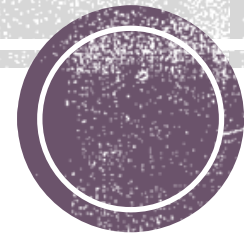


# AMALGAM



Presented by : Dr. Nupur Dhanak

# SILVER AMALGAM RESTORATION

<sup>D</sup> Dental amalgam (silver amalgam or simply amalgam) is a metallic, polycrystalline restorative material originally composed of a mixture of silver-tin- copper alloy and mercury.



# CONTENTS

- ❖ BRIEF HISTORY
- ❖ CLASSIFICATION OF ALLOYS
- ❖ PHASES OF AMALGAM
- ❖ PROPERTIES OF AMALGAM
- ❖ MANIPULATION
- ❖ TRITURATION
- ❖ CONDENSATION
- ❖ CARVING
- ❖ FINISHING AND POLISHING
- ❖ ALLERGY AND TOXICITY
- ❖ DISPOSAL and MANAGEMENT OF MERCURY



# Definition

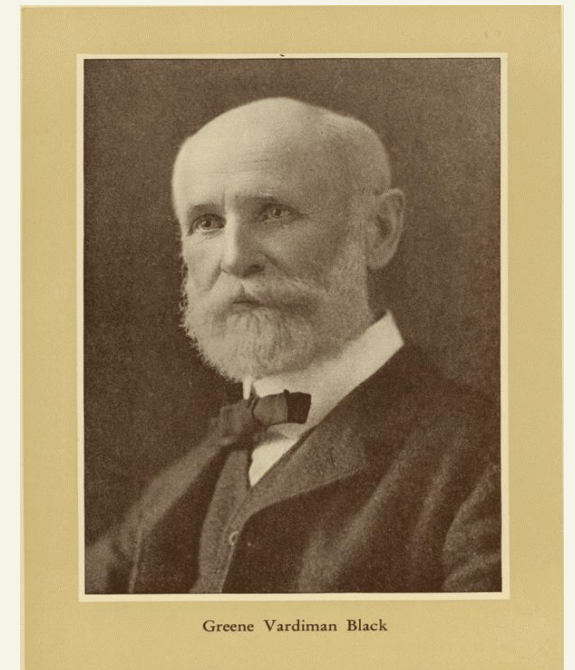
- Dental amalgam alloy: an alloy of silver, copper, tin and other elements that is formulated and processed in the form of powder particles or compressed pellet.
- Amalgam: An alloy containing mercury.
- Dental amalgam is an alloy of mercury, silver, copper and tin, which may also contain palladium, zinc, and other elements to improve handling characteristic and clinical performance.

# History

- **1819**- FIRST Dental silver amalgam was introduced in England by Joseph Bell, a British chemist, and was known as 'Bell's putty'.
- **1833**- amalgam was introduced in united states by crawcour brothers with a cheap coin silver amalgam which they called "royal mineral succedaneum"
- **1845**- American society of dental surgeon declared the use of amalgam as a malpractice



- **1856**-first amalgam war took place questioning the safety of Hg
- **1891**- G.V blacks composition of amalgam was published.
- To overcome expansion,
- 67% Silver, 27% tin, 5%copper, 1% Zinc.
- **1929**- ADA specification no 1 was adapted for amalgam



- 1930-amalgam was stated to be safe for the use as a restorative material
- 1960- Eames was the first to promote a low Hg to alloy ratio

*(JADA vol.129, nov 1998 1547)*

# Historical Development

1650	stocker	Copper amalgam
1818	Dr. Louis Regnart	Father of amalgam
1959	Dr. Wilmer Eames	1:1 ratio of mercury:alloy
1963	Innes and Youdelis	High copper alloy(admixed type)
1974	Asgar	Single composition high copper alloy
1980	Showell	amalgapin



# AMALGAM WARS

## FIRST AMALGAM WAR

In 1845, American society of Dental surgeons condemned the use of all filling material other gold as toxic, thereby igniting “first amalgam war”

### **What ended the amalgam war ??**

- Professional and consumer demand.
- In 1859, the leaders of the profession regrouped to form the American dental association.
- Between 1860 and 1890, many experiments were done to improve amalgam filling materials.
- It was the classical work of GV black in 1895 that a systemic study done on properties and appropriate manipulation of amalgam



# Second amalgam war 1926

- Controversy over amalgam use surfaced again in 1926 and into the 1930s when a German physician, DR. ALFRED STOCK, showed that mercury escaped from fillings in the form of a dangerous vapor that could cause significant medical damage
- Alfred stock ,claimed to have evidence showing that mercury could be absorbed from dental amalgams and that this led to serious health problems. Stock reported that nearly all dentist had excess mercury in their urine.
- During this second amalgam war, the American dental association vigorously defended silver amalgam and its widespread use was continued.



