Glass Fragment Analysis

- **Trace evidence recovery guidelines of "SWGMAT"**
  (Scientific Working Group of Material Analysis)

Physical examination
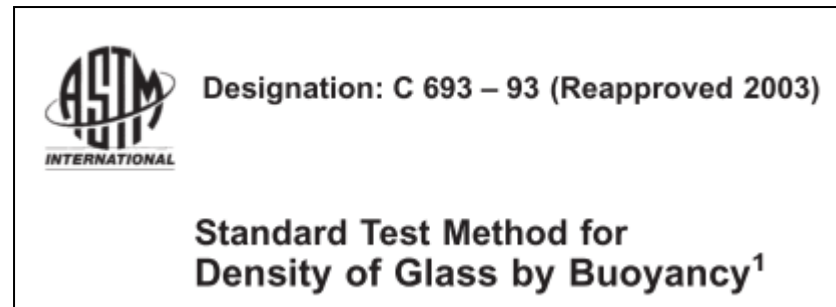
Physical appearance observation

Physical property identification

- Color
- Surface features
- Flatness
- Thickness
- Fluorescence

- **Density**
- Refractive Index

- **Overview** of the density determination of glass fragment

Techniques / Parameters	Buoyancy Method (ASTM C693-93)	Density gradient column	Sink-float method
Size/weight of glass fragment	≥ 20g	2-3mm in ϕ	2-3mm in ϕ (≥ 5mg)
Solution	DI water	Miscible liquids	Bromoform and Bromobenzene
Cost consuming	High	Medium	Low
Time consuming	High	High	Low

Designation: C 693 – 93 (Reapproved 2003)

ASTM INTERNATIONAL

Standard Test Method for
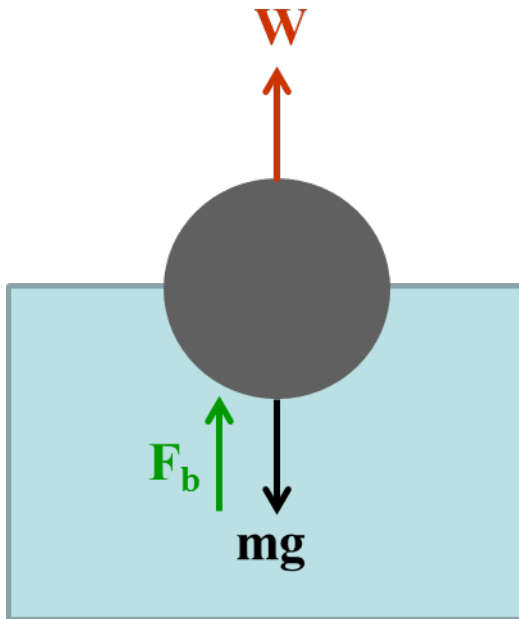Density of Glass by Buoyancy[1]

ASTM International : American Standard Test Method International

- **ASTM Standard Test Method: Buoyancy method**

Archimedes' principle

$$g/cm^3 \ : \ mass/volume$$

W

F_b

mg

Volume of the immerged part
=
Volume of the water replaced

- **Equation of the density determination**

$$\rho_S = \cfrac{W_A}{W_A - W_W} \times (\rho_W - \rho_A) + \rho_A$$

ρ_S	= Density of glass specimen
ρ_W	= Density of water
ρ_A	= Density of air
W_W	= Weight of specimen in water
W_A	= Weight of specimen in air

- **Parameters**

Parameter	Use to
1. Temperature and Pressure of *air* (T_A in ˚C and P_A in hPa)	Find the **density of air** (ρ_A)
2. Temperature of *water* (T_W in ˚C)	Find the **density of water** (ρ_W)

Density of air

$$\rho_A = \frac{0.0012932}{1 + (0.0036728) \times T_A} \times \frac{P_A}{1013.25}$$
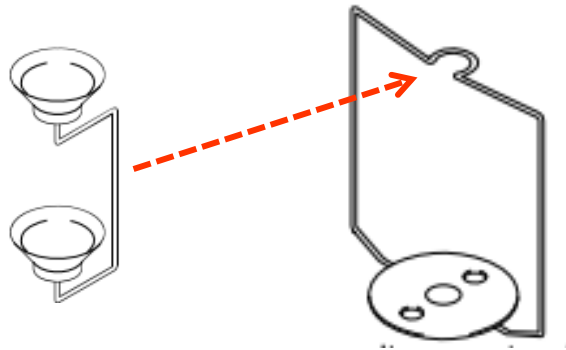
P_A = Pressure of air
T_A = Temperature of air

