Designation: F3022 – 16ε1

Standard Test Method for Evaluating the Universal Design of Fitness Equipment for Inclusive Use by Persons with Functional Limitations and Impairments[1]

This standard is issued under the fixed designation F3022; 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.

ε[1] NOTE—Editorially corrected the introduction and 5.1.6.8*(3)* in June 2017.

INTRODUCTION

The goal of this test method is to provide reliable and repeatable methods for the evaluation of universally designed fitness equipment.

The equipment user must recognize, however, that the standard alone will not necessarily prevent injuries. Like other physical activities, exercise involving fitness equipment involves the risk of injury, particularly if the equipment is used improperly or not properly maintained. In addition, users with physical limitations should seek medical advice and instruction from the fitness facility prior to using this equipment. Certain physical conditions or limitations may preclude some persons from using this equipment as intended by the manufacturer, and using this equipment may increase the risk of injury.

1. Scope

1.1 This test method[2] specifies procedures and equipment used for testing and evaluating the accessibility of fitness equipment for compliance to Specification F3021 design parameters. Where possible and applicable, accepted test methods from other recognized bodies will be used and referenced. In case of a conflict between this document and Specification F3021, Specification F3021 takes precedence.

1.2 This test method is to be used in conjunction with Specification F3021.

1.3 This standard is to be used as additional requirements to address the accessibility of the equipment for persons with disabilities.

NOTE 1—Additional test methods applicable to specific pieces of equipment, such as treadmills, bicycles, ellipticals, and strength equipment are currently under development.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

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 and health 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:*[3]

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

F2571 Test Methods for Evaluating Design and Performance Characteristics of Fitness Equipment

F3021 Specification for Universal Design of Fitness Equipment for Inclusive Use by Persons with Functional Limitations and Impairments

[1] This test method is under the jurisdiction of ASTM Committee F08 on Sports Equipment, Playing Surfaces, and Facilities and is the direct responsibility of Subcommittee F08.30 on Fitness Products.

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[2] This work was funded, in part, by the Rehabilitation Engineering Research Center on RecTech through the National Institute on Disability, Independent Living, and Rehabilitation Research grant #90RE5009-01-00.

[3] 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. Terminology

3.1 *Definitions*—For definitions applicable to this standard see Specification F3021.

4. Sample Preparation

4.1 Assemble and adjust the fitness equipment apparatus on a horizontal surface according to the manufacturer's instructions. Verify that assembled units are done so according to the manufacturer's instructions. Unless otherwise stated, the fitness equipment apparatus must pass the following tests without adjustment from this initial condition.

4.2 Any equipment with a removable/movable seat shall be set up with the seat in the non-moved position.

4.3 The individual test methods will describe any variations or modifications that are required to the test sample.

5. Test Methods and Procedures

5.1 *General Requirements:*

5.1.1 *Access and Set Up:*

5.1.1.1 *Access, Egress, and Transfer*—This test is a visual inspection of the sample to ensure that all access paths to the piece of equipment, set in the start position, are not obstructed by the frame or other structural parts of the equipment.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual inspection only.

Procedure—Inspect all access paths to verify that the path is clear of any obstruction by the frame or other structural parts.

Pass/Fail Criteria—The access path shall conform to the clear space requirements of subsection 5.1.1.1 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.1 for evaluating access since the test result is non-quantitative.

NOTE 2—Performance tests to get on/off the equipment from the perspective of a broad range of people with disabilities, including people using wheelchairs or those who have functional limitations, sensory deficits, cognitive impairments, visual, or hearing impairments, or a combination thereof, is suggested. One possible method would be to use testers with disabilities.

5.1.1.2 *Maximum Approach Positions*—This test is a visual inspection of the sample to ensure that access paths to the piece of equipment, set in the start position, are available from as many positions as possible (that is, front, rear, left, and right).

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual inspection only.

Procedure—Inspect access paths from the front, rear, left, and right of the equipment to verify that the path is clear of any obstruction by the frame or other structural parts from as many points of access as possible.

Pass/Fail Criteria—Equipment must be accessible and shall avoid left/right bias as specified in the requirements of subsection 5.1.1.2 of Specification F3021. There is no pass/fail criteria.

Precision and Bias—Equipment must be accessible and shall avoid left/right bias as specified in the requirements of subsection 5.1.1.2 of Specification F3021. There is no pass/fail criteria.

5.1.1.3 *Step-On Height*—This test is a dimensional inspection of the sample to ensure the dimensional compliance of the step-on height.

Apparatus and Set Up—The sample shall be set up as described in Section 4 in the neutral position with 0 % grade/zero incline.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the height from the floor to the top of the highest portion of the step-on surface/frame or top of the transfer surface (see Fig. 1).

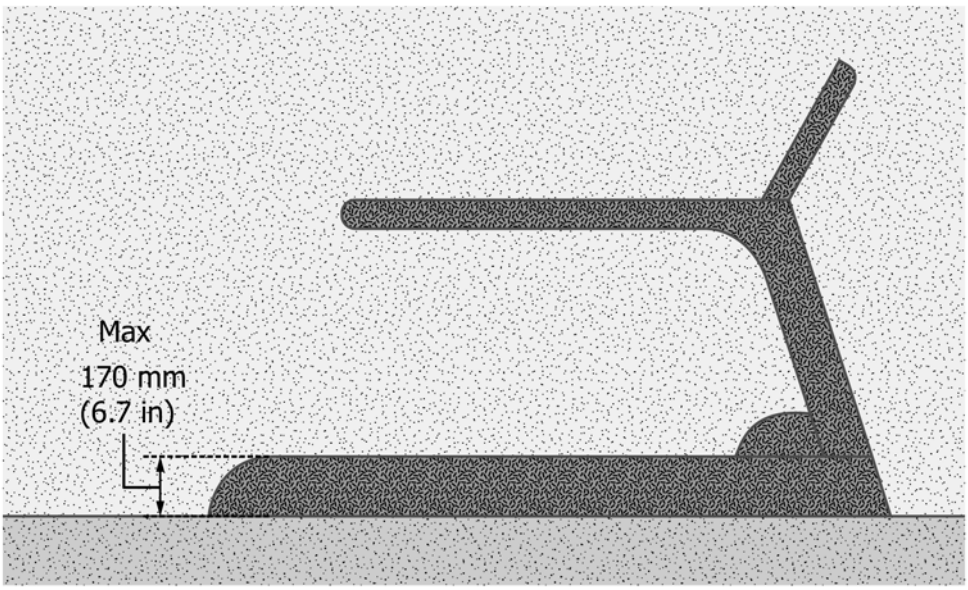

FIG. 1 Maximum Step-on Height Example

Pass/Fail Criteria—The dimensions of the step-on height shall conform to dimensional requirements of subsection 5.1.1.3 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.3 for measuring step-on height dimensions since the test result is non-quantitative.

5.1.1.4 *Step-Over Height*—This test is a dimensional inspection of the sample to ensure the dimensional compliance of the step-over height.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Locate the part of the structure that must be stepped over in order to use the equipment. Measure the distance from the floor to the top of the highest step-over point of the frame (see Fig. 2).

Pass/Fail Criteria—The dimensions of the step-over height shall conform to dimensional requirements of subsection 5.1.1.4 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.4 for measuring step-over height dimensions since the test result is non-quantitative.

5.1.1.5 *Integral Surface/Separate Step Height*—This test is a dimensional inspection of the sample to ensure the dimensional compliance of the step-on/step-over height, with the addition of an integral surface or separate step.

Apparatus and Set Up—The sample shall be set up as described in Section 4 with an integral surface or separate step intact.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Locate the part of the structure that must be stepped on/over in order to use the equipment. Measure the distance from the surface of the integral surface or separate step to the top of the highest step-over point of the frame (see 5.1.1.4).

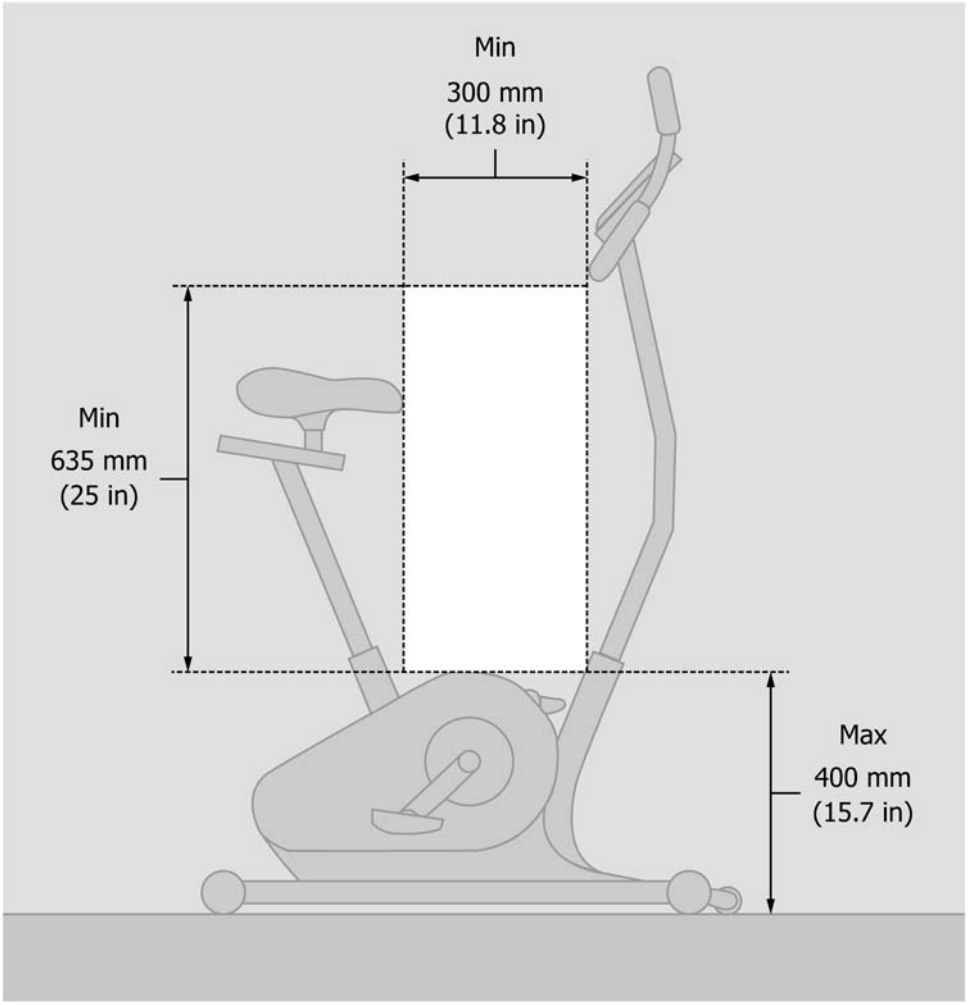

FIG. 2 Maximum Step-over Height Example

Pass/Fail Criteria—The dimensions of the integral surface or separate step height shall conform to dimensional requirements of subsection 5.1.1.5 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.5 for measuring integral surface or separate step height dimensions since the test result is non-quantitative.

5.1.1.6 *Integral Surface/Separate Step Length/Width/Height*—This test is a dimensional inspection of the sample to ensure the dimensional compliance of the integral surface and separate step length, width, and height.

Apparatus and Set Up—The sample shall be set up as described in Section 4 with an integral surface or separate step intact.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the height from the floor to the top of the stepping surface of the integral surface or separate step. Measure the length and width from the outer edge of the stepping surface lengthwise and the outer edge of the stepping surface widthwise on the integral surface or separate step.

Pass/Fail Criteria—The dimensions of the integral surface or separate step length/width/height shall conform to dimensional requirements of subsection 5.1.1.6 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.6 for measuring integral surface and separate step length, width, and height dimensions since the test result is non-quantitative.

5.1.1.7 *Integral Surfaces/Separate Steps—Significant Color Value Contrast*—Perform the color value measurement test in 5.3.

5.1.1.8 *Intentional/Unintentional Movement*—This test is a performance and dimensional inspection of the sample to ensure that separate steps do not unintentionally move during use and that they have appropriate mechanisms to facilitate intentional movement.

Apparatus and Set Up—The sample shall be set up as described in Section 4 on carpet for testing the ease of moving the step and on tile or similar flooring for testing for unintentional movement during use.

Calibration—Verify that the force measuring equipment is calibrated and accurate to within 0.5 N (0.1 lbf) over its entire range.

Procedure—Check for skids or wheel lock mechanism. Step on/off the step on tile or similar flooring and visually inspect for unintentional movement during use. Pull the step over carpet flooring and measure the pull force.

Pass/Fail Criteria—The step unintentional/intentional movement shall conform to performance requirements of subsection 5.1.1.8 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.8 for evaluating and measuring step unintentional/intentional movement since the test result is non-quantitative.

5.1.1.9 *Seated Cardio Back Support*—This test is a visual inspection of the sample to ensure that any seated cardio equipment has an integral back support.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual inspection only.

Procedure—Verify that the seated cardio equipment has a back support intact.

Pass/Fail Criteria—The presence of the seated cardio back support shall conform to the requirements of subsection 5.1.1.9 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.9 for seated cardio back support since the test result is non-quantitative.

5.1.1.10 *Walk Through Structure Clear Area*—This test is a performance inspection of the sample to ensure the dimensional compliance of walk through structure height.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Step through the walk through area of the equipment. Make sure that there is adequate low structure height to step through without impediment or obstruction. Measure the height from the floor to the highest part of the walk through structure.

Pass/Fail Criteria—The dimensions of the walk through structure area shall conform to dimensional requirements of subsection 5.1.1.10 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.10 for measuring walk through structure area dimensions since the test result is non-quantitative.

5.1.1.11 *Walk Through Transition Area Box*—This test is a dimensional inspection of the sample to ensure the dimensional compliance of walk through structure area.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the height and width of the transition area (see Fig. 3).

Pass/Fail Criteria—The dimensions of the transition area box shall conform to dimensional requirements of subsection 5.1.1.11 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.11 for measuring the transition area box dimension since the test result is non-quantitative.

5.1.1.12 *Recumbent Cardio Seat Forwards/Backwards Range*—This test is a performance and dimensional inspection of the sample to ensure the dimensional compliance of the seat forwards/backwards range.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

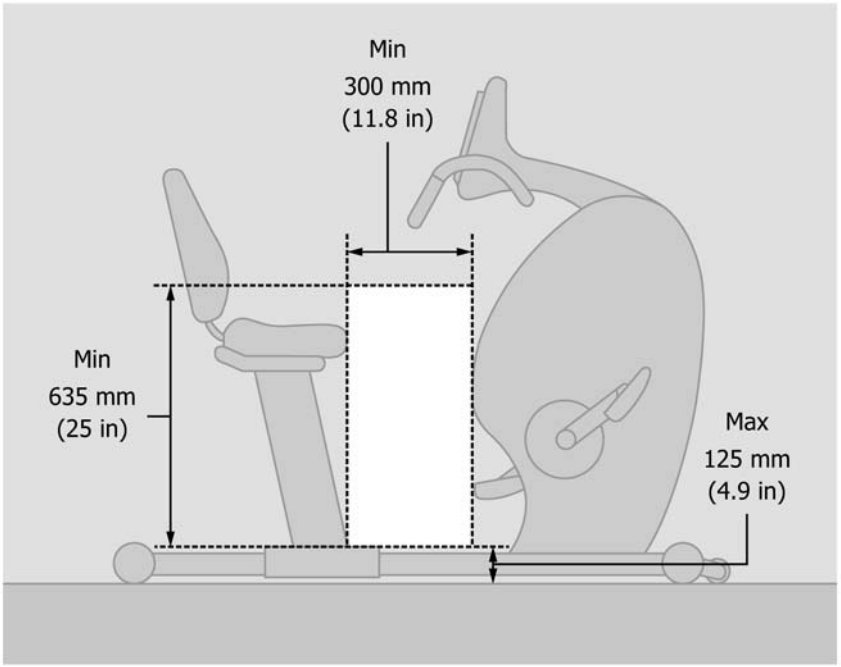

FIG. 3 Minimum Dimensions for Transition Area Box

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Adjust the seat from lowest (forward) to highest (back) position. Set the seat to its lowest position. Measure the horizontal distance of the seat range from a specific point on the seat frame between the lowest (forward) to highest (back) positions (see Fig. 4).

Pass/Fail Criteria—The recumbent bicycle seat forwards/backwards range shall conform to dimensional requirements of subsection 5.1.1.12 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.12 for measuring recumbent bicycle seat forwards/backwards range since the test result is non-quantitative.

