Designation: D642 – 20

Standard Test Method for Determining Compressive Resistance of Shipping Containers, Components, and Unit Loads[1]

This standard is issued under the fixed designation D642; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers compression tests on shipping containers (for example, boxes and drums) or components, or both. Shipping containers may be tested with or without contents. The procedure may be used for measuring the ability of the container to resist external compressive loads applied to its faces, to diagonally opposite edges, or to corners. This test method covers testing of multiple containers or unit loads, in addition to individual shipping containers, components, materials, or combination thereof.

1.2 The test method of applying load may be used to compare the characteristics of a given design of container with a standard, or to compare the characteristics of containers differing in construction.

1.3 This test method is related to TAPPI T 804. This test method fulfills the requirements of International Organization for Standardization (ISO) Test Method 12048. The ISO standards may not meet the requirements for this test method.

1.4 The test may be conducted with the container loaded with contents and interior packaging in cases where the contents share the load.

1.5 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.

1.6 *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.*

1.7 *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]

D685 Practice for Conditioning Paper and Paper Products for Testing

D996 Terminology of Packaging and Distribution Environments

D1968 Terminology Relating to Paper and Paper Products

D4169 Practice for Performance Testing of Shipping Containers and Systems

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

D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials

D4577 Test Method for Compression Resistance of a Container Under Constant Load

E4 Practices for Force Verification of Testing Machines

E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process

2.2 *TAPPI Standards:*[3]

T 412 Moisture in Pulp, Paper and Paperboard

T 804 Compression Testing of Fiberboard Shipping Containers

2.3 *ISO Standard:*[4]

ISO 12048 Packaging—Complete, Filled Transport Packages—Compression and Stacking Test Using Compression Tester

[1] This test method is under the jurisdiction of ASTM Committee D10 on Packaging and is the direct responsibility of Subcommittee D10.21 on Shipping Containers and Systems - Application of Performance Test Methods.

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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 the Technical Association of the Pulp and Paper Industry, 15 Technology Parkway South, Atlanta, GA 30092.

[4] Available from American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

3. Terminology

3.1 *Definitions*—General terms for Packaging and Distribution Environments are found in Terminology D996.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 Terms specific to fiberboard containers are found in Terminology D1968.

3.2.2 *fixed platen testing machine (Fig. 1)*—a testing machine equipped with two platens which are both restrained from tilting.

3.2.3 *swiveled platen testing machine (Fig. 2)*—a testing machine equipped with two platens, one rigidly restrained from tilting while the other platen is universally mounted and allowed to tilt freely.

4. Significance and Use

4.1 Compressive resistance is one of the properties used to evaluate the ability of shipping containers, components, and unit loads to successfully survive the compressive forces they are subjected to during storage and distribution (see Note 1).

NOTE 1—For constant load test refer to Test Method D4577.

4.2 Compressive resistance may be determined with either fixed- or swiveled-platen-type testing machines. However, a fixed-head compression machine is required to perform edge-to-edge and corner-to-corner orientations on test specimens (see Note 2). Also, unit loads are generally tested only in the top-to-bottom orientation.

NOTE 2—Fixed-platen machines generally cause corrugated box specimens to fail at their strongest point, while swivel-platen machines cause corrugated box specimens to fail at their weakest point.[5] The swiveled platen is allowed to move to the weakest point of the container.

5. Apparatus

5.1 *Compression Testing Machines:*

5.1.1 *Fixed-Platen Testing Machine*—Two platens, flat to within 0.01 in. (0.25 mm) for each 12 in. (304.8 mm) in length, and one of which is movable in the vertical direction so as to compress the container between the platens. One is the load-measuring platen, and both should be of sufficient size so that the test container does not extend beyond the edges of the platens. Both platens are fixed in the horizontal directions so as to have no lateral movement greater than 0.05 in. (1.3 mm), and are held parallel throughout the test to within 0.04 in. (1 mm) for each 12 in. (304.8 mm) in the length and width dimensions.