# Third amalgam war 1973

- Primarily began through writings and videotapes of **DR. HA HUGGINS**, a dentist from Colorado springs in the same year

Pressure from mounting clinical evidence forced the ADA to finally publicly concede that mercury vapor does escape from the amalgam filling into the patients mouth.

but problem flared in 1990's by the telecast of television program '60 minutes' in CBC television

But the ADA remained adamant that mercury in patients' mouths is safe, and in 1986 it changed its code of ethics, making it unethical for a dentist to recommend the removal of amalgam because of mercury



## **ADVANTAGES**

- 1. SELF SEALING ABILITY
- 2. Ease of use
- 3. High compressive strength
- 4. Excellent wear resistance
- 5. Favorable long-term clinical research results
- 6. Lower cost than for composite restorations

## **DISADVANTAGES**

- 1. Noninsulating
- 2. Nonesthetic
- 3. Less conservative tooth preparation than for composite restorations (more removal of tooth structure during tooth preparation)
- 4. More difficult tooth preparation than for composite restorations
- 5. Initial marginal leakage



# Classification of alloys

**A.**

On the basis of COPPER CONTENT

LOW COPPER (<6%)

HIGH COPPER (>6%)



HIGH COPPER

ADMIXED or dispersed phase alloy(9-20% wt)

SINGLE COMPOSITION (13-30% wt)

Spherical:lathe



**B.**

BASED ON ZINC CONTENT

Zn containing  $\geq 0.01\%$  wt

Zn free  $< 0.01\%$  wt

## BASED ON SIZE OF PARTICLES

**Micro cut (<25um)**

**Fine cut (<35um)**

**Coarse cut**



## According to number of alloyed metals:

**Binary alloys(silver-tin)**

**Ternary alloys(silver-tin-copper)**

**Quaternary alloys(silver-tin-copper-indium)**



## According to noble metals:

**When metals such as palladium or gold are alloyed to the powder, the resulting amalgam is classified as “*noble metal alloy*”**

# 1. LATHE-CUT ALLOY POWDER (BASED ON SHAPE)

**Main Constituent Metals (Ag, Sn, Cu & Zn)**

melted & subjected to



**Homogenizing Heat Treatment**

cooled slowly to form



**Ingot**

fed to

**Milling Machine / lathe**

to produce filings & further broken down by



**Ball milling**



ACID TREATMENT



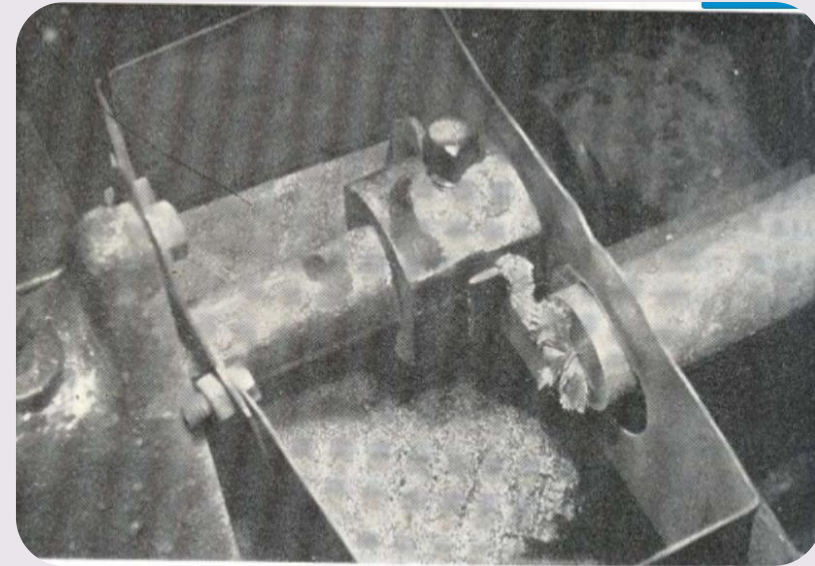
STRESS - RELIEF PROTOCOL (ANNEALING CYCLE)





## **INGOT**

The ingot may be 3–4 cm in diameter and 20–30 cm in length)



The particles are typically 50–100  $\mu\text{m}$  in length, 10–60  $\mu\text{m}$  in width and 10–30  $\mu\text{m}$  in thickness

## **LATHE CUT ALLOY PARTICLES**

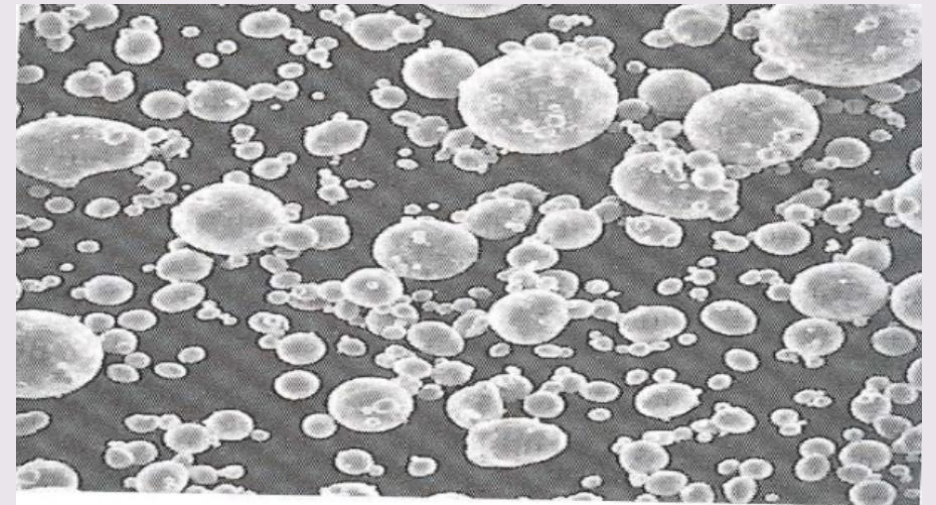


## **ATOMIZED POWDER (SPHERICAL ALLOY) :**

Molten alloy is forced under inert gas (ARGON) through fine crack in the crucible into the chamber.

