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BASIC PHYSICAL PACKAGING PROPERTIES TEST

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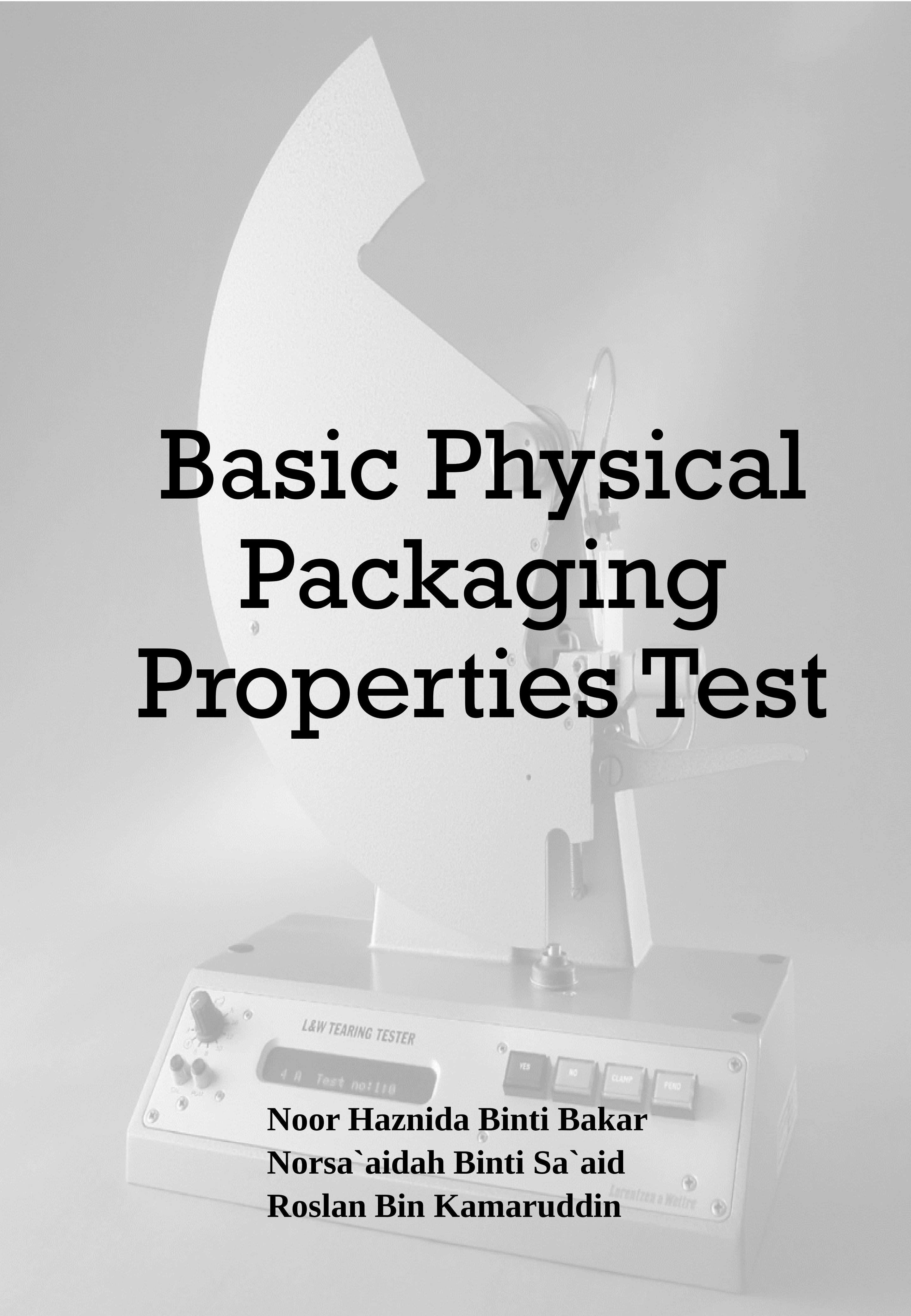

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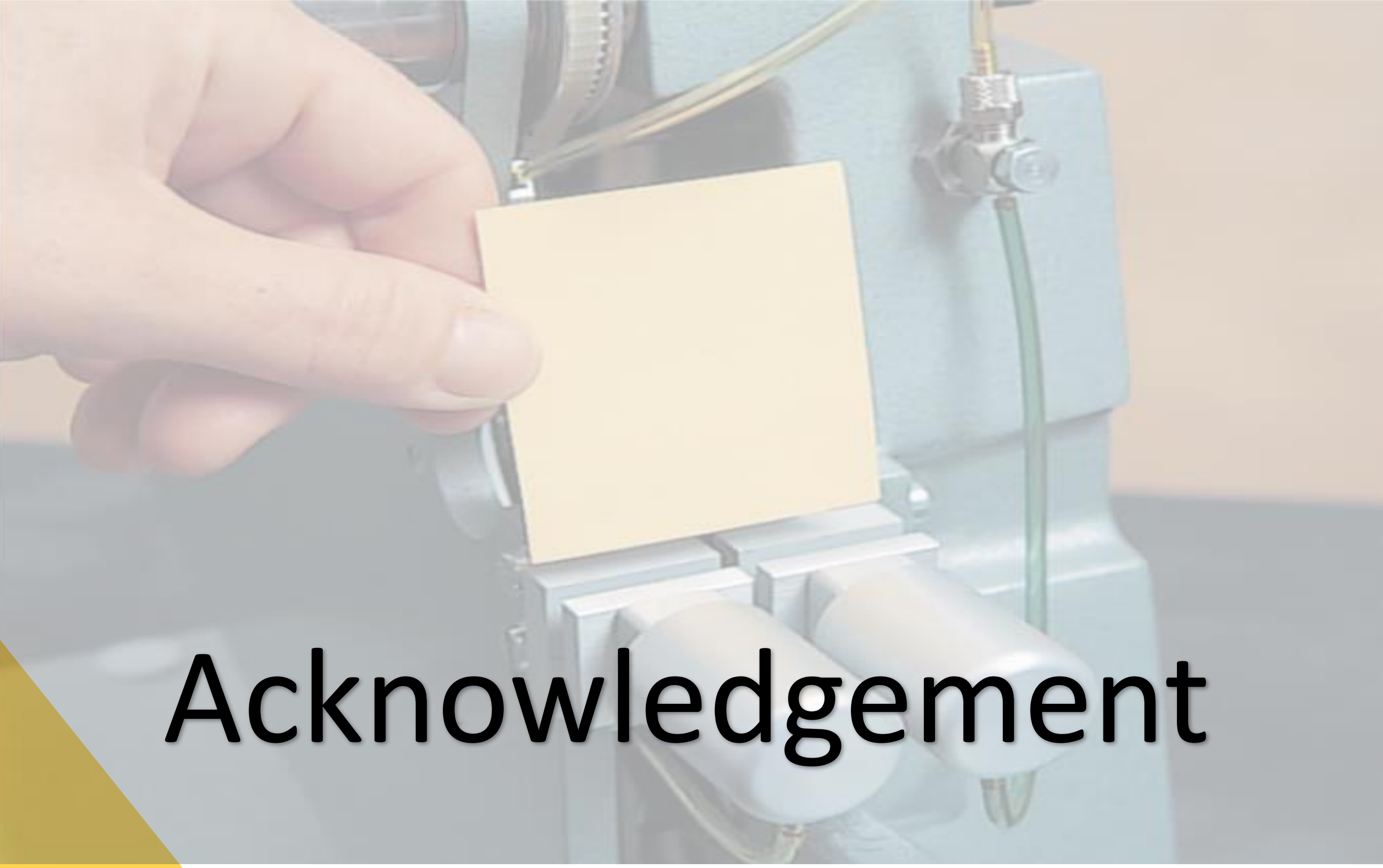


Acknowledgement

There are a limited number of books on packaging testing; therefore, this book has been designed to simplify the knowledge of packaging testing. This book also covers the areas of tearing, endurance, compression and drop tests.

