



Designation: F3581 – 22

Standard Test Method for Exoskeleton Use: Hurdles¹

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1. Scope

1.1 Purpose:

1.1.1 The purpose of this test method, as a part of a suite of exoskeleton use test methods, is to quantitatively evaluate an exoskeleton's (see Terminology F3323) safety (see 1.4) or performance, or both, for traversing hurdles.

1.1.2 Exoskeletons possess a certain set of allowable exoskeleton user movement capabilities, including user-motion adaptability, to suit operations such as: industrial/occupational, military, response, medical, or recreational. Environments in these typical sectors often pose constraints to exoskeleton user movement to various degrees. Being able to traverse hurdles, as intended by the user or test requestor, while using an exoskeleton is essential for exoskeleton deployment for a variety of tasks (for example, traversing logs, objects). This test method specifies test setup, procedure, and recording to standardize this hurdles task for testing exoskeleton user movement.

1.1.3 Exoskeletons need to function as intended, regardless of types of tasks and terrain complexities (for example, carpet, metal, masonry, rock, wood). Required movement capabilities may include, for example: walking, running, crawling, climbing, traversing gaps, hurdles, stairs, slopes, various types of floor surfaces or terrains, or confined spaces, or any combination thereof. Standard test methods are required to evaluate whether or not exoskeletons meet these requirements.

1.1.4 ASTM Subcommittee F48.03 develops and maintains international standards for task performance and environmental considerations that include but are not limited to, standards for safety, quality, and efficiency. This subcommittee aims to develop standards for any exoskeleton application as exemplified as in 1.1.2. The F48.03 test suite consists of a set of test methods for evaluating exoskeleton capability requirements. This hurdles test method is a part of the test suite. The setup, procedure, and apparatuses associated with the test methods challenge specific exoskeleton capabilities in repeatable ways to facilitate comparison of different exoskeleton models or exoskeleton capabilities to tasks.

¹ This test method is under the jurisdiction of ASTM Committee F48 on Exoskeletons and Exosuits and is the direct responsibility of Subcommittee F48.03 on Task Performance and Environmental Considerations.

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1.1.5 The test methods quantify elemental exoskeleton use capabilities necessary for sector applications listed in 1.1.2 and perhaps others. As such, users of this standard should use either the entire suite or a subset based on their particular requirements. Users are also allowed to weight particular test methods or particular metrics within a test method differently based on their specific requirements. The testing results should collectively represent an exoskeleton's overall safety or performance, or both, as required for the task. These performance data can be used: to guide procurement specifications, for acceptance testing, and for training to use exoskeletons intended for specified applications.

NOTE 1—Additional test methods within the suite are anticipated to be developed to address additional exoskeleton capability requirements, including newly identified requirements and even for new application domains.

1.2 *Exoskeleton*—The exoskeleton shall be used as intended by the manufacturer to perform the test described in this test method. If the exoskeleton is not designed for hurdles-use and the test requestor intends to use the exoskeleton to perform a hurdles test (for example, for research, development of hurdles-capable use by a manufacturer, hurdles training as in medical rehabilitation applications), appropriate manufacturer approvals should be sought prior to performing the test method.

1.3 *Performing Location*—This test method shall be performed in a testing laboratory or in the field where the specified apparatus and environmental conditions are implemented.

1.4 *Units*—The values stated in SI units are to be regarded as the standard. The values given in parentheses are not precise mathematical conversions to inch-pound units. They are close approximate equivalents for the purpose of specifying material dimensions or quantities that are readily available to avoid excessive fabrication costs of test apparatuses while maintaining repeatability and reproducibility of the test method results. These values given in parentheses are provided 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:²

