



Designation: F3613 – 22

Standard Practice for Recording the Exoskeleton Fit to the User¹

This standard is issued under the fixed designation F3613; 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 describes a means to record the exoskeleton fit to the user when testing. The practice provides a method for recording exoskeleton: alignment to the user, component distances from the body, sizing, and subjective comfort using a standard recording method.

1.2 This practice is intended to be used with other exoskeleton test methods and practices to provide a clear representation of the exoskeleton fit to the user measured along body planes; provides a basis for comparison of the test circumstances across different exoskeletons or tests, or both; and allows a test to be recreated.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are not precise mathematical conversions to imperial units. They are close approximate equivalents for the purpose of specifying exoskeleton characteristics 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.

1.4 *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.*

1.5 *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:

D5219 Terminology Relating to Body Dimensions for Apparel Sizing

E3003 Practice for Body Armor Wearer Measurement and Fitting of Armor

F1731 Practice for Body Measurements and Sizing of Fire and Rescue Services Uniforms and Other Thermal Hazard Protective Clothing

F3323 Terminology for Exoskeletons and Exosuits

3. Terminology

3.1 Terms used within this standard refer to Terminology **F3323** and Terminology **D5219**.

4. Summary of Practice

4.1 This practice describes a method for recording the exoskeleton fit to the user when performing tests described in exoskeleton test methods. Considering the variability of users, exoskeletons can have a series of adjustments that can affect how well the exoskeleton fits the user and in turn, can cause varying performance. For example:

4.1.1 Loose fit straps can cause the exoskeleton to be misaligned with body limbs and cause chafing, impact, or lower than expected exoskeleton performance, or any combination thereof; or

4.1.2 Not following the manufacturer-suggested exoskeleton component alignment to the body can cause user instability, lower than expected exoskeleton performance, or other unexpected test results.

4.2 This practice also provides a standard method to report the exoskeleton fit to the user which contextualizes exoskeleton test results. For example, the result of a timed test could be dependent upon exoskeleton comfort due to fit to the user on walking speed up to 0.5 m/s or knee angle rotation limitation from 0° through 120°. As such, comparing exoskeletons fit to two different users could allude to which parameters affect exoskeleton performance.

4.3 This practice does not consider the user information (for example, age, exoskeleton experience) nor the hardware and software configuration of the exoskeleton. There are also two important exoskeleton safety and performance areas that are currently being developed in the Standard Practice for Recording the Exoskeleton User Information and the Standard Practice for Recording the Exoskeleton Test Configuration,² respectively.

¹ This practice 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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² Standard designations for these practices are to be added after the standards are approved and published.

5. Significance and Use

5.1 The significance of the information to be recorded in a test report allows for exoskeleton safety and performance to be contextualized with the exoskeleton fit to the user. Exoskeleton tests can also be replicated across similar or different exoskeletons by using this practice to record the exoskeleton fit to the user for a test in a standardized way.

5.2 Limitations of the practice are that not all exoskeletons have the same connections to the body and fit to all users, and therefore, fit to the user may change the exoskeleton capabilities. For example, as users vary in size, shape, gender, etc., an exoskeleton that is fit to one user may allow an increase or decrease in torque applied to the arms, legs, etc. as compared to another user, especially users at the upper and lower limits of manufacturer-suggested exoskeleton sizing. Another example is that an exoskeleton that is not fit properly to a user may be uncomfortable, and as a result the user may not perform tasks as long, as fast, as strong/delicately, or many other possible outcomes.

5.3 It is expected that all exoskeleton tests require the exoskeleton to be fit properly to the user according to manufacturer specifications. However, as testing exoskeletons can vary, so can fit to the user, and variations in fit may also be tested. For example, a test may be performed with the exoskeleton not fit properly to the users' legs (for example, longer fit on shorter legs) to evaluate performance changes when the task requires the user to stand on their toes. Should exoskeleton tests be performed with the exoskeleton not fit properly to the user, the test requestor should verify with the manufacturer that the exoskeleton will not harm the user as a result of a bad fit, and provide this information to the test administrator to record on the test report.

