Designation: D7030 – 04 (Reapproved 2017)

# Standard Test Method for Short Term Creep Performance of Corrugated Fiberboard Containers Under Constant Load Using a Compression Test Machine[1]

This standard is issued under the fixed designation D7030; 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 covers determining the resistance of an empty paper corrugated shipping container to a vertically applied constant compression load for a specified time. The test method may also include palletized or unitized loads made of such containers. The boxes are tested in the orientation that they are most likely to be stacked in a unitized or palletized load.

1.2 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.

1.3 *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.*

1.4 *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

D644 Test Method for Moisture Content of Paper and Paperboard by Oven Drying (Withdrawn 2010)[3]

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

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

## 3. Terminology

3.1 *Definitions*—General definitions for the packaging and distribution environments are found in Terminology D996.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *constant load*—a load that is invariable or unchanging.

3.2.2 *creep*—continued deformation over time while under constant load.

3.2.3 *load*—the force applied to a body.

3.2.4 *static load*—an imposed stationary force, constant in magnitude and direction.

## 4. Significance and Use

4.1 In the distribution system, the packaged product may be stored for a period of time in a manner such that one or more containers are stacked on one another. The bottom package is thus continually subjected to a constant compression load.

4.2 This test method subjects an empty container to a predetermined static load and to specified atmospheric conditions, if required, over a short period of time using fixed platen compression testing equipment. Deflection is measured over time.

[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] The last approved version of this historical standard is referenced on www.astm.org.

4.3 Deflection versus time data can be used to predict time to failure of corrugated shipping containers under constant load.

## 5. Apparatus

5.1 *Fixed-Platen Testing Machine*—Two platens, flat to within 0.01 in. (0.25 mm) for each 12 in. (304.8 mm) in length, 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 that the lateral movement is not 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. See Fig. 1. The testing machine should be capable to maintain load within 1 % of the required level for the duration of the test.

5.2 *Closing Equipment for Fiberboard Boxes*—Suitable materials and application equipment for closing boxes should be used. If adhesives are used, sealing boards described in Test Method D642 may be needed.

5.3 *Conditioning Apparatus*—Adequate facilities shall be provided to maintain a conditioned atmosphere of temperature and humidity as required for the purpose of the test.

5.4 *Miscellaneous Equipment*—Drying oven, scales, knife, saws, and the like, for use in determination of the moisture content or for making other supplementary tests of the materials from which the containers are made.

## 6. Calibration

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

6.1.1 The overall system accuracy of the recorded or indicated applied load (force) shall be verified in accordance with Practice E4. The verified loading range shall be specified, and errors within the loading range shall not exceed ±1.0 % of the reading (as calculated in Practice E4). 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, calculated as follows:

$$E = F_S \times 0.002$$

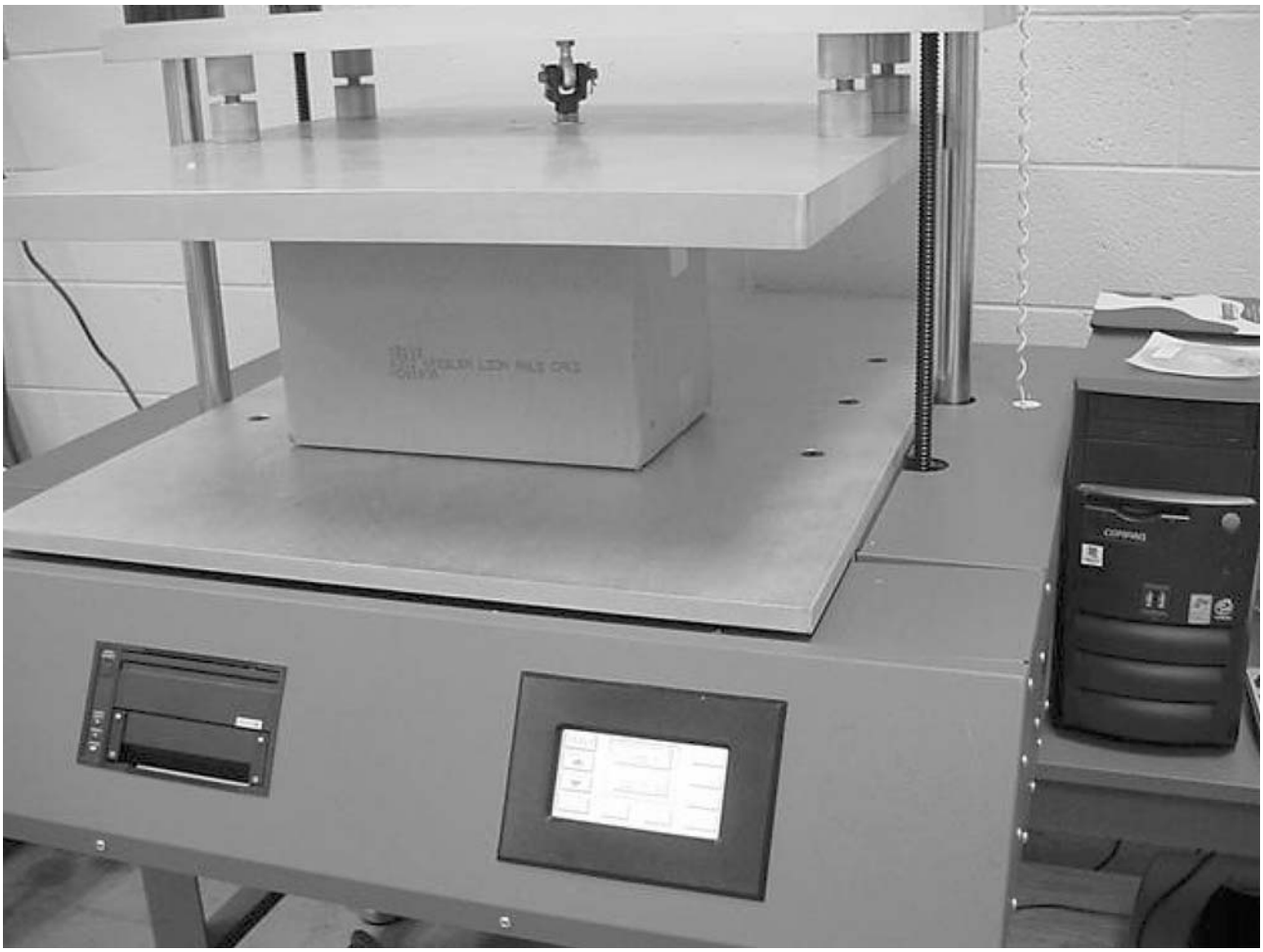

**FIG. 1 Corrugated Container Under Creep Test in Compression Test Machine**

where:

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

6.1.2 The accuracy of the *recorded or indicated* platen displacement must be verified in accordance with the equipment manufacturer's recommended procedures. The error, including the effects of any backlash in the loading system, shall not exceed ±0.1 in. (±2.5 mm).

6.1.3 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).

## 7. Test Specimens and Number of Tests

7.1 The containers being tested shall be complete in all respects. Tests should be conducted on empty containers. The containers should be closed and secured in the same manner as will be used in preparing them for shipment (for example, tape, strapping). Include any internal load-bearing members like partitions, and corner posts, if used in actual shipments.

7.2 Performance should be based on tests of not fewer than five representative specimens of a given size and type of container.

7.3 Refer to Practice E122 for additional information on sample size.

## 8. Conditioning

8.1 When required, the container should be conditioned for the static load test by exposure to fixed or controlled variable conditions of temperature and humidity.

8.1.1 Where applicable, a special atmosphere selected from those specified in Practice D4332 may be used.

8.2 The test container shall be preconditioned in the desired atmosphere for such a time as is necessary to bring the container into equilibrium with that atmosphere and using the techniques in Practice D685.

