WI 240308.01

T 804

BALLOT NO. 02 - SARG

DRAFT NO. 02

DATE October 22, 2024

WORKING GROUP
CHAIR Ben Frank

SUBJECT
CATEGORY
Fiberboard Shipping Container Testing

RELATED
METHODS See "Additional Information"

CAUTION:
This Test Method may include safety precautions which are believed to be appropriate at the time of publication of the method. The intent of these is to alert the user of the method to safety issues related to such use. The user is responsible for determining that the safety precautions are complete and are appropriate to their use of the method, and for ensuring that suitable safety practices have not changed since publication of the method. This method may require the use, disposal, or both, of chemicals which may present serious health hazards to humans. Procedures for the handling of such substances are set forth on Safety Data Sheets which must be developed by all manufacturers and importers of potentially hazardous chemicals and maintained by all distributors of potentially hazardous chemicals. Prior to the use of this method, the user must determine whether any of the chemicals to be used or disposed of are potentially hazardous and, if so, must follow strictly the procedures specified by both the manufacturer, as well as local, state, and federal authorities for safe use and disposal of these chemicals.

Compression Test of Fiberboard Shipping Containers

(Five-year review of Official Method T 804 om-20)

(Underscores, notes, and strikethroughs show changes from Draft 1)

1. Scope

1.1 This method is used for measuring the ability of corrugated or solid fiber shipping containers to resist external compressive forces.

1.2 The method may be applied in several ways. For quality studies, it is usually desirable to test the empty container. For the study of compression resistance where inner packing (corner posts, etc.) is involved, tests may be made with the interior packing in place.

1.2.1 If overall performance of the entire pack is to be studied, the test may be conducted with the container loaded with its contents and all inner packing. In many packs the contents and inner packing share in carrying a portion of the load.

1.2.2 The container may be positioned in the machine to test the compressive resistance in a direction that is relevant to the container's use including top-to-bottom, end-to-end, or side-to-side.

Approved by the Standard Specific Interest Group for this Test Method
TAPPI

2. Summary

This method describes how to determine the resistance of a fiberboard shipping container to compressive forces. This is accomplished by placing the container between two flat platens, one of which is mechanically or hydraulically driven to compress the container. A recording device is incorporated to indicate the force and deformation (deflection) required to compress the container.

3. Significance

These compressive forces measured in this method are related to some of those exerted on containers in stacks or encountered in transportation. The method may be used to compare the compressive resistance of different lots of similar containers or to compare containers of different grades or designs. In addition, the information gained may be used to provide an indication of the load that a particular container may be able to withstand in service.

Deleted: It may also be used to compare the compression characteristics of containers differing in construction or design. …

4. Apparatus

4.1 *Compression tester*[1], having the following:

4.1.1 Two platens which move together to compress a container placed between them. The platens are of sufficient size so that the test container does not extend beyond the edges of the platens. The platens shall be flat with deviations less than ± 0.5 mm (0.02 in.) from the median plane of the platen. The platens may move no more than 1.3 mm (0.05 in.) in the directions perpendicular to the direction of compression. The platens are either held parallel throughout the test or one platen may be allowed to pivot around its center. If the platens are rigidly held, they must remain parallel to at least within 1 mm (0.04 in.) per 305 mm (12 in.) in the length and width directions. The fixed platen type of compression testers should be used for all referee testing.

NOTE 1: The parallelism tolerance called for in this method is in line with the parallelism requirements called out in other methods (see 13.5). It may result in meaningfully different (lower) BCT values than testing of the same cartons using a machine with tighter platen parallelism, particularly for larger boxes. [1]

NOTE 2: Compression testers with floating or swivel platens provide an alternative to evaluate compression strength but may produce different compression values (Appendix B). Platen stiffness may be more critical for this platen configuration.

NOTE 3: For machines where the platen configuration can be changed to accommodate different test approaches, it is critical to confirm and if necessary, adjust the parallelism each time the configuration is changed, to assure the parallelism and flatness in the system satisfies the requirements in 4.1.1.

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4.1.2 Means of driving the movable platen at a uniform speed of 12.7 ± 2.5 mm/min. (0.5 in./min. ± 0.1 in./min.) during the test.

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4.1.3 Means of recording or indicating the applied load to within ± 1% of the measured value.

