💥 1 Compressive Strength

🔹 Basic Concept

🦷 Amalgam is **strong in compression**
❌ Weak in **tension & shear** → (Brittle material)

📊 One-Hour Compressive Strength (According to ANSI/ADA)

Alloy Type	1-hour Compressive Strength
Lathe-cut Low Copper	45 MPa مش مهم الأرقام
Spherical Low Copper	88 MPa
Admixed High Copper	118 – 140 MPa
High Copper Unicompositional	250 MPa
ANSI/ADA Requirement	**AT LEAST 80 MPa**

Compressive strength

- **1 hour** If strength < **80 MPa** →
  ⚠️ Risk of:
- Cracks
- Fracture
- Failure due to premature biting
- **7 days** 💎 Highest compressive strength = **Unicompositional high copper alloys**

Tensile Strength

🔹 Key Facts

- Tensile strength = **only a fraction** of compressive strength
- Unicompositional high copper alloy → **Highest tensile strength**
- Indicates strength of amalgam phases

💪 Strong Phase Order: $\gamma > \gamma_1 > \gamma_2$

- γ (Unreacted Ag_3Sn) = Strongest
- γ_1 (Ag_2Hg_3) = Intermediate
- γ_2 (Sn_8Hg) = Weakest & most corrodible

⚠️ Effect of Mercury Amount on Amalgam Phases

If Excess Mercury (Hg) is Used:

🔹 Excess Hg → ↑ Formation of γ_1 and γ_2 phases
🔹 This occurs **at the expense of the unreacted γ phase**

What Happens Inside the Mix?

- More γ_1 (Ag_2Hg_3) forms
- More γ_2 (Sn_8Hg) forms
- ↓ Amount of unreacted γ (Ag_3Sn) phase

💪 Relation to Strength of Amalgam

With Excess Hg:

➡️ $\gamma_1 + \gamma_2$ ↑
➡️ Unreacted γ ↓
❌ Result: **Weaker amalgam mass**

🏆 With Proper (Optimal) Hg Amount:

➡️ Less γ_1 and γ_2 formation
➡️ More unreacted γ phase remains
💎 Result: **Stronger amalgam mass**

Elastic Modulus (Stiffness)

🔹 **Definition :** 🧠 Indicates stiffness of amalgam.

📌 Facts

- High copper alloys → Higher modulus of elasticity (≈ 11–20)
- Therefore:
  💪 High copper amalgam = **More rigid & stiffer** than low copper

Component	Elastic Modulus (GPa)
Dentin	14–18.6
Enamel	80

Creep (Viscoelastic Behavior)

🔹 Definition

Permanent deformation under static load **below elastic limit.**

Creep Comparison

📏 ANSI/ADA Maximum Allowable Creep = **3%**

Alloy Type	Creep Value
Lathe-cut Low Copper	Highest creep ❌
Unicompositional High Copper	Least creep ☑

🎯 Factors Affecting Creep

- ↓ Number of η crystals
- ↑ Mercury content
- Grain size of γ_1 phase
- Volume of γ phase

Dimensional Changes

🔄 Pattern

- Initial **contraction** بسبب Hg dissolution➔ **then expansion** بسببCrystal formation in different amalgam phases

⏳ Timeline

- Stops after: **6–8 hours**
- Final value reached: **24 hours**
- Final change usually: **Negative (slight contraction)**

🏆 Best Alloy

💎 High Copper (Unicompositional) → Least dimensional change

📏 ADA Permissible Dimensional Change: **± 20 µm/cm**

🚨 Excessive Delayed Expansion (VERY IMPORTANT EXAM POINT)

🔬 **Occurs When:** ➡️ Zinc-containing alloy + Moisture contamination

🧪 **Chemical Reaction:** $H_2O + Zn \rightarrow ZnO + H_2$ (gas)

💣 **Consequences:**

- Blistering of amalgam surface
- Excessive delayed expansion
- Pain (pressure ≈ 400 µm/cm)
- Corrosion later

⏰ Reaction occurs: **24–72 hours after insertion**

👶 Clinical Tip

If moisture contamination is expected (e.g., Children): 👉 Use **Zinc-free alloy**

⚠️ Even in zinc-free:

Moisture contamination:

- Prevents cohesion of amalgam layers
- Leads to formation of a **weak lamellated mass**

Corrosion of Amalgam

- **Definition :** Destruction of metal by **chemical/electrochemical reaction**

😷 Effects of Corrosion

1. Increased porosity
2. Reduced marginal integrity
3. Loss of strength
4. Metallic products lead to a metallic taste in the mouth

