Testing procedure for packaging material –

1. Thickness

It is defined as the distance through an object, as distinct from width or height. Paper thickness is measured by paper thickness gauge. Paper thickness (caliper) charts can also be used for measuring the paper thickness. The tables below show the approximate caliper (or thickness) for a single sheet of paper of various grades and basis weights. These tables are organized by grade, with the left column listing selected standard basis weights for that grade and the right column listing the average caliper for a given grade/basis weight of paper.
Plastic thickness can be measured by using various techniques such as Pulse-echo technique, transmission technique, resonance technique, etc. Resonance technique is primarily used for measuring the thickness of the specimen. This is accomplished by determining the resonant frequencies of a test specimen. Compton photon backscatter, commonly known as the gamma backstabber (gbs0 guaging technique, allows one-sided measurement of film, sheet, pipe, composites, coatings and laminations.

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<th>STD. PAPER SIZE</th>
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Dial Thickness Gauge 0.001mm Tester Meter Paper Film Leather Measuring Tool


2. Tensile strength

Tensile strength is a measurement of the force required to pull something such as rope, wire, or a structural beam to the point where it breaks. The conventional tensile test i.e., the tensile test with constant cross-head speed, is a quasi-static test with fundamental assumptions regarding testing conditions and technique, as well as the specimens used.

The preferred standard for performing tensile tests on plastics is ISO 527, which includes the testing of molding compounds, films and sheets, as well as fibre composite materials. One essential prerequisite for performing such tests is that suitable polymer-compatible specimens are used. Type 1A and 1B specimens are basic specimens corresponding to ISO 3167 and suitable for use in a variety of testing techniques. Specimen 1A, which is generally formed by direct shaping i.e. injection molding, is known as multipurpose specimen while 1B specimen are normally produced by indirect shaping i.e., sawing and milling, from semi-finished products in the form of sheets.
The most common machine used in testing tensile strength is **universal tensile machine**. This type of machine has two cross heads, one is adjusted for the length of specimen and other is driven to apply tension to the test specimen. There are two types - hydraulic powered and electro-magnetic powered machine. These machines tests materials in tension, compression or bending.

The tensile strength formula is:

\[ S = \frac{F}{A} \]

Where, \( S \) = Breaking Strength (stress)

\( F \) = Force that Caused the Failure

\( A \) = Least Cross-sectional Area of the Material

**Ref.** - Wolfgang Grellmann, Sabine Seidler, Polymer testing

### 3. Puncture resistance

Puncture resistance is a measure of the maximum force or energy required to penetrate a material. This type of biaxial stress is seen by packaging films when packing hard protuberances such as pelleted dry foods and frozen vegetables. Because of biaxial loading, a conventional puncture resistance test can be used to test materials under conditions similar to actual use. The procedure is standardized in ISO 6603-1. As test equipment, a device is used that provides for the impact of a guided striker perpendicular to the plane of the specimen. The striker of preference has a polished hemispherical striking surface with a diameter of...
20mm and can be provided with additional weights. Depending on the material and test procedure, characteristic damage features occurring are penetration, initial cracks, breaks and brittle fracture. Based on the damage characteristic, behavior in actual use can be estimated for defined impact loads.

Puncture testing can also be made using a similar ASTM F1306 method. This is a method for determining the force, energy, and elongation to perforation of flexible barrier films and laminates.

Ref. - Wolfgang Grellmann, Sabine Seidler, Polymer Testing

4. Bursting strength

It is defined as the pressure at which a film or sheet (of paper or plastic, for example) will burst. Used as a measure of resistance to rupture, burst strength depends largely on the tensile strength and extensibility of the material. Determined by procedures such as Mullen burst test, it is expressed commonly in pounds per square inch (psi). Burst strength of packaging material used in shipment of merchandise is usually printed on the package. Also called bursting strength.

The burst test is frequently used as a general guide to the strength of paper, solid board and corrugated board. Bursting strength is usually quoted in kPa. We determine bursting strength using a digital hydraulic paper or digital hydraulic board burst tester.

