Designation: F3218 – 17

Standard Practice for Recording Environmental Effects for Utilization with A-UGV Test Methods[1]

This standard is issued under the fixed designation F3218; 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

When conducting test methods, it is important to consider the role that the environmental conditions play in the A-UGV performance. Various A-UGVs are designed to be operated both indoors and outdoors under conditions specified by the manufacturer. Likewise, end users of the A-UGV will be operating these vehicles in a variety of environmental conditions. When conducting and replicating Committee F45 test methods by vehicle manufacturers and users, it is important to specify and record the environmental conditions under which the A-UGV is tested as there will be variations in vehicle performance caused by the conditions, especially when comparing and replicating sets of test results. It is also important to consider changes in environmental conditions during the course of operations (for example, transitions between conditions). As such, environmental conditions specified in this practice are both continuous and transitional; with the A-UGV stationary or in motion. This practice provides brief introduction to the following list of environmental conditions that can affect performance of the A-UGV: lighting, external sensor emission, temperature, humidity, electrical interference, ground surface, air quality.

This practice then breaks down each condition into sub-categories so that the user can record the various aspects associated with the category when conducting A-UGV tests defined in Committee F45 Test Methods , , those listed in the Related Materials section, and Terminology F3200. It is recommended that salient environment conditions be recorded when conducting Committee F45 test methods, but is not required.

1. Scope

1.1 This practice describes a means to record the following environmental conditions that may affect the performance of A-UGVs: lighting, external sensor emission, temperature, ground surface, air quality, humidity, and electrical interference.

1.2 The A-UGV operating ranges for each of the conditions listed in 1.1 are described and parameterized in Section 4 and allow a basis for performance comparison in test methods. The approach is to divide the list of environmental conditions into sub-conditions that represent the various aspects of the major category (for example, sunlight within ambient lighting). Where necessary, this practice also provides guidelines (for example, lighting direction) to record environmental conditions in an existing environment.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are not precise mathematical conversion to imperial 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. 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.*

[1] This practice is under the jurisdiction of ASTM Committee F45 on Driverless Automatic Guided Industrial Vehicles and is the direct responsibility of Subcommittee F45.01 on Environmental Effects.

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2. Referenced Documents

2.1 *ASTM Standards:*[2]

F3200 Terminology for Driverless Automatic Guided Industrial Vehicles

F3244 Test Method for Navigation: Defined Area

F3265 Test Method for Grid-Video Obstacle Measurement

2.2 *Other Standards:*

ISO 14644-1 Cleanrooms and Associated Controlled Environments – Part 1: Classification of Air Cleanliness by Particle Concentration[3]

EN 12895 Electromagnetic Compatibility – Emissions and Immunity[4]

MIL-STD-462 EMI Emissions and Susceptibility[5]

IEC 61000-4-1 Electromagnetic Compatibility (EMC) – Part 4-1: Testing and Measurement Techniques – Overview of Immunity Tests[6]

IEC 61000–6 Emission Standards for Industrial Environments[6]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *between area, n*—an area of the apparatus that is between the start and goal locations within each test apparatus as defined by the test method.

3.1.2 *continuous, adj*—time exposed to a single environmental condition(s).

3.1.3 *emitter, n*—external radiation sources that can affect the A-UGV performance, for example: multiple time-of-flight cameras, fork-lift pedestrian lights, structured light sensor, light detection and ranging sensors (LIDAR).

3.1.4 *transition distance, n*—amount of distance to change from one environmental condition to another.

3.1.5 *transition time, n*—amount of time to change from one environmental condition to another.

3.1.6 *transitional, adj*—movement between environmental conditions and the time exposed to the condition.