🧪 Corrosion of Phases

- Least corrodible phase → γ_1
- Most corrodible phase → γ_2 (Sn_8Hg)

🦷 Feature	🔻 Corrosion in Low Copper	🔺 High Copper Amalgam
Main Site of Corrosion	Occurs throughout γ_2 phase (network structure)	No γ_2 phase present
Phases Affected	γ_2 (Sn_8Hg) network phase	High copper phases: η & eutectic Ag-Cu
Reaction Products	Tin oxychloride + Mercury compounds	$CuCl_2 \cdot 3Cu(OH)_2$
Structural Nature	γ_2 is a network structure → more corrosion	η phase is NOT network like γ_2
Effect on Strength	Causes porosity & ↓ strength of set amalgam	Higher resistance to corrosion → better strength
Overall Corrosion Resistance	Low ❌	High ☑

🛠️ Manipulation of Dental Amalgam (Step by Step)

🧩 1 Selection of Alloy

🔍 Factors Affecting Selection

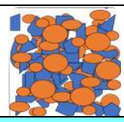
- **Particle size :**

Coarse cut	Fine cut	Microcut
(750 µm) Difficult to dispense and difficult to carve, it leaves rough surface.	(15–35 µm) easy to dispense, better on carving, leaves smooth surface.	(less than 3 µm) very large surface area per volume needs too much Hg to wet all particles → ↑ Hg ratio leads to ↑ setting time, ↓ strength, ↑ creep, ↑ setting expansion, ↑ tarnish and corrosion.

Particle Shape

🔷 Lathe Cut Particles	◯ Spherical Particles
Irregular shape with large surface area per volume → needs more Hg for mixing	Lower surface area → needs less Hg for mixing
Offers high resistance to condensation forces	Less resistance to condensation forces
High friction between particles → better marginal integrity	Less friction between particles → less marginal integrity
Rough surface after carving → requires more finishing 	Smooth surface after carving and finishing 

Spheroidal shaped : cucumber gives good marginal Integrity



Particle Composition

According to Copper Content:

- Low Copper Alloy
- High Copper Alloy (BEST)

💎 Advantages of High Copper:

- Eliminates γ_2 phase
- High early strength
- Low creep
- Better corrosion resistance
- Less marginal fracture

According to Zinc Content

Type	Zinc %
Zinc-containing	> 0.01% Zn
Zinc-free	< 0.01% Zn

⚠️ Zinc alloy must NOT be contaminated with moisture→ To avoid delayed expansion

⚖️ 2 Proportioning of Mercury to Alloy

🎯 Must be Accurate Because:

✖ Excess Mercury

- ↑ γ_1 & γ_2 formation
- ↑ Setting time
- ↓ Strength
- ↑ Creep
- ↑ Tarnish & Corrosion

✖ Less Mercury

- Poor wetting of particles
- Friable mix
- More voids
- ↓ Strength
- ↑ Corrosion liability

📊 Ideal Mercury Ratio

- Lathe-cut particles → 54% Hg
- Spherical particles → 43% Hg

💊 preweighed tablets of 400 mg is used to facilitate proportioning (used with hand trituration)

💊 preweighed proportioned capsules that contain proper amount of alloy and mercury are used with mechanical Amalgamators .

🔄 3️⃣ Trituration (Mixing)

🧠 Definition

Process where mercury reacts with alloy powder to form a **homogenous, shiny, plastic mass**.

🧰 Types of Trituration

✋ Hand Trituration

- Glass mortar & pestle
- Manual rubbing until workable mass obtained

⚡ Mechanical Trituration

- **Amalgamizer** : which provides Automatic dispensing and mechanical mixing .
- **Amalgamator :** which mixes proportioned capsules , in which the capsule is attached to capsule holder , which is attached to a motor that allows eccentric movements giving the force essential for mixing, 7 10 s.

🎯 Objectives of Trituration

1️⃣ Remove oxide film from alloy particles
2️⃣ Coat particles with mercury
3️⃣ Supply energy for amalgamation reaction

🧪 Outcomes of Amalgamation Reaction

- ↓ Unreacted γ phase size
- Formation of γ_1 phase (non-corrodible)
- Formation of γ_2 phase (in conventional alloy)
- Progressive Hg consumption → ↓ plasticity

Mulling Operations

- It aims to produce more homogenous mix with good texture.
- **Hand trituration**: by gentle rubbing of the mix between fingers.
- **Mechanical trituration**: by further amalgamation 2–3 seconds at low speed.

