Designation: F3614 – 22

Standard Practice for Recording the Exoskeleton User Information[1]

This standard is issued under the fixed designation F3614; 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 user information when testing. The practice provides a method for recording exoskeleton user: general information, measurements, activity level, experience with exoskeletons, prior injuries, and other pertinent information that may impact exoskeleton testing.

1.2 This practice is intended to be used with other exoskeleton test methods and practices to provide a clear representation of the exoskeleton user being tested; provides a basis for comparison of the test circumstances across different exoskeletons, users, tests, or all three; 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:*[2]

D5219 Terminology Relating to Body Dimensions for Apparel Sizing

D6240/D6240M Tables of Body Measurements for Mature Men, ages 35 and older, Sizes Thirty-Four to Fifty-Two (34 to 52) Short, Regular, and Tall

D6960/D6960M Tables for Body Measurements for Plus Women's Figure Type, Size Range 14W – 40W

D7878/D7878M Tables for Body Measurements for Adult Female Misses Petite Figure Type, Size Range 00P – 20P (Withdrawn 2022)[3]

D8077/D8077M Tables for Body Measurements for Mature Big Men Type, Size Range 46–64

D8241/D8241M Tables of Body Measurements for Young Men Type, Size Range 32 – 48

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

F3613 Practice for Recording the Exoskeleton Fit to the User

2.2 *ISO Standards:*[4]

ISO 7250-1 Basic human body measurements for technological design–Part 1: Body measurement definitions and landmarks

ISO 15537 Principles for selecting and using test persons for testing anthropometric aspects of industrial products and designs

[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] 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] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

3. Terminology

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

4. Summary of Practice

4.1 This practice describes a method for recording the exoskeleton user information when performing tests described in exoskeleton test methods. Considering the variability of users, fitting users to exoskeletons and performing exoskeleton tests requires knowledge of the user, including many parameters. For example: gender; size; shape; head, limb and trunk sizes; user activities; exoskeleton and task experience; prior surgeries and pains. User variability can therefore cause varying exoskeleton performance, for example:

4.1.1 Users at the upper or lower size limits of the exoskeleton manufacturer specification may have different performance than users more centered on the specification; or

4.1.2 A rectangular-shaped user may have different exoskeleton fit than a pear- or triangle-shaped user (see Fig. 1). 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.

4.1.3 A user that performs moderate-to-high daily activity may have different exoskeleton performance than a user who performs low daily activity.

4.2 This practice also provides a standard method to report the exoskeleton user information, which allows comparison of exoskeleton test results among various users when considering similar user parameters.

4.3 This practice does not consider the exoskeleton fit to the user nor the hardware and software configuration of the exoskeleton. These are also two important exoskeleton safety and performance areas that are currently being developed in Practice F3613 and the Practice for Recording the Exoskeleton Test Configuration,[5] respectively.

[5] Standard designation for this practice is to be added after the standard is 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 user. Exoskeleton test results can be compared across users to determine exoskeleton usefulness, exoskeleton capability for particular users or groups of users, and standardized reporting of user information allows organizations to better replicate tests.

5.2 Limitations of the practice are that not all exoskeletons can or have the same fit to all users and therefore may change the exoskeleton capabilities. For example, as users vary in size, shape, gender, etc., an exoskeleton that fits 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 prior surgeries or pain may affect measured exoskeleton performance as the user may, for example, favor use of one limb to another or may move different when tested with the exoskeleton versus without the exoskeleton.

5.3 Additional user measurement information may be found in the following references:

NOTE 1—The measurements in these references may not consider measurements of the user when dressed in appropriate clothing (for example, shoes – see 6.3.12 – 6.3.14) that will be worn when using an exoskeleton.

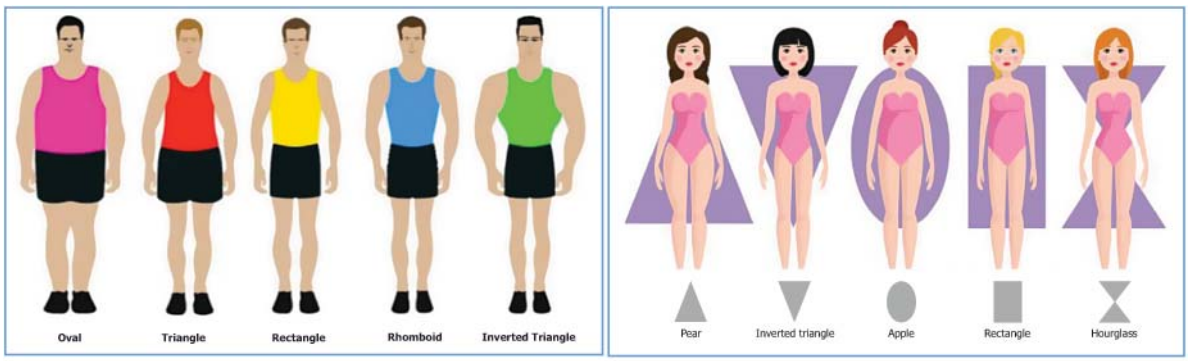
5.3.1 2012 Anthropometric Survey (ANSUR II[6]) of U.S. Army Personnel: Methods and Summary Statistics,

