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 F2137; 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 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.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3.1 *Exception*—The values are reversed in Section 13 since EN standards primarily use SI units.

2. Referenced Documents

2.1 *SAE Standard:*

~~SAEJ211 Instrumentation for Impact Tests~~ [2]

SAE J211 Instrumentation for Impact Tests

2.2 *EN Standard:*[3]

EN 13814 Fairground and amusement park machinery and structures - Safety

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 (CFC)*—a frequency response envelope that conforms to Fig. 1 and is referred 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_N—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_N, 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.

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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.

[3] Available from European Committee for Standardization, http://www.cen.eu/.

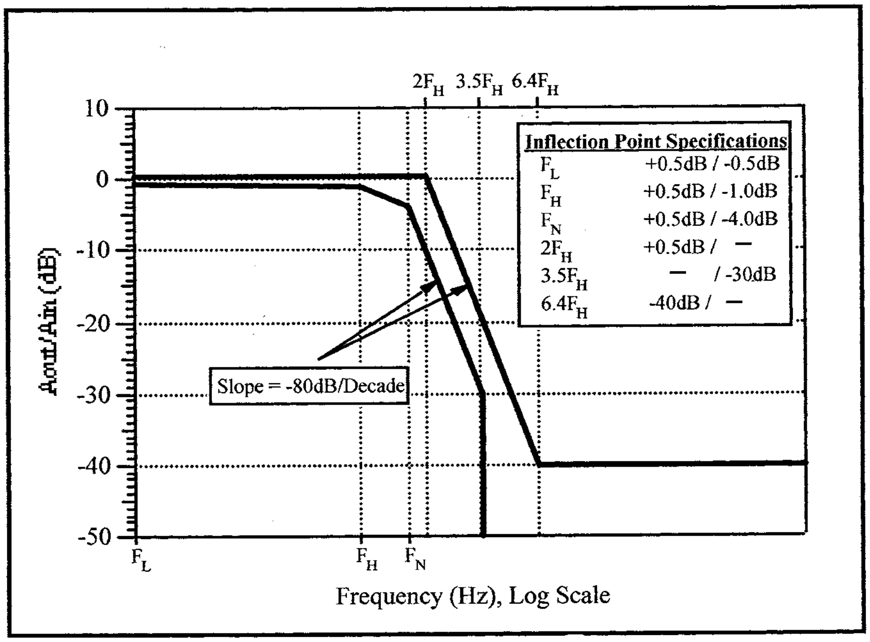

FIG. 1 Frequency Response Envelope

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 *patron 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.

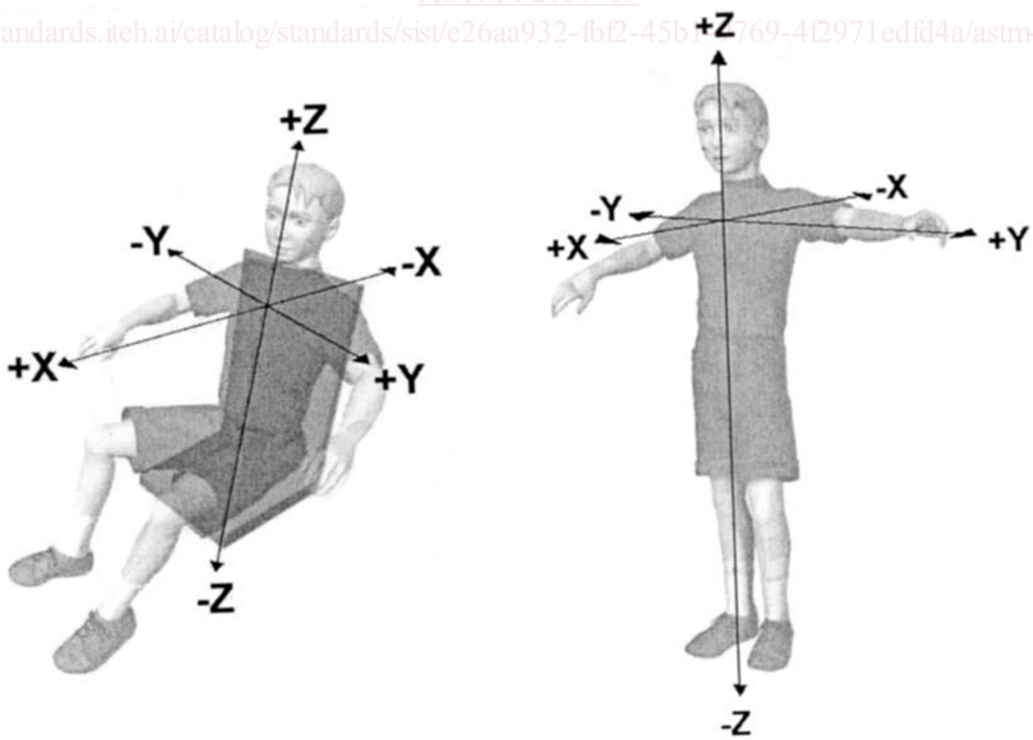

FIG. 2 Patron Coordinate System

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 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.

4.3 Based on the general provisions of this practice, the SARC Test specifications, when followed, will yield standardized test results regarding the patron-related, dynamic motion of amusement rides or devices. The SARC Test will facilitate both the meaningful comparison of the dynamic motion of different amusement rides or devices and the tracking of changes, if any, in the dynamic characteristics of a given ride or device.

5. Data Channel Performance Specifications

5.1 *CFC Definitions*—The following channel frequency classes are defined as standard:

	CFC10[A]	CFC60[B]
F_L	0.0 Hz	0.0 Hz
F_H	10.0 Hz	60.0 Hz
F_N	16.7 Hz	100 Hz
F_S	120 Hz	720 Hz

[A] CFC10 should be used when the data channel is being used for acquisition of lower frequency events.

[B] CFC60 should be used when the data channel is being used for acquisition of higher frequency events.

Other channel frequency classes may be defined as needed or desired by the user of this practice. The proportional relationship between F_H, F_N , and F_S shall be maintained for all channel frequency classes.

5.2 Minimum data channel resolution shall be 2 % of the data channel full scale.

5.3 Maximum nonlinearity shall be 2.5 % of the data channel full scale.

5.4 Minimum time base resolution shall be $1/F_S$ *(s).*

5.5 Maximum relative delay or time shift between data channels that are nominally acquired simultaneously shall be $1/F_S$ *(s).*

6. Transducer Performance Specifications

6.1 Transducer selection shall be consistent with the intended test objectives and generally accepted instrumentation and engineering practice.

6.2 The transducer frequency response curve shall conform to the CFC frequency response envelope from F_L through $2 \times F_H$