5.1.1.13 *Recumbent Cardio Swivel Seat*—This test is a performance inspection of the sample to ensure the compliance of a swivel seat for cardio equipment which enables both upper limb function/movement.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

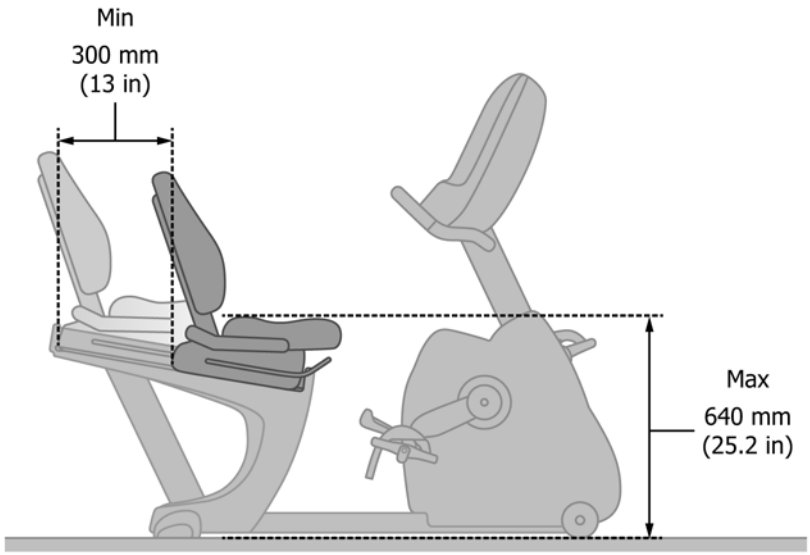

FIG. 4 Recumbent Bicycle Seat Dimensions

Calibration—No calibration required. Performance test only.

Procedure—If cardio equipment enables both upper limb function/movement, verify that the seat swivels to the right and left, in an axis perpendicular to and passing through the center of the primarily horizontal seat pan surface.

Pass/Fail Criteria—The recumbent bicycle swivel seat shall conform to performance requirements of subsection 5.1.1.13 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.13 for the presence of a swivel seat since the test result is non-quantitative.

(1) Recumbent Cardio Swivel Seat Lock—This test is a performance inspection of the sample to ensure the compliance of a swivel seat locking positions.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Performance test only.

Procedure—If cardio equipment has a swivel seat, verify that it locks in the center (primary exercise position), 45° and 90° to the right of center (primary exercise position), and 45° and 90° to the left of center.

Pass/Fail Criteria—The recumbent bicycle swivel seat locking positions shall conform to performance requirements of subsection 5.1.1.13*(1)* of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.13*(1)* for the presence of a swivel seat locking positions since the test result is non-quantitative.

5.1.1.14 *Recumbent Cycle Seat Height*—This test is a performance and dimensional inspection of the sample to ensure the dimensional compliance of the seat height.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Adjust the seat to the lowest (forward) position. Measure the height of the seat from the ground to the top of the sitting surface. If a step is used, then measure the height of the seat from top of the step surface to the top of the sitting surface (see Fig. 4).

Pass/Fail Criteria—The recumbent bicycle seat height shall conform to dimensional requirements of subsection 5.1.1.14 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.14 for measuring recumbent bicycle seat height dimensions since the test result is non-quantitative.

(1) Any separate or integral step used to meet the saddle height requirement must comply with Test Method F3022, subsections 5.1.1.6 – 5.1.1.8.

5.1.1.15 *Hand/Foot Support Locking Mechanism*—This test is a performance inspection of the sample to ensure that the hand/foot supports lock in place during mounting/dismounting.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Performance test only.

Procedure—Adjust the hand/foot supports for mounting and verify that they are able to be locked in place.

Pass/Fail Criteria—The hand/foot support locking mechanism shall conform to the requirements of subsection 5.1.1.15 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.15 for evaluating the hand/foot support locking mechanism since the test result is non-quantitative.

5.1.1.16 *Fixed Hand Grips*—This test is a visual inspection of the sample to ensure that fixed hand grips are provided for seated cardio equipment.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual test only.

Procedure—If the equipment is seated cardio, verify that there are fixed hand grips available.

Pass/Fail Criteria—The fixed hand grips shall conform to the requirements of subsection 5.1.1.16 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.16 for evaluating fixed hand grips since the test result is non-quantitative.

5.1.1.17 *Toe Retention*—This test is a visual and dimensional inspection of the sample to ensure that adjustable toe retentions are provided to prevent the foot from slipping off the pedals during exercise.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual and performance test only.

Procedure—Verify that there are adjustable toe retentions, for example, straps available on any pedals/foot platforms for use during exercise. Test the toe strap while using the bicycle with a shoe size of a 5 % female and a shoe size of a 95 % male.

Pass/Fail Criteria—The toe retentions shall conform to dimensional requirements of subsection 5.1.1.17 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.17 for evaluating toe retentions since the test result is non-quantitative.

5.1.1.18 *Foot Support Length/Width*—This test is a dimensional inspection of the sample to ensure the dimensional compliance of the foot support length and width.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the length of the foot support through the centerline from the front outer guard edge to the rear outer guard edge. Measure the width of the foot support through the centerline from the right outer guard edge to the left outer guard edge.

Pass/Fail Criteria—The foot support length and width shall conform to the dimensional requirements of subsection 5.1.1.18 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.18 for measuring foot support length and width dimensions since the test result is non-quantitative.

5.1.1.19 *Foot Retention*—This test is a visual and performance inspection of the sample to ensure the presence and dimensional compliance of the foot retention, for example, rear raised guard or strap, height on foot supports.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Verify that there are foot retentions present around the inside and outside edges of each foot support. Measure the height of the retention of each foot support from the inner top edge to the inner bottom edge. Measure the length of the retention and the foot support; calculate the percentage of foot retention length compared to the foot support length.

Pass/Fail Criteria—The presence and dimensions of the foot retention height shall conform to dimensional requirements of subsection 5.1.1.19 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.19 for measuring foot retention height dimensions since the test result is non-quantitative.

5.1.1.20 *Heel Retention*—This test is a visual and performance inspection of the sample to ensure the presence and dimensional compliance of the heel retention, for example, rear raised guard or strap, height on foot supports.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Verify that there is heel retention present on the back edge of each foot support. Measure the height of the heel retention of each foot support from the inner top edge to the inner bottom edge.

Pass/Fail Criteria—The presence and dimensions of the heel retention height shall conform to dimensional requirements of subsection 5.1.1.20 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.1.20 for measuring heel retention height dimensions since the test result is non-quantitative.

5.1.1.21 *Highlight Potential Trip Hazards—Significant Color Value Contrast*—Perform the color value measurement test in 5.3.

5.1.1.22 *Foot Support/Pedal Heel and Toe Retentions—Significant Color Value Contrast*—Perform the color value measurement test in 5.3.

5.1.2 *Seats, Sitting Surfaces, and Back Supports:*

5.1.2.1 *Sitting Surface Width/Depth/Back Support Angle*—This test is a dimensional inspection of the sample to ensure the dimensional compliance of the seat/sitting surface width, depth, and back support angle.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.) and the angle measuring equipment is calibrated and accurate to within 0.1°.

Procedure—Measure the width across the top of the sitting support surface from the left outer side edge to the right outer side edge at the widest point in the hip/pelvic area. Measure the depth of the top of the sitting support surface from the front edge of the hip/pelvic area to the back edge through the centerline. If the seat/sitting surface has a back support, measure the seat angle in the middle on top of the hip/pelvic support area from the horizontal reference of the floor (see Fig. 5).

Pass/Fail Criteria—The dimensions of the seat/sitting surface width, depth, and back support angle shall conform to dimensional requirements of subsection 5.1.2.1 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.2.1 for measuring sitting surface width, depth, and back support angle dimensions since the test result is non-quantitative.

5.1.2.2 *Fixed Seat Height*—This test is a dimensional inspection of the sample to ensure the dimensional compliance of the seat height.

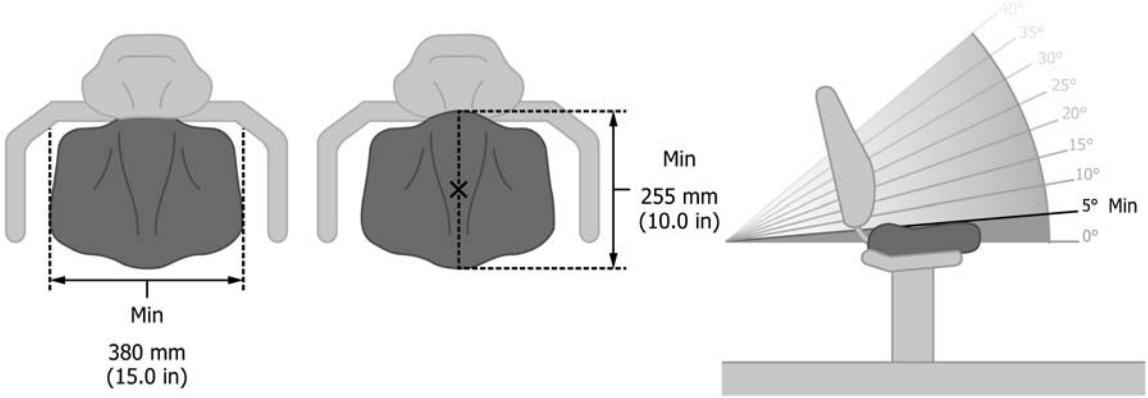

FIG. 5 Minimum Seat Dimensions – Width, Depth, Angle

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the height of the seat from the ground to the top of the sitting surface (see Fig. 6).

Pass/Fail Criteria—The dimensions of the seat height shall conform to dimensional requirements of subsection 5.1.2.2 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.2.2 for measuring fixed seat height dimensions since the test result is non-quantitative.

5.1.2.3 *Adjustable Seat Height Range*—This test is a dimensional inspection of the sample to ensure that there is a seat height option within the specified range on adjustable seats.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the height of the seat from the ground to the top of the sitting surface with the seat in the lowest and highest position. Verify that the seat height can be adjusted within the specified range.

Pass/Fail Criteria—The dimensions of the adjustable seat height range shall conform to dimensional requirements of subsection 5.1.2.3 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.2.3 for measuring the adjustable seat height range since the test result is non-quantitative.

5.1.2.4 *Seat Height Adjustability*—This test is a performance inspection of the sample to ensure that the seat height is adjustable.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Performance test only.

Procedure—Verify that the seat height is adjustable. Adjust the seat from lowest to highest position.

Pass/Fail Criteria—The seat height adjustability shall conform to the requirements of subsection 5.1.2.4 of Specification F3021.

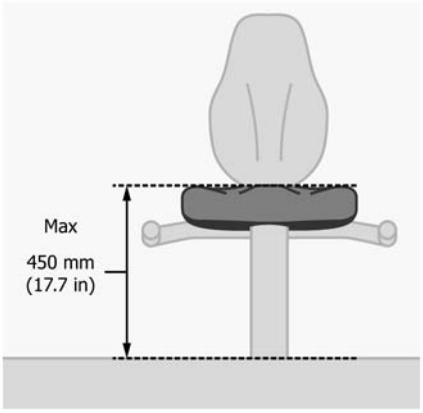

FIG. 6 Maximum Seat Dimensions – Height

Precision and Bias—No information is presented about either the precision or bias of test 5.1.2.4 for measuring the seat height adjustability since the test result is non-quantitative.

5.1.2.5 *Removable/Movable Seat*—This test is a dimensional inspection of the sample to ensure that the clear space and floor area is free of obstacles when a removable/movable seat is removed/moved.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Remove/Move the seat from its active position to its storage position. Measure the length, width, and height of the accessible clear space area. Measure the height of any obstacle(s) that remain in the accessible clear space in the floor area.

Pass/Fail Criteria—The seat shall be capable of being removed/moved into a storage position with an accessible clear space floor area that conforms to the requirements of subsection 5.1.2.5 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.2.5 for evaluating and measuring seat removability/movability, clear space, and obstacle height since the test result is non-quantitative.

NOTE 3—Reminder when testing for stability of the equipment, the seat in the removed/moved position would be the most onerous position for testing.

5.1.2.6 *Start Position/Hand Grip(s) Clearance*—This test is a dimensional inspection of the sample to ensure that when removable/movable seats are removed/moved, that there is sufficient distance between the back support and exercise hand grips when a wheelchair is in the exercise position.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Remove/Move the seat from its active position to its storage position. Measure the horizontal distance between the closest start position of the hand grips designed for wheelchair use and the back support (see Fig. 8).

Pass/Fail Criteria—The start position and hand grip(s) clearance shall conform to the requirements of subsection 5.1.2.6 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.2.6 for evaluating and measuring start position and hand grip(s) clearance since the test result is non-quantitative.

5.1.2.7 *Seats Intentional/Unintentional Movement*—This test is a visual, performance, and dimensional inspection of the sample to ensure that removable/movable seats have appropriate mechanisms, for example, wheels or skids and hand grips or gripping surfaces, to enable the seat to move easily over different floor surfaces and a means of preventing unintentional movement during use.

Apparatus and Set Up—The sample shall be set up as described in Section 4 on carpet for testing the ease of moving the seat and on tile or similar flooring for testing for unintentional movement during use.

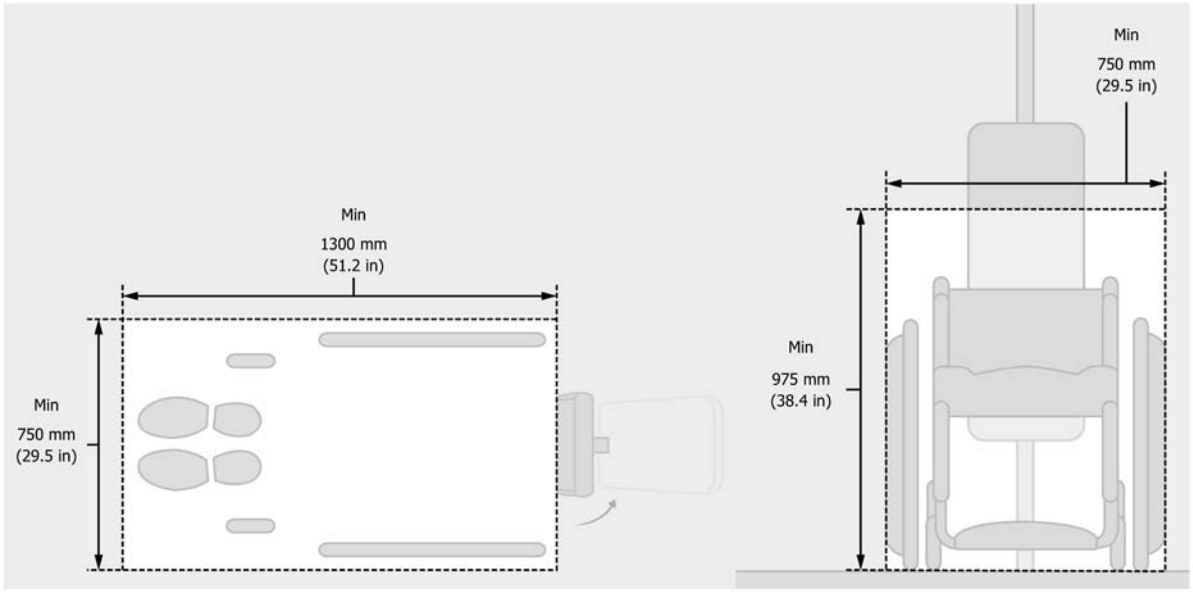

FIG. 7 Removable/Movable Minimum Clear Space Area

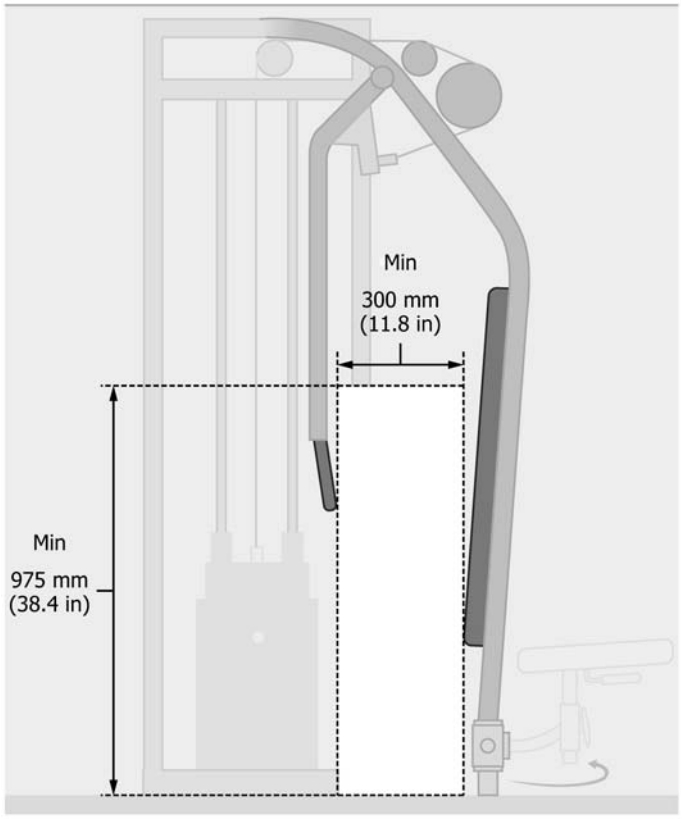

FIG. 8 Minimum Distance from Back Support to Hand Grips with Seat Removed

Calibration—Verify that the force measuring equipment is calibrated and accurate to within 0.5 N (0.1 lbf) over its entire range.

