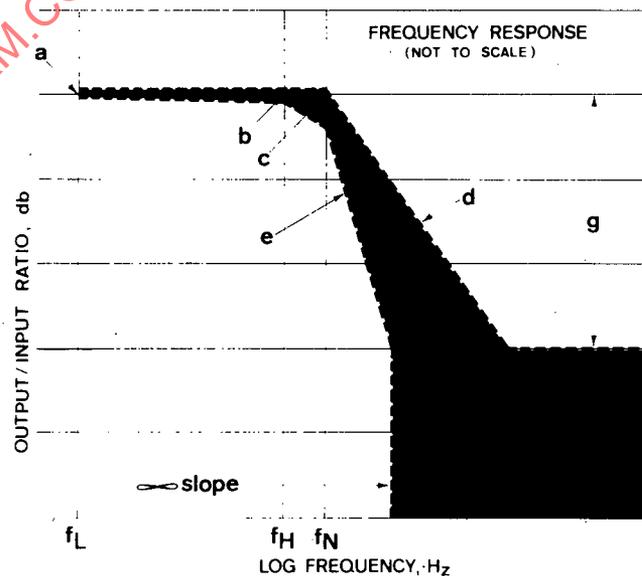

FIG. 1 - DATA CHANNEL DYNAMIC ACCURACY

3. DATA CHANNEL REQUIREMENTS-These requirements fall into two categories: static accuracy and dynamic accuracy.

3.1 STATIC ACCURACY

3.1.1 *Requirements*-The static accuracy of a data channel is dependent upon the complex interaction of many factors, such as linearity, zero drift, hysteresis, etc. As a basis for evaluating the static accuracy of a data channel, each testing agency shall maintain a record of the instrumentation used, listing the equipment by function, manufacturer model and serial number, date of last calibration, and calibration interval.

3.1.2 *Suggested Guidelines*-The following guidelines are suggested when evaluating the static accuracy of a data channel:

(a) Laboratory calibration checks should be made at $\frac{1}{4}$, $\frac{1}{2}$, and full scale for each data channel. A calibration signal equal to at least 80% full scale should be provided at the time of test

(b) Bipolar channels should be checked in each direction.

(c) Data channels should be scaled to make allowance for higher than expected test values.

(d) Consideration should be given to the effects of test site conditions (for example, temperature).

(e) Calibration should be made on a periodic basis utilizing measuring and test equipment traceable to known standards.

3.2 DYNAMIC ACCURACY

3.2.1 *Requirements*-This property of a data channel is specified by a curve which plots the channel output/input ratio versus frequency of the applied calibration signal. Fig. 1 contains recommended limits for the various classes of data channels that are referenced in paragraph 4. If the data channel frequency response falls entirely within the shaded area in Fig. 1, it meets the requirements of this recommmended practice.

3.2.2 *Suggested Guidelines*-The following guidelines are suggested when evaluating the dynamic accuracy of a data channel:

(a) The input signal for testing frequency response should be equivalent to at least 80% of full scale for the data channel. For certain transducers, it may not be practical to obtain 80% of full scale for the full frequency range.

(b) Consideration should be given to the effect of cable length and temperature on frequency response.

3.3 SUBSYSTEM EVALUATION-If desired, transducers and subsystems may be evaluated individually and the results factored into the total data channel accuracy, taking into account interaction effects.

4. DATA CHANNEL SELECTION-The selection of a frequency response class is dependent upon many considerations, some of which may be unique to a particular test. The ultimate usage of the data and judgment will determine what portions of the frequency spectrum are significant or useful. The various classes of frequency response in Fig. 1 are intended to permit appropriate choices for different engineering requirements.

Typical Test Measurements - Frequency Response	Channel Class [a]
Vehicle structural accelerations for use in:	
Total vehicle comparison[b]	60
Collision simulation (for example, impact sled) input	60
Component analysis	600
Integration for velocity or displacement	180
Barrier face force	60
Belt restraint system loads	60
Occupant	
Head acceleration	1000
Chest acceleration	180
Chest deflection	180
Femur force	600
Sled Accelerations	60
Steering column loads	600
Headform accelerations	1000

TABLE 1

It is important to note that valid comparisons using different frequency response classes may be difficult to make. It is useful to establish specific frequency response classes when comparing test results from different sources. The frequency response classes in Table 1 are recommmended for that purpose. These recommendations reflect current practices and equipment. However, it is recognized that other considerations (for example, biomechanics) may impose special instrumentation requirements.

