



Designation: F3493 – 23

# Standard Practice for Measuring Dynamic Characteristics of Water Slide Systems Using Instrumented Humans<sup>1</sup>

This standard is issued under the fixed designation F3493; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This practice covers the acquisition of quantitative data related to the dynamic characteristics of water slides when taken with instrumented humans.

1.2 Prior to the use of this practice, the designer/engineer shall have completed and approved the testing of a new slide such that it is reasonably expected to meet the performance requirements, including accelerations, of Practice F2376-21 and ensure the slide is safe for human testing.

1.3 This practice shall not apply to:

1.3.1 Any other amusement rides or devices, other than water slides and water slide systems as classified by Practice F2376-21.

1.3.2 Non-human accelerometer testing on water slides or water slide systems as defined by Practice F2376-21.

1.4 *Units*—The values stated in SI units are to be regarded as the standard. Other units of measurement are included in this standard for information only and are not considered standard.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

## 2. Referenced Documents

2.1 *ASTM Standards*:<sup>2</sup>

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee F24 on Amusement Rides and Devices and is the direct responsibility of Subcommittee F24.70 on Water Related Amusement Rides and Devices.

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<sup>2</sup> 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.

F2137 Practice for Measuring the Dynamic Characteristics of Amusement Rides and Devices

F2376 Practice for Classification, Design, Manufacture, Construction, and Operation of Water Slide Systems

## 3. Summary of Practice

3.1 This practice provides a procedure for the collection of acceleration data on water slides utilizing instrumented humans.

3.2 One or more accelerometers are mounted on an instrumented human.

3.3 Acceleration values are recorded for the entire length of the water slide.

## 4. Significance and Use

4.1 This standard practice is intended for use whenever the dynamic characteristics of a water slide are to be determined using instrumented humans.

4.2 The use of this standard practice does not preclude the substitution of other published Amusement Industry accepted standard practices developed for use on water slides.

4.3 The existence of this practice is not intended to imply that there is a requirement to perform specific accelerometer testing on water slides.

## 5. Gravity

5.1 The handling of gravity effects shall follow the specification in Practice F2137-19, Section 12.1.8.

## 6. Data Channel Performance Specifications

6.1 The data channel performance specifications shall follow the specifications in Practice F2137-19, Section 5 and Section 12.1.3.

## 7. Transducer Performance Specifications

7.1 The transducer performance specifications shall follow the specifications in Practice F2137-19, Section 6.

## 8. Recorder Performance Specifications

8.1 The recorder performance specifications shall follow the specifications in Practice F2137-19, Section 7.2.

**9. Calibration Specifications**

9.1 The calibration performance specifications shall follow the specifications in Practice F2137-19, Section 8.

**10. Transducer Location and Mounting for Instrumented Humans**

10.1 Transducer location, orientation, and mounting method shall be consistent with the intended test objectives and generally accepted instrumentation and engineering practice. (See Annex A1.)

10.2 To avoid distortion in the data channel values, accelerometers shall be mounted to minimize relative motion between the transducer and the instrumented surface. It is acceptable to perform an analytical or experimental evaluation of transducer mounting effects on the data channel (See Practice F2137-19, Section 12.1.6).

10.3 Refer to Practice F2137-19 section 9.2.2 when multi-axis accelerations at a point are to be measured.

10.4 Transducers shall be oriented and mounted such that the transducer follows the test subject coordinate system as shown in Fig. 1.

10.5 The accelerometer shall be mounted immediately anterior and superior to the test human’s xiphoid process (the smallest region of the sternum, or breastbone) except for all types of headfirst mat slides or other types of slides where it is reasonably anticipated that the test human’s chest may make

contact with the slide surface. See Annex A1 for illustrations of accelerometer placement on an instrumented human.

**11. Procedure**

11.1 When testing the nominal dynamic characteristics of amusement rides and devices that have characteristics that may change, the water slide shall be operated for a minimum of three full cycles prior to data collection.

11.2 It is possible that the unique characteristics of a particular water slide or other circumstances are such that it is not reasonable to test in strict conformance with one or more provisions of this practice. It is acceptable to alter one or more provisions of this practice when unique characteristics of a particular water slide or other circumstances do not allow strict conformance with this practice. Any deviation(s) from the provisions of this practice shall be recorded to clearly provide a description of the specific deviation(s) and a summary of why a deviation was necessary. Pictures and documentation shall be recorded to adequately explain a specific testing arrangement or protocol deviation. In the absence of the designer/engineer the justification shall include a review by a biodynamic expert.