Molten metal falls through a distance of approximately 30 feet and cools

If the droplets solidify before hitting a surface, the spherical shape is preserved.



- Average Particle size of modern powder ranges from **15-35 micro meters**.



# Lathe cut vs spherical

## Lathe cut

- Resist condensation better than amalgams made from spherical powders.

Amalgam with low mercury have better properties

## Spherical powder

- Freshly triturated amalgam with spherical particles are very plastic ,one cannot rely on the pressure of condensation to establish a proximal contour for class 2 restoration.
- Require less mercury than lathe cut.



# According to compositional changes of succeeding generations of amalgam:

- **First generation** amalgam was that of G. V Black i.e. 3 parts silver, 1 part tin (peritectic alloy).
- **Second generation amalgam alloys** Addition of Cu and Zn to the basic composition.
- 
- **Third generation:** First generation + Spherical amalgam – copper eutectic alloy.
- **Fourth generation:** Adding copper upto 29% to original silver and tin powder to form ternary alloy. So that tin is bounded to copper.
- **Fifth generation.** Quaternary alloy i.e. Silver, tin, copper and indium.
- **6<sup>th</sup> generation:** alloying of Pd, Ag, Cu to form a eutectic alloy and blending 1<sup>st</sup>, 2<sup>nd</sup> or 3<sup>rd</sup> generation alloys



# Functions of each constituent

## ▣ SILVER:

- major element in the reaction
- whitens the alloy
- Decrease the creep
- Increase the strength
- Increase the expansion on setting
- Increase the tarnish resistance in the resulting amalgam

## ▣ TIN:

- Controls the reaction between silver and mercury
- Reduces strength and hardness
- Reduces the resistance to tarnish and corrosion
- Reduces expansion



## ▣ COPPER:

- Increases hardness and strength
- Increases setting expansion
- ❖ **Ties up tin and reduces Gamma-2 formation**
- ❖ **Reduces creep and marginal deterioration**

## ▣ PLATINUM

- Hardens the alloy and increases resistance to corrosion

## ▣ PALLADIUM:

- Hardens and whitens the alloy

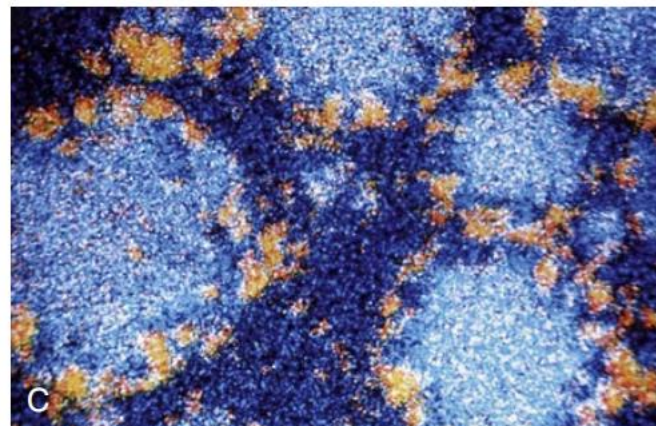
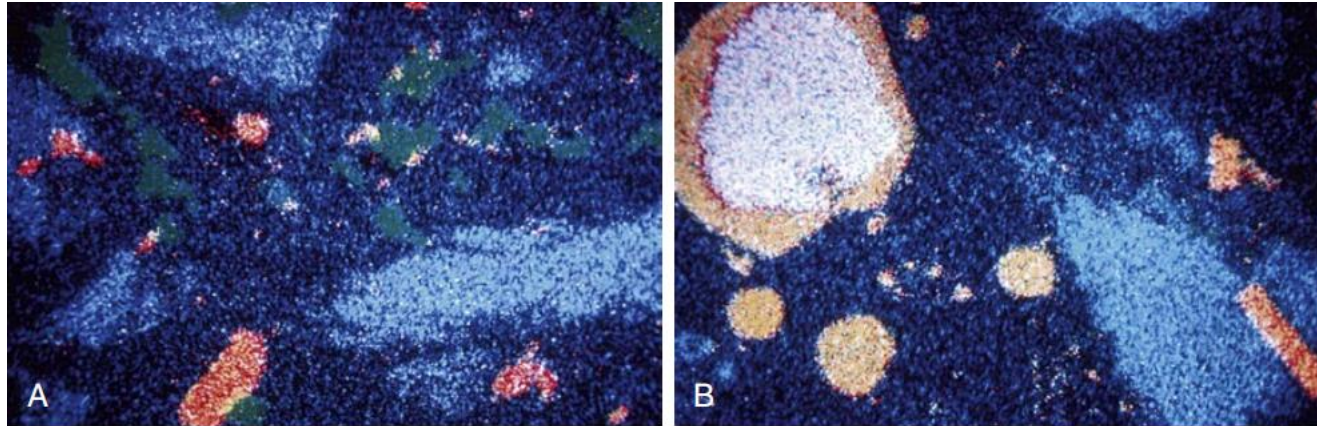
## ▣ INDIUM:

- When added reduces mercury vapor and improves wetting by reducing SURFACE TENSION



# Phases of amalgam

- *Physical properties*
  1.  $\gamma$  – phase is strongest,  $\gamma_2$  phase  $\rightarrow$  weakest
  2. Hardness:  $\gamma > \gamma_1 > \gamma_2$
  3.  $\gamma_2$  has poor corrosion resistance



Symbols and stoichiometry of phases	
Phase Symbols	Composition
$\gamma$	$\text{Ag}_3\text{Sn}$
$\gamma_1$	$\text{Ag}_2\text{Hg}_3$
$\gamma_2$	$\text{Sn}_{7-8}\text{Hg}$
$\epsilon$	$\text{Cu}_3\text{Sn}$
$\eta$ ( $\eta'$ )	$\text{Cu}_6\text{Sn}_5$



# LOW copper amalgam

- Low-Cu amalgam is a composite in which the unconsumed particles are embedded within  $\gamma_1$  and  $\gamma_2$  phases.
- The greater the number of unconsumed Ag-Sn particles, the stronger the amalgam will be.
- The  $\gamma_2$  phase is the weakest and least stable in a corrosive environment.
- The addition of more than 6% of copper by weight can reduce or eliminate the  $\gamma_2$  phase by formation of the Cu-Sn phase.

**Low copper composition:**  
Silver : 63-70%  
Tin : 26-28%  
Copper : 2- 5%  
Zinc : 0-2%



**b)** Silver (0.035wt%)  
has lower solubility  
in MERCURY than  
tin (0.6wt%)



Body Centered  
Cubic  $\text{Ag}_2\text{Hg}_3$   
compound (the  
g1 phase).



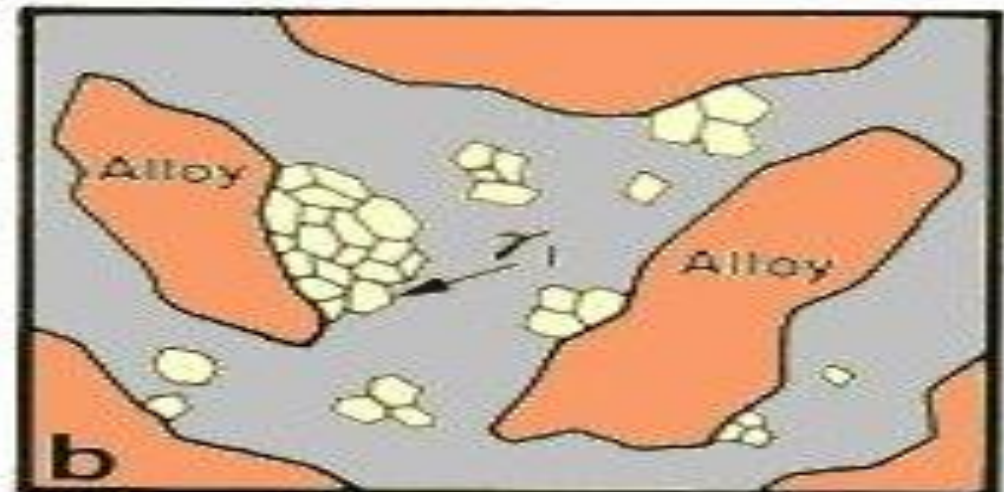
Hexagonal close  
packed  $\text{Sn}_{7-8}\text{Hg}$   
compound (the g2  
phase).



