Some important measurements in packaging

1. Moisture content of paper and wood.

$$MC_d = \frac{W_m - W_d}{W_d} \times 100$$

$$MC_w = \frac{W_m - W_d}{W_m} \times 100$$

where, MC_d is dry moisture content and MC_w wet moisture content. W_m is the wet weight measures by initial weighing of the sample and W_d is the dry weight measured by weighing dried paper/wood.

2. Modular of elasticity (MOE) and modulus of rupture (MOR) of wood which is used to measure the loading possibility with the wood under testing

$$MOE = \frac{PL^3}{4Dwh^3}$$

$$MOR = 1.5 \times \frac{PL}{wh^2}$$

where, P is the load subjected on the wood, h is the height of the wood, w is the width of the wood and L is the length measure between the supports as shown in Fig. 1.

3. Nail withdrawal force estimation

$$F = 300nLd$$

where, F is the force, n is the number of nails, L is the seated nail length, d is the diameter of the nail.

4. Thermal shock resistance of glass

Thermal shock is mainly caused due to temperature difference between internal and external wall of glass bottles. The thermal stress is calculated as

Thermal stress = $k(T_1 - T_2)\sqrt{t}$

where, t is the wall thickness and k is the material constant usually in the range of 0.4 – 0.5. The temperature is expressed in Kelvin scale.

5. Internal pressure resistance for glass containers containing carbonated beverages. It is expressed in terms of limiting hoop stress.

   Limiting hoop stress = $\frac{pd}{2t}$

   where, *d* internal diameter of the bottle, *t* is the wall thickness and *p* is the pressure inside the container.

6. Edge crush test index for corrugated board

   ECT = W/L lbs/in

   where, *W* is the load at which failure occurs and *L* length of the sample

7. Diffusion flux *J* used to measure permeability of the packaging film against gas and vapor molecules in case of a polymer membrane and in stationary condition is expressed in cm^2/s as

   $J = -D \cdot \left(\Delta c / l\right)$

   where, *D* is diffusion constant and expressed as follows considering t_L as the time-lag value in sec.

   $D = l^2 / 6t_L$

   Δc is the concentration difference expressed in mol/cm^3 across the membrane thickness *l* expressed in cm.

8. Taber Stiffness Units are defined as the bending moment of 1/5 of a gram applied to a 1.5" wide specimen at a 5 centimeter test length, flexing it to an angle of 15°. A Stiffness Unit is the equivalent of one gram centimeter.

   $E = 0.006832 \bullet (1/(w \bullet d^3 \bullet \theta)) \bullet S_T$

   Where E = Stiffness in flexure in pounds per square inch

   w = specimen width in inches

   d = specimen thickness in inches

   θ = deflection of specimen converted to radians (15° = 0.2618 radians, 7.5° = 0.1309 radians)

   S_T = Taber Stiffness Units [$\mathbf{S_T = 0.01419 S_G - 0.935}$]

   Where S_T = Taber Stiffness Units

   S_G = Gurley Stiffness Units

9. Impact failure weight, often measured for plastic and paper film to assess the maximum impact it can withstand, and expressed as W_F. Commonly employed for drop test or dart falling test.
   $W_F = W_0 + [\Delta W(A/N - 0.5)]$

10. Box compression test (BCT) is commonly done for corrugated boxes where the flutes are kept vertically. In is expressed in pounds/inch.
    BCT = $k_1 \times ECT \times \sqrt{h \times z}$
    where, $k_1 = 5.87$
    h = thickness of corrugated board
    z = box perimeter = 2(L + W)