

Structural Characteristics of Paper

- Grammage
- Formation
- Caliper
- Porosity

Grammage

Grammage: Mass of paper per unit area
Grams per square meter (g/m²)

- **Measure area, A**
- **Measure mass (weight), M**
- **Grammage = M/A**



Basis Weight

- Historically paper was sold in reams, usually packs of 500 sheets or a specified length and width (not universal)

Paper Grade

Writing and Printing

Newsprint

Paperboard

Ream Size

17 inches X 22 inches

24 inches x 36 inches

1000 feet²

- Basis Weight, ream weight, and substance are all names for mass or weight of one ream of paper (lb)

Example of Basis Weight Label

8 1/2 x 11

Metric: 216x279 mm

SUBSTANCE 20

75 g/m²

White--Long

500 sheets

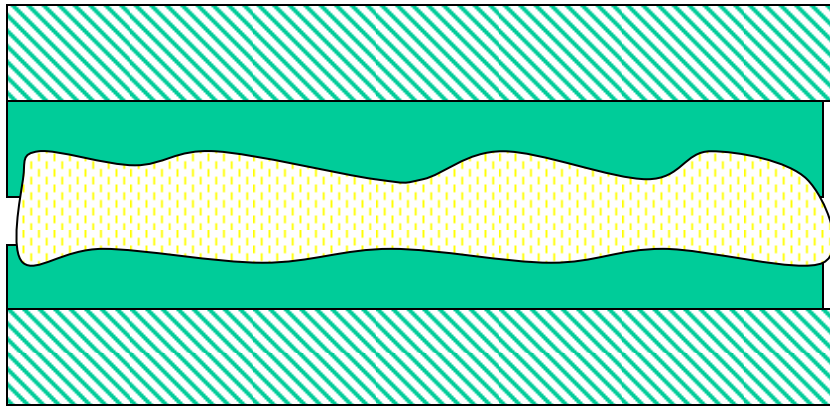
Example

	Copy paper	Linerboard
Grammage =	75 gr/m ²	205 gr/m ²
Ream =	120.6 m ²	92.9 m ²
Basis weight=	20 lb	42 lb

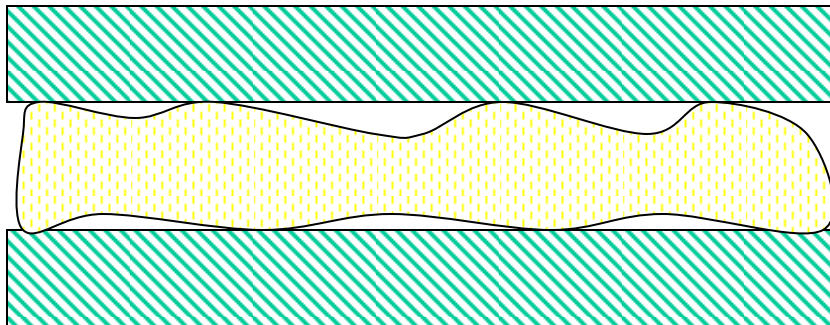
Caliper

- Caliper is the thickness of the sheet
- Usually measured in microns (10^{-6} meters) or mils (0.001 inches)
- Often caliper is given as number of points
 - 1 point = 0.001 inch
- Because of surface irregularity and compressibility of paper, the caliper depends on the method of measurement.

Caliper Measurement



**Soft-Platen
Caliper**



**Hard-Platen
Caliper**

Examples

Copy paper: 0.004 inches
4 mils or points
102 μm

42 lb linerboard: 0.012 inches
12 mils or points
293 μm

Density and Bulk

- Apparent density of paper equals the basis weight divided by the caliper

$$\text{Density} = \frac{\text{grammage}}{\text{caliper}} \quad \text{kg/m}^3$$

- Bulk is the inverse of paper density

$$\text{Bulk} = \frac{\text{caliper}}{\text{grammage}} \quad \text{m}^3/\text{kg}$$

Example

- Copy paper: (75 gr/m², 4 mils) density = 0.74 gr/cm³
- Linerboard: (205 gr/m², 12 mils) density = 0.67 gr/cm³

Porosity

Porosity is ratio of pore volume to total volume

$$\phi = \frac{V - V_f}{V} = 1 - \frac{\rho_f}{\rho_{eff}}$$

Formation

- Pattern of dense and light areas in the sheet
- Small-scale distribution of mass in sheet
- Visual or optical uniformity

**Formation Index = coefficient of variation
of mass distribution**

$COV = (\text{standard deviation}) / \text{mean}$

Index of 5% is good 25% is quite bad

Formation Examples



Number of Fibers in a Sheet

$$BW = N\omega_f l_f$$

BW = grammage of fibers

N = number of fibers
per unit area

l_f = coarseness of fibers

l_f = length of fibers

$$N = \frac{BW}{\omega_f l_f}$$

Say fiber length is 2 mm and coarseness is 0.2 mg/m

$$\text{For } BW=60 \text{ gr/m}^2 \quad N = \frac{60}{0.2 \times 2} 1000^2 = 150 \times 10^6$$