4.1.4 Means of recording or indicating the resultant deformation within ± 2.5% of the measured value or within ± 0.5 mm (0.020 in.), whichever is greater.

4.2 Compression testers, like all laboratory testing equipment, need to be calibrated on a regular basis. Obtain a calibration procedure and recommended calibration frequency from the compression tester manufacturer. Ensure the equipment is calibrated following the provided procedure and frequency.

5. Safety Precautions

5.1 The platens, while slow, can exert large amounts of force. Do not place body parts in tester while a test is being performed. Read and follow all safety precautions suggested by the equipment manufacturer.

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[1] Names of suppliers of testing equipment and materials for this method may be found on the Test Equipment Suppliers list in the set of TAPPI Test Methods or may be available from the TAPPI Standards Department.

6. Test specimens

6.1 Samples shall be obtained in accordance with TAPPI T 400 "Sampling and Accepting a Single Lot of Paper, Paperboard, Containerboard, or Related Product."

6.2 Test at least five representative containers for each direction specified. Select only those containers that have not been damaged by previous handling.

7. Sealing

7.1 Whether this method is used as a quality control test or as a referee test, it is important that a consistent method of flap closure be used to ensure consistent results in both average and variability data.

7.2 In preparation for sealing, square the box blank. Avoid distortions and "out-of-squareness," since this will affect the load-bearing ability of the containers.

7.3 Consistent sealing of boxes is critical for comparison of test results. In top-to-bottom testing, the primary concern is to ensure the minor and major flaps are fastened to each other by some means. The means may include hot melt adhesive, cold set or water-based adhesives, stitches or clips. The important factor is that the flaps not be allowed to freely sink into the depth of the box during the compression test.

7.3.1 Taping may not be an effective form of sealing the boxes for compression testing if it does not meet the requirement stated in 7.3 "to ensure the minor and major flaps are fastened to each other by some means". The literature indicates that taped boxes will produce higher test results than boxes sealed in line with this method because the minor flaps are free to rotate into the box during the loading process. [1-3] This dynamic cannot occur in use when the box has contents.

7.3.2 Up to the 1998 version of this test method (1988's revision), the technique for sealing flaps was very specific. This consisted of water-based adhesive coverage of 100% of flap areas (more than 13 mm (0.5 in.) away from scores) and holding the flaps in contact with one another until the bond is set. For the purposes of this writing, this sealing technique will be referred to as the classical technique outlined in Appendix A.

7.3.3 The compression testing of empty boxes with unsealed flaps can be acceptable if it is understood that this is the procedure being used. There is evidence that the testing of empty boxes with unsealed flaps can result in higher average test values than testing the same boxes with sealed flaps.

7.4 When testing boxes end-to-end or side-to-side, the placement of and action of the flaps during the compression test become even more critical to the average test value attained. When testing boxes end to end or side to side, one should use a technique that simulates the way the flaps will be closed in actual field use.

8. Conditioning

8.1 In accordance with TAPPI T 402 "Standard Conditioning and Testing Atmospheres for Paper, Board, Pulp Handsheets, and Related Products," precondition the test specimens so as to approach the equilibrium moisture content at standard conditions from a drier state and then condition for a minimum of 24 h.

NOTE 5: The criterion for the conditioning period for all boxes is that there should be less than a 0.1% change in their weight between successive weighings taken at intervals of at least 2 h.

8.2 If water-based adhesive is used in sealing the flaps, allow the boxes to dry for 24 h after sealing to permit the adhesive to dry. Precondition and condition the boxes to ensure that the boxes have the same moisture content.

9. Procedure

9.1 Test each box in the conditioned environment. If this is not possible, test each box immediately upon removing it from the conditioned room.

9.2 Center the test container on the bottom platen of the compression machine. Adjust the load indicator to zero, i.e., counterbalance or compensate by adjustment for the gross weight of the box including the sealing board

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Deleted: 7.3 The flaps may be bent directly to the sealing position or the flap scorelines may be pre-broken as follows. Bend each of the four bottom flaps backward 180° on the score line until the flap touches its side of the box. Insert a sealing board or place the box over a sealing device, whichever sealing method is used, then fold the inside flaps forward 270° to the normal closed position.¶

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or its contents. Select the lowest load range of the machine compatible with the greatest anticipated test load. Apply a preload to the specimen and set the deformation point to zero, or begin the deformation measurement at zero at this point. The preload ensures definite platen contact and in most instances levels off any irregularities of the box.