We are thankful to our contributors for their cooperation and support of this book project. We also thank the families for their support and encouragement throughout this project.

CONTENTS

Preface

Packaging function is for providing physical protection, preventing contamination, extending shelf life, and communicating. The specific type and value of the various performance properties required will depend on the needs of the packaging concerned. The material must provide strength for whatever structural shape is necessary for the packaging, be it as wrapping, a label, folding carton or shipping container. Many tests can now be carried out on-line during manufacture and by linking testing with computer technology, a high frequency of such testing is possible. It is also possible to provide feedback within the system to automatically maintain parameters such as strength properties, thickness and grammage within the target range.

This book introduces for the concept of tear, endurance, compression and drop test in packaging. The authors have all adopted this approach in discussing to identify packaging properties for shelf life of the product. The readers will find it a useful and better understanding about the packaging properties concept. It is hoped that this book will lead to the informed development of packaging design. With an increasing focus on sustainability, responsible companies no longer want to overpackage their food products and yet many remain unsure just where reductions can effectively be made. This book should help them in their attempt to achieve their goal.

INTRODUCTION

The role of packaging design is key in securing these multifunctional needs out of the one pack. Properties of material decisions can be the most critical issues since they lead to the effective protection and transportation of the product, and ultimately consumer satisfaction. Ideally, when the packaging testing provides the manufacturer with clear and specific information whether consciously or subconsciously, and possibly a point of comparison which one appears to be a more effective and more convenient package.

Packaging properties test

Technical Association of the Pulp and Paper Industry (TAPPI) test methods for evaluating the properties of tensile and compression strength, bursting strength, tearing resistance and folding endurance.

Most compression testing research has been conducted on corrugated fiberboard boxes, since the walls of boxes are often expected to carry the load of a stack. Factors that are known to influence corrugated fiberboard box compression. It should be noted, however, that in most cases the product inside the box helps to support the stacked load. For example, packages for products like canned goods, glass jars and plastic bottles may not need the shipping container to provide any compression strength at all, and instead use the strength of the product itself.

INTRODUCTION

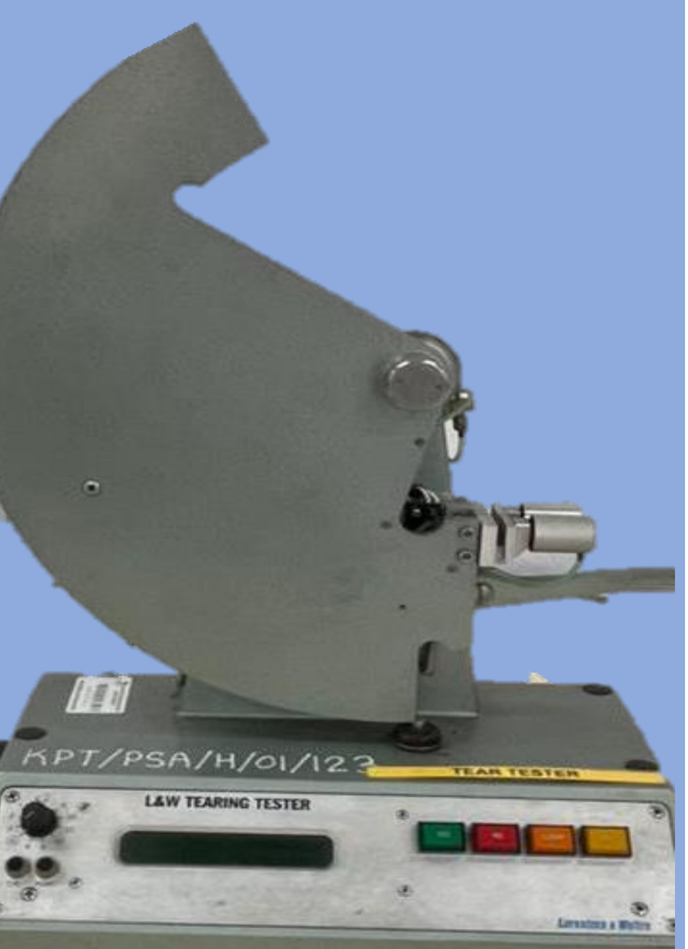
Edge-tearing strength is a measure of the force needed to initiate a tear. The force needed to initiate a tear may be several times the force needed to propagate the tear once it is started. This is commonly known to anyone who has experienced the difficulty of opening a cellophane bag, which, once nicked, tears open easily. Those papers and other film materials that exhibit high tensile stretch or elongation to break also exhibit high edge-tearing strength . High stretch makes it difficult to localize or concentrate stress in a sufficiently small area so that a tear can be initiated.

A folding-endurance test is used to measure the ability of a paper to maintain its strength after repeated folding. Folding endurance can be measured in both machine and cross-machine directions. As a rule, machine direction folding endurance is higher than cross-machine direction folding endurance, which reflects the higher tensile strength usually exhibited by the machine direction. For those papers for which cross-machine direction folding endurance values exceed machine direction values, flexibility or the viscoelastic characteristics of the paper play a more significant role then inherent tensile strength.

Impact is a frequent occurrence during the handling, packing, transportation and distribution. The advantage of using drop weight impact test its ability to conduct impact loading for real structure of packaging component. A specimen does not have to be clamped, depending on the testing arrangement. The method of using the drop weight impact includes the use of a falling weight that impacts the specimen.

WHAT IS TEAR TEST

The most commonly used tearing test is called the Elmendorf tear or Trouser tear test, measures the internal tearing resistance of paper rather than the edge-tear strength of paper. Internal tearing resistance is a measure of the force perpendicular to the plane of the paper necessary to tear a single sheet through a specified distance after the tear has already been started . Edge-tearing strength is a measure of the force needed to initiate a tear. The force needed to initiate a tear may be several times the force needed to propagate the tear once it is started.



Did YOU Know?

This is commonly known to anyone who has experienced the difficulty of opening a cellophane bag, which, once nicked, tears open easily .Those papers and other film materials that exhibit high tensile stretch or elongation to break also exhibit high edge-tearing strength . High stretch makes it difficult to localize or concentrate stress in a sufficiently small area so that a tear can be initiated. The work needed to tear paper is only a fraction of the TEA or the work required for rupture in a tensile strength measurement. This is because the tearing action directs a stress concentration at the pex of an advancing tear, and the route that the tear takes will tend to be the course of least resistance

DEFINE

1 The tear strength of paper means **the resistance of a paper sheet to tearing force that it is subjected to**.

2 It is another important basic physical property of paper and paperboard.

TEAR UNIT

It is measured in both machine direction (MD) & cross direction (CD) and expressed as mN (mili Newton).

Often used as a component for predicting web breaks, and it is also an important property for sack paper. Tearing Tester measures tearing resistance according to the Elmendorf method. Menu-based setup, pneumatic clamping of the test pieces, and automatic calculations of measured values, ensure stable and accurate test results.

