Operative

PRECLINICAL GUIDE

Amalgam

Amalgam : An **alloy of mercury** with one or more other metals.

Dental Amalgam Alloy

- Contains **silver (Ag), tin (Sn), copper (Cu)** , **zinc (Zn), palladium (Pd), indium (In)**

Dental Amalgam

- Formed by mixing alloy particles with mercury in the dental office to form a **plastic mass**
- The mass is inserted into the prepared cavity while soft, then allowed to **harden intraorally**

Properties of Amalgam

✓ Advantages .

Mechanical Properties

- High **compressive strength**
- High **fracture resistance** under occlusal forces
- Adequate **form stability** (maintains anatomical form and proximal contacts)
- Insoluble, **high wear resistance**, and **low creep value** in recent types

Biological Effects

- **Self-sealing** over time due to corrosion products
- ↓↓ Microleakage, ↓↓ sensitivity, and ↓↓recurrent caries

Other Properties

- **Low cost**, low technique sensitivity, easy manipulation
- Widely used with **high durability**

✗ Dis- Advantages .

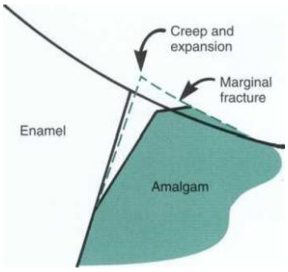
- **Mechanical** : Low **tensile strength** (~25% of compressive strength) → brittle

  Requires **sufficient thickness**; prone to fracture if thin (marginal ditching
- **Physical** : High **thermal conductivity** → requires protective base in deep cavities
- **Aesthetically** : Objectionable **metallic color**, tarnish **(discoloration) + corrosion (destructive breakdown of the metal**

🧪 ⚠️ Tarnish and Corrosion

🔄 Mechanical Flow & Creep

- **Flow**: deformation before setting
- **Creep**: time-dependent plastic deformation after setting under constant load



🚨 Consequences:

- Marginal ditching
- Flattening of contact
- Gingival overhangs
- Saucering of occlusal anatomy

🧱 Elastic Modulus

- High modulus → rigid restoration
- Causes stress concentration and poor stress distribution

⚡ Galvanic Corrosion

- Occurs between dissimilar metals in presence of moisture 💧
- Leads to current flow and corrosion 🔋
- Causes **post-operative sensitivity** 😬

🦷 📌 Uses of Amalgam .

- Posterior teeth due to metallic color 🦷
- Small Class I and II restorations with sufficient sound tooth structure 🧱
- Core build-up under full coverage restorations 👑

📝 **Note:** Composite resin increasingly replaces amalgam due to material improvements

🚫 Contraindications

1. Extensive lesions with undermined cusps (adhesive restorations preferred)
2. Esthetic zones 🎨
3. Presence of opposing metal restorations (to avoid galvanic activity) ⚡

🦷 Cavity Preparation for Amalgam

Based on the brittle and non-adhesive nature of amalgam, cavity preparation must:

1. Be **conservative** ✂️
2. Provide **adequate bulk** 🧱
3. Place amalgam in **self-cleansable areas** 🪥
4. Ensure **supported tooth structure** 🦷

📐 Cavity Outline Form

- **Depth:** 1.5–2 mm or 0.5–1 mm beyond DEJ 📏
- **Width:**
  - Buccolingual: 1/4–1/3 intercuspal distance
  - Mesiodistal: include triangular fossa (minimum marginal ridge thickness 1.5 mm)
- **Wall direction:**
  - Buccal & lingual walls slightly convergent
  - Mesial & distal walls slightly divergent
- **Outline:** Sweeping curves ➿
- **Finishing walls:** Smooth and rounded; flat, uniform floor ✨

Class II:

- Proximal flaring to open contact
- Isthmus wider than cavity to avoid necking of amalgam
- Proximal walls follow external tooth contour
- CSA= 9

⚙️ 🧪 Composition of Amalgam Alloy

Element	Strength	Setting Expansion	Setting Time	Creep	Tarnish & Corrosion Resistance
Ag	↑	↑	↓	↓	↑
Sn	↓	↓	↓	↑	↓
Cu	↑	↑	—	↓	↑
Hg	↓	↑	↑	↑	↓
Zn	• Acts as scavenger to prevent oxides formation during alloy manufacturing • Improve plasticity and workability of amalgam				
In, Pd	Enhance mechanical properties				

