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Standard Guide for Selection of Substitute, Non-hazardous, Liquid Filling Substances for Packagings Subjected to the United Nations Performance Tests[1]

This standard is issued under the fixed designation D7887; 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~~ Scope*

1.1 ~~The purpose of this~~ This guide is intended to clarify the selection, use, and description criteria of non-hazardous liquid substitutes used to replace ~~hazardous materials for the purpose of performance testing packagings.~~liquid hazardous materials on packagings designs being subjected to United Nations (UN) performance-oriented packaging certification as required by United States Department of Transportation Title 49 Code of Federal Regulations (49 CFR) and the United Nations Recommendations on the Transport of Dangerous Goods (UN). This includes identification of the physical parameters of substitute non-hazardous liquid test fill materials that may affect packaging performance and test results and should be considered when selecting and describing a test fill material that conforms to the requirements of the Hazardous Materials Regulations (HMR).

1.2 This guide provides information to assist packaging users, manufacturers, and performance testing service suppliers regarding the types of physical properties that should be considered when selecting substitute liquid filling substances for the testing, certification, and manufacture of packagings under the United Nations packaging protocols ~~(UN Recommendations on the Transport of Dangerous Goods-Model Regulations)~~ as adopted by US DOT in 49 CFR ~~HMR.~~HMR..

1.3 This guide provides the suggested minimum information concerning the physical characteristics of the filling substances that should be documented in the certification test report and notification to users to allow for test repeatability and ~~analysis, and to provide guidance to the user of a packaging of pertinent physical differences between potential hazardous lading and the filling substance with which the packaging was tested.~~analysis. Attention should be paid to the differences in physical characteristics of the substance used in the test compared to the materials transported.

1.4 This guide does not purport to address regulatory requirements regarding the compatibility of filling substances with transport packagings. Compatibility requirements must be assessed separately, but it should be noted that under certain national and international dangerous goods regulations, the selection of the filling substances for package performance testing may be prescribed with respect to chemical compatibility requirements.

NOTE 1—Under the US HMR determination of packaging compatibility with a particular hazardous fill material is "the responsibility of the person offering the hazardous material for transportation" as prescribed in 49 CFR § 173.24(e).

1.5 The units of measurement are consistent with the HMR.

1.6 When testing packaging designs intended for hazardous materials (dangerous goods), the user of this guide shall be trained in accordance with 49 CFR §172.700 and other applicable hazardous materials regulations such as the ICAO Technical Instructions, IMDG Code, other applicable national or international dangerous goods regulations that govern the testing, manufacture and use of packagings authorized for the transportation of Dangerous Goods, and carrier rules such as the IATA Dangerous Goods Regulations.

1.7 *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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *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 test method is under the jurisdiction of ASTM Committee D10 on Packaging and is the direct responsibility of Subcommittee D10.22 on Hazardous Materials.

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***A Summary of Changes section appears at the end of this standard**

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

D891 Test Methods for Specific Gravity, Apparent, of Liquid Industrial Chemicals

D1200 Test Method for Viscosity by Ford Viscosity Cup

D4359 Test Method for Determining Whether a Material Is a Liquid or a Solid

D4919 Guide for Testing of Hazardous Materials (Dangerous Goods) Packagings

D7790 Guide for Preparation of Plastic Packagings Containing Liquids for United Nations (UN) Drop Testing

D8135 Guide for Selection of Substitute, Non-hazardous, Particulate Solid Filling Substances for Packagings Subjected to the United Nations Performance Tests

2.2 *Federal Standard:*[3]

~~U.S. Department of Transportation Code of Federal Regulations Title 49,~~ ~~Transportation~~ U.S. Department of Transportation Code of Federal Regulations Title 49, Transportation (49 CFR) Parts ~~100-199~~100-185

2.3 *UN Standard:*[4]

~~United Nations Recommendations on the Transport of Dangerous Goods,~~ UN United Nations Recommendations on the Transport of Dangerous Goods, Model Regulations (UN Orange Book)

2.4 ~~*International Air Transport Association (IATA)*~~ *IATA Standard:*[5]

~~IATA~~ IATA International Air Transport Association (IATA) Dangerous Goods Regulations

2.5 *ICAO Standard:*[6]

~~International Civil Aviation Organization (ICAO)~~ ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air

2.6 *IMDG Standard:*[7]

~~International Maritime Dangerous Goods Code~~ International Maritime Dangerous Goods Code (IMDG Code)

3. Terminology

3.1 *Definitions:*

3.1.1 *kinematic viscosity, n*—the ratio of absolute or dynamic viscosity to density - a quantity in which no force is involved. Kinematic viscosity can be obtained by dividing the absolute viscosity of a fluid with its mass density:

$$v = \mu/\rho \quad (2) \tag{1}$$

where:

v = kinematic viscosity,
μ = absolute or dynamic viscosity, and
ρ = density.

3.1.1.1 *Discussion*—

In the SI-system, the theoretical unit is m^2/s or commonly used Stoke (St) where: 1 St = 10^{-4} m^2/s.

3.1.1.2 *Discussion*—

Since the Stoke is an impractically large unit, it is usual divided by 100 to give the unit called Centistokes (cSt) where: 1 St = 100 cSt; 1 cSt = 10^{-6} m^2/s.