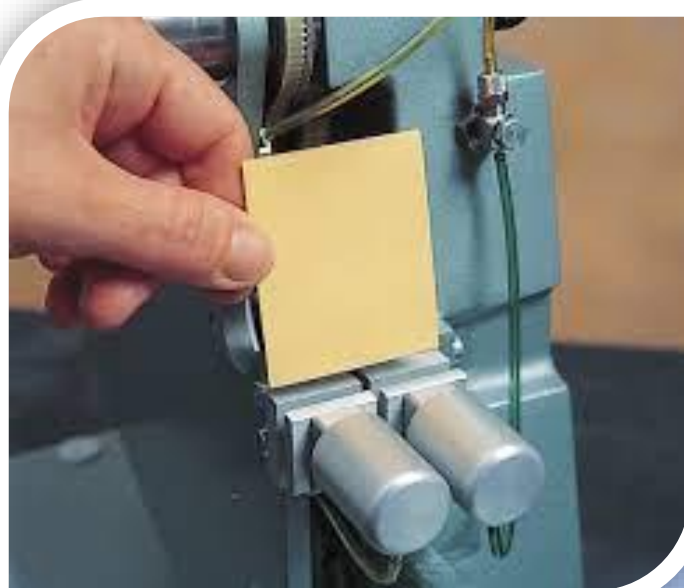
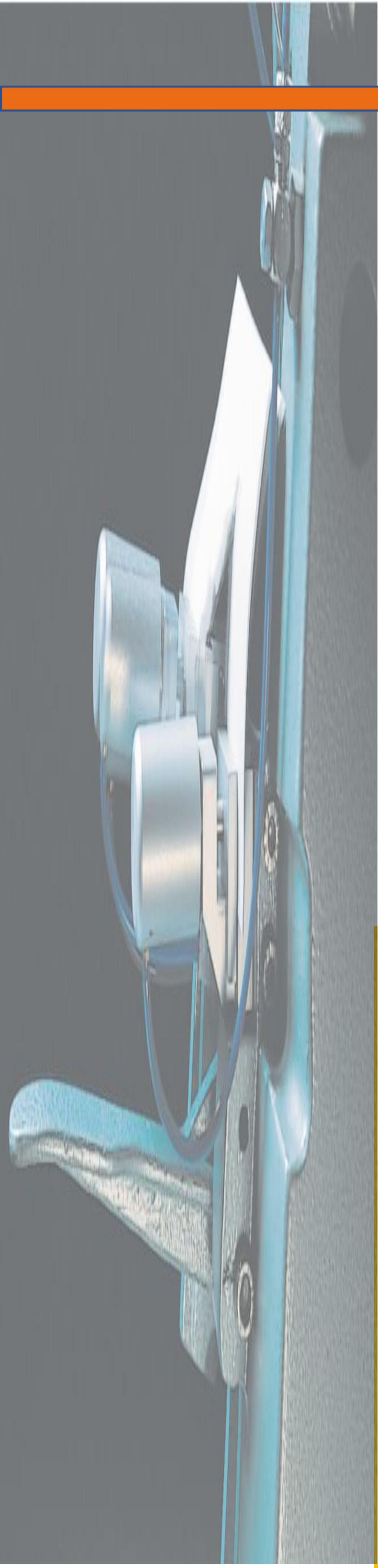


Figure 1: Tearing test machine part

One or more samples are clamped in split jaws and an initial cut is made, in the sample between the jaws, with the built-in knife.



TEAR TEST FUNCTIONS

1. Tearing resistance is a function of the degree of fiber refining; greater interfiber bonding enhances tearing resistance, but excessive refining tends to shorten the fibers, which works to decrease the tearing resistance.

2. The addition of fillers decreases tearing resistance.

3. The procedures that increase tearing resistance sometimes diminish other desirable properties.

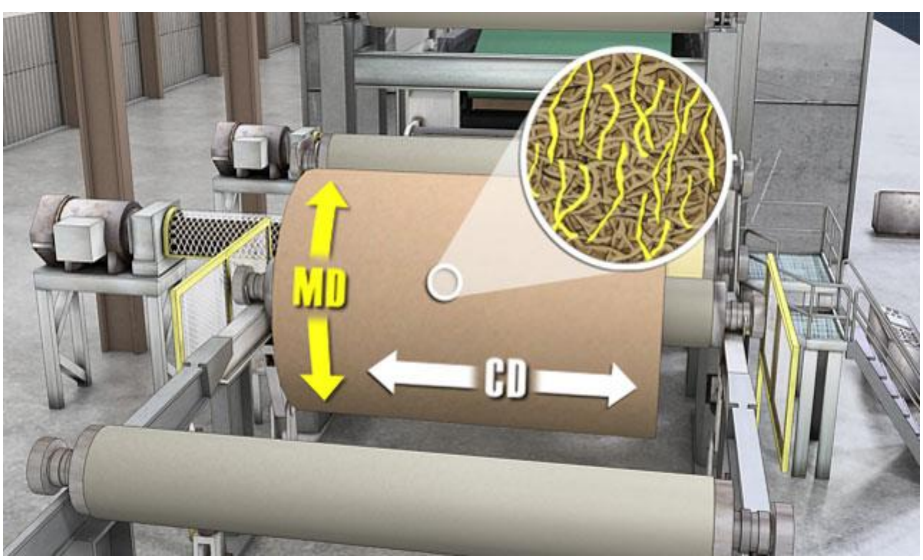
TEARING PROPERTY APPLICATION

The tearing strength property is significant factor for many applications involving cover papers, wrapping, and toughness of packaging papers, bond papers, envelope papers, printer and converter.

FACTORS INFLUENCE TEAR PROPERTY

Fibre length, strength and bonding are the main controlling factors. Although no clear relationship has been reported between tear index and fibre coarseness, in well-bonded sheets the tear index has been found to be higher in sheets with coarser fibres. Fibre length is an important factor in tearing resistance.

DID YOU KNOW?



Machine direction means the direction of the paper web which is running on the machine during paper making. On the other hand cross direction means the direction, which is perpendicular to the paper sheet that is running on the machine during paper making.

Figure 2: Source: https://www.convergencetraining.com/paper-and-board-strength-tests.html

HOW TO CALCULATE TEAR INDEX

Tear Index is defined as tearing strength divided by basis weight. The tear index, however, must be expressed in units of mN/(gf/m2).

As before, suppose that tearing strength (mN) and basis weight (gf/m2). The tear index is then given by;

Tear Index = (tearing strength)/(basis weight) mN/g/m2

Weight (gsm)	Types of paper
35-55	Most newspapers
70-80	A4 white paper
90	Magazine inner pages
130-250	Poster
180-250	Magazine cover
350	Business card

Table 1: Paper weight Descriptions

PERFORMANCE PROPERTIES

Adequate performance to enable a paper or paperboard material to meet the needs of packaging manufacture and use is essential. The material must provide strength for whatever structural shape is necessary for the packaging, be it a tea bag, a label, folding carton or shipping container. Strength is necessary in printing and constructing the packaging, both in packaging manufacture, also known a conversion, and in the packaging operation, whether this is carried out manually or by machinery. Strength is also necessary for the physical protection of the goods in distribution and storage, at the point of sale and in consumer use. Research has identified the specific features of strength and other performance needs, and tests which simulate these features have been developed so that specifications can be established. Specifications fulfil two important functions. Firstly, they provide the basic parameters for manufacture whereby paper and paperboard products are defined. Secondly, by regular testing during manufacture against the specification the manufacturer has an accurate view of the degree of uniformity within a making and of consistency between makings.

Many tests can now be carried out on-line during manufacture and by linking testing with computer technology, a high frequency of such testing is possible. It is also possible to provide feedback within the system to automatically maintain parameters such as moisture content, thickness and grammage within the target range. This approach is being applied to other parameters – e.g. colour, gloss and stiffness. In testing strength and other related performance properties, account is taken of the hygroscopic nature of the cellulose fibre.

The specific type and value of the various performance properties required will depend on the needs of the packaging concerned. Both the thinnest tissue and the thickest paperboard will have specific requirements and the actual properties may be the same properties such as tensile strength, compression strength, impact resistance, elongation (% stretch), tear, creasing and folding, wet strength, etc. The underlying principles and how they are achieved for each type of paper and paperboard have much in common. This is because paper and paperboard are sheet materials formed from an interlaced network of cellulose fibres.