5.1.2 *Swivel-Platen Testing Machine*—Two platens, flat to within 0.01 in. (0.25 mm) for each 12 in. (304.8 mm) in length, and one which is movable in the vertical direction so as to compress the container between the platens. One is the load-measuring platen, and both should be of sufficient size so that the test container does not extend beyond the edges of the platens. One platen is fixed in the horizontal direction so as to have no lateral movement greater than 0.05 in. (1.3 mm). The second platen is attached to the machine by a swivel or universal joint to a point directly centered on the platen, allowing the platen to tilt freely.

5.2 *Suitable Closure Apparatus*—See Appendix X1.

5.3 *Conditioning Apparatus*—Provide adequate facilities for conditioning test containers at proper relative humidity and temperature prior to test in accordance with the requirements of the specifications covering the containers to be tested. It is recommended that the atmospheres for conditioning be selected from those shown in Practice D4332. Unless otherwise specified, fiberboard and other paperboard containers shall be preconditioned and conditioned in accordance with the standard atmosphere specified in Practice D4332 for transit simulation testing or Practice D685 when quantification of box compression strength is required.

6. Sampling, Test Specimens, and Test Units

6.1 Choose test specimens and sample quantities to provide an adequate determination of representative performance. For large production runs, lot sampling is advised. Application of Practice E122 is suggested.

6.2 Whenever sufficient containers and contents are available, it is recommended that five or more replicate tests be conducted to improve the statistical reliability of the data obtained.

6.3 The specimens being tested shall be complete in all respects. Depending on the purpose of the test, interior components may or may not be included. Tests shall be made on specimens with or without contents as prescribed.

6.4 The test specimen shall be closed and secured in the same manner as will be used in preparing them for shipment unless otherwise specified. The method of flap securement for corrugated containers may affect test results (see Appendix X1).

7. Calibration and Standardization

7.1 The accuracy of the test equipment must be verified to ensure reliable test data.

7.1.1 The overall system accuracy of the recorded or indicated applied load (force) shall be verified in accordance with Practice E4. The loading range being verified shall be specified. The individual load levels within that range used for calibration testing shall be specified. The algebraic difference between errors of two applications of the same force level (repeatability) shall not exceed 1 %. If testing below the Practice E4 verified loading range is desired, then the maximum permissible error shall not exceed ±0.2 % of the full range of the force sensor. Calculate as follows:

$$E = F_S \times 0.002 \quad (1)$$

where:

E = maximum permissible error, lbf or N, and
F_S = force sensor's full range, lbf or N.

7.1.2 The required resolution on box displacement during compression testing differs by intended use. The accuracy of the recorded or indicated platen displacement must be verified in accordance with the equipment manufacturer's recommended procedures.

[5] Singh, S. P., Burgess, G., Langlois, M., "Compression of Single-Wall Corrugated Shipping Containers Using Fixed and Floating Test Platens," *ASTM JOTE*, July 1992.

7.1.2.1 For quantification of box strength in compression where the accuracy of the output is affected by displacement (for example, for design testing): The displacement error, including the effects of any backlash in the loading system, shall not exceed ±0.02 in. (±0.5 mm).

7.1.2.2 For sequential testing to a calculated load and quantification of box strength testing where a yield in the load is used as the stop criteria: The displacement error, including the effects of any backlash in the loading system, shall not exceed ±0.1 in. (±2.5 mm).

7.1.3 The accuracy of the platen travel rate at 0.5 in./min (12.7 mm/min) must be verified throughout each loading range in accordance with the equipment manufacturer's recommended procedures. The error, including any backlash in the loading system, shall not exceed ±0.10 in./min (±2.5 mm/min).

8. Conditioning

8.1 Test specimens shall be conditioned prior to test or during test, or both, in accordance with the requirements of the applicable specification. When no conditioning requirements are given and container materials are moisture sensitive, a standard conditioning atmosphere is recommended in accordance with Practice D4332 for transit simulation testing or Practice D685 when quantification of box compression strength is required.

8.1.1 Moisture content determination may be carried out for moisture-sensitive materials at the time of the test to confirm test effects of conditioning (see Appendix X2).

8.2 For special applications, and depending on the purpose of the test, the test specimens may be conditioned prior to the compression test by water immersion, exposure to water spray, or other specific conditions.