- F3323 Terminology for Exoskeletons and Exosuits
- F3427 Practice for Documenting Environmental Conditions for Utilization with Exoskeleton Test Methods
- F3443 Practice for Load Handling When Using an Exoskeleton
- F3444/F3444M Practice for Training Exoskeleton Users
- F3474 Practice for Establishing Exoskeleton Functional Ergonomic Parameters and Test Metrics
- F3517 Practice for Movement Tests When Using an Exoskeleton
- F3523 Test Method for Exoskeleton Use: Confined Space: Horizontal Movement
- F3527 Guide for Assessing Risks Related to Implementation of Exoskeletons in Task-Specific Environments
- F3528 Test Method for Exoskeleton Use: Gait
- F3613 Practice for Recording the Exoskeleton Fit to the User
- F3614 Practice for Recording the Exoskeleton User Information

2.2 ISO Standards:³

- ISO 13482 Robots and robotic devices — Safety requirements for personal care robots

3. Terminology

3.1 General terminology for ASTM F48 standards is listed in Terminology F3323. Terminology specific to this standard is shown in this section.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *apparatus, n*—a structure, object, test component, or artifact thereof, found or placed in an environment and used for a test.

3.2.2 *hurdles, n*—one or more horizontal barriers or step platforms that a user is to traverse.

3.2.3 *test suite, n*—designed collection of test methods that are used, collectively, to evaluate an exoskeleton's safety and/or performance.

4. Summary of Test Method

4.1 The task for this test method, exoskeleton-user traversing hurdles, is defined as the exoskeleton-user performing a hurdles traversal test, including a number of repetitions as set by the test requestor. A test includes at least 5 repetitions to

traverse one or more hurdles that have a change in height above ground height. See Fig. 1 for an illustration. Further, the test requestor can specify the statistical reliability and confidence levels of such a capability and, thus, dictate the number of successful task performance repetitions that are required.

4.2 The test includes two variations of hurdles: (1) barrier hurdle and (2) platform hurdle, briefly described as:

4.2.1 *Barrier Hurdle*—A short, relatively thin wall of which the user steps over.

4.2.2 *Platform Hurdle*—A raised level surface on which the user steps onto or from which the user steps down.

4.3 The test is described as follows:

4.3.1 This test can be used to assess aerobic function, endurance, hurdle traversal speed, or balance, or any combination thereof.

4.3.2 The test metrics can include, for example, the following:

4.3.2.1 Number of hurdles traversed,

4.3.2.2 Height of hurdles traversed,

4.3.2.3 Change(s) in user (for example, heart rate, fatigue, stability, balance, toe drag, stumbles, near falls/falls) by a specified amount,

4.3.2.4 Upon traversing the hurdle set, the ability to turn around on the floor or hurdle step and traverse the hurdle in the opposite direction or to descend the hurdle step.

4.4 For all tests, the specified START point to the END point, TURN point shall be defined by the test requestor prior to the test. This test method can be combined with other test methods, for example, Test Method F3528. The required apparatuses are described in Section 5.

4.5 For any hurdles test, return from the end marker past the start marker may commence as part of the test, or the user may begin each repetition from the start-to-end markers as set by the test requestor.

4.6 The hurdles test can include either or both of the barrier hurdle or platform hurdle tests as requested by the test requestor.

4.7 Barrier Hurdle Test:

4.7.1 A full barrier hurdle test is defined as: the user begins by standing behind a start/end location, walks to the hurdle apparatus, steps over the hurdle, walks past the end marker or repeats the task if more barrier hurdles are included, traversing successive hurdles, and walks past the end marker.

4.7.2 A phased barrier test can include one or more phases of the full barrier test as follows, beginning with the user standing behind a start/end location:

4.7.2.1 *Phase 1*—The user walks to the barrier hurdle apparatus,

4.7.2.2 *Phase 2*—The user traverses the hurdle,

4.7.2.3 *Phase 3*—The user walks past the end marker or repeats phases 1 and 2 if more barrier hurdles are included, traversing successive hurdles, and walks past the end marker.

4.8 Platform Hurdle Test:

4.9 A full platform hurdle test is defined as: the user begins by standing behind a start/end location, walks to the hurdle apparatus, steps onto the platform hurdle, steps across the

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.

³ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.