Procedure—Inspect the sample for skids or wheel lock mechanism. Remove/Move the seat from its active position to its storage position over carpet flooring and measure the pull

force. Visually inspect for unintentional movement during use while on tile or similar flooring.

Pass/Fail Criteria—The seat intentional/unintentional movement shall conform to performance requirements of subsection 5.1.2.7 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.2.7 for evaluating and measuring seat unintentional/intentional movement since the test result is non-quantitative.

5.1.2.8 *Physical Locating/Locking Mechanism*—This test is a performance inspection of the sample to ensure that seats with a specific exercise position have a physical locating or locking mechanism or a visual reference to indicate the correct seat alignment.

Apparatus and Set Up—The sample shall be set up as described in Section 4 with the seat removed.

Calibration—No calibration required. Performance test only.

Procedure—Verify that there is a physical locating or locking mechanism or a visual reference to indicate the correct seat alignment. Have an untrained tester move the seat into the specific exercise position, verify that the seat is in the correct position.

Pass/Fail Criteria—The seat position shall conform to the requirements of subsection 5.1.2.8 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.2.8 for evaluating physical locating/locking mechanism since the test result is non-quantitative.

5.1.2.9 *Bench Width and Length*—This test is a dimensional inspection of the sample to ensure the dimensional compliance of the bench width and length.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the width of the bench across the top of the sitting support surface from the left outer side edge to the right outer side edge at the widest point in the hip/pelvic area. Measure the length of the bench from the front edge to the back edge through the centerline.

Pass/Fail Criteria—The dimensions of the bench width and length shall conform to dimensional requirements of subsection 5.1.2.9 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.2.9 for measuring bench width and length dimensions since the test result is non-quantitative.

5.1.2.10 *Back Support Height and Width*—This test is a dimensional inspection of the sample to ensure the dimensional compliance of the back support height and width.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Determine where the width measured from the left outer edge to the right outer edge on the back support meets minimum width requirements. Measure the height on the back support from this point along the centerline of the back support for which the minimum width requirement is continuously met (see Fig. 9).

Pass/Fail Criteria—The back support height and width shall conform to the requirements of subsection 5.1.2.10 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.2.10 for measuring the back support height and width since the test result is non-quantitative.

5.1.2.11 *Postural Support/Surface Padding*—This test is a dimensional inspection of the sample to ensure that postural support/surfaces are cleanable and padded.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Verify that the postural supports/surfaces can be sanitized from sweat and other bodily fluids. Measure the depth of the foam used in each postural support/surface and verify that the hardness and density meet the specified ISO requirements.

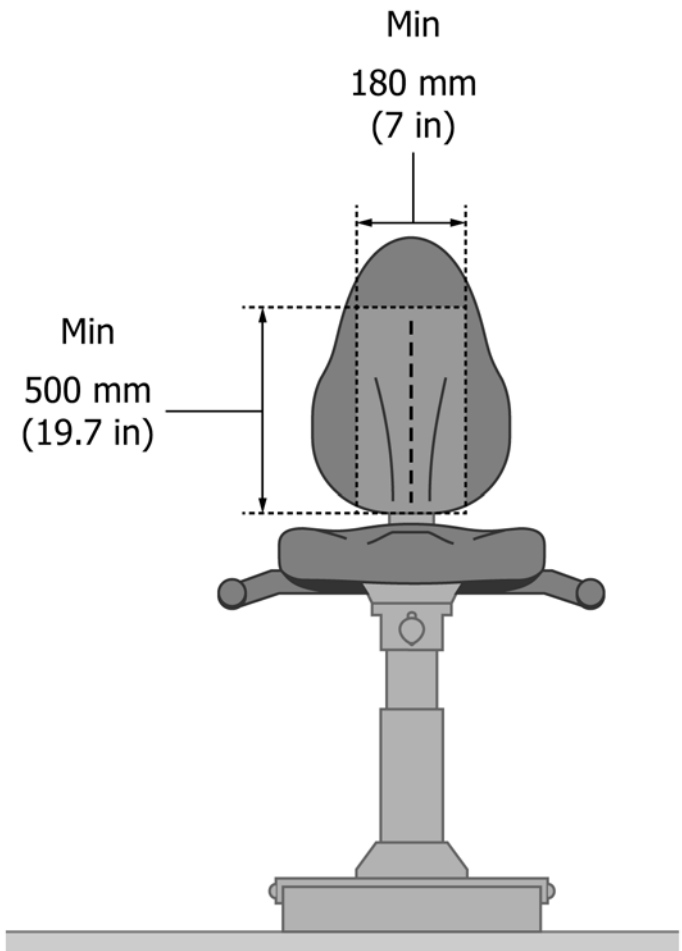

FIG. 9 Back Support Height and Depth

Pass/Fail Criteria—The postural supports/surfaces padding shall conform to the requirements of subsection 5.1.2.11 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.2.11 for evaluating and measuring postural support/surface padding since the test result is non-quantitative.

5.1.2.12 *Seats—Significant Color Value Contrast*—Perform the color value measurement test in 5.3.

5.1.3 *Adjustment Mechanisms:*

5.1.3.1 *Visible Adjustment Mechanisms*—This test is a visual and performance inspection of the sample to ensure that adjustment mechanisms required for set up are visible in a clear line of sight to the user upon approach to the equipment or from the primary exercise position, or both.

Apparatus and Set Up—The sample shall be set up as described in Section 4 with the seat in place and removed/moved.

Calibration—No calibration required. Visual/performance test only.

Procedure—Verify that the adjustment mechanisms are in a clear line of sight without obstruction from the primary exercise position with the seat in place and removed/moved. Perform set up adjustments from the approach position and the primary exercise position with the seat in place and removed/moved.

Pass/Fail Criteria—The visible adjustment mechanisms shall conform to the requirements of subsection 5.1.3.1 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.3.1 for evaluating visible adjustment mechanisms since the test result is non-quantitative.

5.1.3.2 *Left/Right Hand Bias Adjustment Mechanisms*—This test is a performance inspection of the sample to ensure that adjustment mechanisms are not left or right hand biased.

Apparatus and Set Up—The sample shall be set up as described in Section 4 with the seat in place and removed/moved.

Calibration—No calibration required. Performance test only.

Procedure—Make all adjustments using the left hand and then repeat using the right hand with the seat in place and removed/moved.

Pass/Fail Criteria—The left/right hand bias adjustment mechanisms shall conform to the requirements of subsection 5.1.3.2 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.3.2 for evaluating left/right hand bias adjustment mechanisms since the test result is non-quantitative.

5.1.3.3 *One Hand Adjustment Mechanisms*—This test is a performance inspection of the sample to ensure that adjustment mechanisms can be performed with one hand.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Performance test only.

Procedure—Make all adjustments, except those requiring a carabiner, using only one hand.

Pass/Fail Criteria—The adjustments shall conform to the requirements of subsection 5.1.3.3 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.3.3 for evaluating one hand adjustment mechanisms since the test result is non-quantitative.

5.1.3.4 *Adjustment Mechanism Ease of Use*—This test is a visual and performance inspection of the sample to ensure that adjustment mechanisms required for set up are easy to use.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual/performance test only.

Procedure—Verify that the adjustment mechanisms are within reach from the primary exercise position by a 5 % size female (see Table 1). Perform set up adjustments and verify that the adjustment mechanisms can be easily inserted/removed and do not require fine finger control, excessive wrist rotation, tight grasp, or a pinch grip (see Figs. 10 and 11).

Pass/Fail Criteria—The adjustment mechanism ease of use shall conform to the requirements of subsection 5.1.3.4 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.3.4 for evaluating adjustment mechanism ease of use since the test result is non-quantitative.

5.1.3.5 *Adjustment Mechanism Force*—This test is a dimensional inspection of the sample to ensure that adjustment mechanisms are easy to activate.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the force measuring equipment is calibrated and accurate to within 0.5 N (0.1 lbf) over its entire range.

Procedure—Activate the adjustment mechanism and measure the force needed to pull, push, or twist.

Pass/Fail Criteria—The adjustment mechanism force shall conform to performance requirements of subsection 5.1.3.5 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.3.5 for adjustment mechanism force since the test result is non-quantitative.

TABLE 1 Dimensions of US Civilian Male and Females[A]

Dimension Name	5th Percentile Female (in.)	Mean (Average) Male (in.)	Mean (Average) Female (in.)	Mean (Average) Overall (in.)	95th Percentile Male (in.)
Height	58.9	68.21	63.10	65.66	72.6
Sitting Height, Erect	30.9	35.61	33.34	34.48	38.1

[A]Source: Anthropology Research Project Staff, *Anthropometric Source Book, Volume 2. Anthropometry for Designers*, NASA Reference Publication 1024, NASA, Houston, TX, 1978.

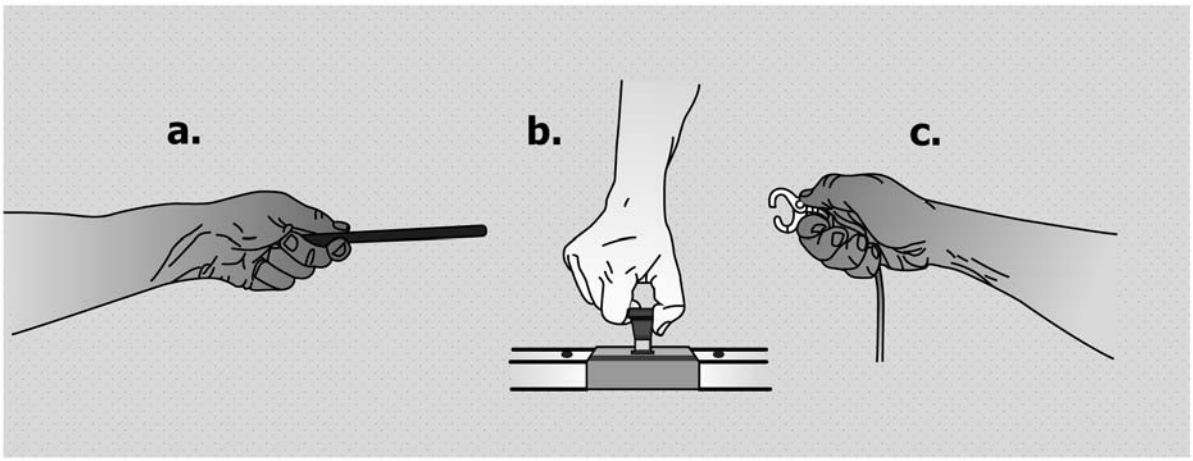

FIG. 10 Examples of Non-Accessible Hand Grips: (a) Twist, (b) Tight Grasp, and (c) Pinch

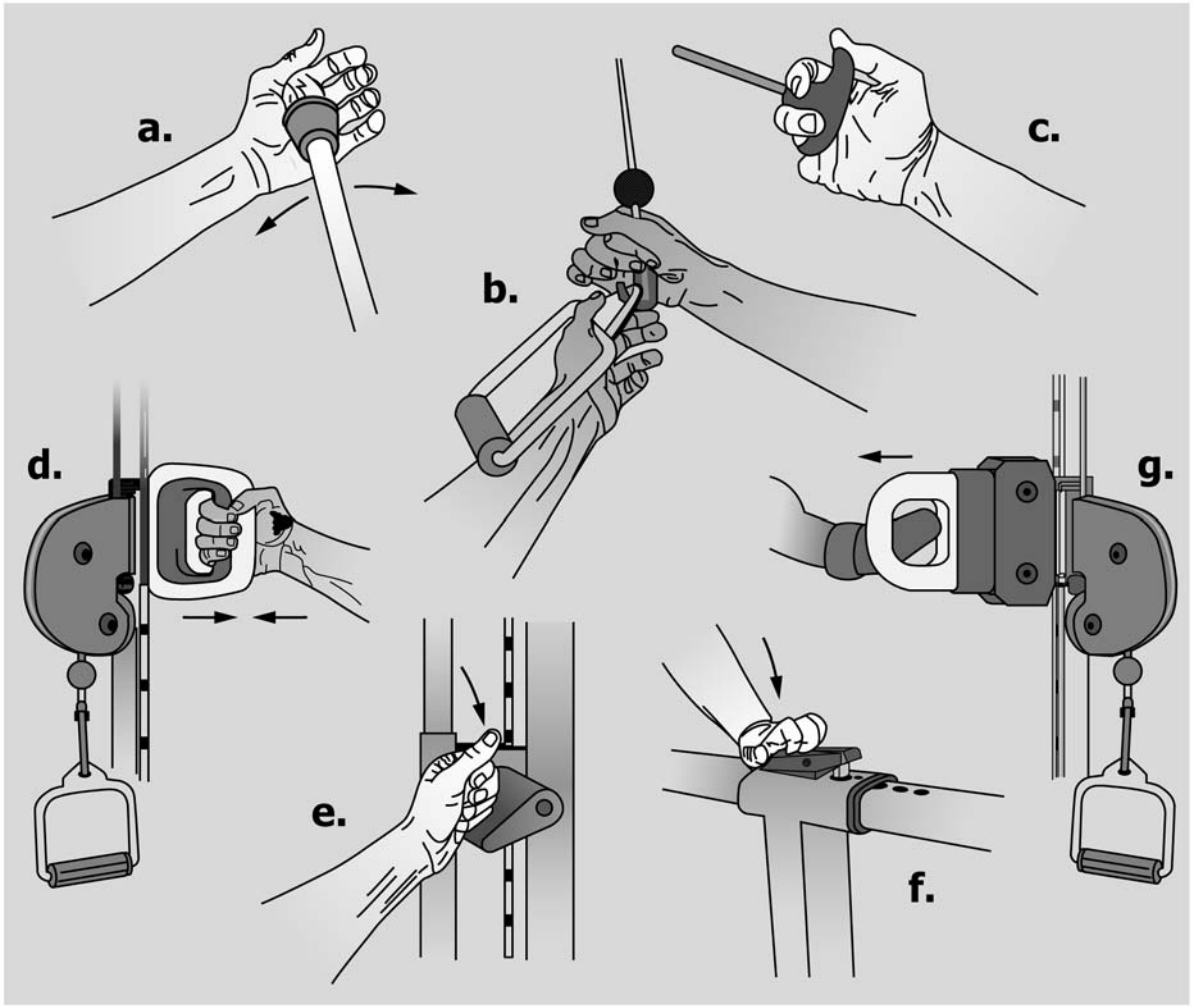

FIG. 11 Examples of Accessible Hand Grips

5.1.3.6 *Controlled Adjustment Mechanisms*—This test is a performance inspection of the sample to ensure that adjustment mechanisms do not free fall during adjustments.

Apparatus and Set Up—The sample shall be set up as described in Section 4 with the seat removed.

Calibration—No calibration required. Performance test only.

Procedure—During each adjustment, release the mechanism, that is, let it go, at places in between adjustment slots. Record slippage of the adjustment mechanism.

Pass/Fail Criteria—The adjustments shall conform to the requirements of subsection 5.1.3.6 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.3.6 for evaluating controlled adjustment mechanisms since the test result is non-quantitative.

5.1.3.7 *Tethered Adjustment Mechanisms*—This test is a visual and performance inspection of the sample to ensure that adjustment mechanisms are tethered and do not interfere with access to or performance of the exercise.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual and performance test only.

Procedure—Inspect all adjustments to verify that they either are tethered to the equipment or have a designated storage spot. Perform the exercise from the exercise position and verify that the tethered adjustment mechanisms do not interfere with the exercise.

Pass/Fail Criteria—The tethered adjustment mechanisms shall conform to the requirements of subsection 5.1.3.7 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.3.7 for evaluating tethered adjustment mechanisms since the test result is non-quantitative.

5.1.3.8 *Adjustment Mechanisms—Significant Color Value Contrast*—Perform the color value measurement test in 5.3.

5.1.3.9 *Marked Fixed Position Settings*—This test is a visual inspection of the sample to ensure that fixed position settings/adjustments are clearly and distinctively marked in an alternative format to Braille.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual test only.

Procedure—Inspect each adjustment, excluding adjustments which lock the user into position and cannot be preset before adopting the exercise position (for example, knee clamps on a lat pull down or seated leg curl) to verify that it is clearly and distinctively marked. Inspect all markings to verify that they are in a format alternative to Braille.

Pass/Fail Criteria—The marked fixed position settings shall conform to the requirements of subsection 5.1.3.9 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.3.9 for measuring the marked fixed position settings since the test result is non-quantitative.

5.1.3.10 *Font Size and Style*—This test is a visual and dimensional inspection of the sample to ensure that any font is sans serif, non-italic font, and meets the size criteria.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Inspect all font to verify that it is non-italic font and sans serif. Measure the height of the smallest letter from the top outer edge to the bottom outer edge.