9.2.1 Initial preload should be 5% of the maximum compression resistance or a value agreed upon by the parties engaged in testing. Most commonly, preloads used in the industry include: (a) single-wall boxes, 223 *N* (50 lbf); (b) double-wall boxes, 446 *N* (100 lbf); (c) triple-wall boxes, 2230 *N* (500 lbf).

9.2.2 Apply the test load at a rate of 12.7 ± 2.5 mm/min. (0.5 in./min. ± 0.1 in./min.). Record the load applied and the deformation until failure of the container. Failure may be determined either by reduction in the load supported or by deformation. The typical value for a decrease in load is 10%. See 12.4 for generally used critical deformations. Take readings at each 2.5 mm (0.1 in.) deformation if a recording device is not used.

10 Report

10.1 As a minimum, report the following:

10.1.1 Dimensions of container, style, flute, flute direction, grade of material, and type of manufacturer's joint. If the container was tested with interior parts, or contents, describe these.

10.1.2 Method of closure.

10.1.3 The orientation in which the containers were tested, e.g., T-B, E-E, or S-S.

10.1.4 Number of specimens tested.

10.1.5 A graph or tabulation of the max loads sustained reported in N (Newton) or lbf (pounds Force) and corresponding deformations reported in mm (millimeter) or in (inch). A summary usually consists of the average of the highest loads at or below the critical deformation, the critical deformations used, the average of maximum loads, the average of the deformation at the maximum loads, and the standard deviation (see 13.4).

10.1.6 A statement identifying the type of compression apparatus used as having fixed or floating platens.

10.1.7 A statement to the effect that all tests were made in compliance with this method including preconditioning or that the method was used with certain specific exceptions.

10.2 Additional reporting requirements, when needed or specified by the customer.

10.2.1 Report any alternative conditioning methods to include type, number of days, etc.

10.2.2 When the samples are subjected to special conditioning (for example high temperature or high humidity) moisture content should be measured using T 412, a moisture balance, or other suitable means and included in the report.

10.2.3 Report any information or observations that may assist in interpreting the results of the test, such as the nature and cause of the failure, any auxiliary tests made, presence of print on the container, etc.

11. Precision

11.1 Repeatability (within a laboratory) = 9.2%.

11.2 Reproducibility (between laboratories) = 16.9%.

Repeatability and reproducibility are estimates of the maximum difference (at 95% confidence) that should be expected when comparing test results for materials similar to those described below under similar test conditions. These estimates may not be valid for different materials and testing conditions.

11.3 The estimates of repeatability and reproducibility listed above are based on data from the CTS Containerboard and Paper, Paperboard & Corrugated Fiberboard Interlaboratory Programs from monthly testing conducted on three sets of BCT samples (BX15, BX16, BX17) from January 2021 through December 2023. Outliers and labs that reported not using TAPPI standard conditions were excluded. On average, 24 labs were included each month, with results for repeatability and reproducibility averaged over the 36 months in the testing period. Boxes included in this estimation were closed using either hot melt or clips, with no meaningful difference in the repeatability or reproducibility values. Average box compression and repeatability/reproducibility data by year are tabulated below:

Sample	Mean Compression (lbs)	%r	%R

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Deleted: 10.2.3 Report any alternative conditioning methods to include type, number of days, etc.

Deleted: 11.1 The values for repeatability and reproducibility have been calculated from the results of a round robin which is discussed in detail in Appendix B. The average and variability data reported by each laboratory were based on 10 individual compression tests. The repeatability and reproducibility reported below were calculated for comparisons of averages of 5 compression tests. This was done since 5 tests is the most common number used in establishing the compression value of an order.¶
11.2 Repeatability (within a laboratory) = 7.0%.¶
11.3 Reproducibility (between laboratories) = 10.6%. This is true when the two laboratories use the same method of sealing the containers.¶
11.4 Repeatability and reproducibility represent the agreement which is expected 95% of the time when two test results are compared. Refer to TAPPI T 1200 "Interlaboratory Evaluation of Test Methods to Determine TAPPI Repeatability and Reproducibility" for complete definitions of these terms.¶
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BX15	824	8.5%	15.6%
BX16	680	8.1%	16.5%
BX17	845	10.8%	18.6%

11.4 The prior precision statement, showing a repeatability of 7% and a reproducibility of 10.6%, was based on tests conducted for TAPPI in 12 laboratories in 1988. That work indicated no difference between classical sealing (Appendix A) and the use of hot melt adhesive to seal the flaps.