Classification of Amalgam Alloys

1 According to Zinc (Zn) Content

Zinc-containing alloys= Zn > 0.1% ○ **Zinc-free alloys =Zn < 0.1%**

- Zinc **acts as a scavenger** during alloy manufacturing
- Prevents **oxide contamination** during manufacturing
- ⚠️ **If moisture contamination occurs:**
  → **Excessive delayed expansion**→ Due to formation of hydrogen gas (H_2)

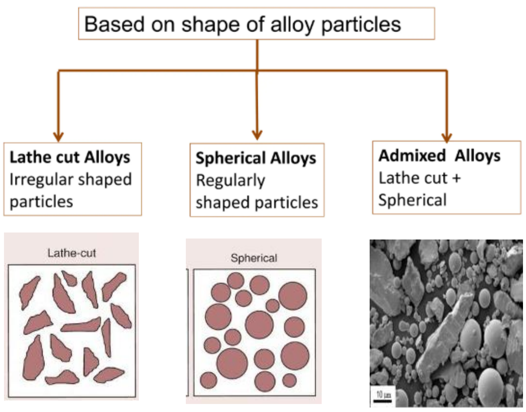
the ↑↑↑ Cu amalgam the most corrodible Y 2 phase is eliminated
But if excess Hg is present→ 2γ phase

2 According to Copper Content

Type	Copper %	Composition	Particle Type	γ_2 Phase
Conventional (Low Cu alloy)	**4% Cu**	Ag–Sn alloy	Lathe-cut	Present
		High Copper Alloys		
Admixed High Cu Alloy	9–20%	Mixture of: • Low Cu alloy particles • Ag–Cu eutectic alloy• Eutectic alloy: 72% Ag – 28% Cu	Lathe-cut + spherical	Eliminated
Unicompositional High Cu Alloy	13–30%	Single type of alloy	Spherical	Eliminated

3 According to Particle Shape

- Lathe-cut alloys
- Spherical alloys ○
- Add mixed alloys



4 According to Particle Size

- Coarse-cut
- Fine-cut
- Micro-cut

Properties of Mercury

- Only metal liquid at room temperature
- High surface tension
- Combines readily with Au, Ag, Sn, Cu, Zn
- **Highly toxic** ☠️

Mercury Toxicity

- Dental staff are at greater risk than patients
- Toxic manifestations: paresthesia, ataxia, joint pain, hearing loss, death

Main Sources of Exposure

- Accidental spills
- Poor mercury hygiene (exposure, ventilation, storage)
- Direct contact
- Amalgamator
- Removal of old restorations

Most serious hazard: Mercury vapor

Mercury Hygiene Procedures

- Use non-touch techniques ✖
- Mechanical amalgamators with good seals
- Store mercury under sodium thiosulfate solution
- Immediate spill cleanup and proper ventilation
- Use pre-capsulated amalgam

Reaction of Amalgam Alloy with Mercury

Low Copper Alloys + Mercury

Reaction

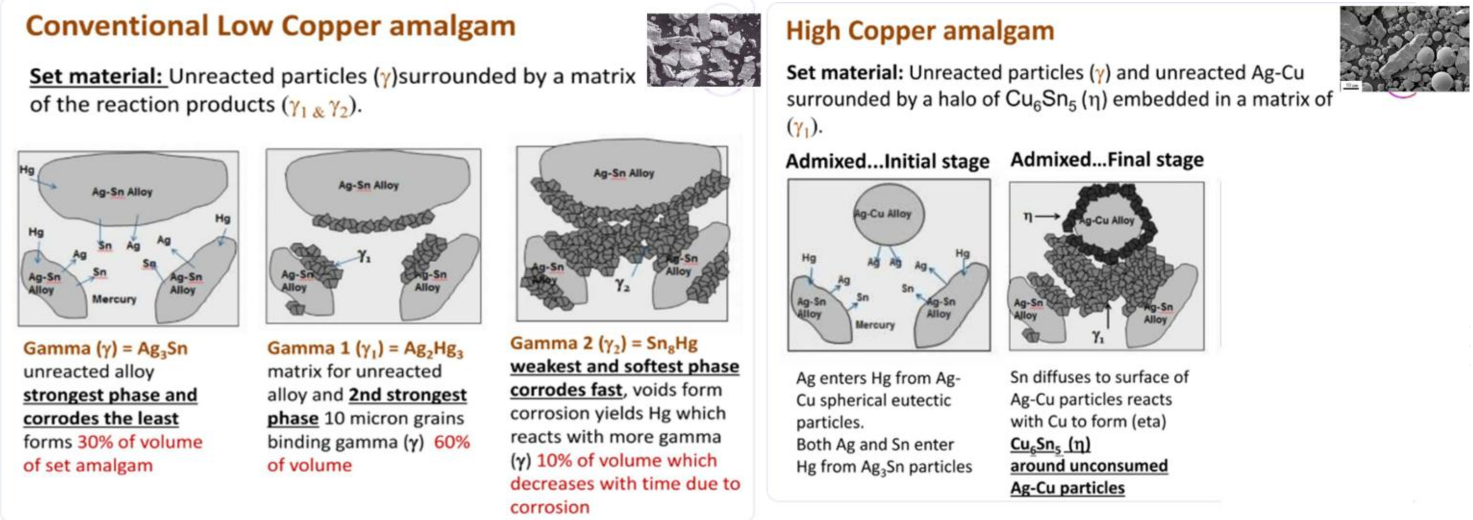
Hg + $\mathbf{Ag_3Sn\ (\gamma)} \longrightarrow \mathbf{Ag_2Hg_3\ (\gamma_1)}$ + $\mathbf{Sn_8Hg\ (\gamma_2)}$ + unreacted γ **27–30%**