4. Significance and Use

4.1 *Lighting:*

4.1.1 Various lighting conditions can potentially affect A-UGV optical sensor performance by affecting sensor and in turn, A-UGV responsiveness. Lighting sources can include ambient lighting as well as light emitters associated A-UGV operation. Two setups for lighting include direct and indirect source applied to the A-UGV. Direct lighting can also include reflected light from a highly reflective surface and implies that the source is directed at the light-affected components of the A-UGV (for example, sensors). Indirect or ambient light includes lighting where the source is not directly applied to the light-affected components of the A-UGV. Lighting exposure is either continuous light applied to the A-UGV or transitional in which the vehicle passes through various lighting conditions and levels. Light intensity is divided into five levels exemplified through dark, typical indoor lighting, and full sunlight.

4.1.2 *Ambient Lighting Type:*

4.1.2.1 Exposed bulb,

4.1.2.2 Spotlight,

4.1.2.3 Sunlight,

4.1.2.4 Reflected,

4.1.2.5 Light from another vehicle,

4.1.2.6 Laser,

4.1.2.7 Filtered.

4.1.3 *Ambient Lighting Source:*

4.1.3.1 Direct Highly-Concentrated, Directional Lighting,

4.1.3.2 Indirect and Diffused.

4.1.4 *Ambient Lighting Source Location*—Record light source location and elevation with respect to the vehicle (refer to Fig. 1).

4.1.4.1 Elevation with respect to A-UGV path.

4.1.4.2 Location with respect to the A-UGV (indicate light source on the test method drawing; for directional lighting only).

4.1.5 *Lighting Levels:*

4.1.5.1 Level 1: 0 to 1 LUX (for example, dark).

4.1.5.2 Level 2: 2 to 99 LUX (for example, dim).

4.1.5.3 Level 3: 100 to 1000 LUX (for example, office environment).

4.1.5.4 Level 4: 1001 to 9999 LUX (for example, bright indoors, dim outdoors).

4.1.5.5 Level 5: 10 000 LUX and above (for example, full sunlight).

4.1.6 *Spectrum*—If useful to the test method, record the spectrum color and approximate wavelength (for example, violet: 400 nm).

4.1.7 *Light Exposure:*

4.1.7.1 *Continuous*—The same lighting sources and lighting levels throughout the test apparatus (for example, start, between area, and goal all have the same lighting condition).

4.1.7.2 *Transitional*—Moving between two lighting levels or lighting sources, or both.

4.2 *External Sensor Emission:*

4.2.1 When emitters are outside of the A-UGV (for example, from another A-UGV, the environment) that can potentially interfere with the A-UGV sensor system. External, unnatural radiation sources can affect the A-UGV performance, for example: multiple time-of-flight cameras, fork-lift pedestrian lights, 3D structured light sensors, light detection and ranging sensors (LIDAR).

4.2.2 *External Emitter Configuration:*

4.2.2.1 Type of emitter(s).

4.2.2.2 Number of emitter(s).

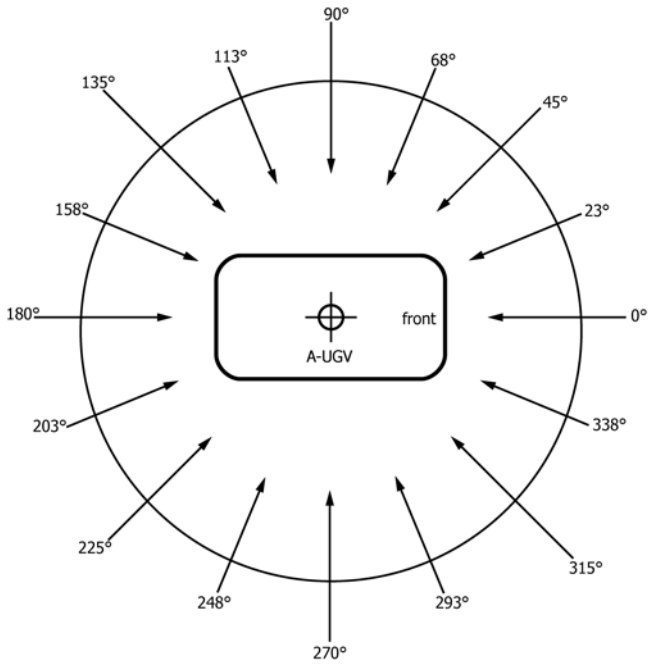
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

