Designation: F3265 – 17 (Reapproved 2023)

Standard Test Method for Grid-Video Obstacle Measurement[1]

This standard is issued under the fixed designation F3265; 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

Safe control of automatic/automated/autonomous-unmanned ground vehicles (A-UGVs) is critical in industrial environments where workers are or may be present. A-UGV safe control is typically based on sensors that detect stationary standard test pieces (used in ANSI/ITSDF B56.5) representing humans. This and other test method developments have been experimented and published.[2, 3] The experimental results were used to recommend improvements to the ANSI/ITSDF B56.5 safety standard stopping distance exception language in 2014. Subcommittee consensus changed ANSI/ITSDF B56.5 to make it mandatory to reduce vehicle kinetic energy should an object (for example, person, materials, or equipment) appear in the vehicle path and within the stop detect range of the vehicle safety sensors. The language that has been proposed as an amendment to the ANSI/ITSDF B56.5 standard is: "Should an object suddenly appear in the path of the vehicle between the leading edge of the sensing field and the vehicle (for example, an object falling from overhead or a pedestrian stepping into the path of a vehicle at the last instant), the vehicle shall initiate braking in accordance with brake system (see 8.8.1), but may not be expected to stop in time to prevent contact with object." While manufacturers of A-UGVs may have access to internal system logs and data that demonstrate the successful initiation of braking as required, users may not have access to that information. This test method provides an optional, standard performance test method for A-UGVs to enable industrial vehicle manufacturers and users to implement a common test to demonstrate expected vehicle operation in the case of objects appearing in the A-UGV path and within the stop-detect range of the vehicle safety sensors.

1. Scope

1.1 This test method measures an automatic/automated/autonomous-unmanned ground vehicle (A-UGV) kinetic energy reduction when objects appear in the A-UGV path and within the stop-detect range of the vehicle safety sensors in situations in which the desired reaction is for the vehicle to stop as opposed to avoiding the obstacle by traveling on an alternative path. The test method measures the performance of the A-UGV only and does not measure the effect on the stability of loads. This test method describes the use of one test piece as described in ANSI/ITSDF B56.5. Other test pieces from ANSI/ITSDF B56.5 could be used. This test method is intended for use by A-UGV manufacturers, installers, and users. This test method does not substitute for required safety testing under ANSI/ITSDF B56.5 or other normative standards.

1.2 *Performing Location*—This test method shall be performed in a testing laboratory or the location where the apparatus and environmental test conditions are implemented. Environmental conditions are recorded as specified in Practice F3218.

1.3 *Units*—The values stated in SI units are to be regarded as the standard. The values given in parentheses are not precise mathematical conversion to inch-pound units. They are close approximate equivalents for the purpose of specifying material dimensions or quantities that are readily available to avoid excessive fabrication costs of test apparatuses while maintaining repeatability and reproducibility of the test method results.

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[1] This test method is under the jurisdiction of ASTM Committee F45 on Robotics, Automation, and Autonomous Systems and is the direct responsibility of Subcommittee F45.03 on A-UGV Object Detection and Protection.

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[2] Bostelman, Roger, Shackleford, Will, Cheok, Geraldine, and Saidi, Kamel, "Safe Control of Manufacturing Vehicles Research Towards Standard Test Methods," *Progress in Material Handling Practice*, Book Chapter, June 2012.

[3] Bostelman, Roger, Norcross, Richard, Falco, Joe, and Marvel, Jeremy, "Development of Standard Test Methods for Unmanned and Manned Industrial Vehicles Used Near Humans," SPIE 2013, Baltimore, Maryland, May 2013.

These values given in parentheses are provided for information only and are not considered standard.

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

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

2. Referenced Documents

2.1 *ASTM Standards:*[4]

F3200 Terminology for Robotics, Automation, and Autonomous Systems

F3218 Practice for Documenting Environmental Conditions for Utilization with A-UGV Test Methods

2.2 *ANSI/ITSDF Standard:*[5]

ANSI/ITSDF B56.5 Safety Standard for Driverless, Automatic Guided Industrial Vehicles and Automated Functions of Manned Industrial Vehicles

3. Terminology

3.1 Terms not defined herein are defined in Terminology F3200.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *collide time, n*—when the automatic/automated/autonomous-unmanned ground vehicle (A-UGV) collides with the test piece.

