Paper No.: 12
Paper Title: FOOD PACKAGING TECHNOLOGY
Module – 31: Quality evaluation of Packaging Materials

1. INTRODUCTION:

In order to evaluate the performance of a package in the market place, it is important to test the different packaging materials used for their manufacture. Thus, quality evaluation of the packaging materials is done mainly for the following purposes:

1) Comparison with competitive packaging material, e.g. to compare offers.
2) Comparison of the current supply of material with the quality of that offered for the first time; also regular checking of uniformity in new supplies of packaging materials.
3) Quality checks during the production of packaging materials.
4) Evaluation of the suitability of a packaging material for a certain specific purpose, for instance protection against mechanical or climatic hazards.

Test procedures that are applicable for general classes of materials or packages are available and published in standardized form (Paine *et al.*, 1992; Griffin *et al.*, 1972).

ASTM - American Society of Testing and Materials Standards
TAPPI - Technical Association for the Pulp and Paper Industry (USA) Standards
BIS - Bureau of Indian Standards
ISO/R - International Standards Recommendations
BS - British Standards
FEFCO - Federation Europeanne des Fabricants de Carton Ondule Test Methods
PIFA - Packaging and Industrial Films Association Standards
ABA - American Box Board Association
BPBMA - British Paper and Board Manufacturers' Association
NFPA - National Flexible Packaging Association

2. CONDITIONING OF THE SAMPLES

It is very important that the quality evaluation of the packaging material should be carried out in standard atmospheric conditions and the samples should be allowed to reach equilibrium prior to evaluation which normally takes 24 hours. This is so because the properties of many packaging materials depend on the climatic conditions to which these materials are exposed. The physical properties of paper are affected by its moisture content and the moisture content varies in proportion to the relative humidity and temperature of the surrounding atmosphere. In special cases it may be necessary to check the moisture content of the test specimen, in order to ensure that the climate has had its effect on the specimen. Quality evaluation laboratories are constructed to maintain the standard atmospheric conditions and no test is considered official if conducted under any other conditions. In a number of countries a standard atmospheric condition has been established, i.e. 20°C and 65% R.H. in Argentina, Australia, Belgium, France, Germany, Netherlands, New Zealand, UK; 23 ° C and 50% R.H. in USA, Canada, Burma, Mexico, South Africa and 27°C and 65% R.H. in India.

3. IMPORTANT QUALITY EVALUATION METHODS

Most of the tests for evaluation of packaging materials are based mainly on evaluation of one or other type of strength of packaging material to be evaluated.

3.1 Grammage or GSM

Papers, foils and films are purchased on weight basis and any deviation from the prescribed weight will affect purchaser and the vender. Most physical properties such as bursting strength, thickness are specified in accordance with a particular basis weight or bulk.

Method of Test: The samples are cut by selecting the suitable template considering the type of the sample. For heavy paper (weighing above 100 GSM) template of the size 10 cm x 10 cm is taken and hung on one of the arms of the instrument. Reading is taken directly on the scale "A". In case the paper or paper board is light and reading remains below 100 GSM then template of size 10 cm x 20 cm is used to get more accurate results and reading is taken on scale "B". At least 5 readings are taken and results are expressed in range as g/m^2.

Suitable size of paper is cut with a template and then weighed on a balance. The weight is recorded and converted in to g/m^2 and expressed as grammage or GSM.

3.2 Thickness

Many physical and mechanical properties of paper, paperboard and flexible packaging materials are dependent upon the thickness of the material. Properties like tensile strength, sealability, and seal strength, moisture, gas and light barrier properties are directly related to thickness. In case of laminates the thickness of the constituent plies are more important as they influence the barrier properties. This test is useful for routine control.

Method of Test: Cut a piece from sample without any irregularities of size 10 cm x 10 cm. Place the specimen between two points of the micrometer, one of which has to be lifted gently to insert the paper and note the corresponding reading. The thickness can be expressed in any unit such as micron, inches, mil etc. Take at least 10 readings.

0.001" = 25 micron = 100 gauge = 1 mil.

3.3. Bursting Strength: (IS 1009-1966 Part I)

Bursting strength of paper and paperboard is determined in order to assess both strength and toughness of the material. It is essentially the ability of the sample to absorb energy.