5.3.2 United States Air Force Research Laboratory Civilian American and European Surface Anthropometry Resource (CAESAR[7]) Final Report,

5.3.3 Tables D6240/D6240M,

[6] Gordon, Claire C.; Blackwell, Cynthia L.; Bradtmiller, Bruce; Parham, Joseph L.; et. al. "2012 Anthropometric Survey of U.S. Army Personnel: Methods and Summary Statistics," *Technical Report NATICK/TR-15/007*, U.S. Army Natick Research, Development and Engineering Center, December 2014.

[7] Kathleen M. Robinette, et. al., *United States Air Force Research Laboratory Civilian American and European Surface Anthropometry Resource (CAESAR) Final Report*, Volume I: SUMMARY AFRL-HE-WP-TR-2002-0169.



a b

FIG. 1 Body Shapes for (a) Men and (b) Women

5.3.4 Tables D8077/D8077M,
5.3.5 Tables D7878/D7878M,
5.3.6 Tables D6960/D6960M,
5.3.7 Terminology D5219,
5.3.8 Tables D8241/D8241M,
5.3.9 Practice E3003,
5.3.10 Practice F1731, and
5.3.11 ISO 7250-1.

6. Exoskeleton User Information

6.1 *Photos of User*—Provide clear photographs of the user not wearing the exoskeleton from the front, left side, right side, and back, and any other distinguishing features that may affect the exoskeleton test. The user should not wear loose clothing for the photos.

6.2 *General Information:*
6.2.1 *Name*—Provide the user's name,
6.2.2 *Organization*—Provide the user's organization,
6.2.3 *Gender*—Provide the user's gender,
6.2.4 *Age (yrs)*—Provide the user's age,
6.2.5 *Handedness (rt, lt, both)*—Provide the user's handedness (that is, right, left, ambidextrous),
6.2.6 *Shape (select from images)*—Provide the user's best estimate of shape using one of the images from Fig. 1,
6.2.7 *Shoe Size*—Provide the user's shoe size including country of size origin, and
6.2.8 *Shoe Sole (soft/hard)*—Provide the user's shoe sole type (for example, soft or hard).

6.3 *Measurements:*
6.3.1 *Weight (kg)*—Provide the user's weight in kilograms;
6.3.2 *Referenced and Non-Referenced Measurements*—To ensure measurements listed in the following subsections are repeatable among users of this practice, 6.3.2.1 and 6.3.2.2 shall be applied. Measurement tools (for example, anthropometer, tape ruler, caliper, etc.) shall be provided;

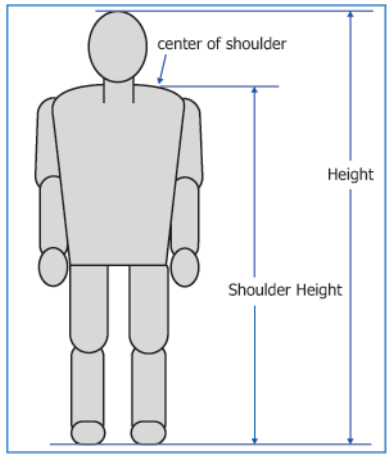
NOTE 2—All user measurements for exoskeleton use are to be performed while the user is wearing, for example, appropriate clothing, PPE, other items, or all three, as they will be when using the exoskeleton during the test. References provided in 5.3 are provided as guidance only as they show body measurements for individuals wearing minimal clothing.

6.3.2.1 When references are not known, a detailed description shall be provided of the measurement method, associated measurement locations, or landmarks on the body, or combinations thereof, and measurement equipment used. Photographs or drawings should also be used to record the method. Examples include those shown in Fig. 2 for (a) shoulder height and (b) fist height.

6.3.2.2 When references are known and used for parameter measurement, for example ANSUR II, CESAR, or other references, the reference shall be provided (see 5.3 for guidance on references). Where provided, each subsection should also be included from within the referenced document. For simplicity, Appendix X1 provides an example list of known references and subsection references from ANSUR II and CAESAR for each of the referenced measurements in 6.3.3 – 6.3.17.

