ASTM INTERNATIONAL

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Standard Practice for
Measuring the Dynamic Characteristics of Amusement Rides and Devices[1]

This standard is issued under the fixed designation F 2137; 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 document establishes a standard practice for acquisition of data related to the dynamic characteristics of amusement rides and devices.

1.2 This practice also defines the specific requirements of a Standardized Amusement Ride Characterization Test (SARC Test) for use in characterizing the dynamic motion of an amusement ride or device.

2. Referenced Documents

2.1 *SAE Standard:*
SAE J211 March 1995 Instrumentation for Impact Tests[2]

3. Terminology

3.1 *Definitions:*

3.1.1 *aliasing*—a phenomenon associated with sampled data systems, wherein a signal containing significant energy at frequencies greater than one half of the system sample frequency manifests itself in the sampled data as a lower frequency (aliased) signal. Aliasing can be avoided only by limiting the frequency content of the signal prior to the sampling process. Once a signal has been aliased, it is not possible to reconstruct the original signal from the sampled data.

3.1.2 *calibration constant*—the arithmetic mean of the sensitivity coefficients, evaluated at frequencies that are evenly spaced on a logarithmic scale between F_L and F_H.

3.1.3 *calibration value*—the ratio of the reference calibration system output, in engineering units relevant to the transducer, to the data channel output, in volts, as measured at constant excitation frequency and amplitude.

3.1.4 *channel frequency class*—a frequency response envelope that conforms to Fig. 1 and is refererred to by the value F_H in hertz. The CFC frequency response envelope is defined by the boundaries shown in Fig. 1 and the following characteristic frequencies:

F_L—Pass band lower limit (hertz). Always equal to zero (0.0) hertz.

F_H—Pass band upper limit (hertz). The CFC designator.

F_C—The corner or knee of the frequency response envelope. Always equal to or greater than $1.667 \times F_H$.

F_S—The minimum sample frequency for a sampled data system that corresponds to the designated CFC. Always equal to or greater than $12 \times F_H$.

3.1.4.1 *Discussion*—F_L, F_H, F_C, and F_S are always specified in hertz. While the characteristics of the CFC may be applied to individual components of a data channel, the CFC is, by definition, the frequency response envelope of the entire data channel from the mounted transducer to the final representation of the acquired data.

3.1.5 *coordinate system*—three orthogonal axes that intersect at an origin whose positive directions correspond to the right-hand rule.

3.1.5.1 *measurement coordinate system*—a coordinate system that provides the reference axes and sign convention for the test data record(s).

3.1.5.2 *occupant coordinate system*—a coordinate system that is fixed with respect to the human upper torso and oriented as in Fig. 2.

3.1.5.3 *vehicle coordinate system*—a coordinate system that is fixed with respect to the ride or device being tested.

3.1.6 *data channel*—the entire instrumentation system for a single channel of data acquisition; from the transducer to the final representation of the data, including all post-acquisition data processing that may alter the amplitude or frequency content of the data.

3.1.7 *data channel full scale*—the maximum usable value, in units of the physical phenomenon being measured, that may be represented by a data channel. This value is determined by the data channel component with the lowest full-scale range.

3.1.8 *free-run time*—a period of time during the ride cycle when no energy is added to the ride vehicle.

3.1.9 *full-scale*—the maximum usable value, in units of the physical phenomenon being measured, which may be represented by a data channel or some component thereof.

3.1.10 *"g"*—the standard acceleration due to gravity at the surface of the earth. Defined as 32.2 ft/s/s or 9.81 m/s/s.

3.1.11 *nonlinearity*—the ratio, in percent, of the maximum difference between a calibration value and the corresponding

