Important quality measurements for board grades

Paper Lab systems have been installed in several board mills around the world. While the testing methods are largely the same as those used in the testing of paper, a range of typical measurements specific to board have been taken into use in daily quality control.

The structure and strength of board means high demands and considerable challenges for testing equipment. Significant improvements have been introduced – for example in the cutting and transport of test specimens, and the measuring modules – to make the Paper Lab even better suited to the testing of board. The objective is to develop a device that can be used in the testing of both paper and board.

A separate paper on the classification of papers and boards presents the various board types and their applications in detail, and reading it before this one is recommended. This document focuses specifically on the properties that are of importance for boards, and how they can be tested with the Paper Lab.

1. Board measurements in brief

Both board and paper have several end users: finishers, printers, box makers, and consumers. Each end user of board also has specific requirements for the board properties, and these requirements are somewhat different for interior and exterior packaging boards. There are, however, some basic requirements that are common to most end users.

Board is primarily used in packaging applications, and therefore its strength properties are extremely important. The board should protect the contents of the package while standing straight and firm. Furthermore, as nearly all boards are printed, it is also vital that they possess excellent printing properties.

Typical quality properties of board can be divided into the following categories:

- basic properties
- strength and stiffness properties
- structural and surface properties
- absorption and barrier properties
- optical properties
- other properties.

2. Basic properties

The basic properties of board are: basis weight, thickness, density, bulk, moisture content, and filler content. All of these can be measured with the Paper Lab.

Basis weight, thickness and density characterize the structure. Basis weight is almost always measured and is one of the primary properties to numerically describe the board grade. Moreover, nearly all other properties are dependent on basis weight; any alteration in basis weight has a direct impact on thickness, stiffness, opacity, various strength properties, printing, and roll run length. In Paper Lab two versions of the basis weight modules are available; the standard version 100 cm^2 and the smaller version 28.3 cm^2.

Board thickness is calculated using a single sheet. Bulking thickness is seldom specified. As a result, board density is also calculated using basis weight and the thickness of a single sheet. Bulking thickness is used when calculating the density of paper. In Paper Lab, however, density is always calculated from a single sheet. Bulk is the inverse of density and an important property for the board maker, as it is integral to board stiffness.

Stiffness is dependent on board thickness and the elasticity modulus of each layer. Good stiffness in a three-ply board is achieved when the core layer is made as thick and bulky as possible, and the elasticity modulus of the outer layers is as high as possible. Bulk alone does not automatically ensure good stiffness. In Paper Lab thickness measurement is available in three different standards: ISO, Tappi and JIS.

Moisture content of board is a key property because it has a decisive impact on all physical property values – first and foremost on the strength properties, because fibers that absorb moisture will become more pliable and this in turn means a reduction in stiffness. With increasing moisture content the tensile strength decreases, resulting in greater stretch. Also tearing strength increases to a certain point. Paper Lab measures moisture content by using microwave technology, which is extremely well suited to the testing of board.

Fillers are primarily used in the surface layers to improve printability, and they usually make up less than 15% of the board structure. For example in corrugated board and hanging board (wall paper) the filler content is 2–10%. Paper Lab is able to measure total ash, clay, $CaCO_3$ and TiO_2 contents in board with the Multi-Filler module.

3. Strength and stiffness properties

The strength and stiffness properties of board are: tensile strength, bursting strength, tearing strength, bending stiffness, various compression resistances (RCT, CCT, CMT, and SCT tests), Z-direction strength (Scott-Bond), surface strength (such as IGT), and wet strength. Nearly all of these, with the exception of the last three, can be measured with Paper Lab.

Board is subjected to high loading speeds and tractive forces on board machines, winders and printing presses. Thus it must possess a high tensile strength to withstand these forces.

Consistent stretch throughout the web in the cross-direction is a key property when printing. Wide cross-directional variations in stretch may cause problems when they come into contact with print. Good stretch is also required in cup stock production, where the lip of paper coffee mugs is formed by rolling.

Board is also exported to countries that have a very humid climate. As the packaging must maintain its form even in these conditions, wet strength testing is also important.