9. Procedure

9.1 Determine the criteria for ending the test. When testing to maximum load, defined failure limits are used. Failure may be defined either by a reduction in the maximum load supported or by reaching a deformation limit.

NOTE 3—Typical failure values for corrugated box testing are a force yield of 10 % (decrease from the maximum load obtained) or a deformation of ¾ in. (19 mm).

NOTE 4—Special applications such as Practice D4169 may require that a specific load be calculated and then applied to the container.

9.2 Center the specimen on the lower platen of the testing machine in the desired orientation, so as not to incur eccentric loading.

9.2.1 Significant errors may result during testing if the specimen is placed off-center on the platen. Also, extensive damage to equipment may occur if test specimens are placed off-center on the platen.

9.3 Bring the platens into contact with the specimen applying an initial pressure or pre-load. Apply the pre-load at a rate not to exceed 0.5 ± 0.1 in./min (12.7 ± 2.5 mm/min).

9.3.1 For single-wall corrugated containers, an initial force or pre-load of 50 lbf (222 N) on the specimen is recommended. For double-wall and triple-wall boxes, pre-loads of 100 lbf (445 N) and 500 lbf (2220 N), respectively, are recommended. For other types of test specimens a suitable pre-load may or may not be selected.

9.4 Fixed-platen machines must be used for tests where the compressive loads are applied on test specimen edges, or on diagonal corners (Fig. 1). Either fixed-platen or swivel-platen machines may be used for face-to-face compressive tests (Fig. 2).

9.5 If the testing machine is not fitted with a load-deformation recorder, record the test load for every 0.1 in. (2.5 mm) of deformation of the container (see 9.5.1). Set the load-deformation recorder to display zero deformation.

9.5.1 When testing full containers, and the load sensing device is located under the bottom platen, be sure to zero the test machine with the product on it, or subtract the container weight from peak load readings.

9.6 Apply the load with a continuous motion of the movable platen of the testing machine at a speed of 0.5 ± 0.1 in. (12.7 ± 2.5 mm)/min until failure or a specified load has been reached (see Note 4).

