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Standard Test Method for Determining the Performance of Passive Radio Frequency Identification (RFID) Transponders on Palletized or Unitized Loads[1]

This standard is issued under the fixed designation D7434; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method quantitatively evaluates the readability of radio frequency identification (RFID) pallet transponders placed on pallet loads that are mechanically handled by material handling equipment such as fork trucks, pallet jacks, and automated guided vehicle systems.

1.2 This test method is intended for use in laboratory settings that simulate, as closely as is practicable, the distribution environment of the product being tested.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that 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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D996 Terminology of Packaging and Distribution Environments

D4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing

E337 Test Method for Measuring Humidity with a Psychrometer (the Measurement of Wet- and Dry-Bulb Temperatures)

3. Terminology

3.1 *Definitions*—Terms and definitions used in this test method may be found in Terminology D996.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *critical transponder distance*—the distance between the transponder and the interrogator antenna at which a transponder becomes undetectable by an RFID system, when moving the RFID transponder out of the read field.

3.2.2 *direct line of sight*—an unobstructed visible path from one object to another.

3.2.3 *firmware*—a series of programmable instructions, stored in read only memory (ROM), which controls the capabilities of an interrogator.

3.2.4 *radio frequency identification (RFID)*— a wireless data communication technology that uses radio waves to transfer data from one source to another.

3.2.5 *read field*—the area in which an RFID transponder is capable of responding to the interrogator. The outermost boundary of the read field correlates to the critical transponder distance. The distance between the critical transponder distance and the transponder acquisition distance represents an area of RF energy that may or may not be sufficient to activate a passive transponder.

3.2.6 *RF*—the energy used by RFID systems to activate transponders and wirelessly transfer information.

3.2.7 *RF inhibiting*—a substance or material that causes a significant reduction in the effectiveness of radio waves that reach an RFID transponder.

3.2.8 *software*—an array of logic, displayed as an application, used to access and control a device.

3.2.9 *transponder acquisition distance*—the distance between the transponder and the interrogator antenna at which a transponder is first detected by an RFID system, when moving the transponder into the read field.

4. Summary of Test Method

4.1 This procedure is used to determine the read performance of the RF system while affixed to a fully assembled, unit

[1] This test method is under the jurisdiction of ASTM Committee D10 on Packaging and is the direct responsibility of Subcommittee D10.17 on Auto-ID Applications.

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

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load. The read field is developed by determining the critical transponder distance and the transponder acquisition distance

5. Significance and Use

5.1 Many materials used in the production of goods can have an adverse affect on the performance of an RFID system. This test method qualifies the performance of an RFID system applied to a unit load.

5.2 This test method is intended for systems used exclusively within the United States. Additional test standards from ISO or other standards bodies may apply to internationally handled goods and may include additional test scenarios not outlined in this test method.

6. Interferences

6.1 RFID systems are subject to interference from metal, water, and ambient RF energy. If significant levels of any of these interferences are present in the immediate testing area, the observed read field will be affected. Due to uncontrolled variation in testing facilities, numerical values for interference cannot be stated. Possible sources of interference shall be documented in the final report.

6.1.1 Documentation of interference shall include information regarding, material, size, and location relative to interrogator antenna.

6.2 If significant levels of interference are unavoidable, testing shall be conducted in such a manner that interferences remain unchanged throughout testing.

7. Atmospheric Conditions

7.1 Testing shall be conducted at standard conditioning atmosphere 23 ± 1°C (73.4 ± 2°F) and 50 ± 2 % relative humidity, unless otherwise noted as per 13.1.1.

7.2 The exact measurement of temperature and relative humidity of the testing atmosphere shall be made as close to the specimen being exposed as is possible. (See Test Method E337 for a detailed description of methods.) The temperature and relative humidity indicated at the control point may not be representative of conditions elsewhere in the conditioned space due to local effects or deficiency in air circulation. Tolerances at the controller usually must be smaller than those at the specimen.

8. Apparatus

8.1 *Material Handling Equipment*—The equipment used to move the unit load. This equipment may consist of a manual or electronic pallet jack, fork truck, or clamp truck.

8.2 *Antenna Stand*—The antenna stand shall be a stationary support constructed of an RF neutral material (wood or plastic, ideally) that can support the weight of the antenna being used while allowing for antenna height adjustment.

8.2.1 *Protractor*—A large protractor shall be placed at the base of the antenna stand to visually guide the operator along the radian being tested.

8.3 *RFID System:*

8.3.1 *Interrogator*—A manufactured device that communicates with RFID transponders via antennae and communicates transponder information to the host computer.

8.3.2 *Interrogator Antenna*—A manufactured device that emits RF energy to transponders and receives information from transponders in the form of reflected RF energy.

8.3.3 *Transponder (pallet transponder)*— A microchip with a small conductive antenna that receives RF energy from the interrogator antenna and reflects the information on the micro chip back to the interrogator antenna in the form of RF energy.

8.3.4 *Host Computer*—Any computer with the proper software to communicate with and operate the RFID interrogator.

9. Test Specimen

9.1 Each unit load shall be comprised of a specified quantity of unit case load(s), representative of a production run unit load.

9.2 Each unit case load shall consist of a representative production run package, or components of an assembled packaging system, to include primary, secondary, and/or tertiary packaging up through the shipping case level.

9.3 An RFID transponder specimen shall be a randomly selected transponder from an RFID transponder inventory.

10. Conditioning

10.1 Test specimens shall be conditioned at the standard conditioning atmosphere of 23 ± 2°C (73.4 ± 3.6°F) for a minimum of 24 h prior to testing (see Practice D4332) unless otherwise noted as per 13.1.1.