The channel class recommendations for a particular application should not be considered to imply that all the frequencies passed by that channel are significant for the application. In several cases, such as the occupant head accelerations, the headform accelerations, and the femur force, the recommendation may be higher than necessary but current biomechanical knowledge will not permit a closer specification.

5. DIGITAL DATA PROCESSING—This section establishes guidelines for digital data processing equipment used by crash testing agencies.

5.1 PRESAMPLE FILTERING—Crash test data generally has high-frequency components above the Channel Class f_H. This can occur more often with undamped accelerometers. Presample filtering should be used to keep these components from causing aliasing errors in the sampling process. The user is cautioned to examine the unfiltered data for signal overloads, since the filtering process can mask certain overload conditions. Since Class 1000 data is generally the highest frequency data required in crash testing, many laboratories set the presample filter to Class 1000 and use digital filtering for lower classes.

5.2 SAMPLE RATE - The minimum acceptable sampling rate is a function of many variables, particularly sophistication of the reconstruction method used in the processing of software. For those installations utilizing only simple reconstruction software, the sample rate should be at least five times the -3db frequency of the presample filters. In installations with Class 1000 pre-sample filters, this corresponds to a minimum sampling rate of approximately 8000 samples/second/channel. If analog recorders are used for time expansion, appropriately lower sampling rates are permissible.

5.3 RESOLUTION—Digital word lengths of at least 8 bits (including sign) should be used to be assured of reasonable accuracy the dynamic range of the data is less than 50% of the A/D converter full-scale, a higher resolution may be required.

5.4 DATA PROCESSING—Processing software is typically used to scale and filter data, determine zero levels, perform mathematical operations and prepare data plot formats.

5.4.1 *Digital Filtering*—Filtering maybe either phase-shifting or phaseless. Phase-shifting filters will cause time offsets and phaseless filters will cause time uncertain either of which will cause problems in comparing data to film, and comparing data to data if the class filters are different. Filtering should precede all non-linear operations, such as calculation of resultant vectors and Severity Index.

5.4.2 *Scaling and Zeroing*—Software should be used to determine zero levels and calibration factors rather than relying on set gains and expecting no zero drift. Zero offset errors in orthogonal components cause comparable errors in resultant computation that are often difficult to detect.

5.4.3 *Injury Index Calculations*—Calculations of Severity Index should use all sampled data points. Head Injury Criterion should use all data points for the integration. However, the maximizing time intervals need be no more precise than 1 ms.

6. OTHER MEASUREMENT RECOMMENDATIONS

6.1 IMPACT VELOCITY-This can be calculated by measuring the time required to traverse a known distance prior to impact. Determination of impact velocity should be accurate to ±1%.

6.2 TEST SPECIMEN CRUSH

6.2.1 Residual crush is a single-valued data point, with respect to

a designated reference point. Determination of residual crush should be accurate to $\pm$ 5%.

6.5.2 Maximum dynamic crush is a measurement of the maximum deformation of the test specimen during the impact. This is also measured with respect to a designated reference point. Contingent on the size of the specimen and the magnitude of the expected dynamic crush, the following are possible measurement methods:

    (a) High-speed motion picture photography.

    (b) Double integration of acceleration data.

    (c) Use of a specific displacement transducer.

Accuracy should be $\pm$ 5%.

6.3 STEERING COLUMN DISPLACEMENT - This can be measured by various techniques relative to a designated reference point on the vehicle. The coordinate system in which displacement is measured should be indicated. Determination of steering column displacement should be accurate to $\pm$ 0.5 in ($\pm$ 1.27 cm).

6.4 TIMING MARKS - Timing marks are essential in data analysis and correlation of high-speed film to other data channels. Timing frequency stability should be $\pm$1%. Timing synchronization should be $\pm$ 1 ms.