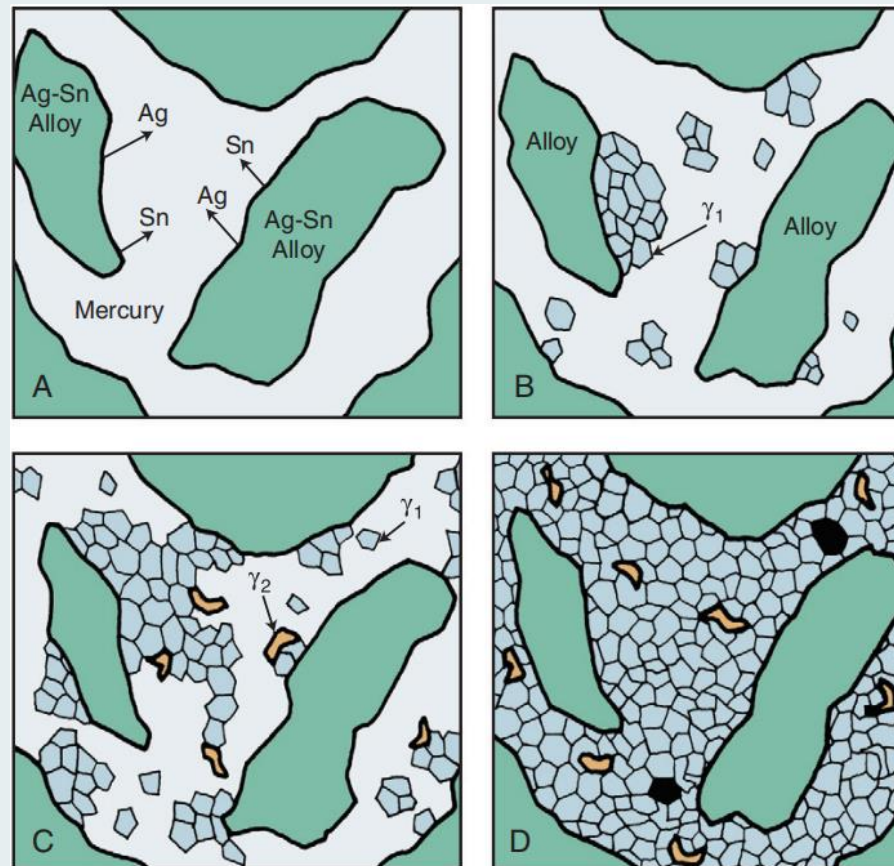
Precipitated first



precipitated later

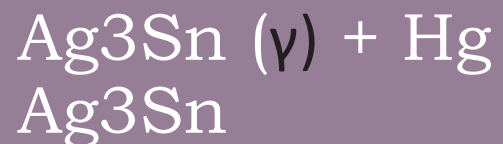


low-copper amalgam is a composite in which the unconsumed particles are embedded within  $\gamma_1$  and  $\gamma_2$  phases.



lathe-cut low-copper alloy particles are mixed with mercury.

### Setting reaction of low copper amalgam:



# HIGH COPPER AMALGAM

## ▪ ADMIXED ALLOY

❖ 1963- Innes and Youdelis added **Spherical silver-copper (Ag-Cu) eutectic alloy** particles to lathe-cut low-copper amalgam alloy particles (Ag-Sn).

❖ Both  $\gamma_1$  and  $\gamma_2$  are formed

❖ The tin in mercury diffuses to the surfaces of the Ag-Cu alloy particles and reacts with the copper to form a layer of  $\eta'$  phase crystals on the surface.

▪  $\gamma_2$  phase is formed but reacts with Cu and to form  $\eta'$ .

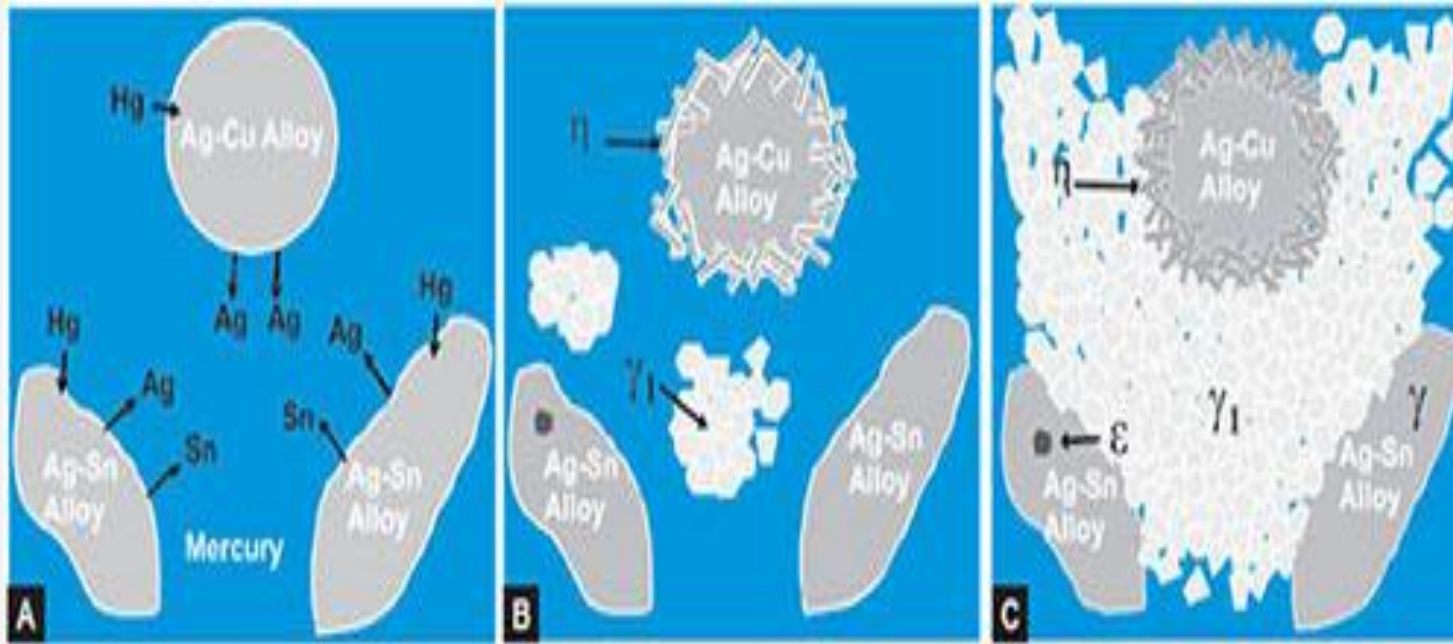
▪ 11.8% by wt COPPER is required to eliminate  $\gamma_2$  phase