6.3.3 *Waist Circumference (cm)*—Provide the user's waist circumference in centimeters and the location of waist circumference measurement (for example, the user preferred height; omphalion (belly button) height);

6.3.4 *Spine Length (cm)*—Provide the user's spine length in centimeters. In the location, origin shall be included, for example: cervical 7 landmark; omphalion height; preferred waist height; posterior superior iliac spine (PSIS);

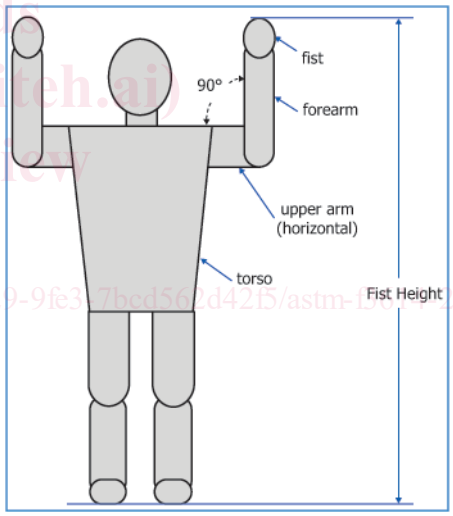


a

Shoulder Height Measurement Method

The vertical distance from a standing surface to the center of the shoulder is measured with an anthropometer. The participant stands erect with the head in the Frankfurt plane. The heels are approximately 10 cm apart with the weight distributed equally on both feet. The arms are relaxed and down. The hands are flat with palms facing the body. The measurement is taken at the maximum point of quiet respiration. The center of the shoulder is approximated as to where the exoskeleton strap will contact the shoulder. If shoes and other clothes or PPE are used when using the exoskeleton, they shall be worn during this measurement.

FIG. 2 (a) Shoulder



b

Fist Height Measurement Method

The vertical distance from a standing surface to the top of the fist is measured with an anthropometer. The participant stands erect with the head in the Frankfurt plane. The heels are approximately 10 cm apart with the weight distributed equally on both feet. The upper arms are in-line with the shoulders (horizontal) and forearms are raised perpendicular (vertical) to the upper arms. The hands are clutched into a fist. The measurement is taken at the maximum point of quiet respiration. If shoes and other clothes or PPE are used when using the exoskeleton, they shall be worn during this measurement.

FIG. 2 (b) Fist Height Measurement Methods *(continued)*

6.3.5 *Hip Width/Breadth (cm)*—Provide the users's hip width (standing) or breadth (seated) in centimeters;

6.3.6 *Shoulder Width (cm)*—Provide the user's shoulder width in centimeters;

6.3.7 *Torso Depth (cm)*—Provide the user's torso depth in centimeters;

6.3.8 *Bicep (cm)*—Provide the user's bicep in centimeters;

6.3.9 *Shoulder to Elbow Length (cm)*—Provide the user's shoulder to elbow length in centimeters;

6.3.10 *Wrist (cm)*—Provide the user's wrist circumference in centimeters;

6.3.11 *Neck Length (cm)*—Provide the user's neck length in centimeters;

6.3.12 *Neck Width (cm)*—Provide the user's neck width in centimeters;

6.3.13 *Height (cm)*—Provide the user's overall height in centimeters in the shoes to be worn for the test;

6.3.14 *Shoulder Height (cm)*—Provide the user's shoulder height (refer to Fig. 2(a)) in centimeters while wearing shoes to be worn for the test;

6.3.15 *Fist Height (cm)*—Provide the user's fist height (refer to Fig. 2(b)) in centimeters while wearing shoes to be worn for the test;

6.3.16 *Calf Width (cm)*—Provide the user's calf width in centimeters from the user front view; and

6.3.17 *Calf Circumference (cm)*—Provide the user's calf circumference in centimeters.

6.3.18 When a measurement is not listed in 6.3 – 6.3.17, a measurement method and reference or non-reference description shall be provided in the additional spaces provided.

6.4 *Activities:*

6.4.1 *Occupation*—Provide the user's occupation. If none, insert n/a; and

6.4.2 *Physical Hobbies/Sports*—Provide the user's typical activities (for example, walking, jogging, gardening) and the average time spent per week performing each activity.

6.5 *Prior Surgeries, Current Pain(s):*

6.5.1 *Prior Surgeries that May Affect Task Performance*—Provide the user's prior surgeries, and the surgery date;

6.5.2 Prior injuries;

6.5.3 *Any Condition that May Hamper Use of Exoskeleton*—Provide any conditions experienced by the user that may hamper the user of the exoskeleton (for example, spasticity, balance issues, any restricted range of motion with respect to any of the joints); and

6.5.4 *Prior Injuries, Surgeries, and Current Pain that May Affect Task Performance*—Select, using the chart shown in Fig. 3, where the user experienced an injury or surgery, and current pain severity.