Pass/Fail Criteria—The font size and style shall conform to the requirements of subsection 5.1.3.10 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.3.10 for evaluating and measuring font size and style since the test result is non-quantitative.

5.1.3.11 *Tactile Markings*—This test is a visual and dimensional inspection and a tactile exam of the sample to ensure that markings are tactile.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 0.1 mm (0.0040 in.).

Procedure—Measure the depth of the thinnest marking from top to surface.

Pass/Fail Criteria—The tactile markings shall conform to the requirements of subsection 5.1.3.11 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.3.11 for evaluating and measuring tactile markings since the test result is non-quantitative.

5.1.3.12 *Adjustment Markings—Significant Color Value Contrast*—Perform the color value measurement test in 5.3.

5.1.4 *Hand Grips:*

5.1.4.1 *Fixed Hand Grip Proximity*—This test is a visual inspection of the sample to ensure that fixed hand grips are provided in proximity of sitting surfaces to assist with transfers.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual test only.

Procedure—Inspect seat/sitting surfaces to verify that there are hand grips or grasping points, or both, to assist with transfers.

Pass/Fail Criteria—The hand grips shall conform to the requirements of subsection 5.1.4.1 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.4.1 for evaluating fixed hand grip proximity since the test result is non-quantitative.

5.1.4.2 *Fixed Hand Grip Position*—This is a visual and performance inspection and tactile exam of the sample to ensure that fixed hand grips do not interfere with transfers.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the space between the inside edge of the hand grip and the outside edge of the seat. Verify that the top of the hand grip does not protrude above the seat surface.

Pass/Fail Criteria—The fixed hand grip position shall conform to the requirements of subsection 5.1.4.2 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.4.2 for evaluating fixed hand grip position since the test result is non-quantitative.

5.1.4.3 *Hand Grip Dimensions*—This test is a visual and dimensional inspection and tactile exam of the sample to ensure that hand grips are functional.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the diameter and length of the hand grip for the intended gripping surface. Verify that hand grips used dynamically during exercise are round or oval. Conduct the slip resistance of the hand grips test in accordance with Test Methods F2571.

Pass/Fail Criteria—The hand grip dimensions shall conform to the requirements of subsection 5.1.4.3 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.4.3 for evaluating and measuring hand grip dimensions since the test result is non-quantitative.

5.1.4.4 *Gripping Surfaces—Significant Color Value Contrast*—Perform the color value measurement test in 5.3.

5.1.4.5 *Color (Hue)/Contrast Pattern*—This test is a visual test of the sample to ensure that movable hand grips are distinguishable from fixed gripping surfaces.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual test only.

Procedure—Inspect the movable hand grips and verify that they have a different hue or contrast pattern than any fixed gripping surfaces.

Pass/Fail Criteria—The hand grip color (hue)/contrast pattern shall conform to the requirements of subsection 5.1.4.5 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.4.5 for evaluating color (hue)/contrast pattern since the test result is non-quantitative.

5.1.5 *Instructions for Use:*

5.1.5.1 *Accessible Format Instruction Label*—This test is a visual inspection of the sample to ensure that the instructions for use label is available in an accessible format.

Calibration—No calibration required. Visual test only.

Procedure—Inspect each instructional format. Record each format available.

Pass/Fail Criteria—The accessible format instruction label shall conform to the requirements of subsection 5.1.5.1 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.5.1 for evaluating accessible format instruction label since the test result is non-quantitative.

5.1.5.2 *Accessible Format Owner's/Training Manual*—This test is a visual inspection of the sample to ensure that the owner's/training manual(s) are available in an accessible format.

Calibration—No calibration required. Visual test only.

Procedure—Inspect the owner's/training manual(s) format. Record each format available.

Pass/Fail Criteria—The accessible format owner's/training manual shall conform to the requirements of subsection 5.1.5.2 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.5.2 for evaluating the accessible format owner's/training manual since the test result is non-quantitative.

5.1.6 *Labeling Requirements:*

5.1.6.1 *Instruction Panel Backing*—This test is a visual inspection of the sample to ensure that the instruction panel(s) are printed on a matt or non-glare finish without any 'show through' of housing details.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual inspection only.

Procedure—Inspect the equipment to ensure that the instruction panel(s) are printed on a matt or non-glare finish without any 'show through' of housing details.

Pass/Fail Criteria—Inspection panel backing shall conform to the requirements of subsection 5.1.6.1 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.6.1 for evaluating instruction panel backing since the test result is non-quantitative.

5.1.6.2 *Instruction Panel(s) Text Size*—This test is a dimensional inspection of the sample to ensure the dimensional compliance of the instruction panel(s) text size.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the height of the smallest lower case letter on the instruction panel(s) from the top outer edge to the bottom outer edge.

Pass/Fail Criteria—The instruction panel(s) text size shall conform to the requirements of subsection 5.1.6.2 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.6.2 for measuring instruction panel(s) text size since the test result is non-quantitative.

5.1.6.3 *Instruction Panel(s) Text Case/Font*—This test is a visual inspection of the sample to ensure that sentence case and sans serif, non-italic fonts are used on the instruction panel(s).

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual inspection only.

Procedure—Inspect the equipment to ensure that the instruction panel(s) text is sans serif, non-italic fonts and that sentence case is used.

Pass/Fail Criteria—Instruction panel(s) text case and front shall conform to the requirements of subsection 5.1.6.3 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.6.3 for evaluating instruction panel(s) text case/font since the test result is non-quantitative.

5.1.6.4 *Instruction Panel(s) Text Alignment*—This test is a visual inspection of the sample to ensure the instruction panel(s) text is aligned left, unjustified, and horizontal without flowing around graphic elements or images.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual inspection only.

Procedure—Inspect the equipment to ensure that the instruction panel(s) text is aligned left, unjustified, and horizontal without flowing around graphic elements or images.

Pass/Fail Criteria—Instruction panel(s) text alignment shall conform to the requirements of subsection 5.1.6.4 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.6.4 for evaluating instruction panel(s) text alignment since the test result is non-quantitative.

5.1.6.5 *Instruction Panel(s) Word/Line Spacing*—This test is a dimensional inspection of the sample to ensure the dimensional compliance of the instruction panel(s) word and line spacing.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the smallest space between words and the smallest space between lines on the instruction panel(s).

Pass/Fail Criteria—The instruction panel(s) word and line spacing shall conform to the requirements of subsection 5.1.6.5 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.6.5 for measuring instruction panel(s) word and line spacing since the test result is non-quantitative.

5.1.6.6 *Specific Component Arrows*—This test is a visual inspection of the sample to ensure that arrows used on the equipment are positioned in between the instructions and the component, with the arrow pointing to the component.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual inspection only.

Procedure—Inspect the equipment to ensure that arrows used on the equipment are positioned in between the instructions and the component, with the arrow pointing to the component.

Pass/Fail Criteria—Specific component arrows shall conform to the requirements of subsection 5.1.6.6 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.6.6 for evaluating specific component arrows since the test result is non-quantitative.

5.1.6.7 *Main Instruction Panel/Label—Significant Color Value Contrast*—Perform the color value measurement test in 5.3.

5.1.6.8 *Inclusive Access Symbol*—This test is a visual inspection of the sample to ensure that if an inclusive access symbol is present, it meets the dimensional inspection of the sample to ensure the dimensional compliance of the symbol location.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Inspect the equipment to determine if an inclusive symbol is present. Measure the shortest distance from the edge of the symbol to the nearest edge of the instruction panel.

Pass/Fail Criteria—The inclusive access symbol location shall conform to the requirements of subsection 5.1.6.8 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.6.8 for the presence and location of the inclusive access symbol since the test result is non-quantitative.

(1) Inclusive Access Symbol Width—This test is a dimensional inspection of the sample to ensure the dimensional compliance of the inclusive access symbol width.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the width of the inclusive access symbol through the centerline.

Pass/Fail Criteria—The inclusive access symbol width shall conform to the requirements of subsection 5.1.6.8*(1)* of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.6.8*(1)* for evaluating the inclusive access symbol width since the test result is non-quantitative.

(2) Inclusive Access Symbol—Significant Color Value Contrast—This test is a visual inspection and color value contrast test of the sample to ensure that an inclusive access symbol meets the color specification. Perform the color value measurement test in 5.3.

Apparatus and Set Up—Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual inspection only.

Procedure—Inspect the inclusive access symbol color and background color.

Pass/Fail Criteria—The inclusive access symbol colors shall conform to the requirements of subsection 5.1.6.8*(2)* of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.6.8*(2)* for evaluating the inclusive access symbol colors since the test result is non-quantitative.

(3) Inclusive Access Symbol—Significant Color Value Contrast—This test is a dimensional inspection of the sample to ensure the dimensional compliance of the inclusive access symbol color contrast background area. Perform the color value measurement test in 5.3.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the clear space around the outside edge of the symbol.

Pass/Fail Criteria—The inclusive access symbol color contrast background area shall conform to the requirements of subsection 5.1.6.8*(3)* of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.1.6.8*(3)* for evaluating the inclusive access symbol color contrast background area since the test result is non-quantitative.

(4) Inclusive Access Symbol—Tactile—Perform the tactile test in 5.2.5.1.

(5) Inclusive Access Symbol—Raised Iconography—Perform the raised iconography test in 5.2.5.4.

5.2 *Control Panels/Consoles:*

5.2.1 *General Positioning:*

5.2.1.1 *Console Main Control Clear Line of Sight*—This test is a visual and performance inspection of the sample to ensure that console main controls are visible in a clear line of sight to the user from the primary exercise position without any physical obstruction.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual inspection only.

Procedure—Verify that the console main controls are in a clear line of sight without obstruction from the primary exercise position. Perform set up adjustments from the primary exercise position.

Pass/Fail Criteria—The console main controls shall conform to the requirements of subsection 5.2.1.1 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.1.1 for evaluating console main control clear line of sight since the test result is non-quantitative.

5.2.1.2 *Console Main Controls Left/Right Hand Bias*—This test is a visual and dimensional inspection of the sample to ensure that console controls are not left/right hand bias.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the distance from the centerline of the console to centerline of the main control buttons. Verify that the main controls of the console are repeated on both the left and right sides of the equipment if they are not centered (see Fig. 12).

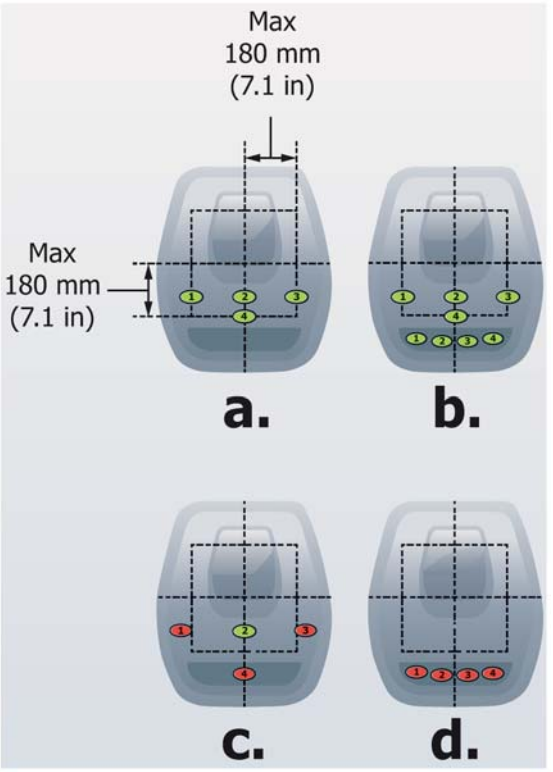

FIG. 12 (a) Demonstrates Main Control Buttons within Centerline, (b) Demonstrates Repeated Controls, and (c) and (d) Demonstrate Main Control Buttons Outside of Centerline (green buttons represent compliant location, red buttons represent non-compliant location)

Pass/Fail Criteria—The console main controls shall conform to the requirements of subsection 5.2.1.2 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.1.2 for evaluating and measuring console main controls right/left hand bias since the test result is non-quantitative.

5.2.1.3 *Console Main Controls Grouping*—This test is a visual inspection of the sample to ensure that console main controls are grouped/paired according to similar operations.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual test only.

Procedure—Inspect console main controls to verify that the following functions are grouped/paired together: start/stop, increase/decrease speed, increase/decrease level or resistance, increase/decrease grade, or equivalent.

Pass/Fail Criteria—The console main controls grouping shall conform to the requirements of subsection 5.2.1.3 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.1.3 for evaluating console main controls grouping since the test result is non-quantitative.

5.2.2 *Button Requirements:*

5.2.2.1 *Main Controls Individual Buttons*—This test is a visual inspection of the sample to ensure that console main controls each have individual buttons.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual test only.

Procedure—Inspect console main controls to verify that the following functions each have an individual button: start/stop, increase/decrease speed, increase/decrease level or resistance, increase/decrease grade, or equivalent.

Pass/Fail Criteria—The main controls individual buttons shall conform to the requirements of subsection 5.2.2.1 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.2.1 for evaluating main controls individual buttons since the test result is non-quantitative.

5.2.2.2 *'Quick Start' Button*—This test is a visual inspection of the sample to ensure that it has a quick start button.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual and performance test only.

Procedure—Verify that the console has a 'Quick Start' button or similar button that starts the machine at the lowest setting with a single actuation of the button. Document the words or iconography, or both, used to depict 'Quick Start.'

Pass/Fail Criteria—The quick start button shall conform to the requirements of subsection 5.2.2.2 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.2.2 for evaluating the quick start button since the test result is non-quantitative.

5.2.2.3 *Single Push/Press Start Button*—This test is a performance inspection of the sample to ensure that power driven equipment has a start button that starts the machine with a single actuation of the button.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Performance test only.

Procedure—Verify that power driven equipment has a start button that starts the machine with a single actuation of the button.

Pass/Fail Criteria—The single push/press start button shall conform to the requirements of subsection 5.2.2.3 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.2.3 for evaluating single push/press start button since the test result is non-quantitative.

5.2.2.4 *Single Actuation Function Change*—This test is a performance inspection of the sample to ensure that each incremental change in the main control functions have a single actuation.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Performance test only.

Procedure—Verify that each incremental change in the main control functions have a single actuation.

Pass/Fail Criteria—The single actuation function change shall conform to the requirements of subsection 5.2.2.4 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.2.4 for evaluating single actuation function change since the test result is non-quantitative.

5.2.2.5 *Console Main Control Button Dimensions*—This test is a dimensional inspection of the sample to ensure that console control buttons meet the size criteria.

Apparatus and Set Up—This test is a dimensional inspection of the sample to ensure that console control buttons meet the size criteria.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the diameter and height of each main control button.

Pass/Fail Criteria—The console main control button dimensions shall conform to the requirements of subsection 5.2.2.5 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.2.5 for evaluating and measuring console main control button dimensions since the test result is non-quantitative.

5.2.3 *Labeling Requirements:*

5.2.3.1 *Console Font Style/Sentence Case*—This test is a visual inspection of the sample to ensure that all text is sans serif, non-italic fonts, and sentence case.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual test only.

Procedure—Inspect all console text to verify that it is sans serif without italics and in sentence case.

Pass/Fail Criteria—The console font style and sentence case shall conform to the requirements of subsection 5.2.3.1 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.3.1 for evaluating console font style and sentence case since the test result is non-quantitative.

5.2.3.2 *Console Font Size*—This test is a visual and dimensional inspection of the sample to ensure that all main controls are labeled and the font meets the size criteria.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Inspect all console main controls to verify that they are labeled with the button function. Measure the height of the smallest lower case and capitalized letter from the top outer edge to the bottom outer edge.

Pass/Fail Criteria—The console font size shall conform to the requirements of subsection 5.2.3.2 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.3.2 for evaluating and measuring console font size since the test result is non-quantitative.

5.2.4 *Color Requirements:*

5.2.4.1 *Green Start/Red Stop Color Elements*—This test is a visual inspection of the sample to ensure that all start controls have an element of the color green and all stop controls have an element of the color red.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual inspection only.

Procedure—Inspect all start and stop buttons to verify that there is an element of green and red, respectively.

Pass/Fail Criteria—The green start and red stop color elements shall conform to the requirements of subsection 5.2.4.1 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.4.1 for evaluating green start and red stop color elements since the test result is non-quantitative.

5.2.4.2 *Console Main Controls Color Code*—This test is a visual inspection of the sample to ensure that all console main controls are color coded according to similar operations.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual test only.

Procedure—Inspect console main controls to verify that the following functions are color coded: increase/decrease speed, increase/decrease resistance or level, increase/decrease grade, or equivalent. Verify that neither green nor red are used for functions other than start or stop.

Pass/Fail Criteria—The console main controls color coding shall conform to the requirements of subsection 5.2.4.2 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.4.2 for evaluating console main controls color coding since the test result is non-quantitative.

5.2.4.3 *Main Control Buttons—Significant Color Value Contrast*—Perform the color value measurement test in 5.3.

