



Designation: E3408/E3408M – 23

Standard Test Method for Evaluating Ground Response Robot Capabilities: Dexterity: Linear Inspection¹

This standard is issued under the fixed designation E3408/E3408M; 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.

INTRODUCTION

The robotics community needs ways to measure whether a particular robot is capable of performing specific missions in complex, unstructured, and often hazardous environments. These missions require various combinations of elemental robot capabilities. Each capability can be represented as a test method with an associated apparatus to provide tangible challenges for various mission requirements and performance metrics to communicate results. These test methods can then be combined and sequenced to evaluate essential robot capabilities and remote operator proficiencies necessary to successfully perform intended missions.

The ASTM International Standards Committee on Homeland Security Applications (E54) specifies these standard test methods to facilitate comparisons across different testing locations and dates for diverse robot sizes and configurations. These standards support robot researchers, manufacturers, and user organizations in different ways. Researchers use the standards to understand mission requirements, encourage innovation, and demonstrate break-through capabilities. Manufacturers use the standards to evaluate design decisions, integrate emerging technologies, and harden systems. Emergency responders and soldiers use them to guide purchasing decisions, align deployment expectations, and focus training with standard measures of operator proficiency. Associated usage guides describe how these standards can be applied to support various objectives.

Several suites of standards address these elemental capabilities including maneuvering, mobility, dexterity, sensing, energy, communications, durability, proficiency, autonomy, and logistics. This standard is part of the *dexterity* suite of test methods.

1. Scope

1.1 This test method is intended for remotely operated ground robots operating in complex, unstructured, and often hazardous environments. It specifies the apparatuses, procedures, and performance metrics necessary to measure the capability of a robot to dexterously inspect objects of interest in the environment at various heights, depths, orientations, and confinement. This test method is one of several related *dexterity* tests that can be used to evaluate overall system capabilities.

1.2 The robotic system typically includes a remote operator in control of all functionality, so an onboard camera and remote operator display are typically required. Assistive features or autonomous behaviors may improve the effectiveness or efficiency of the overall system.

1.3 Different user communities can set their own thresholds of acceptable performance within this test method for various mission requirements.

1.4 *Performing Location*—This test method may be performed anywhere the specified apparatuses and environmental conditions can be implemented.

1.5 *Units*—The International System of Units (SI Units) and U.S. Customary Units (Imperial Units) are used throughout this test method. They are not mathematical conversions. Rather, they are approximate equivalents in each system of units to enable use of readily available materials in different countries. The differences between the stated dimensions in each system of units are insignificant for the purposes of comparing test method results, so each system of units is separately considered standard within this test method.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

¹ This test method is under the jurisdiction of ASTM Committee E54 on Homeland Security Applications and is the direct responsibility of Subcommittee E54.09 on Response Robots.

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1.7 This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

2. Referenced Documents

2.1 ASTM Standards:²

E2521 Terminology for Evaluating Response Robot Capabilities

E2566 Test Method for Evaluating Response Robot Sensing: Visual Acuity

E2592 Practice for Evaluating Response Robot Capabilities: Logistics: Packaging for Urban Search and Rescue Task Force Equipment Caches

E3349/E3349M Test Method for Evaluating Ground Robot Capabilities and Remote Operator Proficiency: Terrains: K-Rails

3. Terminology

3.1 **Definitions**—The following terms are used in this test method and are defined in Terminology **E2521**: *abstain*, *administrator or test administrator*, *emergency response robot or response robot*, *fault condition*, *operator*, *operator station*, *remote control*, *repetition*, *robot*, *stepfield terrain element*, *teleoperation*, *test event or event*, *test form*, *test sponsor*, *test suite*, *testing target or target*, *testing task or task*, and *trial or test trial*.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *alcove*, *n*—a square area with walls on three of four sides whose sides are equal to the chosen apparatus clearance width (*W*); see Fig. 1.