Board stiffness has a direct impact on packaging strength. Folding boxboard in particular requires good stiffness, with the laminar structure achieving sufficient stiffness as economically as possible. Stiffness provides protection for the package contents, it improves appearance and sturdiness, and has an impact on machine runnability. Stiffness is measured either statically, by bending a board sheet, or dynamically by using the resonance principle. Static measurements correspond to slow phenomena, such as problems with end product flimsiness; and dynamic measurements correspond to fast phenomena, for

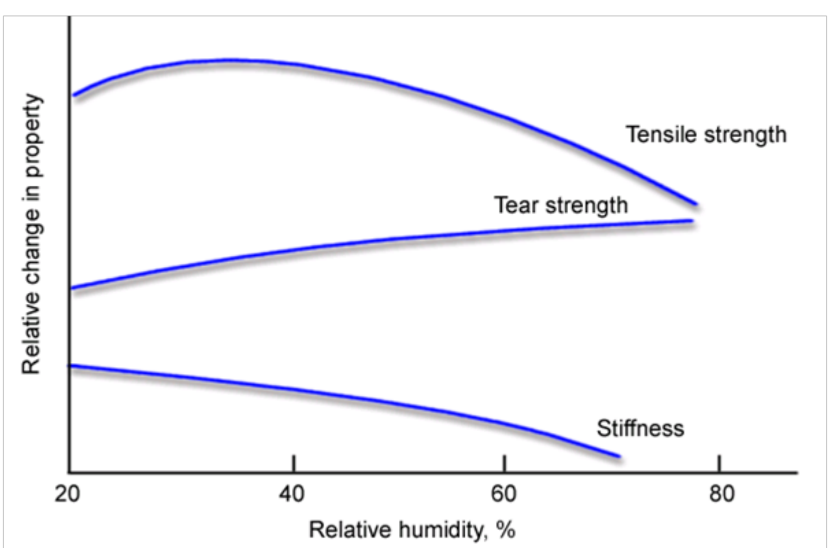


Figure 1:
Effect of humidity (moisture content) on the strength properties of board.

example runnability malfunctions. A menu printed on a board with high stiffness feels sturdy in the hands of a restaurant patron, and high bending resistance is required to keep the board from cracking when bent. Board used in graphics applications only requires a moderate amount of strength.

Bending resistance of board can be measured on Paper Lab with the Bending stiffness (board) module. This module measures bending resistance and calculates then bending stiffness. Bending stiffness can also be determined by means of calculations in the Tensile stiffness orientation module. These calculations are based on TSI, caliper and basis weight values. Calculated bending resistance values have a good correlation to the manual instrument.

Board packaging strength is primarily evaluated based on its compression resistance. When several cartons are stacked on top of each other, the carton at the bottom must be able to bear the weight of the other cartons without collapsing. As a rule, the higher the bending resistance of the board, the better its runnability on automated packing lines and the higher its compression resistance.

Because board is subjected to various compression forces coming from several different directions, basic compression resistance tests are conducted to estimate the durability of the board. The most commonly used packaging board compression resistance test is the SCT (Short Span Compression Test), which is fast, accurate and reliable.

The SCT test has been designed to eliminate test piece buckling, a serious problem in other test methods. Even though recent advances in the development of test piece jigs and devices provide a precisely controlled compression action, the most commonly used methods add lateral stiffness to the board test piece by shaping it in accordance with various profiles. These tests (RCT, CMT, CCT, etc.) are considered unreliable because studies show that they actually measure parameters other than pure compression resistance. The SCT can replace all of the compression resistance tests mentioned above.

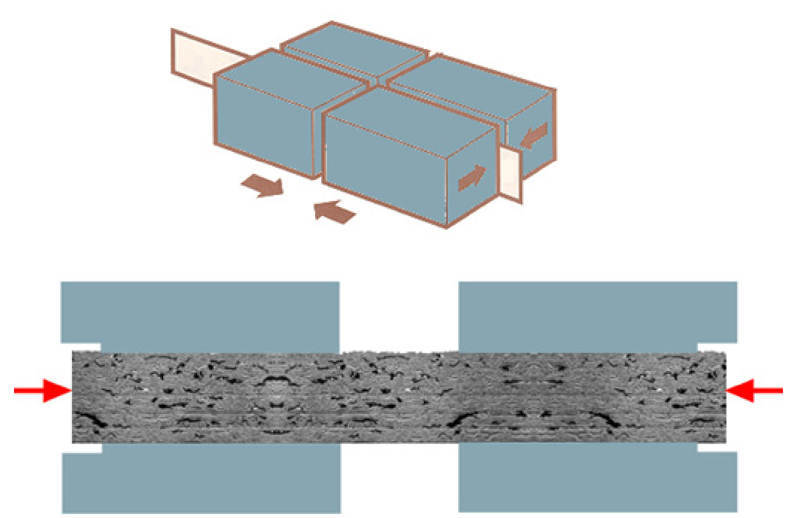
Compression strength can be determined on Paper Lab with the SCT module, or calculated with the Tensile stiffness orientation module. Calculated SCT, RCT, CMT and CCT values correlate well with the manual instrument. However, because the calculated compression resistances are more sensitive to changes in the board machine jet/wire ratios than manual instruments, the calculated parameters should be applied in stable conditions; at the very least, the correlation should be verified regularly. Calculated compression resistances can also produce more grade-specific run models in Paper Lab.