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[1] This practice is under the jurisdiction of ASTM Committee F24 on Amusement Rides and Devices and is the direct responsibility of Subcommittee F24.10 on Test Methods.
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[2] Available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.
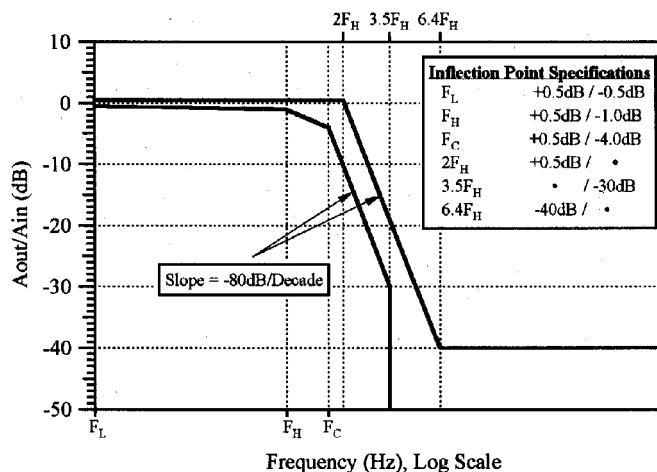
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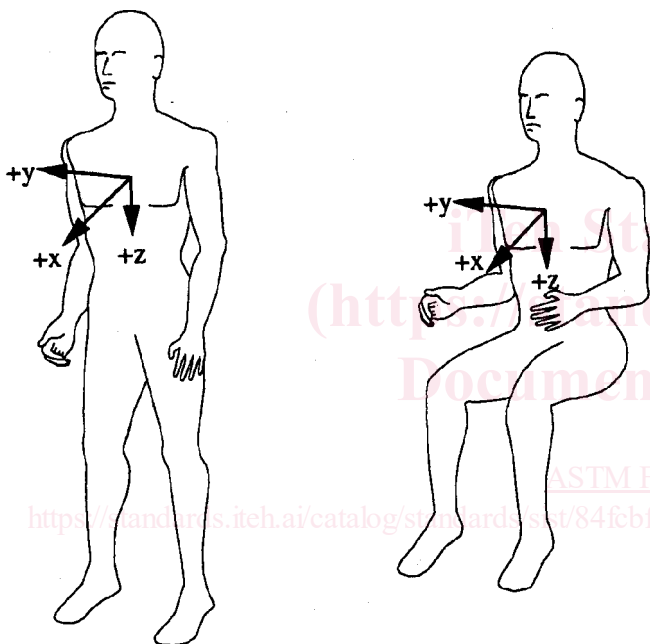

FIG. 1 Frequency Response Envelope

FIG. 2 Occupant Coordinate System

value determined from the straight line defined by the sensitivity coefficient and zero bias.

3.1.12 *reference calibration system*—the entire calibration instrumentation system from the reference transducer to the output device that provides the calibration excitation value in engineering units appropriate to the physical phenomenon being measured.

3.1.13 *resolution*—the lowest magnitude data channel output value that can be identified as non-zero.

3.1.14 *sensitivity coefficient*—the slope of the straight line representing the best fit, as determined by the method of least squares, to calibration values generated at a single frequency and at various amplitudes within the data channel full scale range. In the special case where only a single calibration value is considered, the sensitivity coefficient and the calibration value will be equal.

3.1.15 *standardized amusement ride characterization test (SARC Test)*—an instrumented test of an amusement ride or device that is done in conformance to the general specifications of this standard and the particular specifications of Section 12.

3.1.16 *test data record*—the uninterrupted time record of data channel value(s) that results from a data acquisition session. the length of a data acquisition session is not specified. The data acquisition session is considered complete (or interrupted) when data is not recorded for a time interval longer than the sampling period of the data recorder. Both a strip chart paper record and a computer data file containing periodically sampled data channel values are typical forms of a test data record.

3.1.17 *test documentation*—the entire body of documentation pertaining to a test performed in compliance with this practice, including, but not limited to, the test data record(s), data channel specifications and other test specifications, and information as provided in this practice (see Section 11 and 12.1.9).

3.1.18 *transducer*—the device at the front end of the data channel that converts a physical phenomenon, such as acceleration, to a calibrated electrical signal that may be input to the remainder of the data channel.

3.1.19 *transverse sensitivity*—the sensitivity of a rectilinear transducer to excitation along an axis that is perpendicular to its nominal sensitive axis.

3.1.20 *zero bias*—the magnitude of the data channel output when the transducer input is zero or static.

4. Significance and Use

4.1 This practice is intended for use whenever the dynamic characteristics of an amusement ride or device are to be determined. The existence of this practice is not intended to imply that there is a requirement to perform specific testing on amusement rides or devices.

4.2 The general provisions of this practice provide instrumentation specifications, data acquisition and testing procedures, and documentation requirements that when applied will improve the repeatability, reliability, and utility of the test results.