Differences in the type and value of the strength and other performance properties depend on the amount, type of fibre and processing, whether the paper or paperboard is multilayered, together with any other ingredients, coatings or laminations which provide additional properties. The difference between MD and CD has already been noted. Strength properties and other features show variations which are characterised by these two directions. The value of many of the test-method measurements of properties will vary depending on the direction of measurement.

PHYSICAL/MECHANICAL PROPERTIES

The physical properties of paper and paperboard vary depending on the source of the fibers, how they are pulped, and the papermaking process. Paper fibers can be short and smooth (hardwood or recycled paper) or long and strong (softwood). Mechanical pulping shortens them, and chemical pulping keeps the fibers long, changing their shape from straight and tube-like to flexible because the removal of lignin. Pulp with less lignin removed tends to produce stiffer paper. These factors are why mechanically pulped paper has poorer tensile strength and tear resistance than kraft paper.

Strength is also affected by the degree of inter-fiber bonding. Increasing refining (beating) of the fibers tends to increase inter-fiber bonding, but too much refining reduces fiber length and makes the paper easier to tear. Other conclusions that can be drawn are that, at the same fiber length, thin-walled fibers produce greater tensile strength since they conform better at fiber cross-over points, thus producing stronger inter-fiber bonds. At equal fiber length, thicker fibers produce paper with better tear resistance. Fibers with thicker walls form paper sheets with lower density, as they do not collapse as readily. Long fibers with moderate wall thickness provide the most balanced combination of high tensile strength and high tear strength.

STANDARD TEST USED

<u>Standard TAPPI Conditions for Tests</u>

- TAPPI T 402: Standard conditioning and testing atmospheres for paper, board, pulp handsheets, and related products.
- ASTM D685: Conditioning paper and paper products for testing.
- ISO 187: Paper, board, and pulps–standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples.

MACHINE DIRECTION

The machine direction (MD) is the direction in which the paper comes out of the paper-making machine. More fibers are aligned in the MD than in the cross direction (CD), because the fiber slurry flows in the direction of the forming fabric and the fibers tend to line up in the flow direction. This grain effect is more pronounced for cylinder board, because of the strong directional movement through the vat and around the cylinder than for fourdrinier-produced papers.

The determination of MD is necessary before doing almost any other test, since the direction has so much effect on other properties. Stiffness, tensile strength, and ring crush are higher in the MD. Fold endurance and tearing resistance are greatest across the grain. Brightness and coefficient of friction also differ by direction. Specification of MD is necessary for most paper-based packaging in order to use the properties to their best advantage. For example, folding cartons for cereal are designed with the stiffer MD horizontal to prevent bulging. Labels for bottles are also designed with the MD horizontal, to counter the label's tendency to curl parallel to the MD with the wet side out when a wet adhesive is used.

There are several standard methods to determine the machine direction of paper and paperboard. They illustrate the basic differences in each direction's stiffness, tensile strength, and reaction to water. The axis of curl procedure moistens one side of the paper or board. Before the water has a chance to soak through, the paper or board will curl around an axis parallel to the MD with the wet side out. This is because the fibers on the wet side swell. The curling must be observed right away, as it will disappear as the moisture penetrates evenly through the paper. The drying procedure likewise depends on the fact that unrestrained paper will dry into a curl with the MD parallel to its axis. The bend procedure compares two thin strips cut from each orientation.

The strips are held together at one end and suspended horizontally like a diving board. First one strip is held on top, and then the other one. The one that droops the most is the one cut in the CD. The one with the least deflection is the one cut in the MD, because paper is stiffer in the MD.

The hand tearing procedure is based on the fact that paper tends to tear in a more nearly straight line in the MD than in the CD, since the tear can propagate more easily alongside the fibers. In the CD, tearing requires more fiber pullout. This also gives the CD tear a more ragged, feathery appearance.

ENDURANCE TEST

ENDURANCE LIMIT (Se) is the stress level below which a specimen can withstand cyclic stress indefinitely without exhibiting fatigue failure. If the tensile stress never exceeds a minimum level in most materials, fatigue failure does not occur. Therefore no crack or corrosion occurs. Endurance limit is also known as fatigue limit.

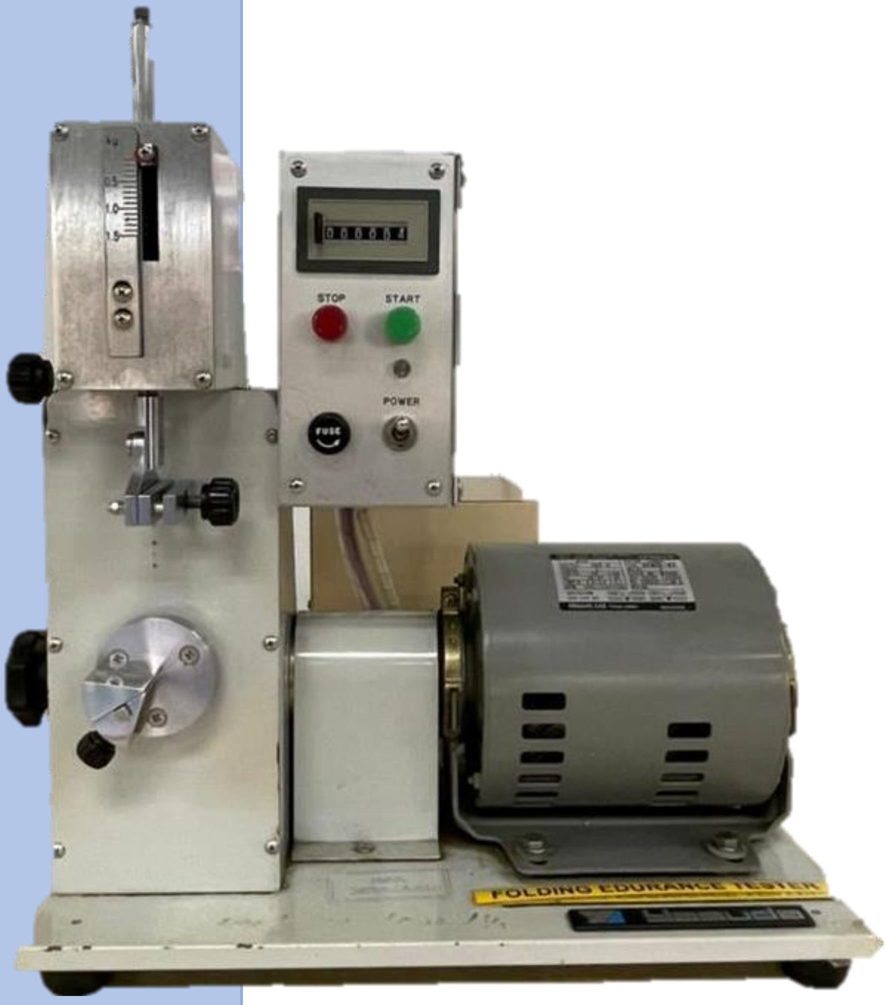


Figure 4: Endurance Tester

FACT ON ENDURANCE TEST

Fold endurance measures the durability of paper when repeatedly folded under constant load. It is used to determine the number of times a paper can be folded until it breaks. The folding strength is quoted as the number of double folds and the folding endurance is the log10 of the number of double folds. The test is primarily used for testing papers that are frequently handled such as currency (bank note) papers, maps and wrapping papers. The ageing characteristics of a paper can be assessed by measuring fold endurance before and after accelerated environmental ageing.

ENDURANCE TESTING

1. Folding endurance tests have been used to estimate the ability of paper to withstand repeated bending, folding, and creasing.
2. Folding endurance has also been useful for measuring the deterioration of paper upon aging.