5.2.5 *Tactile Requirements:*

5.2.5.1 *Tactile Button Border*—This test is a dimensional inspection and a tactile exam of the sample to ensure that buttons are identifiable by touch alone.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 0.1 mm (0.0040 in.).

Procedure—Inspect all buttons to verify that they are raised or have a raised border. Measure the top of the raised surface to the console background.

Pass/Fail Criteria—The tactile button border shall conform to the requirements of subsection 5.2.5.1 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.5.1 for evaluating and measuring the tactile button border since the test result is non-quantitative.

5.2.5.2 *Tactile Button Function Iconography*—This test is a dimensional inspection and a tactile exam of the sample to ensure that button functions are identifiable by tactile touch.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 0.1 mm (0.0040 in.).

Procedure—Inspect all buttons to verify that they have raised iconography identifying the button function. Inspect all button function text to identify simple iconography (maximum of two characters in length). Measure the top of the raised iconography to the button background. Measure the width of the raised iconography through the centerline of the iconography.

Pass/Fail Criteria—The tactile button function iconography shall conform to the requirements of subsection 5.2.5.2 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.5.2 for evaluating and measuring tactile button function iconography since the test result is non-quantitative.

5.2.5.3 *Tactile Button Function Text*—This test is a visual and dimensional inspection of the sample to ensure that button functions are identifiable tactilely using text that meets the size requirements and to ensure that raised iconography is in an alternative format to Braille.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Inspect all button function text to identify non-simple iconography (more than two characters in length). Measure the height of the smallest lower case and capitalized letter from the top outer edge to the bottom outer edge. Inspect all raised iconography to verify that they are in a format alternative to Braille.

Pass/Fail Criteria—The tactile button function text shall conform to the requirements of subsection 5.2.5.3 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.5.3 for evaluating and measuring tactile button function text since the test result is non-quantitative.

5.2.5.4 *Raised Iconography Height*—This test is a performance inspection of the sample to ensure that raised iconography is resistant to wear.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify calibration of the test apparatus of choice as directed by the equipment manufacturer.

Procedure—Inspect the console surface markings. Run the console through 48 600 cycles with a rub test. Verify that the console surface markings meet the minimum height criteria as specified in 5.2.5.1 and 5.2.5.2 of Specification F3021 after 48 600 cycles are complete.

Pass/Fail Criteria—The raised iconography height shall conform to the requirements of subsection 5.2.5.4 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.5.4 for evaluating the raised iconography height since the test result is non-quantitative.

5.2.5.5 *Button Tactile Feedback*—This is a performance and tactile exam of the sample to ensure that button activation is provided in a tactile or kinesthetic feedback.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Performance and tactile test only.

Procedure—Verify that button activation has tactile or kinesthetic feedback.

Pass/Fail Criteria—The button tactile feedback shall conform to the requirements of subsection 5.2.5.5 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.5.5 for evaluating button tactile feedback since the test result is non-quantitative.

5.2.5.6 *Button Feedback*—This is a performance and tactile exam of the sample to ensure that the button activation mechanism is not touch or close proximity sensing activated, for example, capacitive touch sensors, etc.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Performance and tactile test only.

Procedure—Verify that button does not activate upon touch or close proximity sensing.

Pass/Fail Criteria—The button activation mechanism shall conform to the requirements of subsection 5.2.5.6 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.5.6 for evaluating button activation since the test result is non-quantitative.

5.2.6 *Visual Feedback Requirements:*

5.2.6.1 *Numeric Readout Font/Labels*—This test is a visual and dimensional inspection of the sample to ensure that numeric readout font meets the size criteria and is labeled with function and units.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Inspect all numeric readouts to verify that they are labeled with function and units. Measure the height of the smallest number on the numeric readout from the top outer edge to the bottom outer edge.

Pass/Fail Criteria—The numeric readout font and labels shall conform to the requirements of subsection 5.2.6.1 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.6.1 for evaluating and measuring numeric readout font and labels since the test result is non-quantitative.

5.2.6.2 *Numeric Readouts—Significant Color Value Contrast*—Perform the color value measurement test in 5.3.

5.2.6.3 *Numeric Readout Scrolling Feedback*—This test is a dimensional inspection of the sample to ensure that scrolling numeric readout feedback remains static for a sufficient amount of time.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the time measuring equipment is calibrated and accurate to within 0.2 s in 1 h.

Procedure—Time how long the feedback on all scrolling numeric readouts remains static.

Pass/Fail Criteria—The numeric readout scrolling feedback shall conform to the requirements of subsection 5.2.6.3 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.6.3 for measuring numeric readout scrolling feedback since the test result is non-quantitative.

5.2.6.4 *Numeric Performance Feedback*—This test is a visual and dimensional inspection of the sample to ensure that numeric performance feedback at the end remains static for a sufficient amount of time after stopping the exercise.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the time measuring equipment is calibrated and accurate to within 0.2 s in 1 h.

Procedure—Inspect feedback at the end of the exercise to verify that performance information is provided numerically. Time how long the numeric performance feedback at the end of the exercise remains static.

Pass/Fail Criteria—The numeric performance feedback shall conform to the requirements of subsection 5.2.6.4 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.6.4 for evaluating and measuring numeric performance feedback since the test result is non-quantitative.

5.2.6.5 *Surface Start/Stop Feedback*—This test is a performance of the sample to ensure that start and stop feedback is provided in a visual and non-visual format.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Performance test only.

Procedure—Start and stop the exercise in each program. Verify that there is both visual and non-visual feedback.

Pass/Fail Criteria—The surface stop and start feedback shall conform to performance requirements of subsection 5.2.6.5 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.6.5 for evaluating the surface start and stop feedback since the test result is non-quantitative.

5.2.7 *Audio Feedback Requirements:*

5.2.7.1 *Audio Headphone Jack (Socket) Dimensions*—This test is a dimensional inspection of the sample to ensure that the audio headphone jack (socket) meet the size criteria.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the diameter of the audio headphone jack (socket).

Pass/Fail Criteria—The audio headphone jack (socket) dimensions shall conform to the requirements of subsection 5.2.7.1 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.1 for measuring audio headphone jack (socket) dimensions since the test result is non-quantitative.

5.2.7.2 *Audio Headphone Jacks (Sockets) Location*—This test is a dimensional inspection of the sample to ensure that the audio headphone jack (socket) meet the console location criteria.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the distance from the centerline of the audio headphone jack (socket) to the vertical centerline of the console line of tangency closest to the user. Measure the distance from the centerline of the audio headphone jack (socket) to the lower edge of the console.

Pass/Fail Criteria—The audio headphone jack (socket) console location shall conform to the requirements of subsection 5.2.7.2 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.2 for measuring audio headphone jack (socket) console location since the test result is non-quantitative.

5.2.7.3 *Audio Headphone Jacks (Sockets) Distance to Main Controls*—This test is a dimensional inspection of the sample to ensure that the audio headphone jack (socket) meets the main control buttons distance criteria.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the distance from the center point of the audio headphone jack (socket) to the nearest active edge of each of the following main control buttons: start, quick start, speed, incline or resistance, stop, and emergency or safety stop.

Pass/Fail Criteria—The audio headphone jack (socket) distance to the main control buttons shall conform to the requirements of subsection 5.2.7.3 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.3 for measuring audio headphone jack (socket) distance to the main control buttons since the test result is non-quantitative.

5.2.7.4 *Audio Headphone Jacks (Sockets) Tactile Border*—This test is a dimensional and tactile inspection of the sample to ensure the dimensional compliance of the audio headphone jacks (sockets) border.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 0.1 mm (0.0040 in.).

Procedure—Inspect the audio headphone jacks (sockets) to verify that it has a raised border. Measure the height of the raised button border from the top of the raised surface to the console background.

Pass/Fail Criteria—The dimensions of the audio headphone jacks (sockets) border shall conform to dimensional and tactile requirements of subsection 5.2.7.4 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.4 for measuring the audio headphone jacks (sockets) border since the test result is non-quantitative.

5.2.7.5 *Audio Headphone Jacks (Sockets) Headphone Symbol Location*—This test is a visual inspection of the sample to ensure the compliance of the audio headphone jacks (sockets) headphone symbol location.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual test only.

Procedure—Inspect audio headphone jacks (sockets) to verify that it has a headphone symbol adjacent to it as specified in Specification F3021 Fig. 6.

Pass/Fail Criteria—The location of the headphone symbol shall conform to dimensional requirements of subsection 5.2.7.5 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.5 for the audio headphone jacks (sockets) headphone symbol location since the test result is non-quantitative.

(1) Audio Headphone Jacks (Sockets) Headphone Symbol Location Distance—This test is a dimensional inspection of the sample to ensure the compliance of the audio headphone jacks (sockets) headphone symbol location if the symbol is present on a different plane than the jack (socket).

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Inspect audio headphone jack (socket) to verify if the headphone symbol is located on a different plane. If the symbol is on a different plane, then take a direct measurement of the distance from the center of the symbol to the center of the audio headphone jack. Verify that there is a locating arrow pointing from the symbol to the jack.

Pass/Fail Criteria—The location of the headphone symbol shall conform to dimensional requirements of subsection 5.2.7.5*(1)* of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.5*(1)* for the audio headphone jacks (sockets) headphone symbol location distance since the test result is non-quantitative.

NOTE 4—See Specification F3021 Fig. 6 for the headphone symbol iconography. The shape of the minimum contrast border does not have a defined shape, that is, it may be a circle, square, or mimicking the headphone shape as shown in Fig. 6.

5.2.7.6 *Audio Headphone Jacks (Sockets) Symbol Width*—This test is a dimensional inspection of the sample to ensure the dimensional compliance of the audio headphone jacks (sockets) symbol width.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 0.1 mm (0.0040 in.).

Procedure—Measure the width of the raised headphone symbol through the centerline.

Pass/Fail Criteria—The dimensions of the audio headphone jacks (sockets) symbol width shall conform to dimensional requirements of subsection 5.2.7.6 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.6 for measuring the audio headphone jacks (sockets) symbol width since the test result is non-quantitative.

5.2.7.7 *Audio Headphone Jacks (Sockets) Headphone Symbol Height*—This test is a dimensional test of the sample to ensure the dimensional compliance of the audio headphone jacks (sockets) symbol height.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 0.1 mm (0.0040 in.).

Procedure—Measure the height of the raised headphone symbol from the top of the symbol to the console background as shown in Specification F3021 Fig. 6.

Pass/Fail Criteria—The dimensions of the audio headphone jacks (sockets) symbol height shall conform to dimensional requirements of subsection 5.2.7.7 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.7 for measuring the audio headphone jacks (sockets) symbol height since the test result is non-quantitative.

5.2.7.8 *Audio Headphone Jacks (Sockets) and Headphone Symbol –100 % Color Value Contrast*—This test is a visual inspection, dimensional test, and color value contrast test of the sample to ensure that the headphone symbol meets the color specification. Perform the color value measurement test in 5.3.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Verify the audio headphone jack and symbol color. Measure the distance from the center of the audio headphone symbol to the color contrast background area.

Pass/Fail Criteria—The audio headphone jack and symbol color and color contrast background area shall conform to the requirements of subsection 5.2.7.8 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.8 for evaluating the audio headphone jack and symbol color or color contrast background area since the test result is non-quantitative.

5.2.7.9 *Information Button Location*—This test is a dimensional inspection of the sample to ensure the dimensional compliance of information button location.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Measure the distance from the center point of each information button to the audio headphone jack (socket) center point. Verify button compliance with 5.2.5.

Pass/Fail Criteria—The dimensions of the information button location shall conform to dimensional requirements of subsection 5.2.7.9 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.9 for measuring the information button location since the test result is non-quantitative.

5.2.7.10 *Audio Headphone Jacks (Sockets) Activation/Voltage*—This test is an audio and dimensional inspection of the sample to ensure that audio output level meets the mid-range criteria and is activated as described in Specification F3021.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the voltage measuring equipment is calibrated and accurate to within 0.01 V.

Procedure—Prepare a test tone file with the following parameters:

Form: Sine
Frequency: 1000 Hz
Level: –6 dBFS
Duration: 5 s minimum
Sample Rate: 44.1 kHz

Load the file into the console. Play the audio file while measuring the peak to peak voltage [Vpp] at the headphone jack (socket).

Pass/Fail Criteria—The information button initial activation and voltage level shall conform to the requirements of subsection 5.2.7.10 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.10 for evaluating and measuring headphone jack (socket) initial activation and voltage level since the test result is non-quantitative.

5.2.7.11 *Information Button Universal Symbol*—This test is a visual inspection of the sample to ensure the presence of the information button symbol.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Visual inspection only.

Procedure—Inspect the information button to verify that it is composed of a circle surrounding a lower case letter “i” as shown in Specification F3021 Fig. 7.

Pass/Fail Criteria—The design of the information button symbol shall conform to the information button universal symbol requirements of subsection 5.2.7.11 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.11 for measuring the information button universal symbol since the test result is non-quantitative.

NOTE 5—See Specification F3021 Fig. 7 for the information button symbol iconography.

5.2.7.12 *Information Button Symbol Width*—This test is a dimensional test of the sample to ensure the dimensional compliance of the information button symbol width.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 0.1 mm (0.0040 in.).

Procedure—Measure the width of the information button symbol through the centerline.

Pass/Fail Criteria—The dimensions of the information button symbol width shall conform to dimensional requirements of subsection 5.2.7.12 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.12 for measuring the information button symbol width since the test result is non-quantitative.

5.2.7.13 *Information Button Symbol Height*—This test is a dimensional test of the sample to ensure the dimensional compliance of the information button symbol height.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 0.1 mm (0.0040 in.).

Procedure—Measure the height of the information button symbol from the top of the symbol to the button background.

Pass/Fail Criteria—The dimensions of the information button symbol height shall conform to dimensional requirements of subsection 5.2.7.13 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.13 for measuring the information button symbol height since the test result is non-quantitative.

5.2.7.14 *Information Button Symbol – 100 % Color Value Contrast*—This test is a visual inspection, dimensional test, and color value contrast test of the sample to ensure that the information symbol meets the color specification. Perform the color value measurement test in 5.3.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the distance measuring equipment is calibrated and accurate to within 1 mm (0.040 in.).

Procedure—Verify the information button symbol color. Measure the distance from the center of the information button symbol to the color contrast background area.

Pass/Fail Criteria—The information button symbol color and color contrast background area shall conform to the requirements of subsection 5.2.7.14 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.14 for evaluating the information button symbol color or color contrast background area since the test result is non-quantitative.

5.2.7.15 *Audible Feedback Instruction Initiation*—This test is an audio inspection of the sample to ensure that audible feedback instructions are initiated upon pressing the information button.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Audio inspection only.

Procedure—Ensure the sample is out of standby mode, that is, fully operational. Plug in headphones and activate the information button. Verify that audible feedback instructions start.

Pass/Fail Criteria—The initiation of audible feedback instructions upon pressing the information button shall conform to the requirements of subsection 5.2.7.15 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.15 for evaluating initiation of audible feedback instructions upon pressing the information button since the test result is non-quantitative.

5.2.7.16 *Audible Feedback Instruction Volume/Pause Mode*—This test is an audio inspection of the sample to ensure that audible feedback instructions on volume and pause mode status are provided.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Audio inspection only.

Procedure—Put the sample in pause mode. Plug in headphones and activate the information button. Verify that audible feedback instructions on how to adjust the volume and the status of pause mode are provided first in the series of instructions.

Pass/Fail Criteria—The audible feedback instruction volume/pause mode shall conform to the requirements of subsection 5.2.7.16 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.16 for evaluating audible feedback instruction volume/pause mode since the test result is non-quantitative.

5.2.7.17 *Audible Feedback Instruction Content*—This test is an audio inspection of the sample to verify audible feedback instruction content.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Audio inspection only.

Procedure—Plug in headphones, activate the information button, and verify that audible feedback instructions are provided and include specified content.

Pass/Fail Criteria—The audible feedback instruction content shall conform to the requirements of subsection 5.2.7.17 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.17 for evaluating audible feedback instruction content since the test result is non-quantitative.

5.2.7.18 *Bypass/Stopping Audible Feedback Instructions*—This test is an audio inspection of the sample to ensure that instructions on how to bypass or stop audible feedback instructions are provided at the beginning of the instructions.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Audio inspection only.

Procedure—Plug in headphones, activate the information button, and verify that instructions on how to bypass/stop audible feedback instructions are given following the volume and pause mode information.

Pass/Fail Criteria—The instructions on how to bypass/stop audible feedback instructions shall conform to the requirements of subsection 5.2.7.18 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.18 for evaluating the instructions on how to bypass/stop audible feedback instructions since the test result is non-quantitative.

5.2.7.19 *Bypassing/Stopping Audible Feedback Instructions*—This test is a performance inspection of the sample to ensure that bypassing/stopping audible feedback instructions is achievable by pressing any other function button on the console.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Audio inspection only.

Procedure—Plug in headphones, activate the information button, and start workout program. Activate another function button on the console. Verify that audible feedback instructions stop. Repeat for each function button on the console. Repeat for each program setting, including default and pre-set programs.

