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Standard Practice for Accelerometer Use in Vehicles for Tire Testing[1]

This standard is issued under the fixed designation F811; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers guidelines for using accelerometers in test vehicles to evaluate dynamic accelerations resulting from various maneuvers such as braking, accelerating, or cornering.

1.2 This practice is applicable to accelerometers that are rigidly attached to the body of the test vehicle or stabilized to the earth-fixed axis system by means of a gyroscope.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautions are given in Section 6.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F538 Terminology Relating to the Characteristics and Performance of Tires

3. Terminology

3.1 *Definitions:*

3.1.1 *accelerometer*, *n*—an instrument that senses inertial reaction to measure linear or angular acceleration. **F538**

3.1.2 *bandwidth, [1/T]*, *n*—the range of frequencies within which certain performance characteristics occur; specific limits normally apply. **F538**

3.1.3 *g*, *n*—a unit of acceleration where 1 *g* is equal to the acceleration of gravity, 9.8 m/s^2 (32.2 ft/s^2). **F538**

3.1.4 *gyro-stabilized accelerometer*, *n*—a precision vertical gyroscope fitted with one to three accelerometers to provide orthogonal measurements referenced to the earth-fixed axis system. **F538**

3.1.5 *servo accelerometer*, *n*—an accelerometer containing servo mechanisms, electronics, and a seismic element to sense inertial reaction. **F538**

3.1.6 *strain gage accelerometer*, *n*—an accelerometer using strain gages to sense the motion of the seismic element. **F538**

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *performance accelerometer*, *n*—a packaged acceleration measuring system with integral data processing capability.

4. Significance and Use

4.1 The measured accelerometer output can be used to calculate traction properties of combined tire-vehicle systems for passenger cars, light trucks, and heavy trucks through use of applicable methods of testing.

4.2 This practice is intended to achieve uniformity in test vehicle accelerometer use and in accelerometer signal processing. Through such usage, a basis for meaningful comparisons of test results from different sources will be obtained.

4.3 This practice is not applicable to accelerometers used in destructive testing, such as vehicle crash tests or vehicle vibration measurements.

5. Apparatus

5.1 *Body-Mounted Accelerometer*—An accelerometer shall be used to measure vehicle accelerations in any of the three primary vehicle axes (use x, y, z as illustrated in Fig. 1) and shall have the following specifications:

5.1.1 *Range*—The full-scale range of the accelerometer shall be at least ±1.0 g and not more than ±5.0 g for units used in the x and y axes, and at least ±2.0 g and not more than ±5.0 g for units used in the z axis.

5.1.2 *Accuracy*—Amplitude accuracy shall be equal or better than ±1 % of full scale including all error sources.

5.1.3 *Bandwidth*—The frequency response of the complete system shall be from DC to a minimum of 20 Hz. The output shall not vary more than ±2 % of the static output over this frequency range.

[1] This practice is under the jurisdiction of ASTM Committee F09 on Tires and is the direct responsibility of Subcommittee F09.10 on Equipment, Facilities, and Calibration.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