3.1.1.3 *Discussion*—

[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 Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9371 (website: ~~phmsa.dot.gov/hazmat).~~https://www.phmsa.dot.gov/phmsa-regulations).

[4] Available from the UN Economic Commission for Europe, Information Service, Palais des Nations, CH-1211 Geneva 10 Switzerland (website: ~~http://www.unece.org/trans/danger/danger.htm).~~http:// www.unece.org/trans/danger/danger.htm).

[5] Available from the International Air Transport Association (IATA), 800 Place Victoria PO Box 113 Montreal - H4Z 1M1 Quebec - Canada (website: ~~http://www.iata.org).~~http:// www.iata.org).

[6] Available from the International Civil Aviation Organization, (ICAO) 999 University Street, Montréal, Quebec H3C 5H7, Canada (website: ~~http://www.icao.org/).~~http://www.icao.org/).

[7] Available from the International Marine Organization (IMO, 4 Albert Embankment, London, SE1 7SR United Kingdom (website: http://www.imo.org/).

Since the specific gravity of water at 68.4°F (20.2°C) is almost one (1), the kinematic viscosity of water at 68.4°F is for all practical purposes 1.0 cSt.

3.1.2 *liquid, n*—a material, other than an elevated temperature material, with a melting point or initial melting point of 20°C (68°F) or lower at a standard pressure of 101.3 kPa (14.7 psia). A viscous material for which a specific melting point cannot be determined must be subjected to the procedures specified in ASTM D4359 "Standard Test Method for Determining Whether a Material is Liquid or Solid" (IBR, see §171.7).

3.1.3 *Newtonian liquid, n*—a liquid that exhibits a constant coefficient of viscosity as represented by a shear rate/shear stress plot that is both linear and passes through the origin of the shear rate/shear stress plot within the ranges of shear rates encountered in testing. A material not meeting this definition would be considered non-Newtonian.

3.1.3.1 *Discussion*—

Newtonian liquids: Water, ethanol solutions, un-treated glycol solutions (glycol solutions treated to coat surfaces as a de-icing agent, such as airplane de-icing products, are formulated to be non-Newtonian).

3.1.3.2 *Discussion*—

Non-Newtonian liquids: Many paints, toothpaste, peanut butter, ketchup, mayonnaise, blood, drilling mud, many fine particle slurries and pastes.

3.1.4 *shear rate, n*—the relative velocities in the flow of parallel adjacent layers (laminar flow) of a fluid from the application shear force. In aggregate, this is the rate of flow for a liquid in proportion to the amount of force causing the flow.

3.1.5 *shear stress, n*—the resistance (both internal and at the boundary) of a fluid to flow in reaction to a force applied parallel to the direction of motion in the flow channel (shear force).

3.1.6 *specification packaging, n*—a packaging conforming to one of the specifications or standards for packagings in 49 CFR part 178 or part 179 of this subchapter.

3.1.6.1 *Discussion*—

Packaging, as used in this guide, includes packaging constructed and tested to UN performance standards as adopted in the HMR (the focus of this guide) but does not exclude its use for other types of packagings.

3.1.7 *specific gravity, n*—ratio of the testing substance density to a standard substance (i.e. water) density at a specific temperature and pressure.

3.1.8 *viscous liquid, n*—a liquid material which has a measured viscosity in excess of 2500 centistokes at 25°C (77°F) when determined in accordance with the procedures specified in ASTM Test Method D445-72 "Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)" or ASTM Test Method D1200-70 "Viscosity of Paints, Varnishes, and Lacquers by Ford Viscosity Cup."

NOTE 2—Additional terms and definitions are located in 49 CFR section 171.8 and the UN Orange Book, section 1.2.1.

4. Summary of Guide

4.1 The manufacturer, test facility or user of a packaging will apply the procedural considerations, based on the physical characteristics of the liquid hazardous material to be transported, outlined in this guide to select an appropriate fill material to use when testing a packaging. In addition, packaging manufacturers and test facilities will use this guide to provide sufficient information concerning the relevant physical characteristics (density, viscosity, net weight) of the test fill material to the user of a packaging to allow for a proper evaluation of suitability of a packaging for a particular liquid hazardous material.

5. Significance and Use

5.1 Regulations prescribing the test procedures for hazardous materials packaging allow for the substitution of non-hazardous fill materials for packaging performance tests with certain limitations ~~prescribed and guidance offered [See:~~ as outlined in 49 CFR ~~178.602(c)].~~ 178.602(c). This regulatory guidance has proven to be flexible enough, in common industry practice, to produce variations in the selection of fill materials for package performance tests ~~sufficient to~~ that may cause inconsistent and non-repeatable test results. This variation ~~creates~~ has the potential to create significant problems in product liability, packaging selection, and regulatory enforcement in this highly regulated industry. Use of this guide should enhance uniformity in test procedures.

5.2 Consistent and repeatable test results coupled with clear test fill product descriptions will enhance transportation safety by simplifying packaging selection. This will also increase the general level of confidence that package testing, manufacture and use are being guided by sound, generally accepted engineering principles. It also aids in clarifying expectations between the packaging industry and the regulatory authorities.