Equally important as the in-plane compression resistance of components is the in-plane load bearing capacity of finished corrugated board. The edgewise crush resistance of corrugated board (ECT) is the maximum compressive force that a test piece will sustain without being crushed. The test piece is mounted perpendicularly in the test machine and an increasing compressive force is applied until crushing occurs.

Figures 2 and 3 show typical compression resistance tests.

Refining board or corrugated board into boxes requires folding the board. When making the board or

Figure 2:
The SCT is the most commonly used compression resistance test.



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corrugated board fold at the desired point, the bending strength is locally weakened by creasing.

Board has good creasability when it can withstand creasing without breaking and folds easily at the crease formed when being bent. Good creasability requires high strength and high breaking stretch in the board surface layer, as well as a high degree of permanent deformation in the inner board layers when being pressed, and an appropriately low bonding strength. The board should delaminate on the crease and nowhere else.

Bursting strength is used to estimate the ability of packaging to withstand pressure applied by sharp articles. This property, alongside with tearing strength and compression resistance, is especially important to liners. Other key properties of liner are surface strength and abrasion resistance.

The board is loaded in the thickness direction for example in offset printing, where sticky printing inks applied by the print film pull on the paper or board surface. In such a situation the web gives way at its weakest point, and if for example the layers of a multilayer board are not properly bonded to each other, the board may delaminate.

In addition to offset printing, Z-direction strength is also required in the fluting of corrugating medium, and when perforating board or coating it with plastic: board with a low Z-direction strength may delaminate into unattractive jags at the spine corners of a glue-bound book. Z-direction strength is measured with a Scott-Bond pendulum impact tester. Z-direction strength cannot be measured with Paper Lab.

4. Absorption and barrier properties

Absorption properties are crucial to board being printed. The most common measurement demonstrating the absorption properties of board is the Cobb test which tests the water content within a specific period of time. This test is used particularly to indicate sizing degree. Another test indicating absorption properties is the Klemm test. Neither of these tests is available in Paper Lab, and due to the amount of water they require they cannot be easily automated.

For packaging board, it is important that gases (such as oxygen), aromas, moisture, and liquids do not permeate the board. Impermeability (barrier) is extremely important not only in the packaging of foodstuffs but also when dealing with caustic, poisonous or corrosive goods. Liquids, frozen goods and goods sensitive to odors (such as chocolates and cigarettes) require impermeability.

Examples of barrier properties include greaseproofness and water vapor impermeability. In order to

