



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 reappraisal. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reappraisal.

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.

Current edition approved Nov. 15, 2022. Published December 2022. DOI: 10.1520/F3613-22.

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.

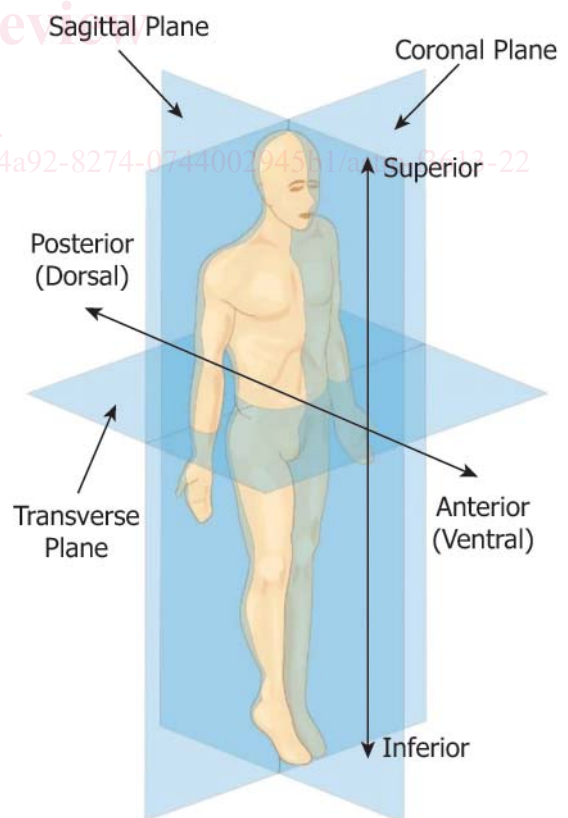


FIG. 1 Graphic Labeling of the Orthogonal Planes and Directional Axes of a Human

7. Procedure

7.1 When conducting the Committee F48 test methods, the test requestor selects the fit of the exoskeleton to the user. The exoskeleton is either fitted/aligned properly to the user or not per the exoskeleton manufacturer specifications (see 5.3).

7.1.1 If the exoskeleton is to be fit properly to the user, the test supervisor shall ensure that the exoskeleton is fit to the user as per the exoskeleton manufacturer specifications and it is to be recorded as described in Section 6.

7.1.2 If the test requestor elects to not fit the exoskeleton properly to the user (for example, to compare the difference between a proper and improper fit), the test supervisor: shall be so informed, shall ensure that the exoskeleton is fit as requested by the test requestor, and shall record on the test report the exoskeleton fit to the user.

7.2 After the exoskeleton is fit to the user, the user should move, ideally as if performing the task when using the exoskeleton, to settle the exoskeleton onto the user. All measurements shall be taken after the user has moved as described here.

7.3 The exoskeleton fit to the user may be changed prior to a test. At any time after the start of a test, as instructed by the

test supervisor, the exoskeleton fit to the user shall not be manually changed by any person. In the event that the exoskeleton fit may automatically change during a test (for example, control changes in support of a different task), the test requestor shall inform the test supervisor of such occurrence(s) prior to the test and the occurrence(s) shall be noted on the test report.

8. Report

8.1 A test report is required for recording the exoskeleton fit to the user. The test report shall include the following features:

8.1.1 Photographs or detailed drawings showing the exoskeleton worn by the user for a test. Ideally, multiple photos along each of the planes labeled in Fig. 1 should be provided.

8.1.2 The test report (see example in Fig. 2) shall be filled out. In the situation where a particular parameter is not known, it shall be noted as such using, “unknown.”

NOTE 1—The implementation of a test report is not standardized. As such, the resulting test reports can be different while conforming to this practice. Fig. 2 provides an illustration of a blank test report for this practice.

9. Keywords

9.1 exoskeleton; exosuit; fit; test report

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date _____

LABELED PHOTOGRAPH OF THE EXOSKELETON FIT TO THE USER:

User Name	
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front view

back view

left view **right view**

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[ASTM F3613-22](#)

<https://standards.iteh.ai/catalog/standards/sist/5f544575-6fc3-4a92-8274-0744002945b1/astm-f3613-22>

NOTES:

TEST TECHNICIAN: _____

FIG. 2 (a) Test Report: Photos

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date _____

Fill in the table as described in section 6. When no information is available for a parameter, leave blank. Attach additional pages as needed.

6.2		Main Exoskeleton Hardware Parameters					
	Make and Model						
	Serial Number(s)						
	Hardware Revision/Version						
6.3		Alignment					
	Is the exoskeleton aligned with the joint as intended by the manufacturer (Yes / No / Not Applicable)						
	Neck						
		left side or hand				right side or hand	
	Shoulder						
	Elbow						
	Wrist						
	Fingers						
	Hip						
	Knee						
	Ankle						
6.4		Exoskeleton distance (mm) from body part measured along a body plane (refer to the planes drawing)					
		Sagittal	Coronal	Transverse			
	Neck						
		left		right			
		Sagittal	Coronal	Transverse	Sagittal	Coronal	Transverse
	Torso						
	Shoulder						
	Elbow						
	Wrist						
	Waist						
	Knee						
	Ankle						

Additional Exoskeleton Fit Information:

TEST TECHNICIAN: _____

FIG. 2 (b) Test Report: Parameters Table (continued)

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date _____

Fill in the table as described in section 6. When no information is available for a parameter, leave blank. Attach additional pages as needed.

6.5	Other Sizing Measurements										
	Body Location	left			right						
		Sagittal	Coronal	Transverse	Sagittal	Coronal	Transverse				
Photos of other sizing measurements:											
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6.6	Subjective Comfort Information										
		extremely uncomfortable					extremely comfortable				
	Exoskeleton comfort	1	2	3	4	5	6	7	8	9	10
	List any exoskeleton unintended										

TEST TECHNICIAN: _____

FIG. 2 (c) Test Report: Parameters Table (continued)

APPENDIX

(Nonmandatory Information)

X1. EXAMPLE EXOSKELETON FIT TO THE USER TEST REPORT

X1.1 An example exoskeleton and user were used to provide the reader an example recording of the exoskeleton fit to the user as described in this standard. Fig. X1.1 shows a

completed test report (without a photo) for the example exoskeleton and user.

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