Burst index (kPa.m2/g) = burst strength/basis weight

For plastics, two basic tests of primary interest are -

A. Long - Term Burst Strength Test (AATM D 1598)

B. Quick -Burst Strength Test (ASTM D 1599)

This method was developed to determine the ability of a plastic pressure vessel to resist rupturing when it is pressurized for a short period of time. Surging is a common phenomena in a fluid-transfer system. A hydraulic burst -strength tester is used for this test. The test is carried out by simply pressurizing the specimen and uniformly increasing the pressure until the failure occurs.. The system must be bled thoroughly, to avoid entrapment or air bubbles, people to commencing each test. The specimen is considered to have failed when it develops a leak, crack or rupture. The hoop stress can be calculated as follows -

\[ S = \frac{P(D-t)}{2t} \]

Where, \( S \) = hoop stress (psi), \( P \) = internal pressure, \( D \) = average outside and Inside thickness (in.), \( d \) = min. wall thickness (in.).

Ref. - Vishu Shah, I Handbook of Plastic Testing and failure analysis

https://research.cnr.ncsu.edu/wpsanalytical/documents/51BURSTINGSTRENGTH.doc
5. Seal Strength

Seal strength is related to the pack opening force and a measure of the consistency of the packaging process. Seal strength is a quantitative measure for use in process validation, process control, and capability. Seal strength is not only relevant to opening force and package integrity, but to measuring the packaging processes' ability to produce consistent seals. Seal strength at some minimum level is a necessary package requirement, and at times it is desirable to limit the strength of the seal to facilitate opening.

A portion of the force measured when testing materials may be a bending component and not seal strength alone. A number of fixtures and techniques have been devised to hold samples at various angles to the pull direction to control this bending force. Because the effect of each of these on test results is varied, consistent use of one technique (Technique A, Technique B, or Technique C) throughout a test series is recommended.

**Technique A**: Unsupported— Each tail of the specimen is secured in opposing grips and the seal remains unsupported while the test is being conducted. **Technique B**: Supported 90° (By Hand) — Each tail of the specimen is secured in opposing grips and the seal remains hand-supported at a 90° perpendicular angle to the tails while the test is being conducted. **Technique C**: Supported 180°— The least flexible tail is supported flat against a rigid alignment plate held in one grip. The more flexible tail is folded 180° over the seal and is held in the opposing grip while the test is being conducted.

This test method covers the measurement of the strength of seals in flexible barrier materials. The test may be conducted on seals between a flexible material and a rigid material.

Ref. - https://www.smitherspira.com/services/materials-testing/plastic-physical-tests/seal-strength

https://www.astm.org/Standards/F88.htm

6. Water vapour permeability
Moisture vapor transmission rate (MVTR), also water vapor transmission rate (WVTR), is a measure of the passage of water vapor through a substance.

The standard method to determine WVTRs (see ASTM E96) is to place a quantity of desiccant in an aluminum dish, which is covered with a sheet of the material being tested and sealed in position with wax. The dish is then placed in a closely controlled atmosphere (typically either 25°C ± 0.5°C and 75% ± 2% RH for temperate conditions, or 38°C ± 0.5°C and 90% ± 2% RH for tropical conditions) and the increase in weight noted as a function of time. If the points are plotted out, then they should fall more or less on a straight line because Δp is constant throughout the test.

\[ \text{WVTR} = \frac{Q}{A t} = \frac{\text{Slope}}{\text{Area}} \]

To convert WVTR into permeance (P/X), it should be divided by the driving force Δp. These methods have several disadvantages, including the length of time needed to make a determination (between 2 and 14 days) and the lower limit of the useful range (about 1 g m\(^{-2}\) day\(^{-1}\) for a typical packaging film). A further disadvantage is that, depending on the desiccant, Δp may not remain constant during the test period. In the case of anhydrous CaCl\(_2\), the partial pressure of water vapor in the dish remains below 2% of the vapor pressure of water at the test temperature during the test, whereas in the case of silica gel, the partial pressure of water sorbed on it increases with coverage.

WVTR tests on flat sheets of film sealed across aluminum dishes do not always correlate closely with actual performance of the film when made up into complete packages. Therefore, it is often preferable to carry out WVTR tests where the desiccant is contained in a finished package which has been closed and sealed in the conventional manner. Details of the test procedures can be found in ASTM D3079.