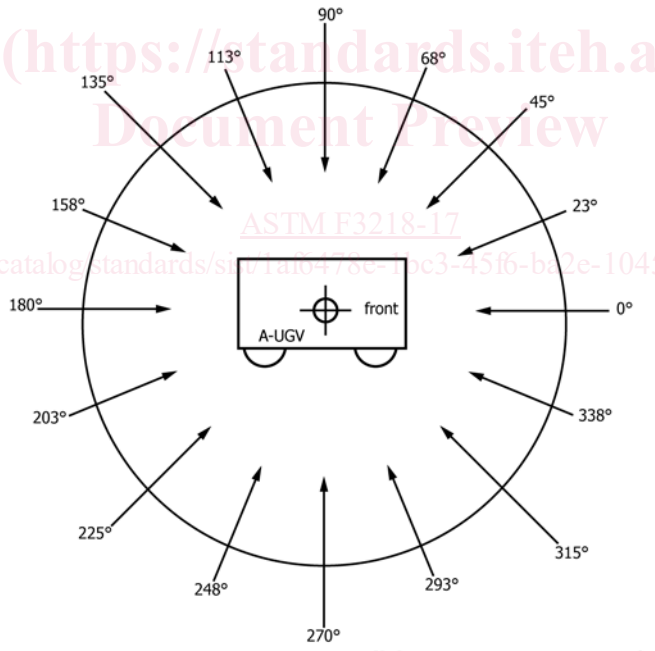
[4] Available from British Standards Institution (BSI), 389 Chiswick High Rd., London W4 4AL, U.K., http://www.bsigroup.com.

[5] Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Washington, DC 20401-0001, http://www.access.gpo.gov.

[6] Available from International Electrotechnical Commission (IEC), 3, rue de Varembé, 1st Floor, P.O. Box 131, CH-1211, Geneva 20, Switzerland, http://www.iec.ch.



(a) top view



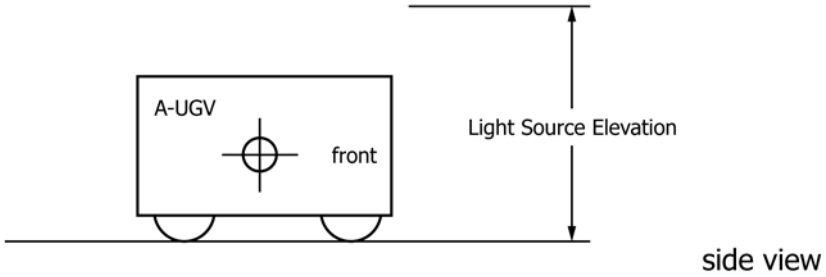
(b) side view

FIG. 1 Lighting and Air Velocity (see 4.7.4) Direction (a) Top View and (b) Side View and (c) Light Source Elevation Side View with Respect to the A-UGV; The "front" of the A-UGV is defined by vehicle manufacturer

4.2.3 *External Emitter Source Location*—Record emitter source location and elevation with respect to the vehicle (refer to Fig. 1).

4.2.3.1 Elevation with respect to A-UGV path.

4.2.3.2 Location with respect to the A-UGV.



(c)

FIG. 1 Lighting and Air Velocity (see 4.7.4) Direction (a) Top View and (b) Side View and (c) Light Source Elevation Side View with Respect to the A-UGV; The "front" of the A-UGV is defined by vehicle manufacturer *(continued)*

4.3 *Temperature:*

4.3.1 Temperature variability and extremes can affect the A-UGV performance. The temperature exposure on the A-UGV can be continuous or transitional while the vehicle is stationary or moving. Temperature ranges span from low to high extremes expressed in five categories. Temperature variations can affect onboard electronics, create condensation, cause hydraulic fluid viscosity, reduce battery life and recharge rate.