Pass/Fail Criteria—The bypassing/stopping audible feedback instructions shall conform to the requirements of subsection 5.2.7.19 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.19 for evaluating bypassing/stopping audible feedback instructions since the test result is non-quantitative.

5.2.7.20 *Deactivating Audible Feedback Information*—This test is an audio inspection of the sample to ensure that audible feedback information can be deactivated.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Audio inspection only.

Procedure—Plug in headphones, activate the information button, and start workout program. Depress the information button twice. Verify that audible feedback information stops for the duration of the workout. Repeat for each program setting, including default and pre-set programs.

Pass/Fail Criteria—Deactivating audible feedback information shall conform to the requirements of subsection 5.2.7.20 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.20*(1)* for evaluating the reactivation of audible feedback information since the test result is non-quantitative.

(1) Reactivating Audible Feedback Information—This test is an audio inspection of the sample to ensure that audible feedback information can be reactivated after being deactivated.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Audio inspection only.

Procedure—Plug in headphones, activate the information button, and start workout program. Depress the information button twice to stop audible feedback information. Once audible feedback information is stopped, press the information button. Verify that the audible feedback information restarts. Repeat for each program setting, including default and pre-set programs.

Pass/Fail Criteria—Reactivating audio information shall conform to the requirements of subsection 5.2.7.20*(1)* of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.20*(1)* for evaluating the reactivation of audio information since the test result is non-quantitative.

5.2.7.21 *Main Control Function Changes Audible Feedback*—This test is an audio inspection of the sample to ensure that main control function changes are available in audible voice/speech format.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Audio inspection only.

Procedure—Plug in headphones, activate the information button, and start workout program. Verify that main control function changes are available in audible voice/speech output. Repeat for each program setting, including default and pre-set programs.

Pass/Fail Criteria—The main control function changes audible feedback shall conform to the requirements of subsection 5.2.7.21 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.21 for evaluating the main control function changes audible feedback since the test result is non-quantitative.

5.2.7.22 *Pre-Programmed Program Selections Audible Feedback*—This test is an audio inspection of the sample to ensure that pre-programmed program selections are available in audible voice/speech format.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Audio inspection only.

Procedure—Plug in headphones, activate the information button, and start pre-programmed program. Verify that the pre-programmed program selections are available in audible voice/speech output upon selection. Repeat for each pre-programmed program setting.

Pass/Fail Criteria—The pre-programmed program selections audible feedback shall conform to the requirements of subsection 5.2.7.22 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.22 for evaluating pre-programmed program selections audible feedback since the test result is non-quantitative.

5.2.7.23 *Pre-Programmed Audible Feedback Change Alerts*—This test is a durational inspection of the sample to ensure that pre-programmed changes provide a sufficient alert in audio voice/speech feedback.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the time measuring equipment is calibrated and accurate to within 0.2 s in 1 h.

Procedure—Plug in headphones, activate the information button, and start workout program. Verify that preprogrammed changes for speed, incline, and/or resistance provide an audible feedback alert. Time how long the change takes to go into effect from the time the alert is given. Repeat for each program setting, including default and pre-set programs.

Pass/Fail Criteria—The pre-programmed audible feedback change alerts shall conform to the requirements of subsection 5.2.7.23 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.23 for measuring pre-programmed audible feedback change alerts since the test result is non-quantitative.

5.2.7.24 *Performance Audible Feedback*—This test is an audio inspection of the sample to ensure that performance audible feedback is available in voice/speech format in set increments and upon demand.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the time measuring equipment is calibrated and accurate to within 0.2 s in 1 h.

Procedure—Plug in headphones, activate the information button, and start workout program. Verify that performance audible feedback, for example, speed or RPM or SPM, time elapsed, distance traveled, incline, heart rate, and calories burned, is available upon demand by pressing the information button. Time how long the interval is between the ending of performance summary feedback before it automatically starts over again. Repeat for each program setting, including default and pre-set programs.

Pass/Fail Criteria—The performance audible feedback shall conform to the requirements of subsection 5.2.7.24 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.24 for evaluating the performance audible feedback since the test result is non-quantitative.

5.2.7.25 *Workout Program Audible Feedback*—This test is an audio inspection of the sample to ensure that workout program audible feedback is available in voice/speech format for any change in parameters.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the time measuring equipment is calibrated and accurate to within 0.2 s in 1 h.

Procedure—Plug in headphones, activate the information button, and start workout program. Time how long the interval is between the audible feedback alerting of an upcoming, automated parameter change and the actual change occurring. Verify that any manual change in parameters has an audible feedback alert immediately upon the change. Repeat for each program setting, including default and pre-set programs.

Pass/Fail Criteria—The workout program audible feedback shall conform to the requirements of subsection 5.2.7.25 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.25 for evaluating the workout program audible feedback since the test result is non-quantitative.

5.2.7.26 *Workout Program Heart Rate Audible Feedback*—This test is an audio inspection of the sample to ensure that workout program heart rate information is available in audible feedback if undetectable when visual feedback is provided.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—Verify that the time measuring equipment is calibrated and accurate to within 0.2 s in 1 h.

Procedure—Plug in headphones, activate the information button, and start workout program. Detect heart rate and then remove heart rate. Verify that if the loss of heart rate is provided in visual feedback, then it is also announced in audible feedback. Time the interval of the first announcement and following announcements. Increase the heart rate until it is out of the pre-set range and verify that if there is visual feedback, then there is corresponding audible feedback. Repeat for each program setting, including default and pre-set programs.

Pass/Fail Criteria—The workout program heart rate audible feedback shall conform to the requirements of subsection 5.2.7.26 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.26 for evaluating the workout program heart rate audible feedback since the test result is non-quantitative.

5.2.7.27 *Performance Summary Audible Feedback*—This test is an audio inspection of the sample to ensure that performance summary feedback is available in audible voice/speech format post exercise.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Audio inspection only.

Procedure—Plug in headphones, activate the information button, start workout program. Verify that performance summary audible feedback is available in voice/speech format post exercise and repeats until the summary screen times out. Repeat for each program setting, including default and pre-set programs.

Pass/Fail Criteria—The performance summary audible feedback shall conform to the requirements of subsection 5.2.7.27 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.27 for evaluating the performance summary audible feedback since the test result is non-quantitative.

5.2.7.28 *Default Language*—This test is an audio inspection of the sample to ensure that the default language matches the written text on the equipment labels/displays.

Apparatus and Set Up—The sample shall be set up as described in Section 4.

Calibration—No calibration required. Audio inspection only.

Procedure—Plug in headphones, activate the information button, and verify that the default audible feedback language matches that used on the written text on the equipment labels/display.

Pass/Fail Criteria—The default language shall conform to the requirements of subsection 5.2.7.28 of Specification F3021.

Precision and Bias—No information is presented about either the precision or bias of test 5.2.7.28 for evaluating the default language since the test result is non-quantitative.

5.3 *Color Value Contrast – Color Value Measurement Method:*

5.3.1 *Measurement Equipment*—In order to perform the following color value measurement test, light meter(s) should be used that perform both incident light and reflected spot operations.

NOTE 6—Some light meters that are currently available on the market perform both incident light and reflected spot operations. However, using two individual light meters that each measure one of the operations may also be acceptable. Limited research has been done using meters other than the Sekonic L-758CINE. Future research should include other meters.

NOTE 7—For reference on how to hold and use the light meter for measuring incident and reflected light, see "ILS Test Protocol," the video created for the interlaboratory study protocol used to measure the precision of this method, online at https://www.youtube.com/watch?v=s1_fSApYyWk.

NOTE 8—For reference on how to display the lux and cd/m^2 modes on the Sekonic L-758CINE light meter, see the manual or the video "Lux on the Sekonic L758CINE meter," online at https://www.youtube.com/watch?v=oBixddCDlok.

5.3.1.1 *Incident Light Meter Operation*—Incident Light Meters operate by reading incident light (or light illuminating an object) through the use of a lumisphere or dome. The user holds the meter away from their person, flush against the object and the meter reads all the light that is illuminating the object. Please reference the specific manual for the meter being used for additional instructions on operation.

(a) Turn the Incident Light Meter's power on.

(b) Set the lumisphere to the extended position.

(c) Set the metering mode to measure illuminance in lux or foot candles (fc).

(d) Place the meter flush against the surface of the object to be recorded, with the lumisphere facing away from the surface, and ensure that the test administrator is not casting a shadow over the lumisphere (see Fig. 13).

NOTE 9—The testing technician should not block the light source when taking a reading with the lumisphere or with the spot meter (see Fig. 13).

(e) Press and release the measuring button.

(f) Record the value seen on the screen of the device.

5.3.1.2 *Reflected Spot Meter Operation*—Reflected Spot Meters measure the amount of light reflecting off an object's surface, also known as luminance. Spot Meters are operated by the user looking through the spot lens much like one would look through the view finder of a camera. Please reference the

FIG. 13 Incident Light Meter Positioning

specific manual for the meter being used for additional instructions on operation.

(a) Turn the Reflected Spot Meter's power on.

(b) Set the metering mode to measure luminance in candela per square meter (cd/m^2).

(c) Remove the lens cap on the spot lens.

(d) Position the meter at the intended user's viewing distance from the surface of the object to be measured. The distance must be a minimum of 1000 mm (39.4 in.) away from the surface of the object to be measured. The maximum distance will be limited by the size of the sample surface that is being measured with the 1° Reflected Spot Meter.

(e) Record the distance on the data form.

(f) Ensure that the subject material of the object to be measured is at least 25.4 by 25.4 mm (1 by 1 in.) if measuring at a distance of 1000 mm (39.4 in.). If measuring from a greater distance, ensure that the subject material completely fills the 1° circle when looking through the Reflected Spot Meter's lens (see Figs. 14-17). If the subject material, for example text on a console, is not large enough to fill the 1° circle when measuring at a minimum distance of 1000 mm (39.4 in.), a color swatch that matches the color and material in the lighting that exists at the time of testing must be used in place of the actual subject material.

NOTE 10—Do not attempt to make readings at distances closer than 1000 mm (39.4 in.). Moving closer to a smaller target area blurs the reading on a 1° Reflected Spot Meter and the measurement will not be accurate. Consult the meter's manual for its minimum measurement distance.

(g) Position the meter at the intended viewing angle of potential users. Ensure that the intended users' viewing angles are within a ±45° range perpendicular to the object's surface. As a reference, see Table 1 for sitting and standing heights of males and females. Record the horizontal and vertical angles using a protractor or a clinometer, or both.

NOTE 11—Preliminary research shows that measuring luminance within a ±45° range from perpendicular provides repeatable results as compared to measuring luminance from perpendicular.

(h) Look through the view finder of the meter, ensuring that the subject material (for example, the gray card, object/text/symbol, or background) fills the 1° circle in the eyepiece (see Fig. 18).

NOTE 12—A light source too far behind the testing technician would block the light and create a shadow on the measurement location, even if the shadow is not visible to the naked eye (see Fig. 18 and Fig. 19).

NOTE 13—If the item being viewed has a surface that is less than one square inch or otherwise does not fill the 1° circle in the eyepiece of the spot meter, a color swatch of the same material with the color applied should be placed on that part of the device for viewing with the light meter (see Fig. 18). For fitness equipment with instructions and labels, the colors used need to be created in a one-inch-square swatch format for viewing with the spot meter.

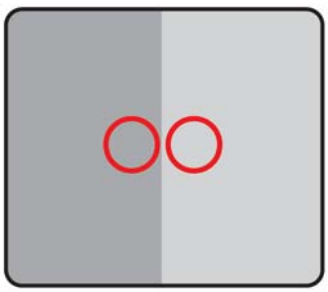

FIG. 14 Proper Measurement: Measurement readings are adjacent on an edge of contrast; the circles of the Spot Meter are close together on each side of the contrast edge

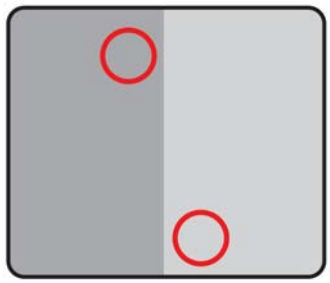

FIG. 15 Improper Measurement: The measurement readings are not adjacent to each other on the edge of contrast

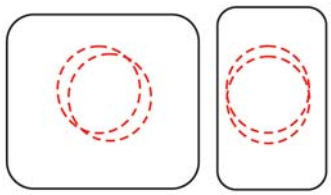

FIG. 16 Proper Measurements: The circle of the Spot Meter is fully contained within the object's surface; the readings are taken at the same spot on the surface

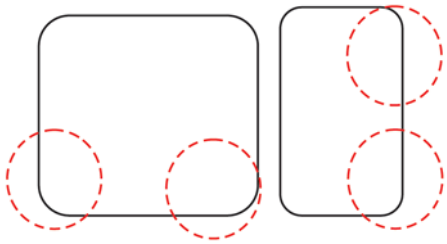

FIG. 17 Improper Measurement: The circle of the Spot Meter extends past the edge of the surface of the object; the reading placement on the object is not representative of the surface; the readings are not taken at the same spot on the surface

NOTE 14—If the subject material is a color swatch, not the actual object, then the color swatch needs to be aligned on the surface of the final subject material that it represents.

(i) Press and release the measuring button. Repeat as indicated in the test procedure.

(j) Record the value(s) seen on the screen of the device.

NOTE 15—Some meters display results differently, for example 110 cd/m^2 may be displayed as 11_0 cd/m^2. Refer to your meter's manual for additional instructions.

5.3.1.3 *Verify Calibration of Meter(s)*—Calibration of the light meter(s) should be confirmed before using the equipment for testing.

(a) Place a standard 18 % reflectance gray card so that it is aligned flush against the object.

(b) Measure the illumination level, positioning the Incident Light Meter (see 5.3.1.1 Incident Light Meter Operation) flush against the gray card. Repeat the measurement three times across the surface of the object to be measured in order to

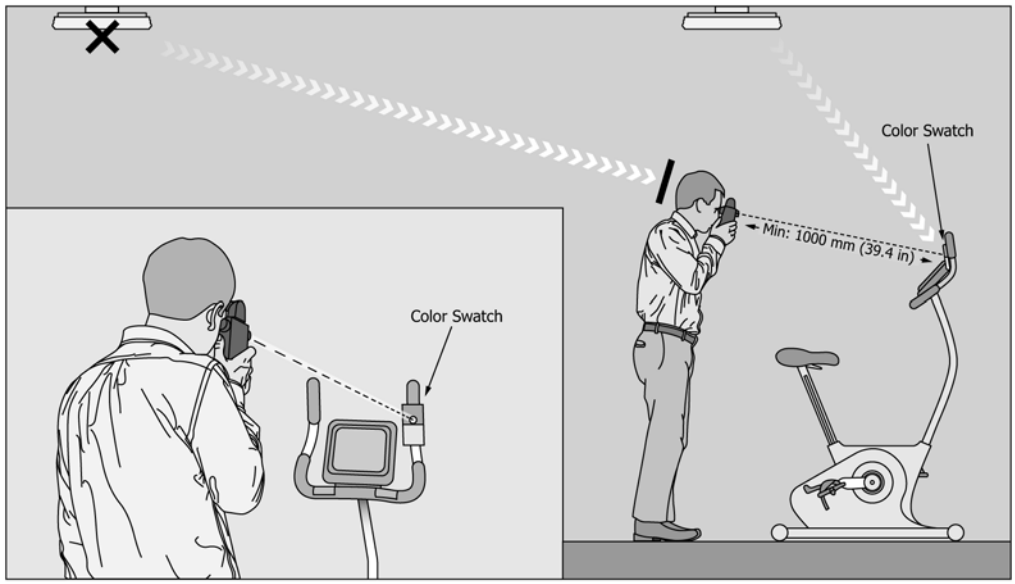

FIG. 18 Reflected Spot Meter Use, Positioning, Lighting, and Color Swatch Alignment

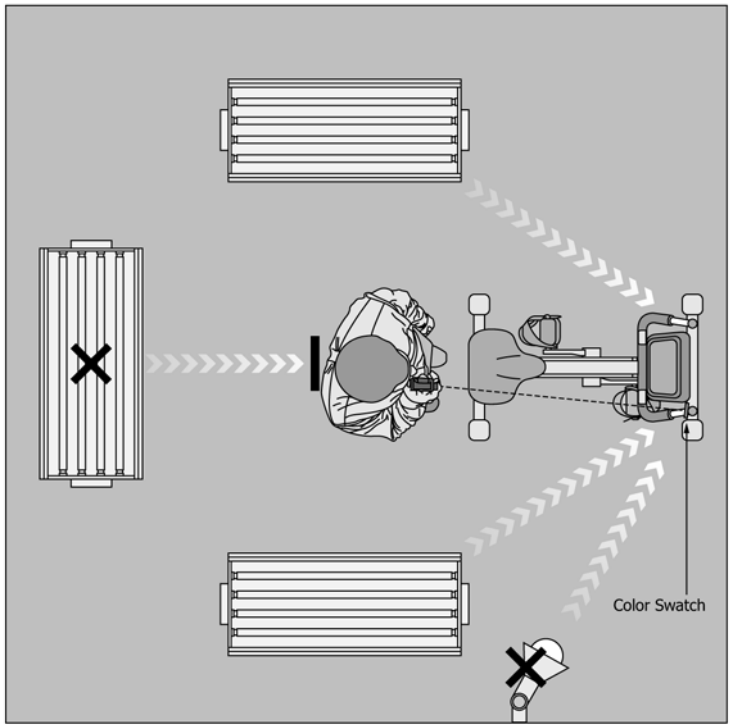

FIG. 19 Lighting Positioning

obtain a representative sample, and record each reading on the data form. Calculate the average of the three readings to one decimal place and record the average illumination on the data form.