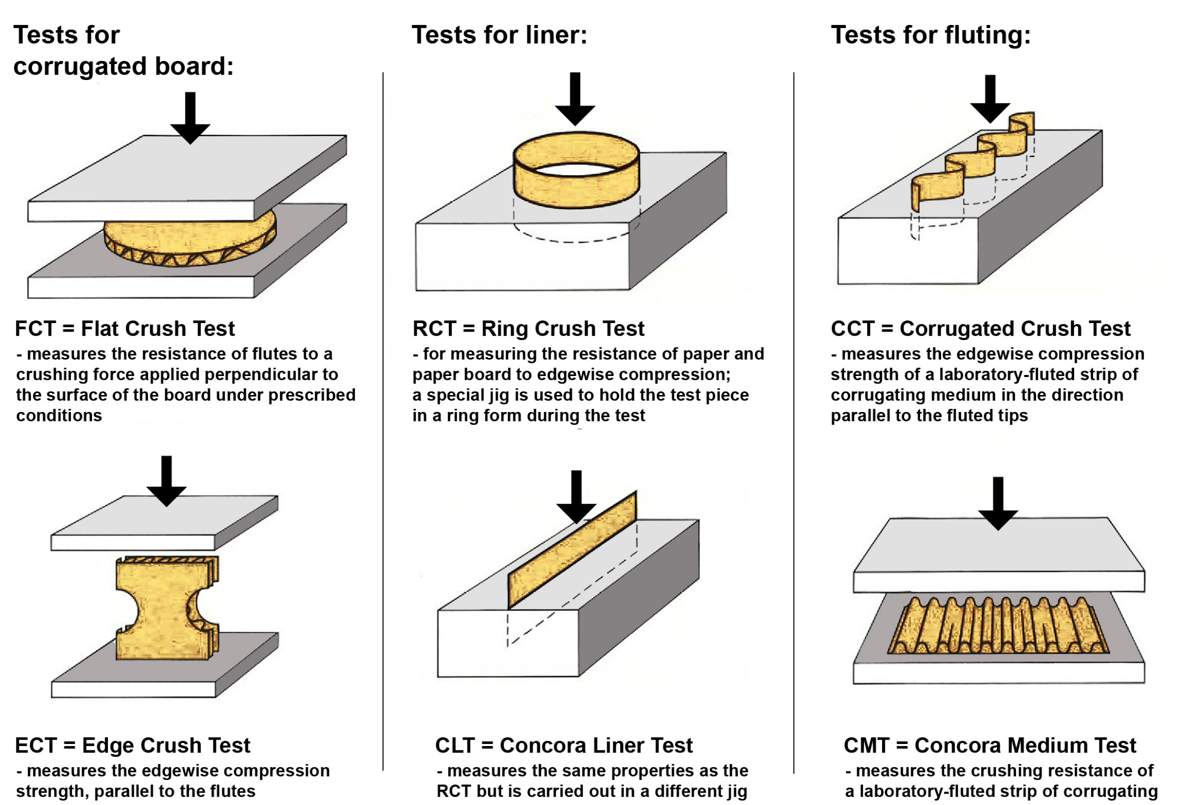

Figure 3: Other typical board compression resistance tests.

enhance impermeability, the board can be treated by sizing or using water and/or grease resistant specialty chemicals. Usually the only way to provide adequate protection is to cover the board with an extruded plastic membrane, laminated aluminum foil, wax, or special lacquer in a separate finishing machine. There are also products that must not be kept in air/liquid-tight packaging, such as freshly packaged breads, which must be able to expel a portion of the condensation that forms inside the package due to the cooling bread.

5. Structural and surface properties

Various air permeability tests describe the board structure. Pores play a key role, particularly in the transport of liquids and gases in the paper. Air permeability, size durability, greaseproofness, and the penetration of printing inks and impregnation agents into the board depend a great deal on porosity, pore distribution and pore orientation within the sheet.

In addition to printing, board cases and cartons are also glued during finishing, so the board should possess adequate porosity to ensure a good gluing and printing result. The printing ink or glue should be absorbed into the board surface with reasonable rapidity, but it should not bleed through or across the surface of the board.

Typical porosity tests are the Gurley, Bendtsen and Sheffield tests. In addition to these the Paper Lab uses the Oken module, compliant with a Japanese standard, which simultaneously measures porosity and smoothness. This module has a wide range of measurement and thus it can also be used to measure extremely dense or smooth papers/boards.

Various roughness and smoothness measurements, surface strength, gloss and friction indicate surface properties. In order to ensure a good printing result, the board must have good smoothness. Typical smoothness measurements used by Paper Lab are PPS, Bendtsen, Bekk, Sheffield, as well as the above mentioned Oken.

Smoothness is of utmost importance in gravure printing, where good contact between the board and printing ink is essential. In gravure printing the printing cylinder rotates in an ink pan, filled with highly fluid ink that is picked up by cells etched into the surface of the cylinder. Excess ink is doctored off and the ink contained in the cells is transferred to the paper in a nip formed between the printing cylinder and pressing cylinder. If smoothness is poor the ink will not be transferred to the board, thus resulting in 'missing dots' at the point in question. Smoothness is therefore vital for the consistency of the print result.

