Testing of Packaging Materials

Debashis Ghosh
debashis.ghosh@pplpack.com
Package - essentially a container.

- Metal
- Wooden
- Plastic
- Glass
Packaging – definition

**Packaging** is the science, art, and technology of enclosing or protecting products for distribution, storage, sale, and use.

Packaging also refers to the *process* of design, evaluation, and production of packages.

Packaging can be described as a *coordinated system* of preparing goods for transport, warehousing, logistics, sale, and end use.
Packaging Materials

Products made of any materials of any nature to be used for the containment, protection, handling, delivery and preservation of goods from the producer to the user or consumer.
Package – different consistency

Rigid                                Semi rigid                           Flexible
A package is essentially a container to

• **Carry**
  Not to loose or damage content. Stop contamination and preserve.

• **Communicate**
  Provide statuary and other information. POS Ad.

• **Convenience**
  Provide aid to dispensing, handling, stacking, display, disposal, dosage control

• **Conform**
  Statutory and legal needs, provide security features.

• **Convert**
  Support consistent conversion into package

*Perform with Commercial viability.*
Carry

- **Macro** – Spillage or Contamination due to torn / open package – Mechanical strength
- **Micro** – Passage of gas / moisture / vapor through the otherwise closed package. This depends on the properties of the packaging materials. – Barrier properties
- **Special needs**- Add or remove flavor, retain special atmosphere, allow conditional breathing.
Conform

- Process
  - ISO 9001, 22000, BRC Iop, Haccp

- Materials of construction
  - US FDA 21 CFR, EU, BFR

- Security feature
Packages – many formats
Basic Requirements of Flexible Laminates

• Aesthetics
• Strength To Withstand Handling / Transportation
• Provide Shelf Life
  – Barrier - Moisture, Gas, Flavor
  – Maintain flavor And Taste of Packed Food
• Conformance to Statutory and other requirements
• Facilitate creation of container with dispensing ease.
• Economics

So we combine different substrate to achieve desired properties within economic scope
Quality - Conformity

So after understanding the needs / requirements, we need to maintain QUALITY – may be defined as

“The totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs.“

Testing / evaluation is necessary to assure and conform to quality needs at different stages.
Testing at Design level (QA)

Strength – Macro carry

- Tensile strength & Elongation – Basic strength of packaging material
- Heat / Cold seal strength - Strength of closing while pack is made
- Interlayer Bond Strength - Strength of holding different layers together
- Tear resistance – Strength required to propagate a tear through laminate.
- Impact resistance - Strength to withstand impact load, say a dropped pack.
- Puncture resistance - Strength required to puncture a pack using sharp protrusions
- Thickness control – Strengths depends on material property and cross sectional area of materials. In packaging application the width of cross section is guided by pack size, so thickness is controlled.
Universal Testing Machine (UTM)

- Tensile strength
- Heat / Cold seal strength
- Tear resistance
- Puncture resistance
Tensile strength & Bond strength

TS : N / Sq mm
BL : N / 15 mm
Elongation : e /L %

BS : N / 15 mm

Layers are manually separated with care to facilitate testing
Heat / Cold seal strength

Seal Strength : N/ 15 mm
Drop resistance

Properties of Material
- Tensile Strength
- Elongation
- Impact Strength

Process condition
- Orientation
- Residual stress
Tear resistance of plastic film or sheeting is a complex function of its ultimate resistance to rupture. The specimen geometry and speed of testing in this test method are controlled to produce tearing in a small area of stress concentration at rates far below those usually encountered in service.

This test method has been widely used as one index of the tearing resistance of plastic film and thin sheeting used in packaging applications.

Reported in mN or grams
With specimen thickness in microns
Impact resistance

Impact Resistance of Plastic Film by the Free-Falling Dart Method

The test method covers the determination of the energy that causes plastic film to fail under specified conditions of impact of a free-falling dart. This energy is expressed in terms of the weight (mass) of the missile falling from a specified height which would result in 50% failure of specimens tested.
This test method determines the resistance of a film to the penetration of a probe at a standard low rate, a single test velocity. Performed at standard conditions, the test method imparts a biaxial stress that is representative of the type of stress encountered in many product end-use applications. The maximum force, force at break, penetration distance, and energy to break are determined.
Testing at Design level (QA)

*Strength – Micro Carry – Regularity conformance*

- **Barrier – MVTR** – Resistance to moisture passage through package
- **Barrier – OTR** - Resistance to oxygen passage through package
- **Migration / leeching** – Transfer of packaging material components to product packed.
- **Absorption / scalping** - Transfer of components from product packed to packaging material
- **Compatibility / Stability** – Inter-relation between product packed and packaging material over a period of intended life of the pack to ensure target performance.
Barrier properties

WVTR: gms / SqM, day at X Rh, Y C
OTR: CC / SqM, day at A Rh, T C
Migration / Leeching

*Tested as per standards – IS 9845*

- The mass transfer from an external source into food by sub-microscopic processes
- May impact food in two ways
  - Safety – migration of harmful substances
  - Quality – migration of substances which impart taint or odour
- Tested by extracting using different stimulants