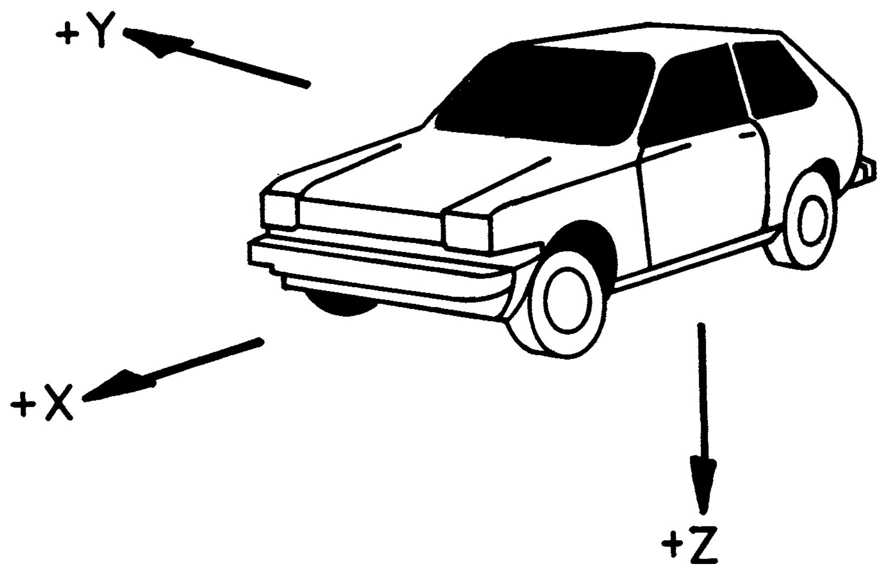

FIG. 1 Sign Convention

5.1.4 *Temperature*—The operating temperature range shall be, as a minimum, between −23 and 66°C (−10 and 150°F) with a temperature sensitivity of less than 0.054 %/°C (0.03 %/°F) of full scale of the sensor.

5.1.5 *Cross-Axis Sensitivity*—The measured output shall not be affected by more than ±3 % of the accelerations acting perpendicular to the measurement axis.

5.2 *Gyro-Stabilized Accelerometer*—Accelerometers that are attached to a gyro-stabilized platform for the purpose of eliminating the effects of vehicle pitch or roll attitudes must meet the requirements of 5.1.

5.2.1 *Gyro-Stabilized Platform*—The platform shall maintain the accelerometer(s) in a horizontal plane for X and Y axes, and in a vertical plane for Z axis, referenced to the earth within ±0.25° during data collection.

5.3 *Low-Pass Filter*—A low-pass filter shall be used to minimize the effect of vehicle-, tire-, and roadway-related vibration on the data. The filter shall be flat ±2 % (±0.2 dB) from DC to 2.5 Hz, – 3 dB at 7.5 ± 3 Hz with a roll-off between 24 and 48 dB per octave. The frequency response shall fall entirely within the shaded area in Fig. 2.[3]

5.4 *Recorder*—The recorder shall have an accuracy equal to or greater than 1 % of full scale over a bandwidth from DC to at least 20 Hz.

5.5 *Performance Accelerometers*:

Several commercial manufacturers have developed solid-state packaged systems to measure the longitudinal and lateral accelerations of a test platform. One system will calculate speed and distance traveled during braking or acceleration maneuvers derived from the accelerations. Other systems will measure the longitudinal and lateral accelerations during cornering or acceleration maneuvers. These systems have in-vehicle calibration procedures suitable for test stability. The software for these units considers the roll rates for several different vehicle suspension combinations and will adjust the data accordingly. The minimum specifications of these units is as follows:

Transducer System:	One, two or three accelerometers in orthogonal alignment either referenced to earth gravity or component axis
Measurement Resolution:	±0.01 g
Measurement Orientation:	g's measured in plane of road
Data Sample Rate:	Ten (10) samples/second (minimum)
Anti-Alias Filter:	Third order Bessel function or Nyquist filter to 2.56:1 (25 samples/s)

6. Hazards

6.1 Upon completion of the installation, verify that vehicle dynamics and vibrations acting on the accelerometer do not produce g levels outside the operating range or produce voltage levels that would exceed the input rating of the filter.

6.1.1 When using a body mounted accelerometer or gyro-stabilized platform, observe the unfiltered accelerometer output on an oscilloscope or recorder with a bandwidth greater than that of the accelerometer while performing maneuvers similar to the type that will be encountered in actual testing.

6.1.2 Should the signal exceed the full-scale range (for example, due to vibration caused by local effects and structural ringing), either provide a more rigid mounting method or replace the accelerometer with another unit with a higher full-scale range.

6.2 The accuracy of body-mounted accelerometers will depend on the change in horizontal attitude during dynamic vehicle testing where an error is introduced into the data that is equal (in g) to the sine of the roll or pitch angle.

6.3 The dynamic accuracy (see 5.1.2) should be verified annually if used regularly by returning the accelerometer to the manufacturer or other calibration facility or by means of an

[3] Neill, A. H., et al., "A Note on Filtering Techniques," *Tire Science and Technology*, Vol. 6, No. 4, Nov. 1978, pp. 263–275.