11. Procedure

11.1 *Mapping the Read Field:*

11.1.1 *Determining the Critical Distance Read Field of the Unit Load:*

11.1.1.1 Assemble RFID system.

11.1.1.2 Affix RFID pallet transponder to the unit load.

(1) The location of the RFID pallet transponder shall be documented and held constant throughout testing.

NOTE 1—Transponder placement was observed to be an instrumental variable affecting the readability of the transponder affixed to the unit load.

11.1.1.3 Mount the interrogator antenna to the antenna stand.

(1) Document the distance from the floor to the center of the interrogator antenna. If a fixed antenna is being used, document this in final report.

11.1.1.4 Place the unit load along the +90° radian, as close to the antenna stand as possible, such that a direct line of sight exists between the interrogator antenna and the transponder.

11.1.1.5 The location of the material handling equipment relative to the interrogator antenna shall be documented and held constant throughout testing.

NOTE 2—The metallic nature of material handling equipment was observed to have a significant affect on the readability of the transponder affixed to the unit load.

11.1.1.6 Slowly, move the unit load along the radian, away from the interrogator antenna, at a consistent speed until the RFID system no longer detects the transponder.

NOTE 3—Transponder detection is usually indicated by the graphical user interface on the host computer screen.

11.1.1.7 Record the critical transponder distance.

11.1.1.8 Repeat steps 11.1.1.5 through 11.1.1.7 for all radii in the in the ±90° spectrum at increments of 15°.

NOTE 4—Testing may also be done at increments of less than 15° depending upon the level of precision desired.

11.1.2 *Determining the Transponder Acquisition Read Field of the Unit Load:*

11.1.2.1 Place the unit load along the +90° radian at a distance that exceeds the corresponding critical transponder distance by 5 ft.

11.1.2.2 Slowly, move the unit load along the radian, toward the interrogator antenna, at a consistent speed (equal to the speed used in 11.1.1.6) until the RFID system first detects the transponder.

11.1.2.3 Record the transponder acquisition distance.

11.1.2.4 Repeat steps 11.1.2.1 through 11.1.2.3 for all radii in the in the ±90° spectrum at increments of 15°.

12. Interpretation of Results

12.1 *Graphical Representation:*

12.1.1 The acquisition distance and the critical distance for the unit load shall be graphically displayed in separate scaled diagrams representing the ±90° quadrant around the interrogator antenna (Fig. 1).

NOTE 5—Additional composite graphs may be produced to include acquisition and critical distances on the same diagram (Fig. 2).

12.2 *Data Analysis:*

12.2.1 The composite graph represents the read field of the RFID system relative to the tested unit load.

12.2.2 If the RFID transponder remains undetected while affixed to the unit load, the load is considered to have RF inhibiting characteristics.

13. Report

13.1 Report the following information:

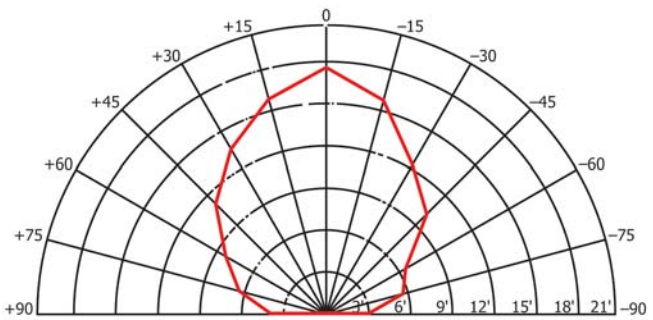

FIG. 1 Example of an Individual Graphical Representation

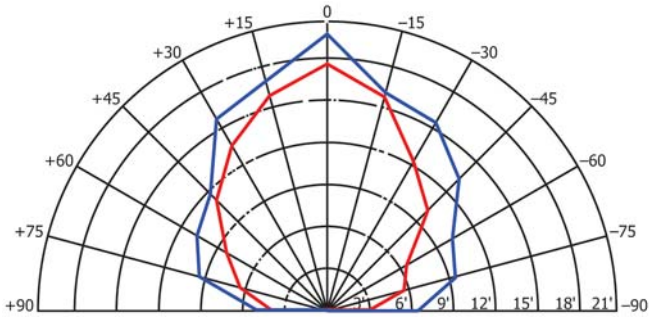

FIG. 2 Example of a Composite Graphical Representation

13.1.1 A statement that the test was conducted in compliance with these test methods or a description of any deviation(s) from these test methods.

13.1.2 Identification of the RFID system including:

13.1.2.1 Identification of the make, model, and firmware version of the interrogator.

13.1.2.2 Identification of the make and model of the interrogator antenna.

13.1.2.3 Identification of the make and model of the transponder.

13.1.2.4 Identification of the make, model, and software version (where applicable) of the host computer.

13.1.2.5 All relevant reader settings where available (that is, power setting, reader operation mode).

13.1.3 Description of the unit load.

13.1.3.1 Description of the product, internal packaging, shipping container, and closure system, where applicable.

13.1.4 The temperature and humidity conditioning prior to testing.

13.1.5 Graphical representations of the observed read fields (individual or composite) including:

13.1.5.1 Critical transponder distance for the unit load.

13.1.5.2 Transponder acquisition distance for the unit load.

14. Precision and Bias

14.1 *Precision*—Based on replicate testing in one laboratory using Alien Gen 2 'Squiggle' transponders and a Sensormatic Agile 2 reader, the pooled standard deviation of acquisition distance was 3.4 in. The pooled standard deviation of critical distance was 4.0 in. These estimates of within-laboratory repeatability may vary with other equipment, transponders, test conditions, and so forth.

14.2 *Bias*—The procedures in this test method have no bias because there are no accepted reference materials or procedures.

15. Keywords

15.1 critical transponder distance; mapping; packaging; radio frequency identification; read field; RFID; transponder; transponder acquisition distance; unit load

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