3.2.2 *defined areas, n*—space constrained by test method boundaries for A-unmanned ground vehicle (A-UGV) operation.

3.2.3 *enter time, n*—when the test piece enters the stop zone triggering photosensor 1.

3.2.4 *start line, n*—line across the path of the vehicle used to signal when the test piece can be inserted into the stop detection range as measured in 7.3.

3.2.5 *start location, n*—the initial zero velocity position of A-UGV at beginning of each test repetition; the start location should be at a point from which the vehicle can accelerate up to test speed before the leading edge crosses the start line along the test trajectory.

3.2.6 *start time, n*—when the A-UGV crosses the start line while traveling at speed.

3.2.7 *stop time, n*—when the A-UGV stops because of detection of the test piece.

3.2.8 *stop zone, n*—the area in front of the direction of travel of the A-UGV where activation of the obstruction sensor causes a safety stop of the vehicle as per ANSI/ITSDF B56.5.

3.2.9 *stopping distance, n*—distance required for vehicle to stop after detecting obstruction.

3.2.10 *repetition, n*—performance of a task.

3.2.11 *task, n*—sequence of movements and measurements that compromise one repetition within a test.

3.2.12 *test, n*—a collection of task repetitions.

4. Significance and Use

4.1 Assuming the vehicle stays on its path and an obstacle appears within the stop zone, the vehicle will collide with the obstacle. Even within the stop zone, obstacle detection should cause the vehicle to slow down as early as possible using non-contact sensing or contact bumpers. ANSI/ITSDF B56.5:2012 discusses a test method to detect standard test pieces beyond the minimum vehicle stopping distance at 50 % and 100 % of vehicle rated speeds.

4.2 This test method can apply to A-UGVs for testing obstacle-sensing capabilities and automatic guided industrial vehicles in automatic mode of operation in non-restricted areas as described in ANSI/ITSDF B56.5.

4.3 Researchers[2, 3] used two-dimensional (2D) laser detection and ranging (LADAR) sensors mounted to an A-UGV. In contrast to the earlier experiments in which the test piece was static, in these experiments the A-UGV and the test piece were both moving. The 2D sensor was mounted to the A-UGV to scan horizontally with the beam approximately 10 cm (4 in.) above and parallel to the floor and confined to detecting the vehicle path (vehicle width) at the maximum stopping distance (coasting or braking). Note that the sensor scan width can be set to any width, including the ANSI/ITSDF B56.5 standard, non-hazard zone vehicle path width of the vehicle plus 0.5 m (1.6 ft). The test piece entered the A-UGV path within the exception zone, was detected by the safety sensor, and the distance of the test piece to the A-UGV and the A-UGV stopping distance measurements were calculated and analyzed.

5. Apparatus

5.1 *List of Materials:*

5.1.1 Grid printed on paper or marked on the floor at regular intervals.

5.1.2 Photosensors 1 and 2.

5.1.3 Lights 1 and 2.

5.1.4 Video camera and recorder with nominal 30 frames per second (fps) frame rate or higher.

5.1.5 Straight bar and clamp (or optional length of rope or string, or both, not shown in Fig. 1).

5.1.6 A-UGV.

5.1.7 Vertical cylinder test piece, 70 mm (2.75 in.) diameter by 400 mm (16 in.), as described in safety standards and representing a human leg.

5.1.8 Onboard A-UGV camera or sighting scope (optional) (see Fig. 2).

5.1.9 Timer to be placed in camera field of view.

5.2 *Experimental Setup:*

[4] 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.

[5] Available from the Industrial Truck Standards Development Foundation (ITSDF), 1750 K St. Nw, Suite 460, Washington, DC 20006, www.itsdf.org.