Over vs Under Trituration

Over-trituration

- ↓ Working time
- ↑ Creep
- Slight ↑ contraction

Under-trituration

- More voids
- ↓ Strength
- ↑ Corrosion liability

Condensation (VERY CLINICAL)

Definition : Packing amalgam into cavity **layer by layer** using condensers.

• During this step the material is highly adapted to the cavity walls

Time required ≈ **3 minutes**

• the amount of mercury in the final restoration is determined in this stage

amalgam carrier carrying amalgam into a prepared cavity layer by layer

Condensation of amalgam; a: small condenser, followed by exceedingly larger condenser (b) to overpack restoration

Principal of condensation:

Condense the amalgam mass and adapt it to the **preparation walls, floor, and matrix** (when used).

Purpose:

• Produces a restoration free of voids → ↑ density & ↓ marginal leakage

• Minimizes mercury content → ↓ corrosion & ↑ restoration strength

• Ensures cohesion with subsequent increments & prevents layering

• Facilitates blotting of excess mercury for better final restoration properties

Methods of Condensation

✋ Hand Condensation

- Adjusted **according to cavity size and particle size**
- **Lathe cut alloys:** small diameter (1–2 mm) + large vertical force
- **Spherical alloys:** large diameter + less lateral force

⚙️ Mechanical Condensation

- Based on **impacts or vibration**
- More effective for **lathe cut alloys** than spherical alloys
- ⚠️ Not recommended for spherical alloys → can spread droplets & ↑ mercury vapor

Effects of Delayed Condensation

- Amalgam partially sets → loses plasticity → poor adaptation to cavity walls
- Excess mercury cannot be removed →
- ↓ compressive strength
- ↑ corrosion susceptibility
- ↑ setting expansion
- ↑ creep

💧 Moisture Contamination

- **Zinc-containing alloys:** release H_2 → delayed expansion
- **Zinc-free alloys:** weakened by lamellation

5 Pre-Carve Burnishing

- **Tool:** Large ball burnisher
- **Purpose:**
- ↑ adaptation of condensed amalgam to cavity margins
- Facilitates carving

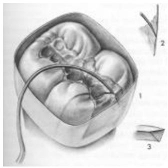
⚠️ **Objection:** may carry excess Hg into critical CSA

6 Carving

- **Definition:** Procedure to reproduce anatomical & functional relations of restored tooth

⏱️ Timing & Technique

- **After initial setting**
- **Direction:** Any direction except **from restoration to tooth** → prevents submargins
- **Carver:** Must be **sharp** → dull carver induces stress, cracks & Hg distribution issues



Steps

1. **Initial carving:** Use carving explorer to reproduce occlusal embrasures
2. **Final carving:** Sharp carver parallel to cusp inclined planes using **discoid, cleoid, diamond-shaped, or Hollenback carvers**

7 Post-Carve Burnishing

- **Aim:** Smooth restoration, enhance adaptation
- **Technique:** Light rubbing with anatomical burnisher from **center ➔ cavity margins**, follow anatomical landmarks
- **Appearance:** Satin, not shiny
- **Timing:** After carving, before finishing & polishing

8 Finishing & Polishing

Timing

- Low copper alloys → after 24 hours
- High copper alloys → 8–10 min (high early strength)

Objectives

- Avoid rough surfaces → prevent micropits → ↓ galvanic action → ↓ tarnish & corrosion
- Remove marginal flashes/overhangs, correct contacts & contours
- Produce **lustrous, homogeneous surface** → ↑ corrosion resistance, ↓ plaque retention, ↑ biocompatibility, ↓ gingival irritation, ↑ stress response
- Encourage better home care

Limited Lifespan of Amalgam Restoration

Survival Factors

- Inversely proportional to restoration size
- Failures mainly due to:
  - Creep
  - Corrosion
  - Marginal breakdown

Preferred Choice in Modern Dentistry:
➡ **High Copper Amalgam** (Low creep + High corrosion resistance)

☣️ Mercury Safety & Hygiene (Clinical Must-Know)

- Ensure good ventilation
- Use sealed capsules
- Clean spills immediately (NO vacuum cleaner)
- Wear gloves, mask, eye protection
- Proper waste disposal
- Avoid direct skin contact with amalgam mix

🧰 Instruments Required for Amalgam Restoration

- Diagnostic set (Mirror, Tweezer, Explorer)
- Amalgam carrier
- Condensers (small & large)
- Burnishers
- Carvers
- Mortar & pestle / Amalgamator
- Infection control kit (Gloves, Mask, Napkin)