## 9. Procedure

9.1 Select the constant load to which the container will be subjected. The selection may be based on:

9.1.1 The load to which a bottom container in a stack will be subjected to in storage.

9.1.2 A percentage of the value obtained by Test Method D642 on a similar container.

9.2 Center the specimen on the bottom platen of the testing apparatus so as not to incur eccentric loading.

9.3 Place the test load on the specimen. The load shall be applied 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 the specified load is attained. Maintain the compressive force at that setting with an accuracy of 1 %.

9.4 The entire duration of the compression creep test should be performed under fixed climatic conditions such as standard conditions of 73°F and 50% relative humidity or at other climatic conditions as described in Practice D4332.

9.5 The deflection shall be taken as zero the moment when full load has been established.

9.6 Record the deflection versus time values over a predetermined period. The recommended test time is 12 h.

9.7 *Moisture Content (when Specified):*

9.7.1 *Fiberboard Containers*—Determine the moisture content of fiberboard at the end of the test in accordance with Test Method D644.

## 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 fiberboard containers.

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

10.1.2.3 Description and specifications for interior packaging, if used.

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

10.1.2.5 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 conditions of the container.

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 of failure and description of sidewall deformation (inwards or outwards).

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

10.1.3.5 Graph or table showing the deformation-time relationship for each test.

10.1.3.6 Number of specimens tested.

10.1.3.7 Mean and standard deviation calculations of all specimens tested for the slope of the deflection-time plot reported in inches/hour.

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. Include details of any known modifications.

10.1.4.2 Orientation in which the specimen was tested.

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 fiberboard, if determined.

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

## 11. Precision and Bias

11.1 *Precision*—The subcommittee has conducted an analysis of the data based on limited testing by one laboratory. These

were top loaded empty regular slotted corrugated containers tested for 12 h at 20, 40, 60 and 80 % of the container's Test Method D642 compression strength. The within-laboratory repeatability (standard deviation of the deflection after 12 h as a percent of the mean of five replicates of two different size boxes tested at 20, 40, 60 and 80 % of their Test Method D642 compression strength) was 3.75 %.

11.2 *Bias*—No justifiable statement can be made on the bias of this test method since a true or absolute value cannot be established by an accepted reference method.

## 12. Keywords

12.1 compression test; creep test; duration of load; packaging; shipping container; shipping unit; stacking life; storage environment

## ANNEX

### (Mandatory Information)

### A1. PROCEDURE TO PREDICT CONTAINER LIFE TO FAILURE

A1.1 The following discussion demonstrates a method of calculation for time-to-failure using 12-h creep data. A straight line is fitted to the deflection versus time data for a particular load level from the 12-h creep test. The fit can be done graphically or by using curve fitting software. The slope of the straight line is the average creep rate during the 12-h test for this load level. This average creep rate is then adjusted to yield the average creep rate over the time-to-failure using[4,5]

$$R = R_{12} \times P/(100 - P) \quad \text{(A1.1)}$$

where:

$R_{12}$ = average creep rate in 12-h test (slope of straight line fitted to creep data), and

$P$ = load level expressed as a percent of Test Method D642 compression strength.

A1.2 The predicted time-to-failure is the time required to reach the Test Method D642 failure deflection while deforming at the adjusted creep rate,

$$T = \frac{D}{R} \quad \text{(A1.2)}$$

where:

$T$ = time to fail,
$D$ = Test Method D642 failure deflection, and
$R$ = adjusted creep rate.

A1.3 The data in the reference studies[4,5] show that the predicted values were within 3 days for actual values for top loads that are between 40 to 60 % of the compression strength. This method allows the use of an accelerated test method to predict failure time more accurately than traditional methods of using factors with compression strength values.

[4] Burgess, G., Singh, S. P., and Srinangyam, M., "Predicting Collapse Times for Corrugated Boxes Under Constant Top Load Using Short Term Creep Tests," *Journal of Testing and Evaluation*, Paper Under Review for Publication, 2003.

[5] Singh, S.P., and Burgess, G.,"Creep Performance Data for Corrugated Boxes: Accelerated vs. Long Term Compression Strength," *Inside PreShipment Testing*, 3rd Quarter, 2003.