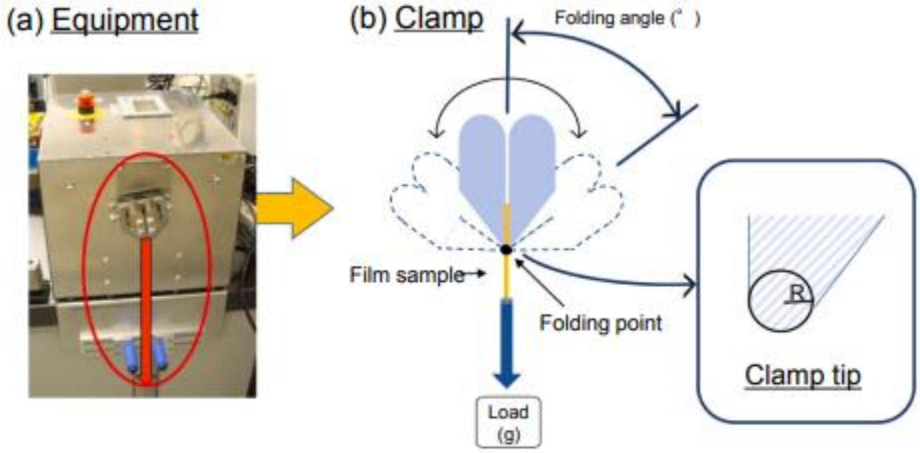


Figure 1: Schematic of the folding-endurance-test system.
Source: Y. Takeuchi, et al. International Journal of Pharmaceutics 589 (2020) 119876

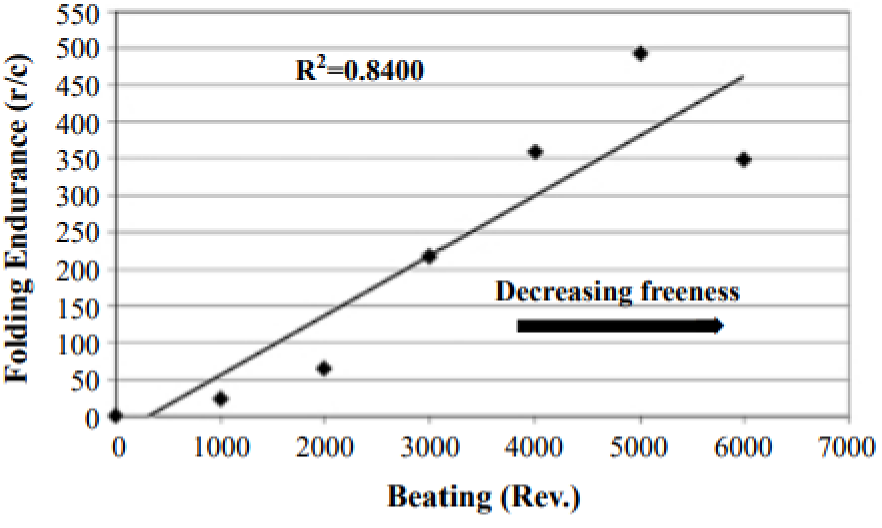
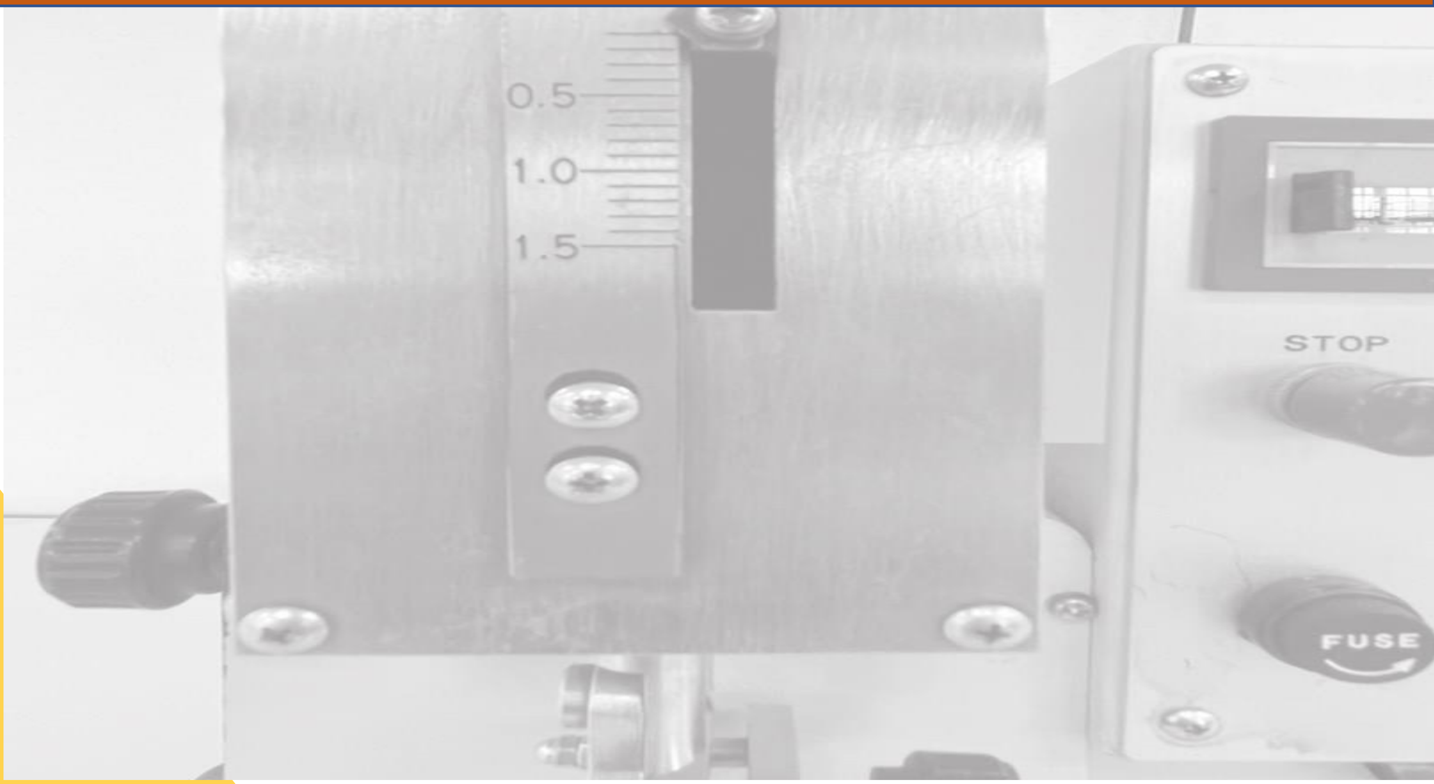


Figure 2: The relationship between folding endurance and beating level of unbleached sweet bamboo kraft pulp
Source: Suphat Kamthai and Pratuang Puthson, CMU. Journal (2005) Vol. 4(2) 137

ENDURANCE TESTING



Folding endurance may be considered a modified tensile strength test because the test specimen is under a tension that eventually causes failure. Bu t the results of the test are affected as much by the flexing ability of the paper as by its tensile strength . Lack of folding endurance can result from lack of sufficient fiber length , inadequate fiber bonding, or brittleness. As a rule, rag pulps produce paper high in folding endurance, whereas groundwood papers and heavily filled papers show poorer folding endurance. In the early stages of beating, folding endurance increases as does tensile strength . As beating proceeds, however, folding endurance eventually decreases as inter fiber bonding increases the brittleness of the paper. (D. F. Caulfield et al.,1988)

WHAT IS COMPRESSION TEST

The container compression test measures the compressive strength of packages such as boxes, drums, and cans. It usually provides a plot of deformation vs compressive force. It is commonly used to evaluate shipping containers made of corrugated fiberboard as well as wooden boxes and crates. Industrial and consumer packages other than boxes can also be subjected to compression testing: drum, pail, bottle, etc. Package components are also evaluated for compression resistance. It is usually a laboratory test involving a special machine, a compression tester, to apply controlled compression on a test specimen. A universal testing machine is sometimes configured to perform a package compression test.