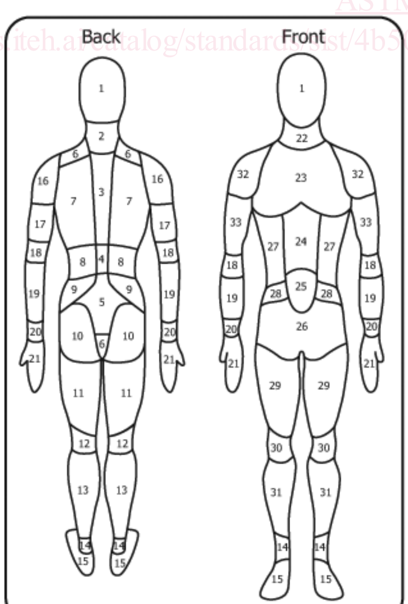
7. Procedure

7.1 When conducting the Committee F48 test methods, (*1*) the test requestor may complete, as much as possible or appropriate, the test report of user information (see Section 8) for the type of user requested to be tested and (*2*) the test administrator, test technician, or user shall complete the test report of user information for the user being tested.

7.2 The user should complete the test report, referring to 6.1 – 6.5 prior to the test.

8. Report

8.1 A test report (see example in Fig. 4) is required for



Area of the body	Slight	Moderate	Severe	Extreme
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④

FIG. 3 Body Areas Chart of Prior Injury or Surgery Location(s) and Current Pain Severity that May Affect the Exoskeleton Test

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PHOTOGRAPHS OF THE EXOSKELETON USER – Additional photographs or drawings showing measurement details should also be included with the test report.

User Name	

front view **back view**

left side view **right side view**

NOTES:

TEST TECHNICIAN: _____

(a)

FIG. 4 Test Report: (a) Drawing

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Fill in the table as described in section 6. When information is not known or not applicable, mark as "unknown" or "n/a", respectively. Attach additional pages as needed.

section #						
6.2	**General Information**					
	Name					
	Organization					
	Gender (m/f/o)					
	Age (yrs)					
	Handedness (rt, lt, both)					
	Shape (*select from images*)					
	Shoe Size					
	Shoe Sole (soft/hard)					
6.3	**Measurements**					
	Weight (kg)					
		Measurement Location and/or Landmarks		Measurement Equipment	Reference(s)	
	Spine Length (cm)					
	Waist Circumference (cm)					
	Hip Width or Breadth (cm)					
	Shoulder Height (cm)					
	Shoulder Width (cm)					
	Torso Depth (cm)					
	Bicep (cm)					
	Shoulder to Elbow Length (cm)					
	Wrist (cm)					
	Neck length (cm)					
	Neck Width (cm)					
	Height with shoes (cm)					
	Shoulder Height (cm)					
	Fist Height (cm)					
	Calf Width (cm)					
	Calf Circumference (cm)					
	Other Measurements not listed above:					
6.4	**Activities**					
	Occupation					
	Physical Hobbies/Sports					
	Activity Time (hrs/wk)					

TEST TECHNICIAN: _____

(b)

FIG. 4 Test Report: (b) Parameters Table *(continued)*

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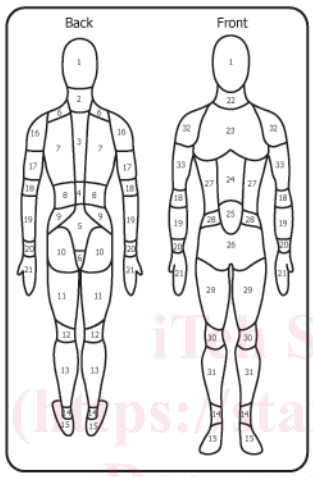
Fill in the table as described in section 6. When information is not known or not applicable, mark as "unknown" or "n/a", respectively. Attach additional pages as needed.

6.5	**Prior Injuries, Surgeries, Current Pain(s)**				
	Prior surgeries that may affect task performance				
	Surgery Date(s)				
	Any condition that may hamper use of exoskeleton				
	Current pain(s) that may affect task performance:	*(show on the diagram below)*			



Area of the body	Slight	Moderate	Severe	Extreme
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④
	①	②	③	④

Additional User Information:

TEST TECHNICIAN: _____

(c)

FIG. 4 Test Report: (c) Parameters Table *(continued)*