(c) Measure the luminance of the standard 18 % reflectance gray card using the Reflected Spot Meter (see 5.3.1.2 Reflected Spot Meter Operation). Repeat the measurement three times across the surface of the object to be measured in order to obtain a representative sample, and record each reading on the data form. Calculate the average of the three readings to one decimal place and record the average luminance on the data form.

(d) Check the calibration of the meter(s) by comparing the average illumination to the average luminance of the gray card. Using the illumination value as the x-axis value and using the luminance value as the y-axis value, plot these two numbers as one point (x, y) on the graph in Fig. A3.1 or the graph in Fig. A3.2. Refer to the graph in Fig. A3.1 if illumination was

recorded in lux. Refer to the graph in Fig. A3.2 if illumination was recorded in foot candles. If the plotted data point falls within the shaded area on the related graph, then the meter(s) are calibrated and appropriate to use for testing. If the point does not fall within the shaded area, one or both of the meters are not properly calibrated and should be checked before testing.

NOTE 16—Preliminary testing and the interlaboratory precision study on color value contrast procedures and methods were performed using the Sekonic L-758CINE meter (2012/2013/2015/2016). Preliminary testing with other meters under the same conditions and using the same color sets as used in the interlaboratory precision study showed significantly different color value contrast readings. Until more testing is done, the current best practice is to use the Sekonic L-758CINE meter for color value contrast testing.

5.3.2 *Test Setup:*

5.3.2.1 *Testing Environment – Laboratory*—This test environment will be a controlled laboratory environment. For a field environment, please see the following section, 5.3.2.2. Objects that will be used in a variety of environments should be tested in a laboratory environment.

(a) Test Environment Set Up—The environment in which the color value contrast test is being conducted should be able to sustain the same lighting conditions for the duration of the test. It is recommended that the test environment be a windowless room. Allow light fixtures to warm up for at least 15 min before performing testing, as lighting levels may vary as the lights warm up. The test administrator should wear non-reflective clothing, avoiding shiny clothing, including leather.

(b) Lighting Requirements—Luminance values should be measured under lighting conditions for the equipment or object's intended environment of use. Lighting conditions should be within the range of 9 to 37 foot candles or 100 to 400 lux for testing. Refer to the three readings and average for illumination recorded in 5.3.1.3b. If the illumination level is uniform across the surface and measures between 9 to 37 foot candles or between 100 to 400 lux, then the environment has suitable minimum levels of lighting. If the illumination level is outside this range, then the test environment will need to be altered by adding or removing lighting fixtures or light bulbs until the illumination level is within the specified range.

NOTE 17—Light in the laboratory should come equally from both sides. Avoid lighting the testing area from only one side (see Fig. 19). Equal lighting can be confirmed by steady lux readings across the surface of the gray card when calibrating the meter.

NOTE 18—Readings should not be made when there is a reflection or glare being caused by the lighting. When making a measurement under field conditions in an existing facility, if there is reflection or glare, this is a problem with the facility layout, not the contrast of the colors on the device or signage.

NOTE 19—In the interlaboratory precision study, less variability between data from different labs was seen at the high end of the light level range specified in this standard. Less variability between tests done by the same technician was seen at the low end of the light level range specified. As a result, it is a best practice to test the color value contrast of color pairings at both the low and the high ends of the light level range specified to obtain a more accurate color value contrast result.

NOTE 20—Future research should include examining the effects of different types of lighting on the color value contrast results to determine whether the type of lighting should be specified. Three different types of lighting were used in the interlaboratory study.

5.3.2.2 *Testing Environment – Field*—This test environment will be a field environment in which the fitness equipment is intended to be used for verifying compliance. For a laboratory environment, please see the previous section, 5.3.2.1. Follow the testing environment setup in 5.3.2.1. Do not alter existing lighting. Record the range of illumination values on the data sheet.

NOTE 21—Illumination levels (measured in lux or foot candles) will fluctuate in different environments. For example, an office may have higher illumination levels averaging 450 to 900 lux. For a single-lab study of this color value contrast test method at office light levels, see Appendix X1.

5.3.2.3 *Color Value Contrast Documentation*—Record the following information on the data form (see Fig. A2.1 for a blank data form, Fig. A2.2 for a data form with sample data, and Fig. A2.3, Fig. A2.4, and Fig. A2.5 for examples of correct and incorrect numbers of measurements):

(1) Organization, address, phone number, and test administrator

(2) Date, time, and location

(3) Object make and model

(4) Object description (example: seated leg press machine)

(5) Luminance descriptions (example: black frame and yellow seat)

(6) Photographs of the object and the test environment (optional, for reference)

(7) Light meter(s) make/model - incident light/illumination and reflected spot/luminance operations

5.3.3 *Color Value Contrast Measurement Method*—Measurement readings for Luminance 1 (L1) and Luminance 2 (L2) should be done adjacent to the edge of contrast, see Figs. 14 and 15.

5.3.3.1 *Luminance Measurements for Lighter Subject (L1)*—Luminance 1 (L1) will be the lighter/brighter object, text, symbol, or background.

NOTE 22—The value for L1 should always be larger than L2. If the data you record for L1 is smaller than L2, then the identification of the lighter and darker subjects were switched.

(a) Using the Reflected Spot Meter (see 5.3.1.2 Reflected Spot Meter Operation), measure the luminance of the brighter/lighter object, text, or symbol. Record between two and four readings for L1 (see Table 2 and Fig. A2.3, Fig. A2.4, and Fig. A2.5 for examples of correct and incorrect numbers of measurements).

(b) Take two initial readings of L1 at the same point or spot on the surface (see Figs. 16 and 17). Keep the meter stationary throughout the duration of the readings. If the first two readings are identical, record these values on the data sheet. If the first two readings are not identical, repeat the measurement a third or fourth time until you have two consecutive readings that are identical. If readings 2 and 3 are identical this is also valid.

(c) If the measurements alternate back and forth across four readings between two values (for example 14 cd/m^2 and 15 cd/m^2), then the luminance is borderline. Record the two values on the data form. Calculate the average of the two readings to one decimal point and record the average luminance for L1 on the data form.

(d) If a third measurement value occurs during the readings (for example 14 cd/m^2, 15 cd/m^2, and 16 cd/m^2), verify that the

TABLE 2 Example Luminance Measurement Collection Process

Situation	Readings		Record		Match or Average
Readings 1 & 2 are identical	Pt1	30 cd/m^2	No. 1	30 cd/m^2	30 cd/m^2
	Pt2	30 cd/m^2	No. 2	30 cd/m^2	
	Pt3	NA			
	Pt4	NA			
Readings 2 & 3 are identical	Pt1	30 cd/m^2			45 cd/m^2
	Pt2	45 cd/m^2	No. 1	45 cd/m^2	
	Pt3	45 cd/m^2	No. 2	45 cd/m^2	
	Pt4	NA			
Readings 3 & 4 are identical	Pt1	30 cd/m^2			30 cd/m^2
	Pt2	45 cd/m^2			
	Pt3	30 cd/m^2	No. 1	30 cd/m^2	
	Pt4	30 cd/m^2	No. 2	30 cd/m^2	
Readings 1-4 alternate between two values	Pt1	30 cd/m^2	No. 1	30 cd/m^2	37.5 cd/m^2
	Pt2	45 cd/m^2	No. 2	45 cd/m^2	
	Pt3	30 cd/m^2			
	Pt4	45 cd/m^2			
Readings alternate between three or more values	Pt1	30 cd/m^2	No. 1	NA	Check measurement distance, angle, and lighting. Then start over.
	Pt2	45 cd/m^2	No. 2	NA	
	Pt3	30 cd/m^2			
	Pt4	50 cd/m^2			

TABLE 3 Color Value Contrast at Low Light Level of 100 to 150 lux (%)

Contrast	Average	S_r (repeatability standard deviation)	r (repeatability limit)	S_R (reproducibility standard deviation)	R (reproducibility limit)
Black and Bluish-Green	83.08	0.49	1.38	2.91	8.15
Blue and Yellow-Green	72.25	0.70	1.96	4.58	12.84
White and Yellow	36.66	1.22	3.42	5.66	15.84

TABLE 4 Color Value Contrast at High Light Level of 300 to 400 lux (%)

Contrast	Average	S_r (repeatability standard deviation)	r (repeatability limit)	S_R (reproducibility standard deviation)	R (reproducibility limit)
Black and Bluish-Green	85.49	0.63	1.76	2.22	6.22
Blue and Yellow-Green	74.51	0.99	2.79	3.45	9.65
White and Yellow	34.44	1.29	3.61	4.82	13.49

following are remaining static: measurement distance, angle, and lighting and then restart the measurement procedure for L1.

5.3.3.2 *Luminance Measurements for Darker Subject (L2)*—Luminance 2 (L2) will be the darker object, text, symbol, or background. Follow the procedure from 5.3.3.1, measuring the luminance of the darker object, text, or symbol.

5.3.3.3 *Calculate Contrast*—Calculate the contrast between L1 and L2 using the Contrast Equation (Eq 1) to one decimal place and record the result on the data form.

$$Contrast = [(L1 - L2)/L1] \times 100 \quad (1)$$

where:

L1 = luminance of the lighter area, and
L2 = luminance of the darker area.

NOTE 23—If the calculated contrast result is negative, the luminance readings were reversed. Repeat the calculation, correcting the order of the luminance readings in the contrast formula.

5.4 *Color Value Contrast Precision and Bias:*

5.4.1 *Potential Sources of Error or Deviations:*

5.4.1.1 Variations in illuminance levels due to change in position of the operator, light source, or object.

5.4.1.2 Variations in luminance levels due to change in position of the operator, light source, or object.

5.4.2 *Precision*—The precision of this test method is based on an interlaboratory study conducted in 2015 and 2016.[4] Eleven laboratories tested pairings of standardized color cards for color value contrast at the high and low ends of the light range specified in the standard. Every "test result" represents

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:F08-1014. Contact ASTM Customer Service at service@astm.org.

an individual determination; and all laboratories reported triplicate test results. Practice E691 was followed for the design and analysis of the data. For a single-lab study done at a higher light level (500 to 850 lux), see Appendix X1.

5.4.2.1 *Repeatability (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

(1) Repeatability can be interpreted as the maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

(2) Repeatability limits are listed in Table 3 and Table 4.

5.4.2.2 *Reproducibility (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

(1) Reproducibility can be interpreted as the maximum difference between two results, obtained under reproducibility conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

(2) Reproducibility limits are listed in Table 3 and Table 4.

5.4.2.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

5.4.2.4 Any judgment in accordance with statements 5.4.2.1 and 5.4.2.2 would have an approximate 95 % probability of being correct.

NOTE 24—Due to the approximately 10-point reproducibility limit for color pairings close to 70 % color value contrast, it is a best practice to choose color pairs that have a color value contrast of greater than 80 %. This will provide a better chance of the color pair meeting the 70 % color value contrast requirement if tested under reproducibility conditions.

5.4.3 *Bias*—At the time of the study, there was no accepted certified reference material suitable for determining the bias for this color value contrast method, therefore no statement on bias is being made.

5.4.4 The precision statement was determined through statistical examination of all usable test data points, from 11 laboratories, on 3 different color combinations. To judge the equivalency of two test results, it is recommended to choose the color combinations closest in characteristics to the test pairings.

6. Certification

6.1 These test methods permit self-certification. It is recommended that each manufacturer employ an independent laboratory to evaluate and validate that their designs and test procedures conform and comply with these test methods and Specification F3021.

NOTE 25—The test methods and procedures described in Section 5 should be supported by conducting user testing using subjects across a range of disabilities, impairments, and ages and those without disability on the sample equipment.

7. Report

7.1 *Record of Tests*—Maintain complete test records and test summary reports for all testing, whether performed by the manufacturer or an independent laboratory. The records can be stored on paper, electronically, or on photographs, or a combination thereof. A copy of the test summary must be kept by the laboratory that performed the test for a minimum of five years from the date of the test and by the manufacturer for a minimum of five years past the end of production of the model tested. The summary shall include the signature of the person(s) performing the tests and a management representative of the laboratory performing the test. The test summary shall include the following information:

7.1.1 Manufacturer's name and location,

7.1.2 Information provided by the manufacturer to accurately identify the configuration of, and specific unit provided to, the testing agency,

7.1.3 Dates over which the tests were conducted,

7.1.4 Name and location of the testing laboratory, if different from the manufacturer, and

7.1.5 Summary and results of each test performed including method and apparatus used. This shall include what the desired requirement was and whether the test sample met that parameter or failed. If the test requires a specific number of cycles to be met, then the report must include the number of cycles actually conducted. If the apparatus fails to meet a parameter, then that failure must be noted in clear and accurate terms to enable a reader of the report to understand at a later date what transpired.

8. Keywords

8.1 accessibility; Americans with Disabilities Act (ADA); disability; disabled; inclusive; universal

ANNEXES

(Mandatory Information)

A1. ADDITIONAL READING

A1.1 ASTM Standards[5]

F1250 Standard Safety Specification for Stationary Exercise Bicycles

F1749 Standard Specification for Fitness Equipment and Fitness Facility Safety Signage and labels

F2106 Standard Test Methods for Evaluating Design and Performance Characteristics of Motorized Treadmills

F2277 Standard Test Methods for Evaluating Design and Performance Characteristics of Selectorized Strength Equipment

F2811 Standard Test Methods for Evaluating Design and Performance Characteristics of Elliptical Trainers

A1.2 European Standards[6]

EN 957-1: Stationary training equipment. General safety requirements and test methods

EN 957-2: Strength training equipment. Strength training equipment, additional specific safety requirements and test methods

EN 957-5: Stationary training equipment. Stationary exercise bicycles and upper body crank training equipment, additional specific safety requirements and test methods

EN 957-6: Stationary training equipment. Treadmills, additional specific safety requirements and test methods

A1.3 US Access Board[7]

"Accessible Sports Facilities." (June 2003.) Retrieved June 28, 2013.

"The Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities." (Sept. 2002.) Retrieved January 11, 2010.

A1.4 Other

BS 8300: Design of Buildings and their approaches to meet the needs of disability people- code of practice – British Standard Institute[8]

[5] 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.

[6] Available from European Committee for Standardization (CEN), Avenue Marnix 17, B-1000, Brussels, Belgium, http://www.cen.eu.

[7] Available from US Access Board, www.access-board.gov, or contact the US Access Board Customer Service at ta@access-board.gov.

[8] Available from British Standards Institution (BSI), 389 Chiswick High Rd., London W4 4AL, U.K., http://www.bsigroup.com.

A2. SAMPLE VALUE (COLOR) CONTRAST DATA FORM

Color Contrast Data Form

Testing Organization Information

Organization _____ Contact Name _____

Address _____ Phone _____

_____ Email _____

Testing Equipment

Incident Light Meter

Make/Model _____

Reflected Spot Meter

Make/Model _____

Illumination level [lux or foot candles (fc)]
From 100 to 400 lux or 9 to 37 fc

#1	#2	#3	Average

Luminance of 18% Gray Card [candela per square meter (cd/m²)]

#1	#2	#3	Average

Meter Calibration

Plot the average illumination and average luminance as a point on the graph in Annex C1 (for lux) or the graph in Annex C2 (for fc):

(X, Y) = (_____ , _____)
lux or fc cd/m²

where
X = average illumination level (lux or fc)
Y = average luminance of gray card (cd/m²)

Does the above plotted point fall within the shaded area of the graph in Annex C.1 (for lux) or the graph in Annex C.2 (for fc)?