<table>
<thead>
<tr>
<th>Simulant</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol 10% (v/v)</td>
<td>Simulant A</td>
</tr>
<tr>
<td>Acetic acid 3% (w/v)</td>
<td>Simulant B</td>
</tr>
<tr>
<td>Ethanol 20% (v/v)</td>
<td>Simulant C</td>
</tr>
<tr>
<td>Ethanol 50% (v/v)</td>
<td>Simulant D1</td>
</tr>
<tr>
<td>Vegetable Oil</td>
<td>Simulant D2</td>
</tr>
<tr>
<td>Modified polyphenylene oxides, particle size 60-80 mesh, pore size 200 nm</td>
<td>Simulant E for dry foods</td>
</tr>
</tbody>
</table>
Absorption / Scalping

- It is the sorption of constituents of the packed materials, by polymeric packaging materials.
- The process of testing this is by keeping packed materials in accelerated shelf life condition and periodically checking the product constituents using HPLC etc.
- The product contact polymeric layers are modified based on the study report.
Compatibility / Stability study

This is to ensure successful performance over the life cycle (Shelf life) of the package

- Products packed in trial packaging materials (Sometimes more than one options) kept in accelerated test conditions.
  - Packaging material manufacturer checks the package performances mostly .
- Common conditions are 38, 45 and 60 degree C and 55 & 90 % Rh.
  - Accelerated compatibility study conducted by dipping packaging material in products at elevated temperatures.
Testing at Design level (QA)

*Communicate – Printing, shape*

- Gloss
- Transparency / clarity / Opacity / Optical density
- Haze
- Scuff resistance
- Product resistance
- Stiffness
- Light fastness
Gloss is the ratio of specula reflection to the Incident light.
Optical Properties

- Haze: measure of scattering calculated by the ratio of diffuse transmission to total transmission. Diffused transmissions are which goes beyond 2.5 degree of incident ray.
- Clarity: Ratio of transmission (Within 0.1 degree deviation) to incident ray through a transparent film.
- Opacity: Opacity represents a substrate's light blocking ability.
Scuff resistance

- Scuff resistance tested for surface printed materials.
- Test conditions may vary depending on mutual contract between supplier and buyer. (Ref ASTM D 5462)
- Packaging designs are altered based on results.
Stiffness

- The bending resistance/stiffness testers measure the force required to bend flat specimens.
- The bending force is expressed in Grams force or can be converted to bending moment in gram-cm.
Light fastness

- Accelerated exposure to controlled standard light simulates color changes in inks etc. that may reasonably be expected.
- Color difference units are calculated by the CIE L*a*b* color difference equation (ASTM D 4303)
- Blue wool standard (Scale of 0 – 8) is also used, sample colour is compared with a standard blue wool card kept in same exposure.
Testing at Design level (QA)

Convenience

- Tear Strength
- Stiffness
- Seal strength
- Slip Resistance (COF – Outside)
Testing at Design level (QA)

**Convertability**

- **Seal Initiation Temperature** — Temperature at which heat sealing initiates
- **Hot Tack** — Tackiness of the seal material when it is hot
- **COF** — Resistance to slip.
- **Flex resistance (Gelbo)** — Effect on flexing damage.
- **VOC retention** — Amount of retained volatile organic contains in the packaging material.
Sealing Curve - SIT

- Seal strength [N/15mm]
- Plateau Initiation Temperature
- SIT at 5 N
- SIT at 0.5 N
- SIT at 50% Seal Strength
- Temperature [°C]
- Seal Strength
Hot tack

the sum of the cohesive strength of a
sealant material as well as its adhesive strength to
the remaining elements of the multilayer structure
while in the heat-seal temperature range

Normally the seal strength value after 500 m-sec of
sealing is recorded at different temperature. Peak
strength in N/15 mm and corresponding temperature
in °C is declared.
Gelbo Flexing
VOC Retention

Retained solvent is tested in Gas Chromatograph. The limiting Values are normally agreed upon. A gross value is 20 mg / SqM
QC Tests – In coming

• Dimensions, Substance weight (gsm)
• Bond strength
• Print quality
• Odour

QC Tests – In process

• Leak Test
• Drop test
• Visual
Testing for problem solving

Corrective action / benchmarking

• Differential Scanning Calorimeter
  – Thermal property of Polymers – Identification
• Infra Red Spectrometer & Microscope
  – Identification of Substrates, adhesives etc.
  – Analysis of inclusions and failure mode.
• All tests discussed, as required.
• GLC, HPLC, NMR, Atomic absorption spectrometer, Radiation spectrometer - occasionally on specific needs.
Differential Scanning Calorimeter

- Identification of polymers through analysis of thermal property.
- Mix ratio can be approximated if constituent material properties are known.
IR Spectrometry with Microscope

- Unknown materials can be checked.
- Thin cross section of laminates is analysed.
- Inclusions / Contamination can be identified.
Thank You