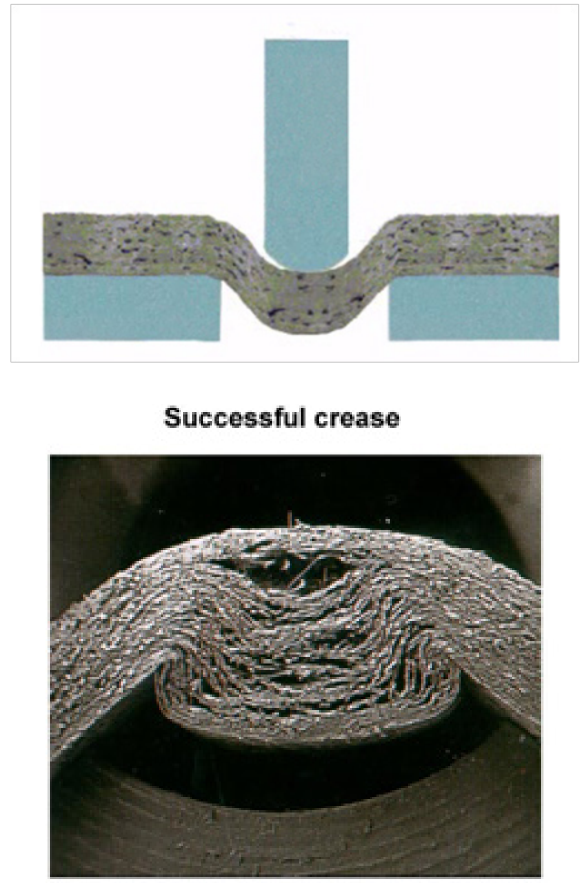

Figure 4: Good creasing is important for many boards.

Calendering and coating have an even greater impact on board smoothness. However, board cannot be calendered too much, as this will compromise stiffness. Only graphic boards can be calendered, because boards used in graphic applications do not require very high strength or stiffness. The most important attribute of graphic board is its ability to produce a high-quality print result.

The surface of packaging materials rubs up against metal in the packaging machine. If the board friction is too high or too low, it may cause problems in the packaging machine.

6. Optical properties

The optical properties of board determine its appearance. Optical properties are expressed in the interaction of board and light striking its surface. In most cases board gloss is not an end in itself. The goal is to achieve gloss in the print result, particularly in 4-color printed images.

Board gloss tends to cause readability problems with the printed text. In any case gloss is an attractive paper state value which is easy to measure and can be used to predict the final print result. Gloss according to Tappi 75° is available in Paper Lab.

Some key optical properties of board to be tested are ISO brightness, whiteness and CIE color values. Opacity is an important property for thinner hanging boards: the hanging board should be able to cover any flaws or dirt found on the wall surface. Board mills typically need to perform two-sided optical measurements. Brightness is especially important in pharmaceutical, cosmetics and cigarette packaging, as a portion of the board surface will remain unprinted. In cases such as this, the brightness requirement can be as high as 88%. Several optical properties can be measured with the UV color module that can be installed both on the top and bottom side.

For graphic boards, optical properties and gloss are absolutely vital. When purchasing a greeting card, the consumer makes his purchase decision based on how the card looks and how it feels in the hand. Gloss, brightness and smoothness as well as a good print result serve to distinguish the card from others. Permanence of brightness is required for items such as calendars, so that the beautiful white finish of the calendar does not yellow during the passage of a year. Board surface properties (achieved by the choice and method of coating) that are important to the printer are a high and even brightness and the right color tone.

7. Other properties

Other properties typically measured in board are fiber orientation and formation. Optical formation measurement is only suitable for thinner boards, as light cannot penetrate thick boards.

Two of the most important properties of foodstuffs are their taste and aroma. This is why the materials used in foodstuffs packaging must be able to protect the contents from foreign odors and tastes. The packaging material itself must not contaminate the packaged contents with odors or tastes. The same applies for toys, including toy packaging and children's picture books, as these types of items are often the child's favorite item to place in their mouth.

Odor and taste contamination of contents by the packaging material itself is tested organoleptically. One of the most commonly used tests is the Robinson test, wherein a test group evaluates the aroma and taste of a food product (usually chocolate) organoleptically. Comparison samples are often used. The test group should consist of at least 8 members, each of which is pretested for their suitability in participating in an organoleptic test.

The packaging material should also possess a sufficient level of microbiological purity. In this respect only packaging materials made from primary fibers can reliably fulfill purity requirements. Recycled boards contain thousands, even hundreds of thousands of times more microbes than primary fiber boards.

For more information, contact your local Valmet office. www.valmet.com

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