Method of Test: The sample is fixed between clamps. The area exposed is 1.2 in^2. The sample is subjected to steadily increasing pressure hydraulically exerted on a rubber diaphragm beneath the sample until it ruptures. The maximum pressure required to rupture the sample is automatically recorded by a pressure gauge. This test is of importance in routine quality check of packaging material during manufacture. Eg. Corrugated Boxes.

3.4 Tear Strength or Tearing Resistance: (ASTM, D 689-79 Part 20)

This test is performed on papers and it gives an indication towards the strength of the paper. It is helpful in making selection of papers based on material for packaging purposes. The tear strength requirements may be high or low according to end use of the packaging material. This test measures the energy absorbed by the test sample in propagating a tear that has already been initiated by cutting a small nick in the test piece.

Method of Test: The Elmendorf tearing tester has two grips set side by side with only a small separation. One grip is stationary and is mounted on an upright on the instrument base. The second grip is movable and is mounted on a pendulum. The pendulum is mounted on a frictionless bearing and swings on a shaft. The sample of 50 x 62 mm size is clamped in the two grips and a cut is made using a sharp knife fixed on the tester. When the pendulum is released, it swings down on pre-cut sample. This indicates the residual energy lost in tearing and expressed in mN (milli Newton).

3.4 Water Penetration-Cobb Test: (IS: 4006-1966 Part I):

This test measures the amount of water absorbed by the sample during penetration from one side to another. It is useful in assessing the suitability of paper and paperboards to be used for shipping containers, which may be exposed to water spray.

Method of Test: A weighed sample is clamped under a metal base plate and exposed to water for one minute (paper/paper board). The area exposed is 100 cm^2. After the specific time, the sample is removed, blotted and reweighed. The difference in weight indicates the amount of water absorbed by the sample. The results are expressed as gm / m^2.

3.5 Grease Resistance: (ASTM D-722; TAPPI T - 454)

This test is important for the packaging materials used for fat rich food products like butter, ghee, oil etc.

Method of Test: This test is performed by putting 5 g sand on the specimen through a hollow cylinder metallic piece and then topping the sand with 1.1 ml of coloured turpentine dye. This is placed on a white paper sheet and at specified intervals, the indicator sheet is examined for the first spot and after it the experiment is discontinued. The time between the application of turpentine dye and appearance of first stain is recorded as transudation time in seconds.

3.6 Water Vapour Permeability: (IS: 1060- 1960 Part II)

One of the prime functions of the packaging materials is to act as barrier to gases and vapours. Many hygroscopic foods have to be protected from oxygenated water vapour pick up. The measurement of permeability is therefore very important.

Method of Test: The water vapour permeability may be measured by means of high-vacuum techniques, although there are simple gravimetric methods available which determine Water Vapour Transmission Rate (WVTR) much easily. In this method the value of water vapour permeability is determined by the increase in weight of a dish filled with desiccant (Eg. anhydrous calcium chloride), covered with the test specimen and sealed with molten wax or vacuum grease. The sealed dish is placed in a humidity cabinet maintained at 38 ± 1°C and R.H. 90 ± 2 %.

The WVTR is computed by the following formula:

$$\text{WVTR} = \frac{G \times 24}{A \times T} \ g/m^2/24 \text{ hrs}$$

Where;

G = weight gained in gm

T = time during which gain in weight is observed

A = area of the sample exposed in m^2

4. IDENTIFICATION OF PACKAGING MATERIALS:

Over the past decades packages have become more complex and we are presently using number of plastic films in packaging. Film users and converters may use a variety of instruments from high-powered microscopes to spectrophotometers. However, for easy and rapid identification of films, film users and converters usually go for simple non-instrumental techniques.

Method of Test: The first step in analyzing a flexible film is to measure some of its physical properties by density, hardness, stiffness etc. The laminates are to be delaminated into its separate plies so that they can be separately identified. There are several methods available to separate and isolate laminated components. They can be separated by heating on a flame or by immersing in boiling water up to 5 hours.

Tetrahydrofuran vapours are used for rapid separation of different laminates. The plastics can be identified by solubility or by the observation of burning characteristics where the colour of the flame, the way of dripping and the odour of the fumes assist to identify the type of plastic. The characteristics are shown in Table 1. Solubility of films in a particular solvent is an excellent and more dependable test for identification. In this test one-square inch of sample is put into 15 ml of the appropriate solvent and heated to boiling point with proper care to prevent solvent loss.