3.2.2 *apparatus clearance width (W)*, *n*—a specification for the apparatus dimensions chosen from one of four possible measurements, based on the intended robot deployment environment:

(1) 240 cm ± 2.5 cm tolerance [96 in. ± 1 in. tolerance], such as open and outdoor public spaces;

(2) 120 cm ± 2.5 cm tolerance [48 in. ± 1 in. tolerance], such as indoor spaces in accessibility-compliant buildings;

(3) 60 cm ± 1.3 cm tolerance [24 in. ± 0.5 in. tolerance], residences and aisles of public transportation; or

(4) 30 cm ± 1.3 cm tolerance [12 in. ± 0.5 in. tolerance], cluttered indoor spaces, ductwork, and voids in collapsed structures.

3.2.2.1 **Discussion**—The measures for these scales are nominal and do not represent the measurement of the narrowest point in the apparatus through which the robot should pass. Consult Section 6 for the overall measurements and dimensions of the apparatus at each scale.

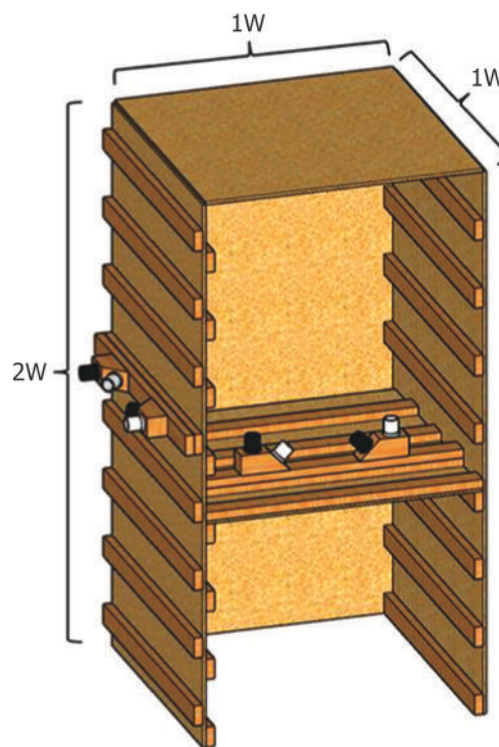


FIG. 1 Alcove Apparatus with a Linear Rail Mounted on the Outside Wall and a Linear Rail Mounted on Top of a Platform Inside of the Alcove

3.2.3 *diagonal rail*, *n*—a solid piece of dimensional lumber that is sized to fit horizontally inside a subfloor at a 45° angle to the direction of travel.

3.2.4 *Landolt Ring or Landolt C*, *n*—an optotype, or symbol, consisting of a black circular ring with a white gap or vice versa, both with specified sizes, as defined in Test Method **E2566**.

3.2.5 *linear rail*, *n*—a length of wood, plastic, or metal with four mounting points used to hold additional hardware to perform dexterity tasks; the two outermost points are each positioned normal to the rail and the two innermost points are each angled 45° to the rail.

3.2.5.1 **Discussion**—In this standard, the linear rail contains inspect tasks that consist of PVC pipes and visual acuity targets, as shown in Fig. 2. See Section 6 for more information.

3.2.6 *platform*, *n*—a flat square panel, whose sides measure one apparatus clearance width (*W*), that can hold a linear rail.

3.2.6.1 **Discussion**—See Section 6 for more information.

3.2.7 *subfloor*, *n*—an underlayment of Oriented Strand Board (OSB) or similar material with dimensional lumber borders used to affix multiple subfloors to one another and can contain apparatus elements such as terrains or obstacles.

3.2.8 *visual acuity target*, *n*—a printed graphic of nested Landolt C symbols of varying sizes and orientations. The orientation of each C is defined by the direction of the gap in the ring out from the center.

3.2.8.1 **Discussion**—This is the same type of artifact used in Test Method **E2566** – 17a. See Fig. 3.

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