When we discuss compression in the context of packaging needs, we usually mean the effect of externally applied loads in the storage, distribution and use of packed products in packaging, such as cartons, cases and drums

Figure 7: Compression testing machine

Corrugated Board: Compression Tests

STANDARD TEST USED

Dynamic Increasing Load Test (BCT)

TAPPI T 804: Compression Test of Fiberboard Shipping Containers ASTM D642: Standard Test Method for Determining the Compression Resistance of Shipping Containers, Components, and Unit Loads.

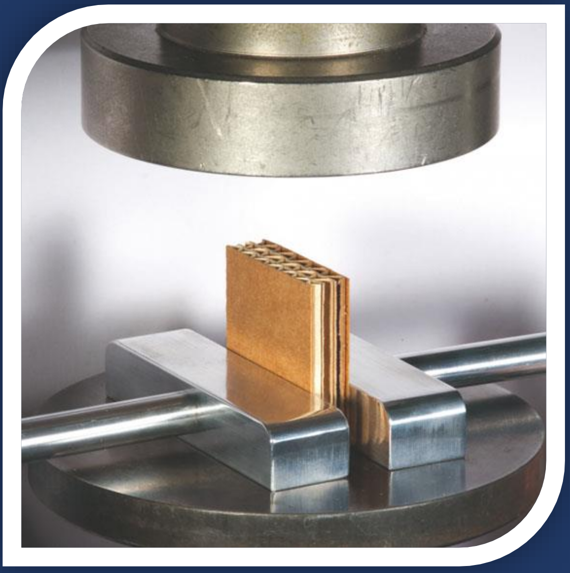
ISO 12048 Packaging—Complete, Filled Transport Packages— Compression and Stacking Tests Using a Compression Tester.

Constant Load/Creep Tests

ASTM D4577, Standard Test Method for Compression Resistance of a Container under Constant Load.

ASTM D7030 Standard Test Method for Short Term Creep Performance of Corrugated Fiberboard Containers Under Constant Load Using a Compression Test Machine.

Compression strength is a laboratory value for the strength of a box, measured under ideal conditions. Although an empty corrugated box's compression strength is not equal to its realistic stacking strength in use conditions, it provides a starting point for predicting the box's contribution to stacking strength. Compression testing judges the box materials. There are two types of test methods for compression strength. They can both be performed on either empty or full boxes, although when a box's compression strength (BCT) is given, it generally refers to that of the empty box in a dynamic increasing load test with its flaps sealed.



Corrugated Board: Compression Tests

a) Dynamic Increasing Load Test (BCT)

The BCT is directly related to the ECT of the board, but it also judges the quality of the box's construction, including the quality of the scores and slots. A box is placed between the platens of a compression test unit, and a preload is applied to ensure proper contact with the top platen and to level off. The preload should be 5% of the maximum compression resistance or a value agreed upon by the parties engaged in testing; 50 lb (223 N) is common for single-wall boxes. The applied force is measured as the top platen descends at a rate of 0.5 in/min. The load increases until failure or until a specified force (for example, the weight of a stack) is reached. Failure is usually defined at the point where the box first begins to buckle and lose its resistance. The top platen can either be fixed or floating. In the fixed platen method, the top platen is fixed in a level horizontal position, perfectly parallel to the bottom platen. The fixed platen tests the ability of the stronger parts of the box to resist load. Most of the compression data in the literature relating ECT to BCT relies on the fixed platen test, and TAPPI T804 requires that the fixed platen be used for all peer-refereed published research.

FACT ON COMPRESSION STANDARD

TAPPI T804 and ASTM D642 alternatively allow for a floating platen that contacts the entire flat top face of the box, even if that surface is not exactly perpendicular to the base. In contrast to the fixed platen, the floating platen tests for the weakest part of the box. If the box were perfectly square, the two methods would give identical results, but for real boxes the results will differ. At least five samples should be tested. The flaps are sealed as they would be
in distribution, although if this is by glue, TAPPI recommends using a fixture to ensure good adhesion. There is a general recognition that the method of sealing affects the BCT, especially if the box is empty (which causes un-taped inner flaps to fold down into the case and can actually improve BCT values slightly).The precision of the compression test is pretty good. ASTM gives a reliability of 8.5% and reproducibility of 11.3%, and TAPPI gives a repeatability of 7% and reproducibility of 10.6%. ASTM notes that "these values may reflect the inherent variability of the test specimen as much as the actual variability of the test method and apparatus" (ASTM D642, Note 4).

Corrugated Board: Compression Tests

b) Constant Load/Creep Tests

This test is intended to reproduce the situation where packages are stored for a long period. The load is chosen to match the load on a bottom box in the stack or to be a percentage (less than 85%) of the value obtained in the increasing load test, D642. The test apparatus can be either a standard compression tester or a dead load apparatus that guides a weight onto the top of a box or stack. Initial deformation is compared to observations over increasingly long intervals (first 5 minutes, then 10, 30, 60, and 120 minutes). The test continues until failure occurs (the box or stack buckles) or a specified test period is over.

This is a test for creep, a time-dependent test in which the stresses are constant but the strains increase with the duration of the load application. It has been found that the time to failure decreases logarithmically as the dead load approaches the BCT; the time to failure with a dead load of 95% of the BCT is less than 2 minutes, and at 75%, boxes fail within 7 hours.

a) Basis weight (substance or grammage)

The amount of fibre in paper and paperboard is measured by weight per unit area. In the laboratory, this is done by weighing an area of material which has been cut accurately. Basis weight is expressed in a number of ways – typically the units are grammes per square metre or pounds per 1000, 2000 or 3000 square feet. For a given paper or paperboard product, most of the strength-related properties increase with increasing basis weight. This also has commercial implications as for a specific paper or paperboard the higher the basis weight the lower the number of packs from a given weight of packaging material. Higher basis weight means more fibre per unit area, and more fibre requires the removal of more water and lower output on the paper or paperboard machine.

b) Box Specifications

Corrugated box specifications generally include the material properties of flute and combined weight of facings and burst strength or edge crush. The direction of the flutes, although, if not specified, it is assumed that the flutes are vertical to add to compression strength. The conventional way to express dimensions is in order of L × W × D.

Figure 8 : Tested area of the box

Corrugated Board: Edge Crush Test

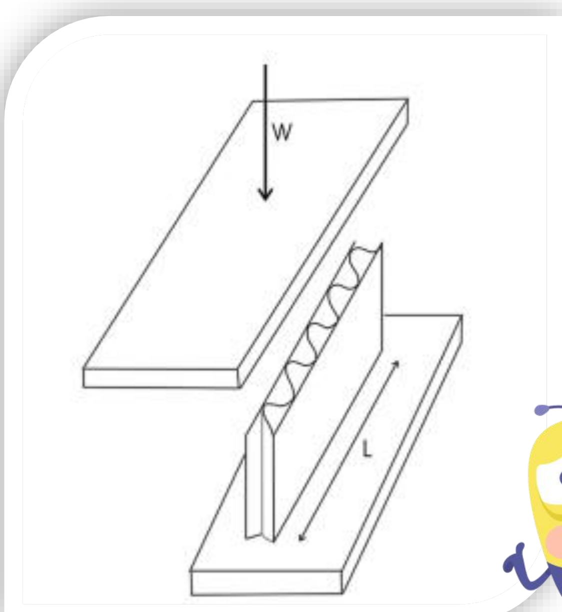
STANDARD TEST USED

TAPPI T 811: Edgewise compressive strength of corrugated fiberboard (short column test)
ISO 13821: Corrugated fiberboard—Determination of edgewise crush resistance—Waxed edge method.