10. Report

10.1 Report the following information:

10.1.1 A statement indicating that the tests were performed in accordance with this test method, except where noted.

10.1.2 *Container Structural and Physical Specifications:*

10.1.2.1 Inside dimensions should be specified for all corrugated and solid fiberboard containers.

10.1.2.2 Description of the contents (products) of the container and gross weight of the filled container, as tested.

10.1.2.3 Description and specification of materials, style of container, access holes, and double scores.

10.1.2.4 Description and specifications for interior packaging, if used.

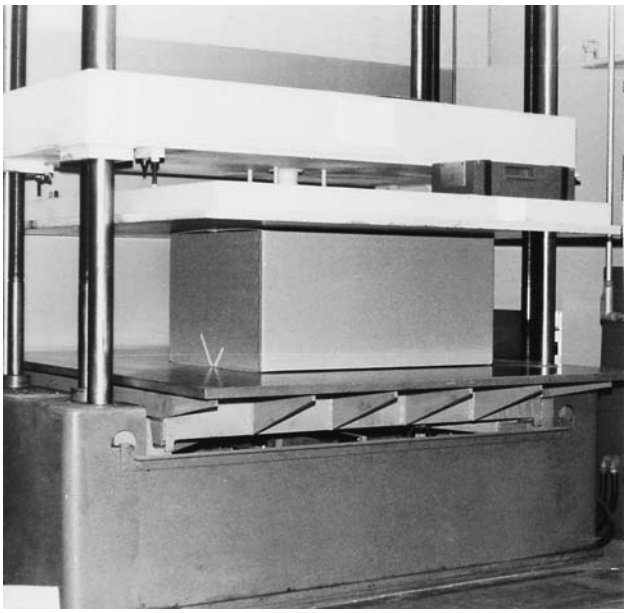

FIG. 1 Box Compression Top to Bottom Using a Fixed-Platen Machine

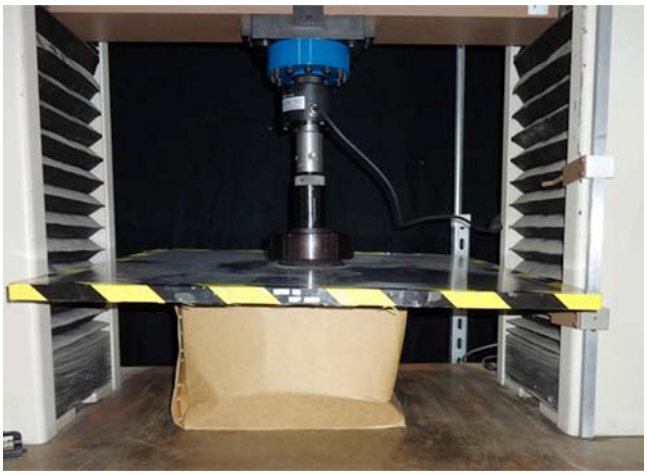

FIG. 2 Compression Top to Bottom Using a Swivel-Platen Machine

10.1.2.5 Spacing, size, and type of fasteners, and method of closure.

10.1.2.6 Printing amount and location on container. Record caliper of printed and plain surfaces.

10.1.3 *Detailed Results for Each Test Specimen:*

10.1.3.1 Pre- *and post-test* damage to the container and contents.

10.1.3.2 Any observations that may assist in correctly interpreting the results or aid in improving the design of the container (for example, photographic evidence of container damage).

10.1.3.3 Nature and cause of failure.

10.1.3.4 Any tests performed on the test specimen prior to compression testing.

10.1.3.5 A tabulation of individual maximum load and deformation results.

10.1.3.6 Graph or table showing the load-deformation relationship for each test.

10.1.3.7 Number of specimens tested.

10.1.3.8 Mean and standard deviation calculations of all specimens tested.

10.1.4 *Identification of Test Apparatus and Instrumentation Used, Including Manufacturer's Names and Model Numbers:*

10.1.4.1 Type of test machine used, such as fixed or swiveled platen. Include details of any known modifications.

10.1.4.2 Orientation in which the specimen was tested, such as platen speed and pre-load applied to the test specimen, if any.

10.1.4.3 Date of last calibration of apparatus and recording instrumentation.

10.1.5 Method, if any, of conditioning the container.

10.1.6 The moisture content of the wood, plywood, or fiberboard, if determined.

10.1.7 Description of test setup used such as pallets, fixtures, or simulation devices.

10.1.8 The results of any supplementary tests of the materials from which the container is made.

11. Precision and Bias[6]

11.1 The precision and bias statement is based on data developed from a round-robin compression test[7] conducted by eleven laboratories. The test specimens consisted of 200-lb test C-flute regular slotted containers measuring 16 by 12 by 10 in. When testing empty RSC-style corrugated containers for top-to-bottom compression strength using a fixed-platen compression tester, the precision of the test method is as follows:

11.1.1 *Repeatability*—The difference between successive results obtained by the same operator with the same apparatus under constant operating conditions on identical test materials would in the long run, in normal and correct operation of the test method, exceed the following values only one time in 20:

$$\text{Repeatability} = 8.5\,\%\ (\text{standard deviation}) \tag{2}$$

11.1.2 *Reproducibility*—The difference between two single and independent results obtained by different laboratories on identical material would, in the long run, in normal and correct operation of the test method, exceed the following values only one time in 20:

$$\text{Reproducibility} = 11.3\,\%\ (\text{standard deviation}) \tag{3}$$

NOTE 5—The repeatability and reproducibility values may reflect the inherent variability of the test specimen as much as the actual variability of the test method and the apparatus.

11.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in this test method, no statement on bias is being made.

12. Keywords

12.1 compression; compression strength; corrugated boxes; dynamic load; fixed platen; floating platen; packaging; shipping containers; unit loads

[6] Miles, J. G., "Compression Strength of Corrugated Containers: An Interlaboratory Study," *Materials Research Standards*, Vol 6, No. 3, March 1966, pp. 142–146.

[7] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D10-1015. Contact ASTM Customer Service at service@astm.org.