## ▪ SINGLE COMPOSITION:

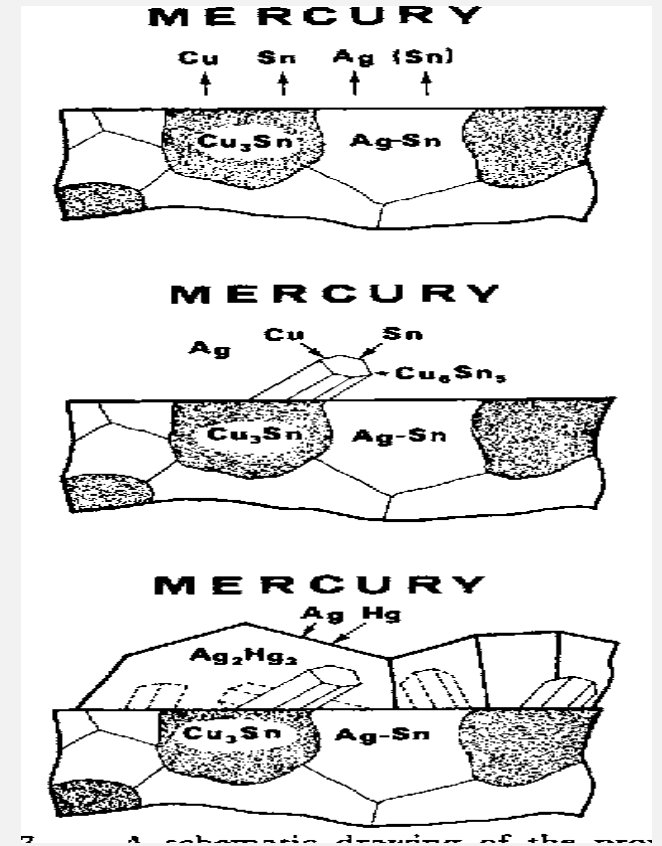
▪ The major components of single-composition particles are usually silver, copper, and tin.

▪ The copper content of various single-composition alloys ranges from 13% to 30% by weight.





High copper alloy mixed with mercury

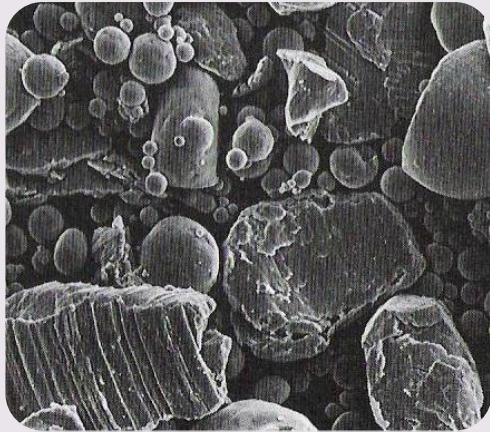


After one week, the  $\gamma_2$  phase reacts completely with eutectic and replaces all the  $\gamma_2$  phase by  $\gamma$  and  $\gamma_1$



# ADMIXED AMALGAM

- The irregular shape of many of the particles results in a mass that requires greater condensation pressure



## **Composition:**

Silver-69 %

Copper-13 %

Tin-17 %

Zinc-1 %

# SPHERICAL UNICOMPOSITIONAL AMALGAM

- Contains small, round alloy particles that are mixed with mercury
- Because of the shape of the particles, the material requires little condensation pressure.

## **Composition:**

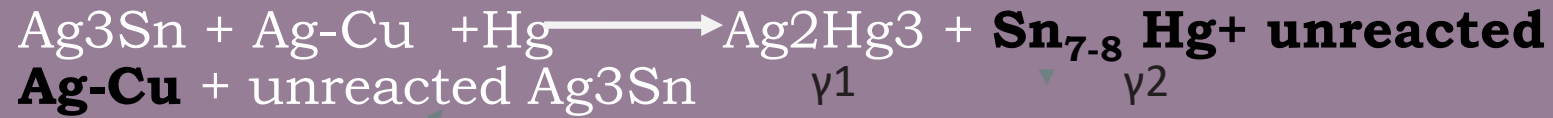
Silver 60%,

tin 25%,

copper 15%



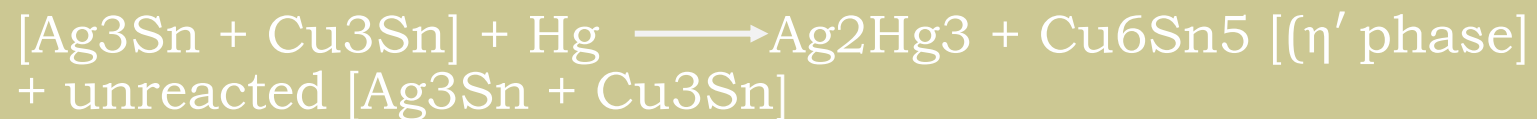
### High-copper admix alloy:



