



Designation: D8409 – 21

Standard Guide for Conducting Stacking Tests on UN Packagings Using Guided or Unguided Loads¹

This standard is issued under the fixed designation D8409; 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 guide is intended to provide a standardized method and a set of basic instructions for conducting stacking tests on United Nations (UN) non-bulk, intermediate bulk container (IBC), and Large Packagings. Using guided or unguided loads in accordance with the U.S. Department of Transportation Title 49 Code of Federal Regulations (CFR) and the UN Recommendations on the Transport of Dangerous Goods (“The Orange Book”). The combination or interchange of these regulations will be referred to as the Hazardous Material Regulations (HMR).

1.2 The Dangerous Goods Regulations require performance tests to be conducted on packaging designs prior to being authorized for use. The regulations do not include standardized procedures to accomplish this which can result in differences between testing facilities. The purpose of this document is to provide guidance and to establish a set of common practices for conducting stack testing on packagings undergoing UN certification.

1.3 The user of this guide must be trained in accordance with 49 CFR as required by 172.700 and should be familiar with other applicable hazardous materials regulations such as; International Civil Aviation Organization (ICAO) Technical Instructions for the Safe Transport of Dangerous Goods by Air, the International Maritime Dangerous Goods Code (IMDG Code), and carrier rules such as International Air Transport Association (IATA) Dangerous Goods Regulations.

1.4 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

1.5 *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.

1.6 *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

- D642 Test Method for Determining Compressive Resistance of Shipping Containers, Components, and Unit Loads
- D685 Practice for Conditioning Paper and Paper Products for Testing
- D996 Terminology of Packaging and Distribution Environments
- D4332 Practice for Conditioning Containers, Packages, or Packaging Components for Testing
- D4577 Test Method for Compression Resistance of a Container Under Constant Load
- D4919 Guide for Testing of Hazardous Materials (Dangerous Goods) Packagings

2.2 ISO Standards:³

- ISO 2234 Packaging – Complete, filled transport packages – Stacking tests using static load
- ISO 16495 Packaging – Transport packaging for dangerous goods – Test methods

¹ This guide 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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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, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <https://www.iso.org>.

2.3 *Federal Standard*.⁴

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

2.4 *UN Standard*.⁵

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

2.5 *IATA Standard*.⁶

IATA International Air Transport Association (IATA) Dangerous Goods Regulations

2.6 *ICAO Standard*.⁷

ICAO Technical Instructions for the Safe Transport of Dangerous Goods by Air

2.7 *IMDG Standard*.⁸

International Maritime Dangerous Goods Code (IMDG Code)

3. Terminology

3.1 *Definitions*:

3.1.1 General definitions for packaging and distribution are found in Terminology **D996**.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *deflection, n*—amount of vertical deformation in the height of the package under the test load during the test period.

3.2.2 *dynamic compression test, n*—a top loading compression test performed using a machine capable of applying a dynamic top loading on a package. This test is performed in conformance with Test Method **D642** and the regulations as applicable.

3.2.3 *guided load, n*—a static top loading test performed with fixed platen compression machines or in a “dead load” stack arrangement where the packaging and weight stack are constrained from tipping due to deformation or collapse of the packaging.

3.2.4 *intermediate bulk container (IBC), n*—a rigid or flexible portable packaging, other than a cylinder or portable tank, which is designed for mechanical handling, has volumetric capacity of not more than 3000 L and includes: flexible, composite, and rigid IB Cs.

3.2.5 *large packaging, n*—a packaging that contains articles or inner packagings, which is designed for mechanical handlings, exceeds 400 kg net mass or has a volumetric capacity greater than 450 L but not more than 3000 L.

3.2.6 *load spreader, n*—rigid plate that spreads the stack load across the entire top surface area of the package under the

load. The load spreader shall extend to the outside edge of the perimeter or beyond the perimeter of the test specimen.

3.2.7 *packagings, n*—receptacles and any other components or materials necessary for the receptacle to perform its containment function in conformance with the minimum requirements of the HMR; and includes non-bulk, IBC, and Large Packagings.

3.2.8 *stacking test (top load compression test), n*—a test designed to ascertain the performance capability of a packaging under top load compressive forces in storage or transportation. It is a required design type test for all non-bulk packagings except bags, and all IB Cs intended to be stacked.

3.2.9 *unguided load, n*—a constant top loading test performed with floating (swivel) platen compression machines or a “dead load” (constant load) mass applied in manner that would allow the stack load to tip over in the event of excess deformation or collapse of the packaging. Floating platens swivel to maintain constant load on parts of the packaging that are deforming under pressure.

3.2.9.1 *Discussion*—Additional packaging terms and definitions specific to the regulations are located in 49 CFR, Section 171.8, and the Orange Book, Section 1.2.1.

4. Significance and Use

4.1 This guide is intended to provide a standardized method and a set of basic instructions for performing stack testing on UN packaging designs using either guided or unguided top loads. This guide provides the suggested minimum information that should be documented when conducting stacking test and provides information for recommended equipment.

4.2 All packaging design types other than bags must be subjected to a stacking test. Packagings subject to the stacking test must be capable of withstanding a superimposed top load of a specified minimum mass for a specified period of time without failure as these parameters are defined in the regulations. The test is not intended to determine the absolute top load capability of a packaging.

NOTE 1—When quantification of box compression strength is desired for determining stacking strength or for design purposes use Test Method **D642** and conditioning as recommended in **4.5**.

4.3 Design qualification testing procedures are intended, as explicitly stated in the HMR, to be the minimum performance capability levels for packaging manufactured to transport Hazardous Materials under conditions normally incident to transportation.

4.4 The HMR tests are designed to be gross package capability evaluations that can be performed in a similar manner in all parts of the world, but under circumstances with some variance in test facility capabilities. This is an intentional feature of the test designs and protocols. The focus of HMR testing is not the determination of quantifiable, comparison data to allow for analytical evaluation.

4.5 It is recommended that facilities performing the HMR tests consult the guidance on conditioning in the relevant ASTM documents for any particular packaging material as

⁴ Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9371 (website: <https://www.phmsa.dot.gov/phmsa-regulations>).

⁵ 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>).

⁶ Available from the International Air Transport Association (IATA), 800 Place Victoria PO Box 113 Montreal - H4Z 1M1 Quebec - Canada (website: <http://www.iata.org>).

⁷ Available from the International Civil Aviation Organization, (ICAO) 999 University Street, Montréal, Quebec H3C 5H7, Canada (website: <http://www.icao.org>).

⁸ Available from the International Marine Organization (IMO), 4 Albert Embankment, London, SE1 7SR United Kingdom (website: <http://www.imo.org>).