- Mercury **should not be enough** to react with all γ phase

Reaction Stages

- In the beginning of formation of $\boldsymbol{\gamma_1}$ **&** $\boldsymbol{\gamma_2}$
- ➜ the mix is **plastic** → can be **condensed** into the cavity
- With time ➜ γ_1 & γ_2 crystals grow ➜ amalgam **hardens** ⚠ **NB**

- $\boldsymbol{\gamma_2}$ **phase** =
  ✖ *most corrodible*
  ✖ *highest creep phase*



🔴 High Copper Alloys + Mercury

1️⃣ Admixed High Cu Alloys + Hg

🧩 Alloys composed of TWO different particles:

🔹 **(A) Conventional Lathe-cut Low Cu Particles** Same reaction as low Cu alloy:

$Hg + Ag_3Sn \longrightarrow \gamma_1 + \gamma_2 + \text{unreacted } \gamma$

🔹 **(B) Ag–Cu Eutectic (Spherical Particles)** ⚗️ **Solid-state reaction begins:**

$Sn_8Hg\ (\gamma_2) + Ag\text{–}Cu \longrightarrow$ **Cu_6Sn_5 (η phase) + Ag_2Hg_3 (γ_1)**

🧠 Summary (Admixed)

- **γ_2 phase**:
  - Formed around **low Cu particles**
  - **Eliminated around eutectic particles**
- Net result:
  ➜ Much **less γ_2** than low Cu alloys

🧪 Solubility of Hg

Hg dissolves in metals in this order:

Sn > Ag > Cu

Metal	Hg solubility
Sn	170 mg
Ag	10 mg
Cu	1 mg

📌 That's why:

- Reaction of **low Cu alloy with Hg happens first**
- Then reaction with **Ag–Cu eutectic**

2 Unicompositional High Cu Alloys + Hg

🧬 Composition

- One type of particles containing:
  Ag + Cu + Sn

⚙️ Reaction Characteristics

- Elimination of **γ_2 phase in ONE step** ☑
- Due to difference in Hg solubility:
  Sn > **Ag** > **Cu**

🧪 Reaction Sequence

- Sn reacts first with Hg at particle periphery → temporary γ_2 formation
- Sn decreases → formation of **Ag–Cu eutectic**
- Final reaction:

$[Ag_3Sn + Cu_3Sn] + Hg \longrightarrow \mathbf{Cu_6Sn_5\ (\eta)} + \mathbf{Ag_2Hg_3\ (\gamma_1)}$ + unreacted particles

🧠 Summary (Unicompositional)

- Same particles:
  - Act first as **γ phase**
  - Then act as **eutectic**
- Final structure:
  - **$\eta + \gamma_1$**
  - **No γ_2** ❌

🔬 🦷 Microstructure of Amalgam

1 Low Copper Amalgam

- Unreacted **γ cores**
- Held together by:
  - **γ_1**
  - **γ_2** (matrix)
- **Voids present**
- Weakest structure ❌

2 High Copper Amalgam

Feature	Admixed High Cu Alloys	Unicompositional High Cu Alloys
Alloy particles	γ phase **& eutectic phases** as unconsumed alloy particles	**Unconsumed alloy particles**
Unreacted cores	Present	Present
Surrounding structure	Unreacted cores surrounded by **meshes & rods of η phase**	Unreacted particles surrounded by **meshes & rods of η phase**
Binding phase	Held together by **γ phase**	Held together by **γ_1 phase**
Eutectic phase	Eutectic particles surrounded by **η layers**	
Matrix	**γ_1 matrix**, may contain **η crystals**	

✨ Thank You