### Secondary solid-state reaction:



### High-copper spherical alloy:



# TYPES OF HIGH COPPER ALLOYS

- **SINGLE-COMPOSITION LATHE-CUT :E.G.,**

EPOQUE

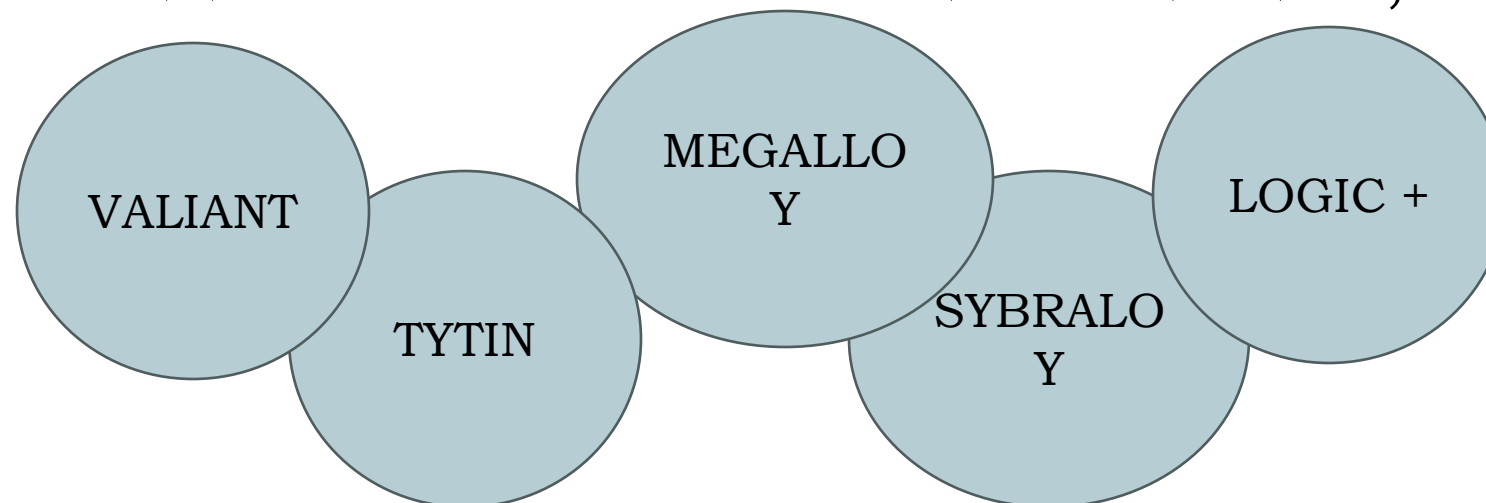
JENTALLOY III

ANA 2000

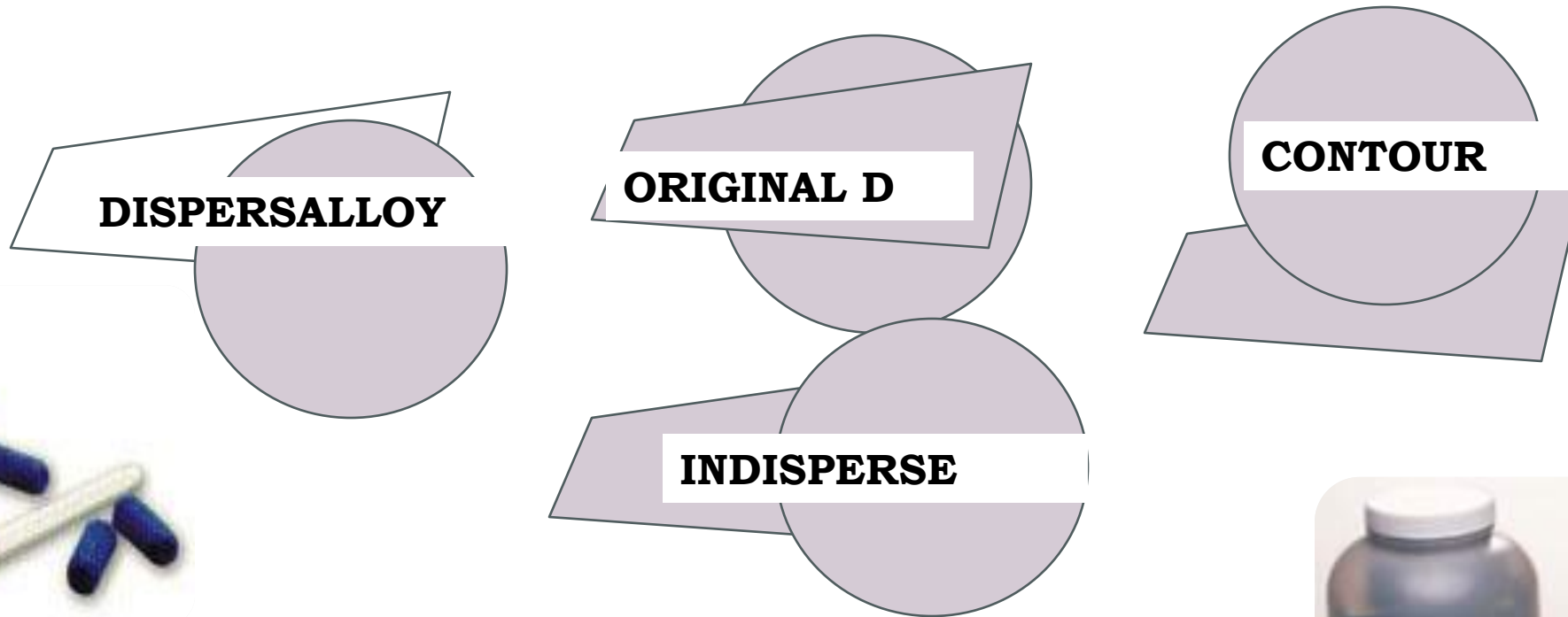
NORDISKA DENTAL



- **SINGLE-COMPOSITION-SPHERICAL : E.G.,**



# ADMIXTURE OF LATHE-CUT WITH SPHERICAL SILVER-COPPER EUTECTIC PARTICLES :E.G.,



## ADMIXTURE OF LATHE-CUT WITH SINGLE-COMPOSITION SPHERICAL E.G.,

✓ Valiant Ph.D



▪ Zinc (Zn)

❖ **decreases oxidation of other elements**

❖ **provides better clinical performance**

❖ **CLEANER CASTINGS**

❖ *causes delayed expansion with low Cu alloys*

❖ *if contaminated with moisture during manipulation.*



Palladium (Pd)



Corrosion

Marginal deterioration

Luster

Thermally stability

Eg - Valiant PhD (Ivoclar Vivadent)  
0.5% palladium