Table 1: Characteristics of different plastics

Film	Density range (gm/cc)	Flammability (self extinguishing)	Colour	Behaviour	Odour
Polyethylene	0.910 - 0.965	No	Top yellow bottom blue	Melts and drips	Burnt wax

			white smoke		
Polypropylene	0.900 - 0.915	No	Top yellow bottom blue white smoke	Melts and drips	Burnt wax and acrid
PVC	1.28-1.38	Yes	Yellow orange with green edge	Darkens, softens & decomposes	Chlorine
PVDC	1.68	Yes	As above with green spurts	Black, hard residue	Chlorine
PVA	1.21-1.33	Yes but slowly	Yellow with gray smoke	Swells, softens and turns brown	Pungent
Poly carbonate	1.2	Yes	Yellow orange with black smoke	No drips, decomposes	Pleasant
Polyester	1.38	No	Yellow-black smoke	No drips, softens, burns steadily	Pleasant
Polystyrene	1.04-1.09	No	Yellow orange black shoots	No drips, softens	Floral (sweet)
Nylon	1.06-1.14	Yes	Blue, yellow top	Melts, drips and froths, Rigid drips	Burnt Hair
Cellophane	1.48	No	Yellow, orange, Grey and smoke	Burns fast and complete, burnt area brittle	Burnt Paper
Cellulose acetate	1.28-1.32	No	Yellow with blue base	Melts, burns quickly and leaves beads	Burnt Vinegar
Cellulose Nitrate	1.35-1.40	No	Yellow	Burns at once and fully	Acrid

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5.0 QUALITY EVALUATION OF FABRICATED PACKAGES

Once packaging materials have been fabricated into package, it is important to measure properties of these packages to ensure that they conform to the desired specifications. These tests involve measurement of critical dimensions and one or two critical properties.

5.1 Evaluation of Glass Bottles (IS: 1392 -1967)

5.1.1. Dimensional Measurements:

Height, body diameter, wall thickness and finish are measured to detect possible variations that may exceed the tolerance limits, which have been established by glass manufacturers. Adherence to these tolerance limits is an important factor in operation of high speed filling lines. For checking body dimensions, gauges are used which have been specially designed for each specific bottle. The capacity of glass container is measured by selecting a sample of 12 bottles at random and checking them for volume.

5.1.2 Pressure Test:

Bottles used for liquor, carbonated beverages and soda water etc. have to withstand certain amount of internal pressure. Devices are available which subject the bottles to internal pressure using a gas or liquid. The bottles are subjected to an internal pressure of 150 kg /cm^2 for 1 minute. The temperature at which the test is carried out is very important since, a bottle withstanding 150 kg/cm^2/at 30°C may fail to withstand the same pressure at 60°C. Bottles, which have to withstand pressure, should be carefully designed.

5.1.3 Thermal Shock Test:

This test is performed when the bottles are subjected to sudden temperature difference during actual filling and use. In food industry sterilized product/beverage is packed in bottles and in pharmaceutical industry, the bottles are sterilized by hot steam before use. In this test few bottles are immersed in a hot water bath at a temperature of 72 ±2°C for 300 ± 10 seconds and when the bottles have reached the temperature, they are taken out along with hot water inside and suddenly dipped in a cold water bath at 30 ± 2° C for 30 seconds. The difference between the hot water bath temperature and cold water bath temperature gives the thermal shock to the bottles. The time for transfer of bottles from the hot water bath should not be more than 60 seconds or less than 15 seconds.

5.1.4 Impact Test:

Bottles that are used again and again, often meets certain amount of impact in their daily use. In order to ensure that such bottles do not fail, this test is performed. In this test a steel ball of 400 gm is dropped from a height of 10 cm on the bottle held rigidly. In case of milk bottles the ball is dropped thrice on the same spot on the bottle and the bottle should not freak or crack. In the pendulum test the steel ball swings and strikes at the bottle held rigidly.

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6. Conclusion

Packaging materials need specific properties in order to protect the contents. The quality evaluation of different packaging materials is important for manufacturers, raw material suppliers and as well as the users. The manufacturer is always interested in testing the basic quality and to find out what new applications can be developed based on the properties of the packaging material and also to check the quality of the material. The converter has interest in the conformity to specifications and suitability for application. The user wants to ensure that the material he is purchasing is of required quality and adequate to protect the product from spoilage. Thus, quality evaluation of packaging material is an important operation in the food packaging industry.

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