4.3.2 *Temperature Exposure:*

4.3.2.1 *Continuous*—A single temperature for a period of time.

4.3.2.2 *Transitional*—Moving between two continuous temperature levels.

4.3.3 *Temperature Levels (in °C):*

4.3.3.1 Level 1: below 0 to 0°C (for example, freezing conditions).

4.3.3.2 Level 2: 0 to 15°C (for example, perishable storage).

4.3.3.3 Level 3: 16 to 26°C (for example, office, warehouse).

4.3.3.4 Level 4: 27 to 49°C (for example, warehouse).

4.3.3.5 Level 5: above 49°C (for example, foundries, forges).

4.4 *Humidity:*

4.4.1 Humidity refers to the amount of water vapor contained in the air around the vehicle. High humidity combined with dew point temperature causes condensation that can short electronics and affect lenses and other A-UGV components. Greater than 60 % humidity causes a large increase in corrosion of metallic parts. Low humidity, on the other hand, will see a dramatic rise in static electricity and the need for adequate discharge.

4.4.2 *Relative Humidity Level:*

4.4.2.1 Low – less than 30 %.

4.4.2.2 Moderately Low – 31 to 55 %.

4.4.2.3 Moderately High – 56 to 75%.

4.4.2.4 High – greater than 75 % and above.

4.4.3 *Dew Point Temperature*—The highest temperature at which airborne water vapor will condense to form liquid dew.

4.5 *Electrical Interference:*

4.5.1 Some surfaces are not conductive enough to provide adequate grounding for an A-UGV. Most ground vehicles have a floating ground and all electronics are typically grounded to the vehicle chassis. As static builds up causing the voltage difference between the positive lead of the battery and the chassis to change, the performance of the electronic components of the vehicle may be negatively impacted. Strong magnetic fields can impact the onboard electrical components, in particular any data storage within the onboard computer. Many A-UGVs require wireless network connections for full functionality. Radio frequency (RF) interference can degrade these networks and A-UGV capability.

4.5.2 For Electro-magnetic compatibility issues, refer to:

4.5.2.1 EN 12895 Electromagnetic Compatibility – Emissions and Immunity.

4.5.2.2 MIL-STD-462 – EMI Emissions and Susceptibility.

4.5.2.3 IEC 61000-4-1 Electromagnetic Compatibility (EMC) – Part 4-1: Testing and Measurement Techniques – Overview of Immunity Tests

4.5.2.4 IEC 61000-6 – Emission Standards for Industrial Environments

4.6 *Ground Surface:*

4.6.1 A-UGV mobility is affected by ground surface conditions including surface: consistency and texture/roughness, gaps or step changes to elevation, deformability, grade (ramp) or undulation (lack of flatness), friction and particulates.

4.6.2 *Ground Surface Consistency:*

4.6.2.1 *Continuous*—A single condition for a period of time.

4.6.2.2 *Transitional*—Moving between two continuous ground surface conditions.

4.6.3 *Ground Surface Type (record 'Smooth' or 'Rough' and the surface type):*

4.6.3.1 Smooth (for example, concrete, tile, linoleum, carpet).

4.6.3.2 Rough (for example, gapped wood, cobblestone, large gravel, vegetation, raised metal floors, catwalks).

4.6.4 *Elevation Change:*

4.6.4.1 *Gap*—Depth and length of gap.

4.6.4.2 *Step*—Height and length of step.

4.6.5 *Deformability:*

4.6.5.1 Rigid (for example, concrete, asphalt).

4.6.5.2 Semi-rigid (for example, compacted dirt or gravel, wet sand, industrial carpet).

4.6.5.3 Soft – malleable (for example, snow, mud, dry sand, padded carpet).

4.6.6 *Grade (Ramp):*