12. Keywords

Containers, Compression tests, Fiberboard, Compressibility, Compression strength

13. Additional information

13.1 Effective date of issue: To be assigned.
13.2 This method was first published in 1945 as a Tentative Standard, became an Official Standard in 1967 and was revised in 1975.
13.3 For special purposes or studies (non-referee tests), this method may be used as described at conditions such as high humidity, low temperatures, and other specially prescribed conditions. Such special procedures used must be specifically stated in the report.
13.4 Common practice is to give particular consideration to the highest load attained up to the point of critical deformation. The critical deformation is the deformation beyond which the contents might be forced to carry a significant part of the load, and will vary depending on the application.
13.4.1 The maximum load and the deformation at maximum load are also recorded even if they occur above these critical deformations. Deformation is the reduction in height which the specimen undergoes, measured in terms of reduced platen separation, as measured from the preload.
13.5 Related methods: ASTM D 642 "Standard Test Method for Determining Compressive Resistance of Shipping Containers, Components, and Unit Loads," American Society for Testing and Materials, West Conshohocken, PA.; APPITA P 800 "Compression Resistance of Fiberboard Boxes (Cases)," Technical Association of the Australian and New Zealand Pulp and Paper Industry, Parkville, Australia; ISO 12048, "Packaging — Complete, filled transport packages — Compression and stacking tests using a compression tester."
13.6 Revisions:
13.6.1 Notes were added to the 2012 revision regarding parallelism of the platens, in addition to minor language corrections throughout the document.
13.6.2 In 2024, the literature cited section was added in support of Note 1 and sections 7.3 and 7.4, the R&R statement was updated and consolidated (eliminating an appendix), and a range of other minor edits were made to improve language and clarity.

14. Literature Cited

1. Frank, B., "Corrugated Box Compression- A Literature Survey", *Packag.Technol.Sci.* 27(2);2014(105), https://doi.org/10.1002/pts.2019
2. Sheehan, RL. Box and Closure: Partners in Performance. *J. Packaging Technology* 1988; 2(4): August
3. Koning J. Corrugated Crossroads: A Reference Guide for the Corrugated Containers Industry, TAPPI Press, Atlanta, GA, 1995

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Deleted: The critical deformations generally used in the industry for A- or C-flute, single-wall, regular slotted containers are: (a) top-to-bottom, 19 mm (0.75 in.); (b) end-to-end, 13 mm (0.5 in.); (c) side-to-side, 13 mm (0.5 in.).

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Appendix A: Classical technique for sealing flaps

A.1 *Sealing equipment*, consists of the following:

A.1.1 A means of clamping the inner and outer flaps together, after the adhesive has been applied and the flaps have been closed, and for holding the flaps flat and in good contact.

NOTE A1: The adhesive may be any water-based case-sealing glue.

A.1.2 Sealing board used for the purpose should be wooden boards thick enough to apply the sealing pressure uniformly, and with dimensions about 38 mm (1.5 in.) to a maximum of 102 mm (4 in.) smaller than the inside container, so that the board left in the container will not influence the test. See A.3 for suggested methods of clamping.

A.2 Apply a uniform film of adhesive to the inner flaps. Keep the adhesive approximately 13 mm (0.5 in.) but not more than 25 mm (1 in.) away from all the score lines. Close the outer flaps and square them, and, with the sealing equipment, apply firm pressure to assure complete and flat contact of the flaps. Do this quickly to prevent undue drying of the adhesive before contact is made. After the adhesive has been dried sufficiently to prevent disturbing the bond, remove the pressure.

A.3 When the box is to be tested empty, the flaps may be sealed by one of the following methods or an equivalent one which will ensure a firm seal without damage to the container.

A.3.1 The bottom flaps may be clamped by one of these devices:

A.3.1.1 A spring loaded bottom sealer which clamps the flaps between two flat platens.