The edge crush test (ECT) is the most significant of the corrugated board tests. ECT is a key test to show relationship to the compression strength of a corrugated fiberboard shipping container. ECT is used to predict a corrugated box's compression strength. Most corrugated board is currently specified on the basis of ECT values (rather than thickness or basis weight). ECT measures the columnar strength of the board, and is also called the short column test. It measures the amount of force required to crush a piece of board standing on its edge with its flutes vertical, as shown in Figure 2.

The most common form of the ECT test, TAPPI T 811, is performed in a small compression tester that can also be used to perform the ring and edge crust tests. Samples are cut 50.8 ± 0.8 mm (2 in) wide, and the load-bearing edges must be cut squarely with precise, straight parallel edges. The sample height depends on the flute type. For B-flute, the height is 31.8 ± 1.6 mm (1.25 in), for C-flute 38.1 ± 1.6 mm (1.5 in), and 50.8 ± 1.6 mm (2 in) for A flute, double-wall, and triple-wall boards. The corrugation runs in the short (height) direction.

Figure 9: Edge Crush Test (ECT)
Source: Mark J. Kirwan, Paper And Paperboard Packaging Technology



Corrugated Board: Edge Crush Test

The long edges are dipped in one-quarter inch wax to stiffen and prevent the edges from crinkling or rolling over. This forces the failure to occur in the body of the board (the columns of the flutes) rather than at the edges. The samples need to be conditioned for 2 hours after waxing. The sample is balanced on edge between the compression platens with the help of guide blocks. It is compressed until it buckles. The results are reported in units of pounds-force/inch (kilonewtons/meter) of specimen length:

$$ECT = \frac{W}{L}$$

where,
W = load (weight) at which failure occurs
L = length of sample

For example, if 64 pounds pressing on the edge of a 2 in long, 1.5 in tall (flutes vertical) sample of C-flute corrugated board causes it to buckle, what is the ECT?

$$ECT = \frac{W}{L} = \frac{64 \text{ lb}}{2 \text{ in}} = 32 \text{ lb/in}$$

For single-wall board, ECT values range from 20–80 lb/in. The test is prone to errors if the samples are not cut or prepared properly. If the flutes are crushed when cutting or the edges are not straight and parallel, the ECT value will be reduced. Samples should be cut with a precision sample cutter or some other method that will cut perfectly clean, parallel, and perpendicular edges ( ).

The repeatability of the ECT test is 4% and the reproducibility is 19%. There are variations of the ECT test in which the samples are not waxed, including ISO 3037. There are two other ECT tests that use taller samples, 2″ × 2″, and are designed to better measure compression strength of the combined board. In the T 839 Clamp Method, the sample is placed in a fixture with the ends supported by clamps to ensure that the sample is held and loaded vertically. In the T 838 Neckdown method, parts of the sample are cut away leaving a 1 in neck in the middle, with less bearing capacity than the rest of the sample, where the sample is intended to fail. While all three tests are similar in principle, they do not give the same results.

Corrugated Board: Edge Crush Test

When an unsupported sample of paper or paperboard is compressed by applying a force to opposite edges in the same plane as the sample, the material will, not unexpectedly, bend. This does not give a measure of compression strength (Figure 1)).

If, however, the sample height in the direction of the applied force is reduced below the average fibre length, say to 0.7 mm (Fig 1(b), the force is applied to the fibre network in such a way that the network itself is compressed causing the fibres to move in relation to each other. In this situation, interfibre bonding and the type(s) and quantity of fibre become important to the result which we call the 'short-span compression strength'. It is this inherent characteristic of the sheet, in the direction of measurement, MD or CD, together with stiffness, which relates to box compression strength.

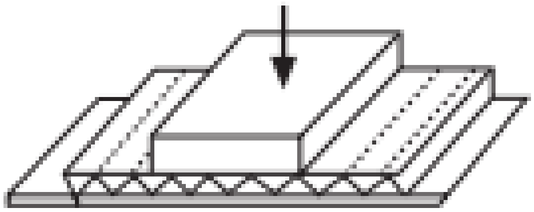


Figure 9: Specimen is compressed in the Flat Crush Test
Source: Mark J. Kirwan, Paper And Paperboard Packaging Technology

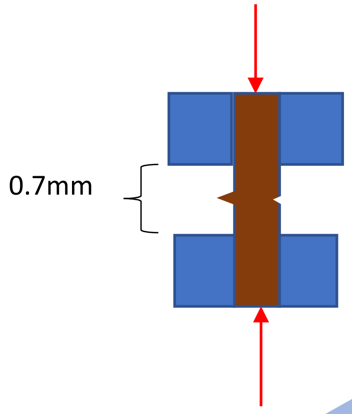


Figure 10: Force Application
Source: Mark J. Kirwan, Paper And Paperboard Packaging Technology

Corrugated Board: Edge Crush Test

The Edgewise Compression Test (ECT) is increasingly used as an alternative. The Edgewise test involves placing a specimen of board (typically 50 x 50 mm) vertically in a compression tester and applying a load until failure occurs (Figure 1c). The ECT measures the stiffness of the combined facings and medium and, as a result, is a better indicator of stacking strength. Using ECT measurements, case container strength can be calculated using the simplified McKee formula:

$$\textbf{Case compression strength} = 5.87 \times ECT \sqrt{BP} \times T$$

where estimated RSC top-to-bottom case compression strength is expressed in kilo Newtons (kN)), ECT = edge crush (kN/m),
BP = inside case perimeter (m), and T = combined board thickness (mm).

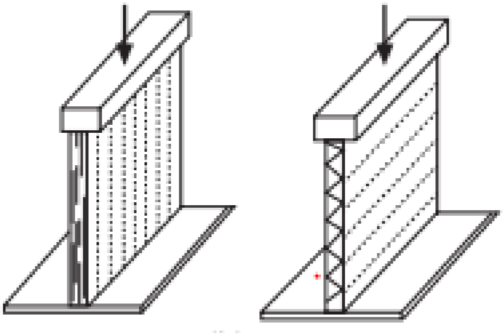


Figure 11: Edgewise Compression Test (ECT
Source: Mark J. Kirwan, Paper And Paperboard Packaging Technology

FACT ON EDGE CRUSH TEST

- The flat crush test is similar to the edge compression test (ECT) except that the specimen is compressed in the Flat Crush Test (see Fig. 2(b)). The test provides a measure of flute rigidity.

- The Box Compression Tester is a platen with either four columns (fixed head) or a single central column (floating head) configuration. These columns have lead screws that drive the top plate of the platen downward. An erected box is placed

- centrally in the tester and the platen is driven down until the point of failure is reached and measured. This test has become particularly relevant when specifying suitable

- material combinations for multi-piece or perforated retail ready packs (RRPs). It can be used for ‘bench marking’ and validation where theoretical calculations such as the modified McKee formula are unreliable due to the complexities of such packs.

- As there is a strong correlation between the in-plane compression strengths of liners and fluting and ECT values, the Short Span Compression test (SCT) was developed. This allows the ECT and thence the BCT values of a given case to be extrapolated. The paper sample is clamped between the four segments of the apparatus, which has a 0.7 mm gap between the pairs of clamps. When the two pairs are driven together

- the length of the strip reduces and the stresses increase. As the sample is short relative to its thickness, buckling is prevented and the measured failure is due solely to compression.

- Either BCT values or ECT values can be used to specify the boards used to construct a corrugated container. As a general rule, shippers interested in warehouse stacking

- strength find it advantageous to use BCT.