5.4 Additional fit and measurement information may be found in Terminology D5219, Practice E3003, and Practice F1731.

6. Exoskeleton Fit Information

6.1 *Photos of the User wearing the Exoskeleton*—Provide photographs or videos of motion, or both, of the user wearing the exoskeleton from the front, sides, and back, and of any other distinguishing features.

6.2 Main Exoskeleton Hardware Parameters:

6.2.1 *Make and Model*—Provide the manufacturer and model of the exoskeleton.

6.2.2 *Serial Number(s)*—Provide the serial number for the exoskeleton.

6.2.3 *Hardware Revision/Version*—Provide any revision or version numbers for exoskeleton.

6.3 Alignment:

6.3.1 *Is the Exoskeleton Aligned with the Joint as Intended by the Manufacturer (Yes / No / Not Applicable)*—Provide the answer for each of the neck, shoulder, elbow, wrist, fingers, hip, knee, and ankle for both the left side or hand and the right side or hand.

6.4 Exoskeleton distance (millimeters) from body part (that is, the gap) measured along a body plane:

6.4.1 Along each of the sagittal, coronal, and transverse body planes (refer to Fig. 1), measure and record the distance between the body and the exoskeleton for the neck, shoulder, elbow, wrist, fingers, hip, knee, and ankle for both the left and right sides.

6.5 Other Sizing Measurements:

6.5.1 Provide any other sizing measurements (for example, buttocks strap) and the measurement method (for example, strap length, body circumference) that are important or useful, or both, to the test as measured along the sagittal, coronal, or transverse planes, or any combination thereof, of the body (see Fig. 1).

6.5.2 Provide any photos of the other sizing measurements, including any details important or useful, or both, to the test that may provide additional clarifying information about the exoskeleton fit to the user.

6.6 Subjective Comfort Information:

6.6.1 Upon completion of a test, the user shall provide answers to these questions and other important or useful, or both, information to the test, including:

6.6.1.1 *Perceived Exoskeleton Comfort?*—The test administrator shall ask the user prior to the test what is their comfort when wearing the exoskeleton gauged from 1 through 10 where 1 is extremely uncomfortable and 10 is extremely comfortable.

6.6.1.2 *List any Exoskeleton Contact Pressure Points on the User*—Provide any pressure points that the exoskeleton causes on the user.

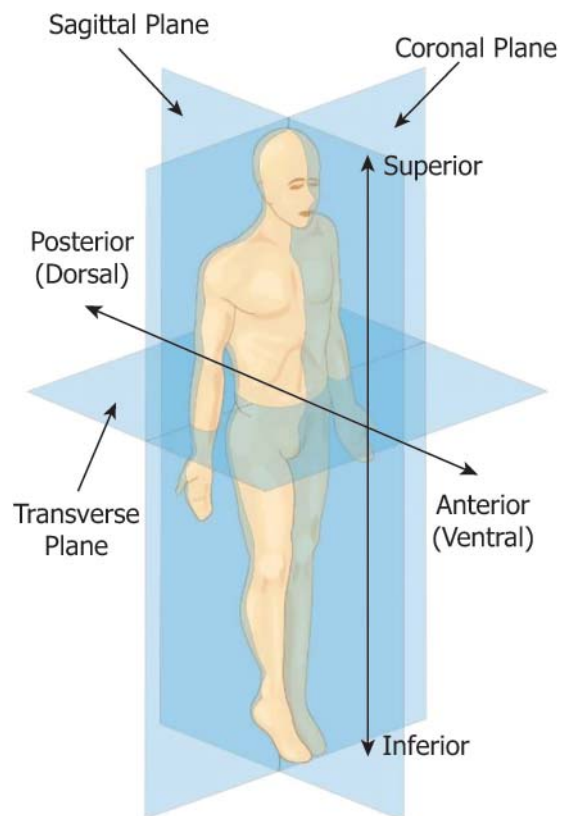


FIG. 1 Graphic Labeling of the Orthogonal Planes and Directional Axes of a Human