11.3 Triaxial accelerometers shall have the characteristics required in 10.3.

11.4 Complete a field calibration as defined in Practice F2137-19, Section 10.2.

11.5 Orient the accelerometer(s) on the instrumented human so that the axes of the accelerometer(s) align with those of the

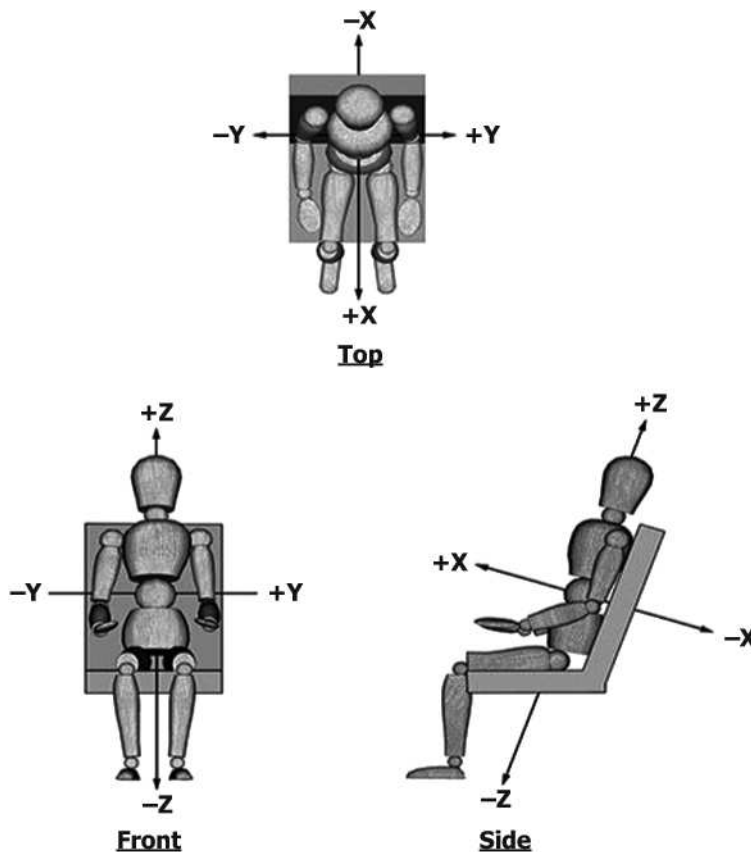


FIG. 1 Test Subject Coordinate System Relative to Human Body

test subject's coordinate system, see Fig. 1. See Annex A1 and Annex A2 for examples of human accelerometer mounting locations on various slide types/classifications.

11.6 Start the accelerometer recording prior to releasing the instrumented human into the water slide.

11.7 Release the instrumented human down the water slide while the accelerometer records the accelerations.

11.8 Upon entering the designated landing or stopping area for an individual run or at the end of all testing, stop the accelerometer from recording to capture the data for the ride cycle(s).

11.9 Download the data from the accelerometer(s) between tests if the download can be conducted without affecting the fixation of the transducer's location on the instrumented human. Otherwise, conduct the download after the completion of all tests.

11.10 Perform a minimum of three (3) consecutive cycles from one accelerometer mounting location and test configuration, or vehicle loading configuration (as applicable).

11.11 The acquired test data shall be post-processed, with a 4-pole, single pass, Butterworth low pass filter using a cutoff frequency ( $F_n$ ) of 5 Hz.

11.12 Procedures for evaluating the post-processed test data against the acceleration limits of Practice F2376-21 include either manual (for example, graphic, hand calculations, etc.) or automatic (for example, computational, computer, etc.) procedures.

## 12. Test Documentation

12.1 The test documentation shall include (when applicable) the general test information including the following:

- 12.1.1 Date and time.
- 12.1.2 Facility name and address.
- 12.1.3 Slide name or designation (facilities designation).
- 12.1.4 Anthropometric or other requirements for the slide.
- 12.1.5 An instrumented human identifier.
- 12.1.6 Instrumented human(s) weight(s).
- 12.1.7 Instrumented human(s) height(s).
- 12.1.8 Description of the instrumented human's attire.

12.1.9 The environmental conditions at the beginning and end of the test including temperature, humidity, and wind conditions.

12.1.10 Slide manufacturer's information including:

12.1.10.1 Serial number,

12.1.10.2 Slide classification based on Annex A2,

12.1.10.3 Slide vehicle type (as applicable, when used), and

12.1.10.4 Water flow in Liters per Hour (or USGPM) where specified by the Designer/Engineer.

12.1.11 The test data record(s).

12.1.12 An indication establishing a relationship between at least one time point in each test data record and a corresponding known physical position of the Instrumented Human on the slide or device during the ride cycle. In the case where a known physical position of the Instrumented Human in the ride cycle cannot be established due to the random or non-repeatable nature of the slide, an indication establishing a relationship between at least one time point in each test data record and a corresponding time point in the ride cycle shall be provided.

12.1.13 A record of all field calibration procedures performed as part of the test procedure, as per Practice F2137-19, Section 10.2.

12.1.14 Documentation of the transducer mounting method including the results from any analytical or experimental evaluation of transducer mounting effects on the data channel.

12.1.15 Documentation of transducer mounting location(s) and orientation(s).

12.1.16 Documentation of the measurement coordinate system.

12.1.17 A description of each data channel utilized during the test, including but not limited to:

12.1.17.1 Data channel title, engineering units, Channel Frequency Class 10 (CFC10), and data channel resolution.

12.1.17.2 Documentation regarding the inclusion of gravity effects in the zero bias for data channels that are sensitive to gravity.

12.1.18 The manufacturer, model, serial number, and most recent calibration date for all data channel components that are subject to the calibration requirements of this practice.

## 13. Keywords

13.1 acceleration; body; instrumented human; testing; waterslide; water slide