Density of water

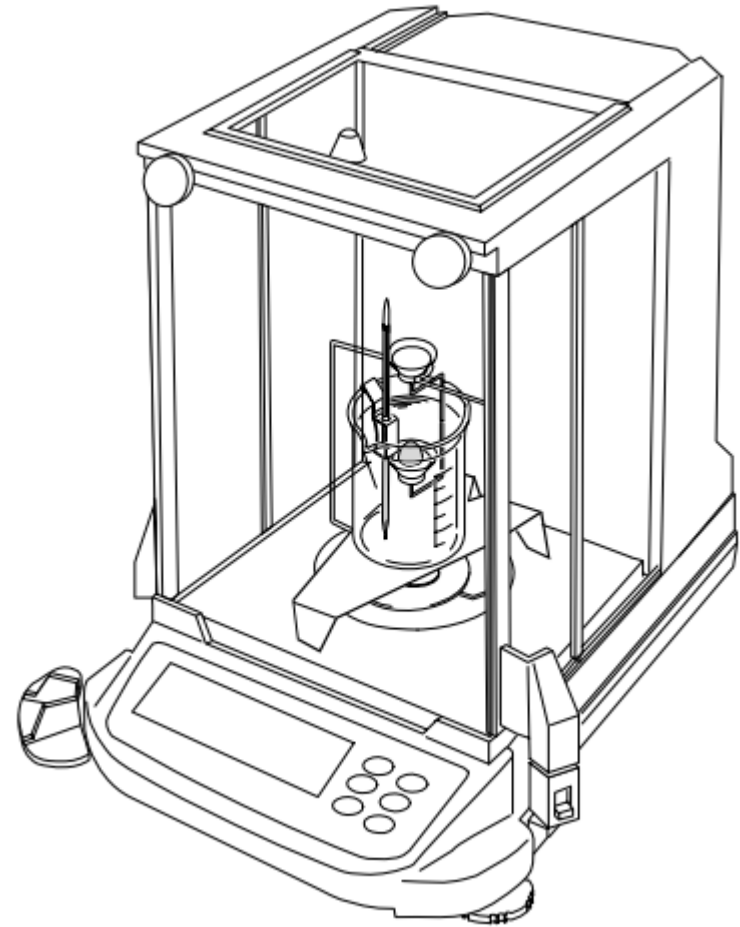From the Table of Air density (g/cm^3) of *ASTM C693-93 (2003)*

- **Commercial density determination kit**
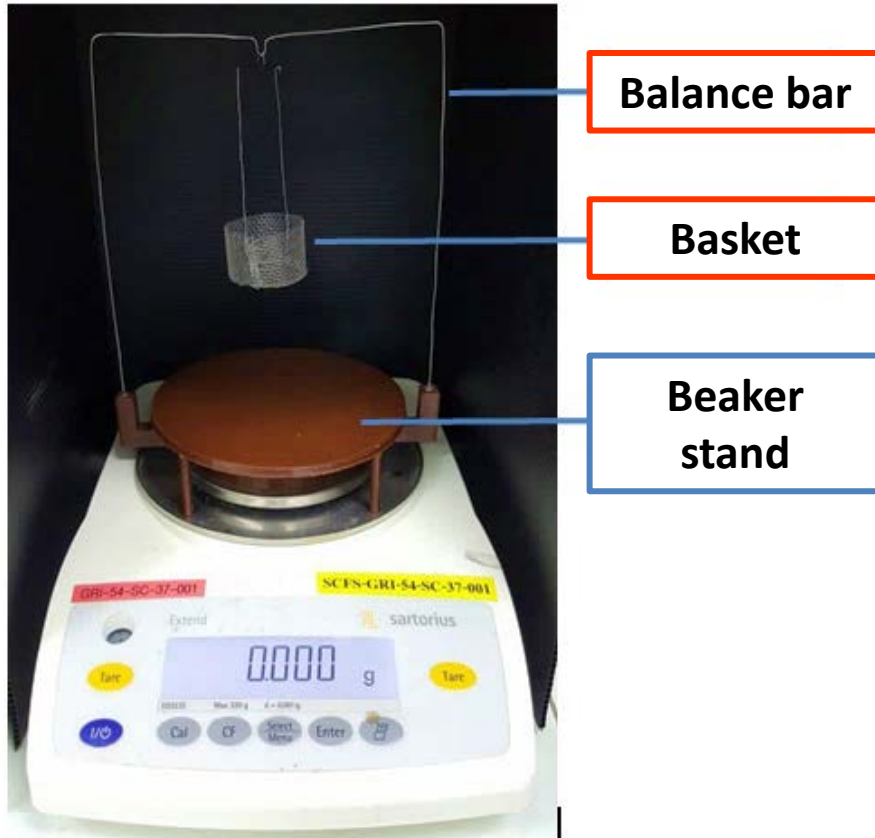
  Two main parts of the kit