6.5 TIME OF CONTACT - Time of initial contact can be accomplished by recording a switch actuated by the impact or by observing the instant the test acceleration exceeds $\frac{1}{2}$ g. It should also be recorded in film data through strobe lights or timing mark channels. Time of contact should be known within $\pm$ 1ms.

6.6 TRANSDUCER MOUNTING - Mechanical resonances associated with transducer mounting should not distort readout data.

In cases where properties of non-mechanical test subjects preclude rigid transducer mounting, an analytical or experimental evaluation of mounting effects on the data should be provided.

7. REPORTING REQUIREMENTS - In reporting results of tests, the following information should be provided with data tabulations, time history traces, etc.:
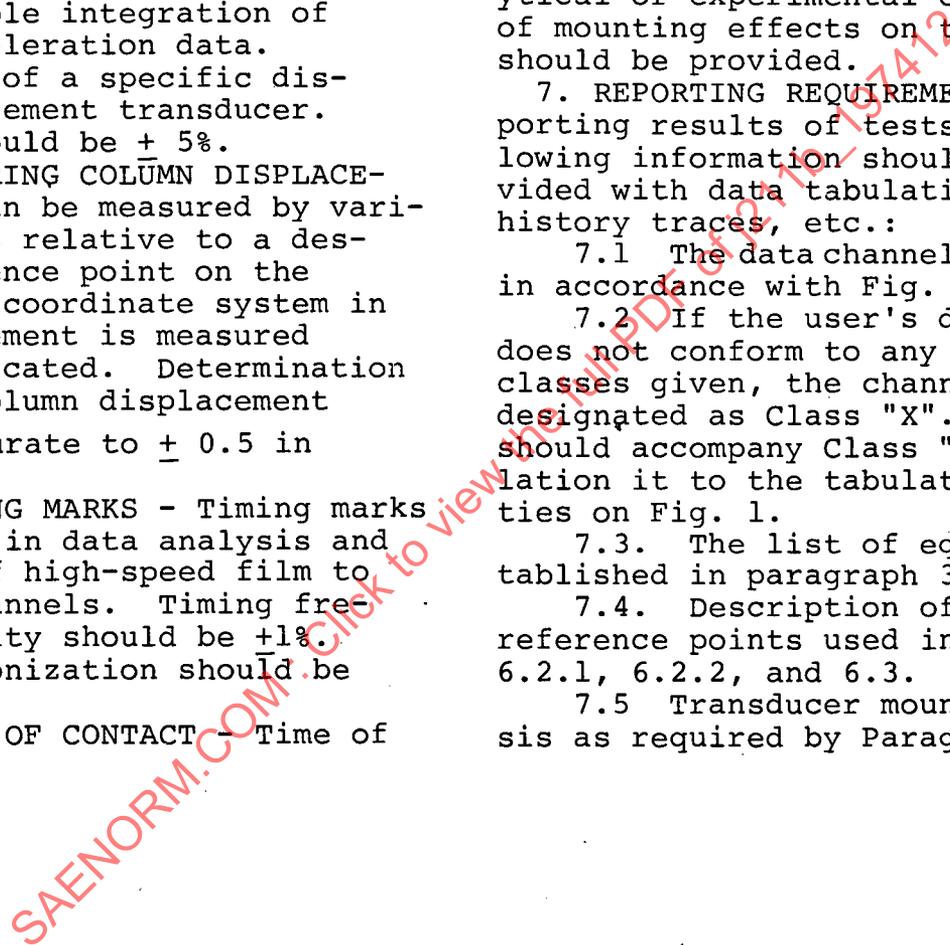
7.1 The data channel class if in accordance with Fig. 1.

7.2 If the user's data channel does not conform to any of the classes given, the channel can be designated as Class "X". Information should accompany Class "X" data relation it to the tabulated quantities on Fig. 1.

7.3 The list of equipment established in paragraph 3.1.1.

7.4 Description of designated reference points used in paragraphs 6.2.1, 6.2.2, and 6.3.

7.5 Transducer mounting analysis as required by Paragraph 6.6

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