



Designation: F3580 – 24

Standard Test Method for Exoskeleton Use: Stairs¹

This standard is issued under the fixed designation F3580; 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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

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 ascending/descending stairs.

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 ascend/descend stairs, as intended by the user or test requestor, while using an exoskeleton is essential for exoskeleton deployment for a variety of tasks (for example, ascending/descending stairs, ramps, hills). This test method specifies test setup, procedure, and recording 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 combinations 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 in [1.1.2](#). The F48.03 test suite consists of a set of test methods for evaluating exoskeleton capability requirements. This stairs 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 stair use and the test requestor intends to use the exoskeleton to perform a stair test (for example, for research, development of stair-capable use by a manufacturer, stair 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 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

- F3200** Terminology for Robotics, Automation, and Autonomous Systems
 - 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
 - F3576** Practice for Recording the Exoskeleton Test Configuration
 - F3613** Practice for Recording the Exoskeleton Fit to the User
 - F3614** Practice for Recording the Exoskeleton User Information
- ### 2.2 ISO Standards:³
- ISO 12100** Safety of machinery — General principles for design — Risk assessment and risk reduction
 - ISO 13482** Robots and robotic devices — Safety requirements for personal care robots
- ### 2.3 Federal Standards:⁴
- 29 CFR 1910.25** Occupational Safety and Health Standards, Walking-Working Surfaces, Stairways

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.

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

³ Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandinnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <http://www.iso.org>.

⁴ Available from U.S. Government Publishing Office (GPO), 732 N. Capitol St., NW, Washington, DC 20401, <http://www.gpo.gov>.

3.2.2 *stairs, n*—a set of steps leading from one floor of a building to a landing or another floor.

3.2.3 *test requestor, n*—person or organization selecting the test(s) and defining the conditions under which they are performed.

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

4. Summary of Test Method

4.1 The task for this test method, exoskeleton user ascending/descending stairs, is defined as the exoskeleton-user performing a stair ascend/descend test including a number of repetitions as set by the test requestor. Guidance on number of repetitions for a binomial (for example, pass/fail) test is shown in **Appendix X1**; see Ref (1).⁵ The test requestor should consider user sampling, for example to account for a potentially varied user population of age, anthropometry, etc., and define a minimal user sample size to ensure statistical significance (for example, a p-value of 5 % or lower). The set of stairs includes at least a 2.3 m (93 in.) change in height and includes at least 12 steps including the landing or upper floor. 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 is required.

4.2 The test is described as follows:

4.2.1 This test can be used to assess aerobic function, endurance, stair ascent/descent speed, balance, or other parameters, or combinations thereof as required by the test requestor.

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

4.2.2.1 Number of stair sets (that is, full flights from floor to landing or upper floor) ascended/descended,

4.2.2.2 Number of steps ascended/descended,

4.2.2.3 Change(s) in user (for example, heart rate, fatigue, stability, handrail force, non-handrail use, toe drag, missed steps, gait symmetry, near falls/falls) by a specified amount,

4.2.2.4 Upon ascending the stair set, the ability to turn around on the landing or floor and descend the stair set.

4.3 For all tests, the specified START point to the END point, and 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.

4.4 A full test is defined as: the user begins by standing behind a start/end location, walks to the stair apparatus, ascends the staircase until reaching the landing or next level, turns around 180°, descends the staircase, and walks past the start/end marker. A phased test can include portions of the full test as follows:

4.4.1 *Phase 1*—The user stands behind a start/end location and walks to the stair apparatus,

⁵ The boldface numbers in parentheses refer to a list of references at the end of this standard.