  - *Balance bar*

  - *Beaker stand*

(Source: A&D Company)

- **Experimental Instruments: Density determination kit**

Balance bar

Basket

Beaker stand

Level of water (higher than level of glass specimens in 1cm)

Part of glass specimen (below 1cm of water)

Two main parts of the kit
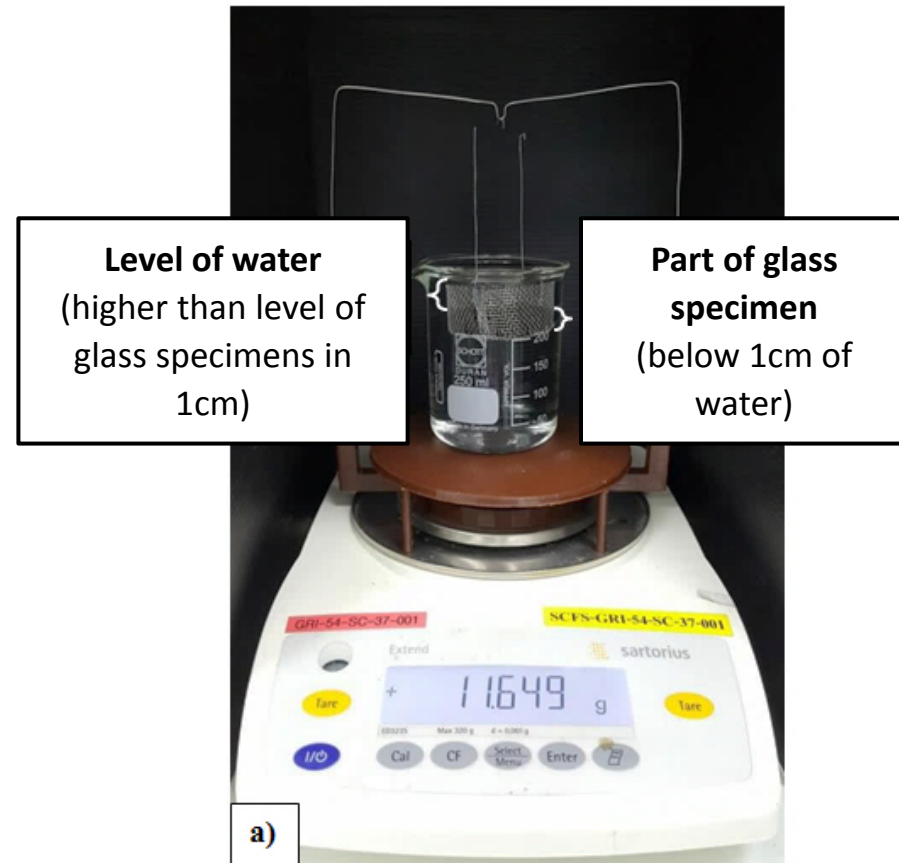
The kit set on weighing

Experimental Setup

Thermometer (0-100°C)

Black PP board box (a wind shielding)

Barometer (hPa)