A.3.1.2 A flat surface of a bench on which the container is placed after the bottom flaps have been closed, a board of proper size inserted inside and further by:

A.3.1.2.1 Placing a weight on the board, or

A.3.1.2.2 Hanging a weight on the board by means of a hook through a slot in the bench, or

A.3.1.2.3 Passing a long carriage bolt through a hole in the board, the flaps, and the bench, and drawing tight with a wing nut.

A.3.1.3 A sealing board on the inside and outside with a carriage bolt extended through a hole in the inside board, the flap and the outside board, drawn tight with a wing nut or toggle clamp.

A.3.2 The top flaps may be clamped as follows:

A.3.2.1 Inserting the sealing board in the container,

A.3.2.2 Inverting the container on the bench, and

A.3.2.3 Hanging a weight on the board as in A.3.1.2.2 above, or

A.3.2.4 Using a long bolt and wing nut as in A.3.1.2.3 above, or

A.3.2.5 Using a sealing board outside as in A.3.1.3 above.

A.4 When the adhesive has set, release the clamping device and permit the inner sealing board to fall loose, holding the box upright so that the board falls flat and does no damage. If the box has interior dividers or contents, that are capable of supporting the inner flaps, use a board and weight to hold the top flaps in place while the glue sets.

A.5 Make sure that the sealing board is in such a position that it will not offer any support to the box during the test.

Appendix B. Floating platens

B.1 Some pieces of compression test equipment can be altered to enable the user to allow the top platen to float or to swivel. This means that the top platen is not always parallel to the bottom platen. As the test proceeds the top platen is allowed to seek the weakest point on the horizontal plane of the test surface. This is a good technique to use when seeking the weak link in a stacking pattern as might be experienced in a warehouse stacking situation.

B.2 The floating platen technique is likely to yield different test results from the fixed platen technique. If the floating platen technique is used, it should be highlighted in the test report. If the purpose of the testing being conducted is to gather quality assurance data on individual boxes or to gather comparative data for a referee situation, it is highly recommended that the fixed platen technique be used.

Your comments and suggestions on this procedure are earnestly requested and should be sent to the TAPPI Standards Department. ■

Deleted: Appendix B: A discussion of the repeatability and reproducibility data¶
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B.1 These precision data are based on tests conducted for TAPPI in 12 laboratories in 1988.¶
B.2 All the corrugated board in this study was taken from one position off the corrugator and was made at a constant speed over approximately a two-minute period. These sheets were run in order through a flexo folder gluer at a constant speed over about a 3-minute period. The boxes were numbered in order of production off the flexo. A random numbers table was used to select the sets of boxes for testing at each laboratory. The board used in the test was 200-pound test C-flute. The boxes were tested top to bottom.¶
B.3 The results for repeatability and reproducibility were compared in the following ways:¶
B.3.1 Only three of the 12 laboratories were equipped to run the test using the classical sealing method. These three laboratories tested groups of boxes according to the classical sealing method and the hot melt adhesive sealing method, which was the most common.¶
B.3.2 Seven laboratories tested using the hot melt adhesive sealing technique. Repeatability and reproducibility were determined for those 7 laboratories.¶
B.3.3 Repeatability and reproducibility were determined for all 12 laboratories. Methods of Sealing were: 7 - Hot Melt; 1 - PVA; 1 - Clipped; 1 - Stitched; 1 - Tape, Clipped; 1 - Bottom Stitched, Top Clipped and Taped.¶
B.3.4 The results:¶
¶
Technique Number of Compression¶
method laboratories average,
lbf. Repeatability Reproducibility ¶
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Classic 3 810 7.1% 9.3%¶
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Hot melt 3 805 7.5% 8.5%¶
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Hot melt 7 818 7.0% 10.6%¶
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Results for¶
laboratories¶
described¶
in B.3.3 12 840 6.5% 16.2%¶
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Repeatability and reproducibility are for averages of 5 samples.¶
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B.4 Reproducibility is about 10% when the two laboratories follow this procedure and use the same flap fastening method. Comparing compression averages when two different flap fastening methods have been used adds to the uncertainty of the comparison.¶
B.5 The following table was derived from the Containerboard Interlaboratory Program using participating laboratory results from 2016 to 2019. This is provided for information purposes about the performance of this metho ...

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