<table>
<thead>
<tr>
<th>Plastic material</th>
<th>Percent Absorption</th>
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<tr>
<td>1. ABS</td>
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<tr>
<td>2. Cellulose Acetate</td>
<td>2-7</td>
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<tr>
<td>3. Epoxy</td>
<td>0.08-0.15</td>
</tr>
<tr>
<td>4. PPO</td>
<td>0.06-0.07</td>
</tr>
</tbody>
</table>

Ref. -Robertson, Food Packaging Technology

7. Gas permeability (carbon dioxide and oxygen permeability)

Gas permeability is the ability of a barrier material to allow gases (O2, N2, CO2 etc.) to permeate through it in a specific time. Gas permeability may vary with temperature, humidity,
pressure and specimen thickness. The permeability of oxygen gas through a material is a critical factor when it concerns the ability of a package to prolong the lifetime of packaged food.

There are many methods for measuring gas permeability; the four major methods will be considered here.7

A. Pressure Increase Method

The ASTM manometric method for measuring gas transmission rates and permeabilities of flat films is designated D1434. It is sometimes referred to an isochoric or constant volume method. Test gas (normally at 1 atm) is introduced on one side of the flat film or sheet which is supported with a filter paper and sealed with an O-ring. The pressure in the receiving chamber is measured with an open-ended mercury manometer. Provided that the pressure on the high-pressure side remains much larger than that on the low-pressure side, the pressure difference remains essentially constant. Through equations relating the geometry of the cell with the rate of pressure rise in the manometer, the gas transmission rate can be calculated.

B. Volume Increase Method

In the ASTM standard volumetric method (also designated D1434), the change in volume (at constant pressure), due to the permeation of gas through the film, is measured. Variable volume permeation cells are used for rapid measurement of relatively high steady-state permeation rates. Although the volume increase method is generally simpler to implement, it is less sensitive than the pressure increase method. Volumetric methods are used relatively infrequently compared with the use of the pressure increase or concentration increase methods. A simple whole bag method based on a constant pressure/volume increase method has been described (Moyls, 2004). Interlaboratory testing has revealed that permeances measured by the D1434 procedures exhibit a strong dependence on the procedure being used, as well as on the laboratory performing the testing. Agreement with other methods is sometimes poor and may be material-dependent. The materials being tested often affect the between-laboratory precision. The causes of these variations are not known at this time and it is suggested that this method not be used for referee purposes.7

C. Concentration Increase Method

D. Detector Film Method

Ref. -Robertson, Food packaging

https://www.sp.se/en/index/services/gaspermeability/Sidor/default.aspx

8. Grease Resistance

This test method covers paper and paper products that have been treated or designed to resist penetration by oils or greases commonly found in foodstuffs. Such papers include but are not limited to greaseproof, glassine, and vegetable parchment papers. This test method provides relative data regarding the degree of grease resistance for the materials tested.
based on time required for penetration of a test specimen by turpentine under specified laboratory conditions. **For paper or paper products** that are not penetrated under these conditions by the upper arbitrary time limit of the test (1800 s), no relative information is provided. The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

http://www.balibago.org/Files/Tappi/DOCS/T559.PDF

A. The Kit Test (Tappi T559)

The Kit test measures the degree of repellence or anti-wicking of paper and boards which have been treated with fluorochemical sizing agents used to prevent wetting of the cellulose fibres of the material. Test solutions with varying strengths of castor oil, toluene, heptane and turpentine are used. The highest numbered solution (the most aggressive) that remains on the surface of the paper without causing failure is reported as the "kit rating" (maximum 12). The Kit test is used to quantify or compare the performance of papers and boards, used for food contact and other packaging applications where resistance to grease staining is important.

B. Turpentine Test (Tappi T454)

Silica sand is placed on the paper and dyed turpentine added to saturate the sand. The time taken for the dye to penetrate the paper is determined. This test is usually applied to greaseproof, glassine, vegetable parchment. It is not always suitable for assessing papers and boards that are given grease or oil resistance by means of a coating or internal treatment.

C. Permeability Test (ISO 16532-1)

The grease resistance of both creased and uncreased paper and board is determined as the time taken for a simulated "fat material" (palm kernel oil) to penetrate the board coating. This test method has the advantage that it is equally applicable to paper and board that has been internally or surface sized with organophobic materials, or plastic coated.