Tweezers use for handling

Density determination kit set on weighing

b)
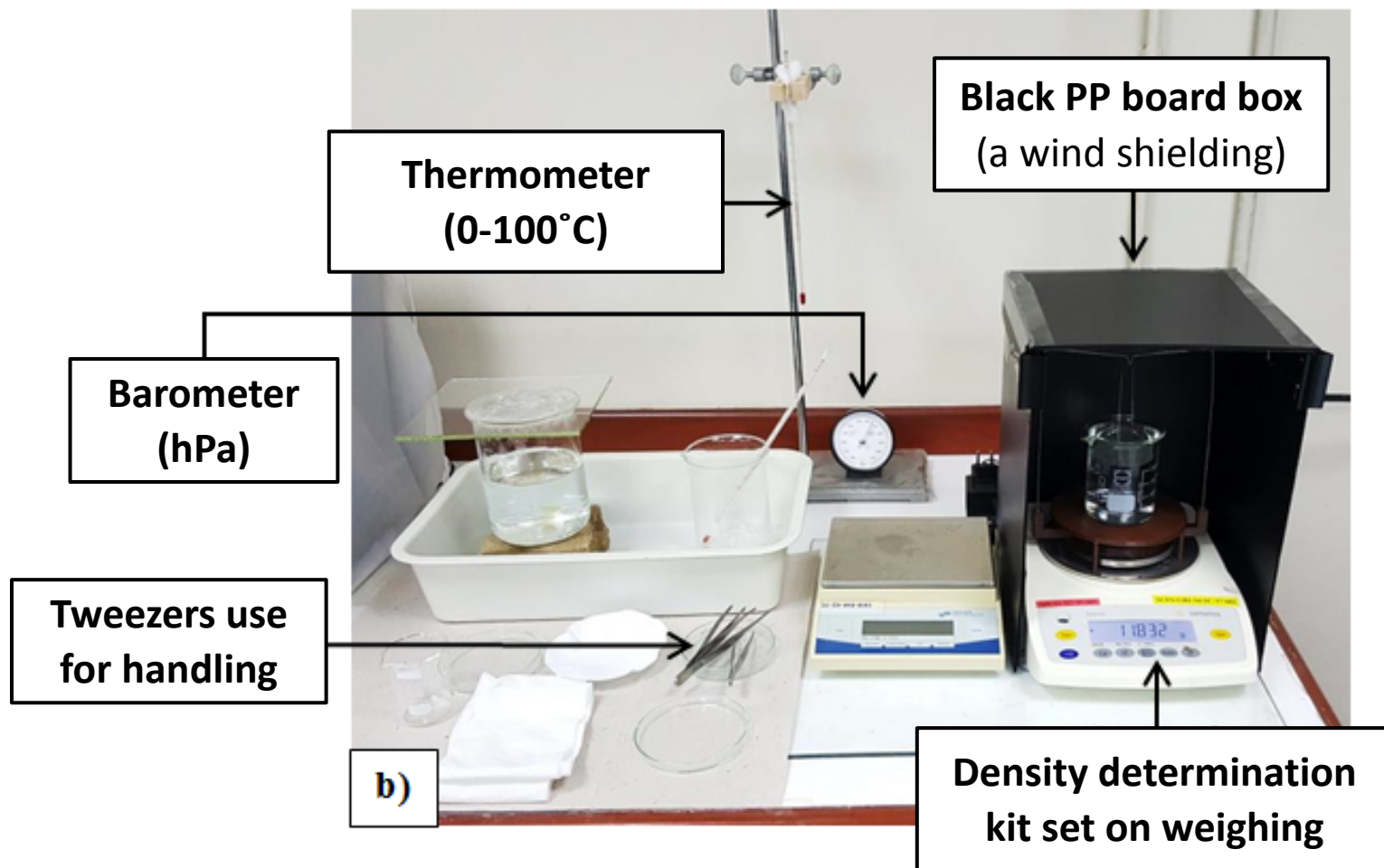
➢ Activity

Sample	Temp of air (T_A , °C)	Pressure of air (P_A)	Weight in air (W_A , g)	Temp of water (T_W , °C)	Weight in water (W_W , g)	ρ_A	ρ_W	ρ_S

- *Density of glass specimen*

$$\rho_S = \frac{W_A}{W_A - W_W} \times (\rho_W - \rho_A) + \rho_A$$

- *Density of air*

$$\rho_A = \frac{0.0012932}{1 + (0.0036728 \times T_A)} \times \frac{P_A}{1013.25}$$

➢ **Answers**

Group	Glass sample	Density (g/cm^3)
1	LAB3	2.133 ± 0.032
	CAR2	2.497 ± 0.002
2	LAB4	2.151 ± 0.029
	CAR7	2.494 ± 0.003
3	BOT2	2.398 ± 0.016
	BOT5	2.396 ± 0.013
4	CAR8	2.508 ± 0.003
	ARC3	2.509 ± 0.017
5	CAR9	2.499 ± 0.001
	ARC5	2.567 ± 0.009

Density values of each glass sample (60 samples)

Density (g/cm³) — *Glass samples*

○ Laboratory glass   ○ Bottle glass   ○ Car glass   ○ Architectural glass   ○ Kitchenware glass