WHAT IS DROP TEST

DEFINE

Packaging drop tests simulate the **drops and rotational impacts** that packages may experience during shipping and handling. These tests allow for the **calculation of damages** that a package's corners, edges and surfaces may suffer, as well as knowing how a drop may affect the transported product. Thanks to a correct drop test procedure it is possible to evaluate the ability that a package has to **protect the product** that is being transported, and optimize it so that it guarantees the safety of the load.

Performing **drop test in packaging** also has several **advantages:**

1. It provides **data** related to a package's resistance to impacts and allows for the necessary changes to guarantee the safety of products.
2. Characterize the package or the protection of goods translates into **savings** for companies. Packaging drop tests help avoid over-packaging, which is more expensive for businesses, as well as under-packaging, which endangers goods and implies higher costs due to shrinkage of the destruction of products during transportation.
3. Package drop tests also allow for the product to be evaluated, and for **compliance with laws**, as well as with industry or specific company standards.

STANDARD TEST USED

The two most common packaging drop test standards include: **International Safe Transit Association (ISTA) ISTA's A1 procedure**: This standard is applicable for packaged-products weighing 150 lb (68 kg) or less.

A drop test **simulates the freefall of package on its corners, edges and surfaces**.
To achieve this the packaging is filled with the envisaged products and dropped from a defined height. This enables realistic conditions encountered during shipment to be simulated.

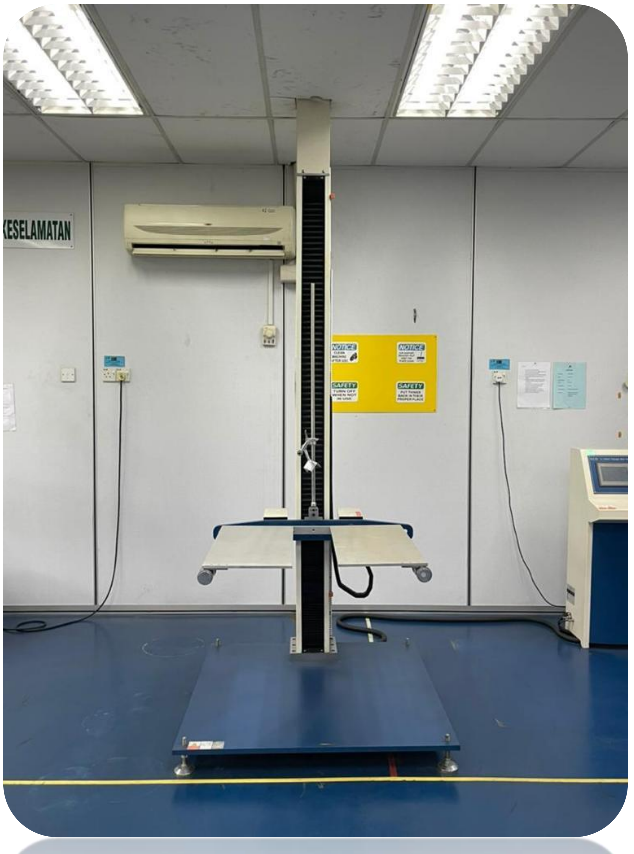


Figure 12 : Drop test machine

WHAT IS DROP TEST

Packaging drop tests simulate the drop of a package and the impact that it receives from a specific height and in various angles. During these package drop tests, a product is dropped in the same way that it would when being shipped or handled. A Packaging drop test procedure vary depending on the standards to be complied with and the characteristics of the load, among others. The tests are defined based on three variables:

1. The height of the drop, which reproduces what actually happens when workers handle the products. This height is usually 100mm to 450mm (though it may be as high as 900mm in some highly stringent cases). The height of the fall is based on ergonomic criteria (taking into account the package measurements and weight).
2. The position from which the cargo is dropped, which may vary to evaluate the more common areas where impacts may affect the products. Generally, the base of the package, the edges of the base and the corners of the base are tested; however, every side is tested for flat products.
3. The number of drops undergone by the package, which is generally set at six drops for one same product (which may include an extra series of six drops). Each of the drops is performed on a different area of the package, in order to measure the damages suffered during the distribution cycle.

FACT ON EDGE DROP TEST

The values of these three variables within packaging drop test procedures are defined based on the type of product and how hazardous the distribution cycle to be experienced during its transportation will be. Some standards require three different testing levels for compliance.

Therefore, various heights, orientations and numbers of drops are used for each test, obtaining results for a large number of possible scenarios.

The purpose of drop test procedure will be to determine the consistency of packages when facing these issues. Tests will be passed if a visual inspection shows that the package has been able to protect the product after the drop.

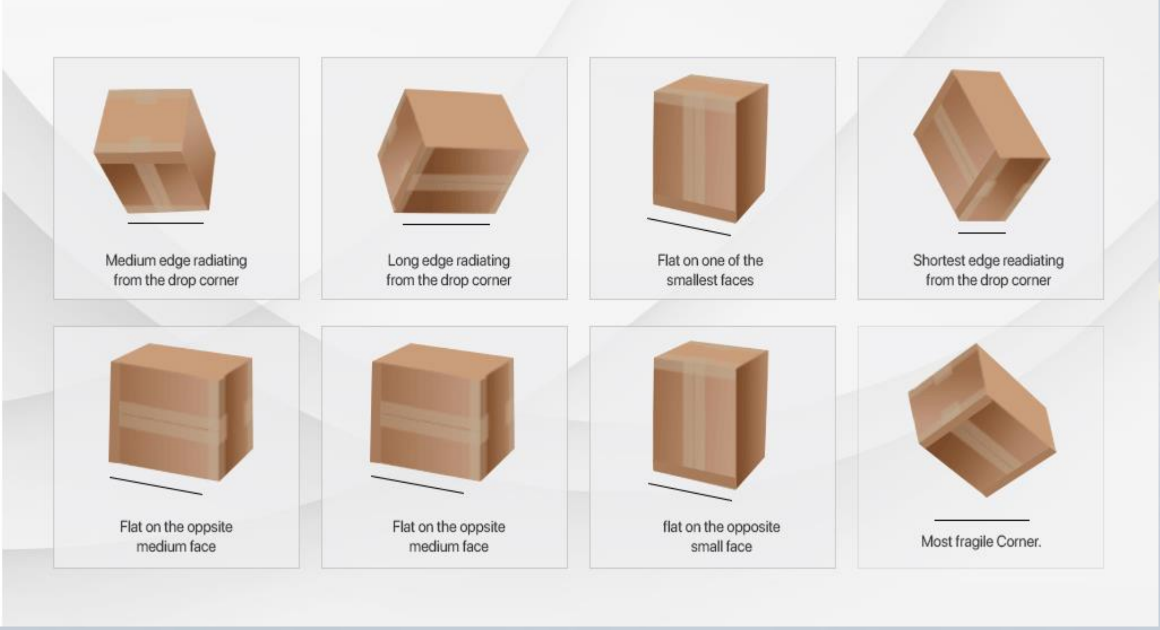


Figure 13 : Drop box face in the drop test procedure

EXCERCISE

1. What is the difference between material tests and package performance tests? How does their use differ?
2. What do these acronyms mean: TAPPI, ASTM, and ISO?
3. What is the difference between repeatability and reproducibility in test standards?
4. Is it more common to specify paperboard by thickness or basis weight? Which is more common for paper?
5. What is the range of thickness most common for paperboard?
6. Does paper have more tearing resistance in the MD or CD? In which direction does it have higher tensile strength? In which direction is it stiffer? In which direction does it have the greatest fold endurance?
7. When would a high tear resistance be a benefit? When might it cause problems?
8. What are the names of the instruments and units of measurement for the tearing test?
9. What characteristics of corrugated board does compression test evaluate?
10. Which factor most affects the stiffness of paperboard?

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