☐Yes – The meter(s) are calibrated
☐No – Check the meter(s)' calibration before testing

Testing Environment

Is the test environment able to sustain same lighting conditions throughout the test? ☐Yes ☐No

Is the test administrator wearing non-reflective clothing? ☐Yes ☐No

Does the test environment have windows? ☐Yes ☐No

If the test environment has windows are they shaded? ☐Yes ☐No ☐N/A

What kind of light does the test environment have?
☐ natural ☐ incandescent ☐ fluorescent ☐ light-emitting diode (LED) ☐ other:_____

Are the illumination levels within 9 to 37 fc or 100 to 400 lux? ☐Yes ☐No

FIG. A2.1 Blank Data Form

Test Information

Date:_____ Test Location:_____

Time:_____ Test Administrator(s):_____

Object Information

Object Description:_____

L1 Description (lighter part of object):_____

L2 Description (darker part of object):_____

Is the distance to object 1 meter (39.4 in.) or more? ☐Yes ☐No

Can the 1° circle be completely filled with the desired subject? ☐Yes ☐No

Intended viewing angles are within ± 45 degrees perpendicular to the object's surface? ☐Yes ☐No

Horizontal Angle:_____ Vertical Angle:_____

Luminance Measurements

L1 (cd/m²) lighter		**L2 (cd/m²)** darker	
1	2	1	2
3	4	3	4
Match or Average		Match or Average	

Contrast Calculation

Contrast = [(L1 – L2)/L1] × 100

where

L1 = Luminance of the lighter area and,

L2 = Luminance of the darker area

Contrast should be ≥____% *

[(_____ - _____)/ _____] × 100 =_____ %
L1 L2 L1 Contrast

Subtract L2 from L1, the result of which is divided by L1. Multiply the result by 100 to get a percentage.

*US Access Board recommends a contrast of ≥ 70% in Clause A4.30.5 of the 2002 ADA Accessibility Guidelines (ADAAG)

This project was funded by the Rehabilitation Engineering Research Center on RecTech through the National Institute on Disability and Rehabilitation Research under the US Department of Education grant #H133E070029

FIG. A2.1 Blank Data Form *(continued)*

Color Contrast Data Form

Testing Organization Information

Organization	Beneficial Designs, Inc.	Contact Name	Harmony Hilderbrand
Address	2240 Meridian Blvd	Phone	775-783-8822
	Minden, NV 89423	Email	mail@beneficialdesigns.com

Testing Equipment

Incident Light Meter

Make/Model: Sekonic L-758CINE

Reflected Spot Meter

Make/Model: (same) Sekonic L-758CINE

Illumination level [lux or foot candles (fc)]
From 100 to 400 lux or 9 to 37 fc

#1	#2	#3	Average
140	130	120	130 lux

Luminance of 18% Gray Card [candela per square meter (cd/m^2)]

#1	#2	#3	Average
6.5	6.5	7.5	6.8

Meter Calibration

Plot the average illumination and average luminance as a point on the graph in Annex C1 (for lux) or the graph in Annex C2 (for fc):

(X,Y) = (130 (lux) or fc , 6.8 cd/m^2)

where
X = average illumination level (lux or fc)
Y = average luminance of gray card (cd/m^2)

Does the above plotted point fall within the shaded area of the graph in Annex C.1 (for lux) or the graph in Annex C.2 (for fc)?

☒ Yes - The meter(s) are calibrated
☐ No - Check the meter(s)' calibration before testing

Testing Environment

Is the test environment able to sustain same lighting conditions throughout the test?	☒ Yes ☐ No
Is the test administrator wearing non-reflective clothing?	☒ Yes ☐ No
Does the test environment have windows?	☐ Yes ☒ No
If the test environment has windows are they shaded?	☐ Yes ☐ No ☒ N/A

What kind of light does the test environment have?
☐ natural ☐ incandescent ☒ fluorescent ☐ light-emitting diode (LED) ☐ other:_____

Are the illumination levels within 9 to 37 fc or 100 to 400 lux? ☒ Yes ☐ No

FIG. A2.2 Data Form With Sample Data

Test Information

Date: 20 December 2012 Test Location: Clinic

Time: 3:02 pm Test Administrator(s): Harmony Hilderbrand

Object Information

Object Description: Recumbent Bike

L1 Description (lighter part of object): Bike frame, off-white

L2 Description (darker part of object): Resistance knob, blue

Is the distance to object 1 meter (39.4 in.) or more? ☒ Yes ☐ No

Can the 1° circle be completely filled with the desired subject? ☒ Yes ☐ No

Intended viewing angles are within ± 45 degrees perpendicular to the object's surface? ☒ Yes ☐ No

Horizontal Angle: 0° Vertical Angle: 5°

Luminance Measurements

L1 (cd/m²) lighter		L2 (cd/m²) darker	
21 (1)	23 (2)	5.3 (1)	5.3 (2)
23 (3)	(4)	(3)	(4)
23 Match or Average		5.3 Match or Average	

Contrast Calculation

Contrast = [(L1 – L2)/L1] × 100

where

L1 = Luminance of the lighter area and,

L2 = Luminance of the darker area

Contrast should be ≥ 70 **%***

$$[(\frac{23}{L1} - \frac{5.3}{L2})/\frac{23}{L1}] \times 100 = \frac{77.0\ \%}{\text{Contrast}}$$

Subtract L2 from L1, the result of which is divided by L1. Multiply the result by 100 to get a percentage.

*US Access Board recommends a contrast of ≥ 70% in Clause A4.30.5 of the 2002 ADA Accessibility Guidelines (ADAAG)

This project was funded by the Rehabilitation Engineering Research Center on RecTech through the National Institute on Disability and Rehabilitation Research under the US Department of Education grant #H133E070029

FIG. A2.2 Data Form With Sample Data *(continued)*

Object Information

Object Description: Color Set C Test 3

L1 Description (lighter part of object): White (Row 3 Column 1)

L2 Description (darker part of object): Yellow (Row 3 Column 4)

Is the distance to object 1 meter (39.4 in.) or more? ☒Yes ☐No

Can the 1° circle be completely filled with the desired subject? ☒Yes ☐No

Intended viewing angles are within ± 45 degrees perpendicular to the object's surface? ☒Yes ☐No

Horizontal Angle: 0° Vertical Angle: 0°

Luminance Measurements

L1 (cd/m²) lighter (**White**)		**L2 (cd/m²)** darker (**Yellow**)	
100 (1)	97 (2)	64 (1)	64 (2)
100 (3)	100 (4)	(3)	(4)
100 Match or Average		64 Match or Average	

Contrast Calculation

Contrast = [(L1 – L2)/L1] × 100

where

L1 = Luminance of the lighter area and,

L2 = Luminance of the darker area

Contrast should be ≥ _____%*

[(100 (L1) – 64 (L2)) / 100 (L1)] × 100 = 36,0 % (Contrast)

Subtract L2 from L1, the result of which is divided by L1. Multiply the result by 100 to get a percentage.

*US Access Board recommends a contrast of ≥ 70% in Clause A4.30.5 of the 2002 ADA Accessibility Guidelines (ADAAG)

This project was funded by the Rehabilitation Engineering Research Center on RecTech through the National Institute on Disability and Rehabilitation Research under the US Department of Education grant #H133E070029

FIG. A2.3 Data Form with Correct Number of Sample Luminance Measurements

Object Information

Object Description: Color Set C Test 1 at **300–400 lux**

L1 Description (lighter part of object): White (Row 4 Column 1)

L2 Description (darker part of object): Yellow (Row 3 Column 4)

Is the distance to object 1 meter (39.4 in.) or more? ☑ Yes ☐ No

Can the 1° circle be completely filled with the desired subject? ☑ Yes ☐ No

Intended viewing angles are within ± 45 degrees perpendicular to the object's surface? ☑ Yes ☐ No

Horizontal Angle: 0° Vertical Angle: 0°

Luminance Measurements

L1 (cd/m^2) lighter (**White**)		**L2 (cd/m^2)** darker (**Yellow**)	
70 (1)	74 (circled) (2)	52 (circled) (1)	52 (circled) (2)
74 (circled) (3)	~~74~~ (4)	~~56~~ (3)	~~56~~ (4)
74 ~~73~~ Match or Average		**52** ~~54~~ Match or Average	

Contrast Calculation

Contrast = [(L1 – L2)/L1] × 100

where

L1 = Luminance of the lighter area and,

L2 = Luminance of the darker area

Contrast should be ≥ ____ %*

[(**74** ~~73~~ (L1) – **52** ~~54~~ (L2)) / **74** ~~73~~ (L1)] × 100 = **29.7** ~~26.0~~ % (Contrast)

Subtract L2 from L1, the result of which is divided by L1. Multiply the result by 100 to get a percentage.

*US Access Board recommends a contrast of ≥ 70% in Clause A4.30.5 of the 2002 ADA Accessibility Guidelines (ADAAG)

This project was funded by the Rehabilitation Engineering Research Center on RecTech through the National Institute on Disability and Rehabilitation Research under the US Department of Education grant #H133E070029

FIG. A2.4 Data Form with Too Many Sample Luminance Measurements (Example 1, Corrected)

Object Information

Object Description: Color Set A Test 2 at **100 to 150 lux**

L1 Description (lighter part of object): Bluish Green (Row 1 Column 6)

L2 Description (darker part of object): Black (Row 4 Column 6)

Is the distance to object 1 meter (39.4 in.) or more? ☒ Yes ☐ No

Can the 1° circle be completely filled with the desired subject? ☒ Yes ☐ No

Intended viewing angles are within ± 45 degrees perpendicular to the object's surface? ☒ Yes ☐ No

Horizontal Angle: 0° Vertical Angle: 0°

Luminance Measurements

L1 (cd/m²) lighter (**Bluish Green**)		**L2 (cd/m²)** darker (**Black**)	
11 (1)	12 (2)	2.6 (1)	2.6 (2)
11 (3)	12 (4)	~~2.6~~ (3)	~~2.5~~ (4)
11.5 Match or Average		2.6 Match or Average	

Contrast Calculation

Contrast = [(L1 – L2)/L1] × 100

where

L1 = Luminance of the lighter area and,

L2 = Luminance of the darker area

Contrast should be ≥ 70 **%***

[(11.5 (L1) – 2.6 (L2)) / 11.5 (L1)] × 100 = 77.4 % (Contrast)

Subtract L2 from L1, the result of which is divided by L1. Multiply the result by 100 to get a percentage.

*US Access Board recommends a contrast of ≥ 70% in Clause A4.30.5 of the 2002 ADA Accessibility Guidelines (ADAAG)

This project was funded by the Rehabilitation Engineering Research Center on RecTech through the National Institute on Disability and Rehabilitation Research under the US Department of Education grant #H133E070029

FIG. A2.5 Data Form with Too Many Sample Luminance Measurements (Example 2, Corrected)

A3. METER CALIBRATION GRAPHS

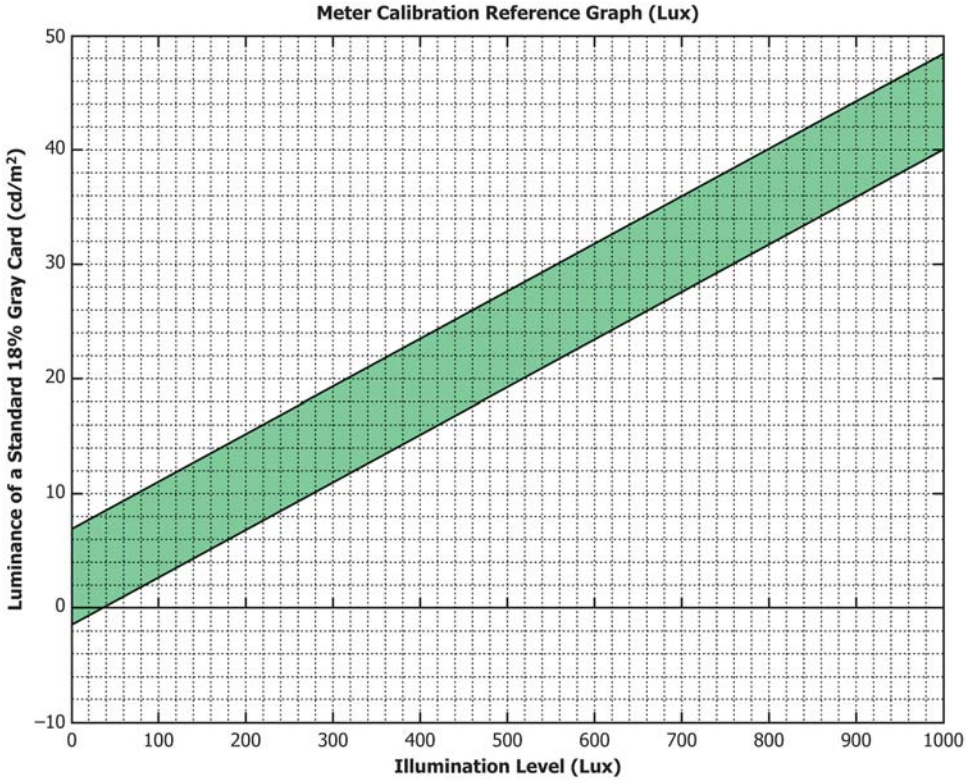

FIG. A3.1 Meter Calibration Graph (Lux)

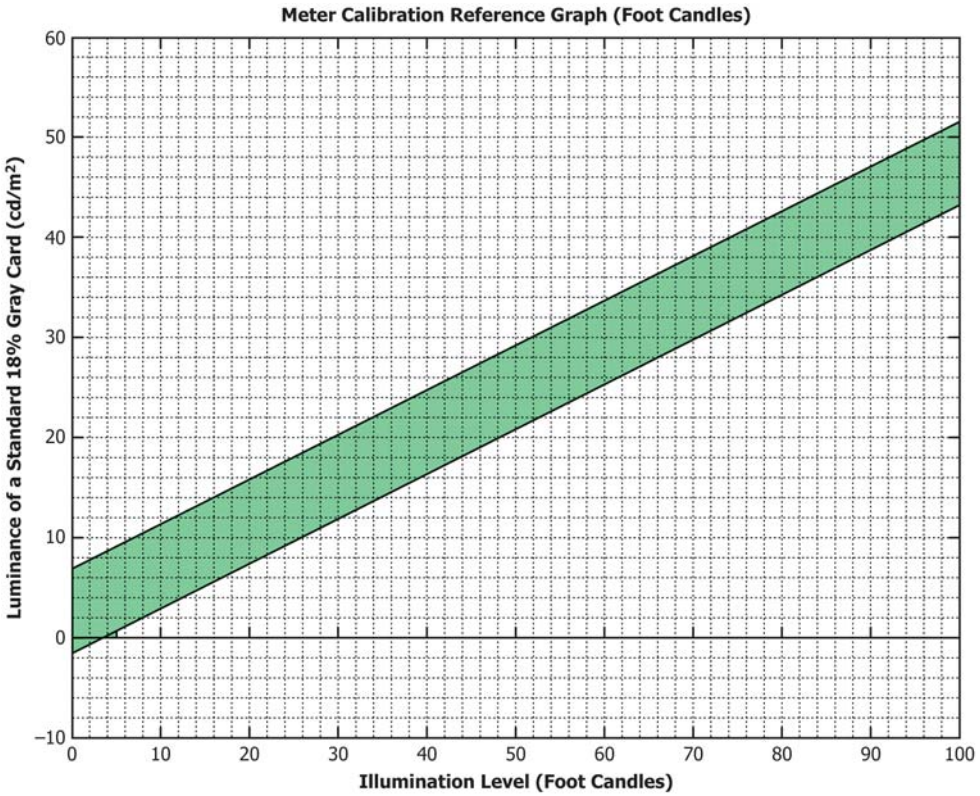

FIG. A3.2 Meter Calibration Graph (Foot Candles)

APPENDIX

(Nonmandatory Information)

X1. INTRA-LABORATORY STUDY OF CONTRAST LEVELS[9]

X1.1 *Preliminary Test*—A preliminary intra-laboratory study of contrast levels was conducted based upon Practice E691 with 9 different operators and 3 different color sets, with each operator obtaining three test results for each color set. Examination of the results of this study showed repeatability within the results and showed that there was a respectable inter-operator precision.

X1.1.1 *Repeatability Conditions*—All nine operators conducted testing at the same test site and with the same equipment over a period of one week.

X1.1.2 *Test Result*—For purposes of this study, a contrast level was calculated by subtracting L2 from L1, the result of which is divided by L1, and then the result was multiplied by 100 to get a percentage.

$$Contrast = [(L1 - L2)/L1] \times 100 \quad \text{(X1.1)}$$

where:

L1 = luminance of the lighter area, and
L2 = luminance of the darker area.

X1.2 *Preliminary Estimate of Repeatability and Inter-Operator Precision*—The terms repeatability standard deviation (within a laboratory) and repeatability limit are used as specified in Practice E177. The inter-operator precision was calculated using the inter-laboratory reproducibility calculations in Practice E177. See Table X1.1 for more information, r is the repeatability limit and R_{IO} represents the inter-operator precision.

[9] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:F08-1012. Contact ASTM Customer Service at service@astm.org.

TABLE X1.1 Contrast Value Repeatability (r) and Inter-Operator Precision (R_{IO})

Contrast	Average (%)	Repeatability (r) standard deviation	Repeatability (r) limit	Inter-operator precision (R_{IO}) deviation	Inter-operator precision (R_{IO}) limit
Black and Bluish-Green	85.73	0.52	1.46	0.70	1.96
Blue and Yellow-Green	72.51	0.60	1.69	0.88	2.46
White and Yellow	35.26	0.90	2.51	1.39	3.90