# INDICATIONS

- Amalgam may be used for **Class I, II, V, and VI** restorations; for foundations; and for caries-control restorations
- Occasionally for **Class III** ( DISTAL aspect of canine), and **CLASS V** with high caries risk and difficult to isolate.
- Greater wear resistance than composite
- Can be used for cuspal restorations (with pins usually)
- As a Core build up
- As a Die material.

# CONTRAINDICATIONS

- Allergy to alloy
- Esthetic regions like anteriors and maxillary premolars and molars
- Where composite will conserve more tooth with equal clinical performance

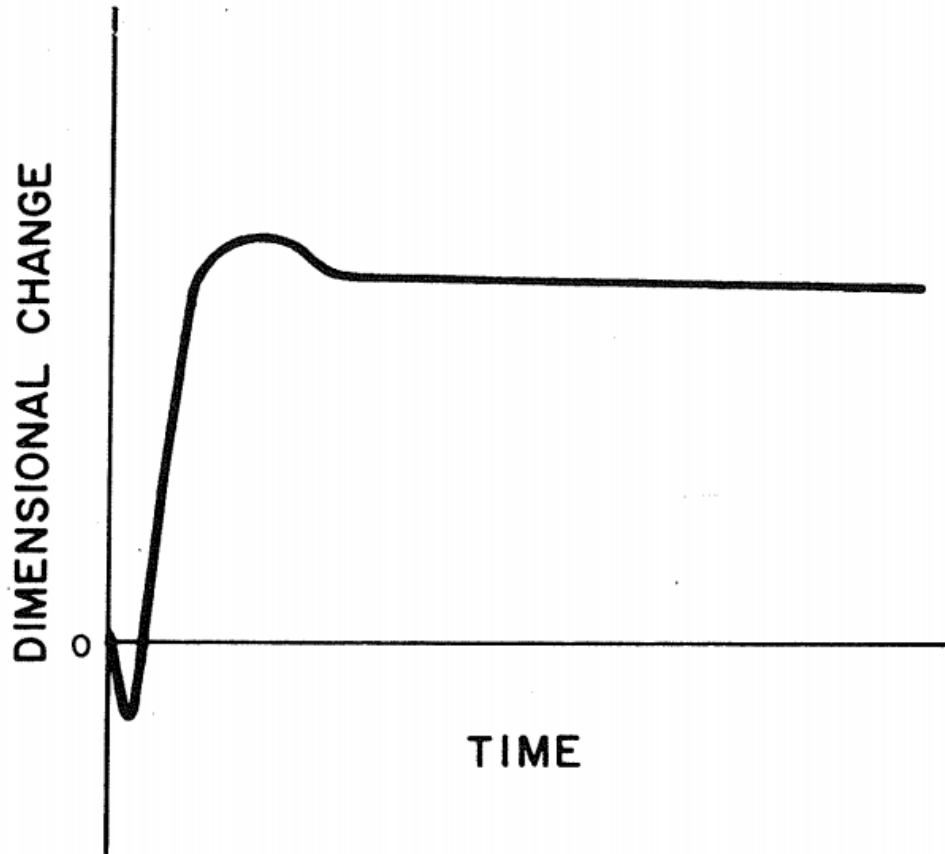


# PROPERTIES OF SILVER AMALGAM

ANSI/ADA specification No. 1 (ISO 24234) lists three physical properties as a measure of amalgam quality: compressive strength, creep, and dimensional change



# DIMENSIONAL CHANGE



## 1. INITIAL CONTRACTION

Absorption of mercury into interparticles of ALLOY POWDER.

## 2. EXPANSION:

Due to formation and growth of crystals.

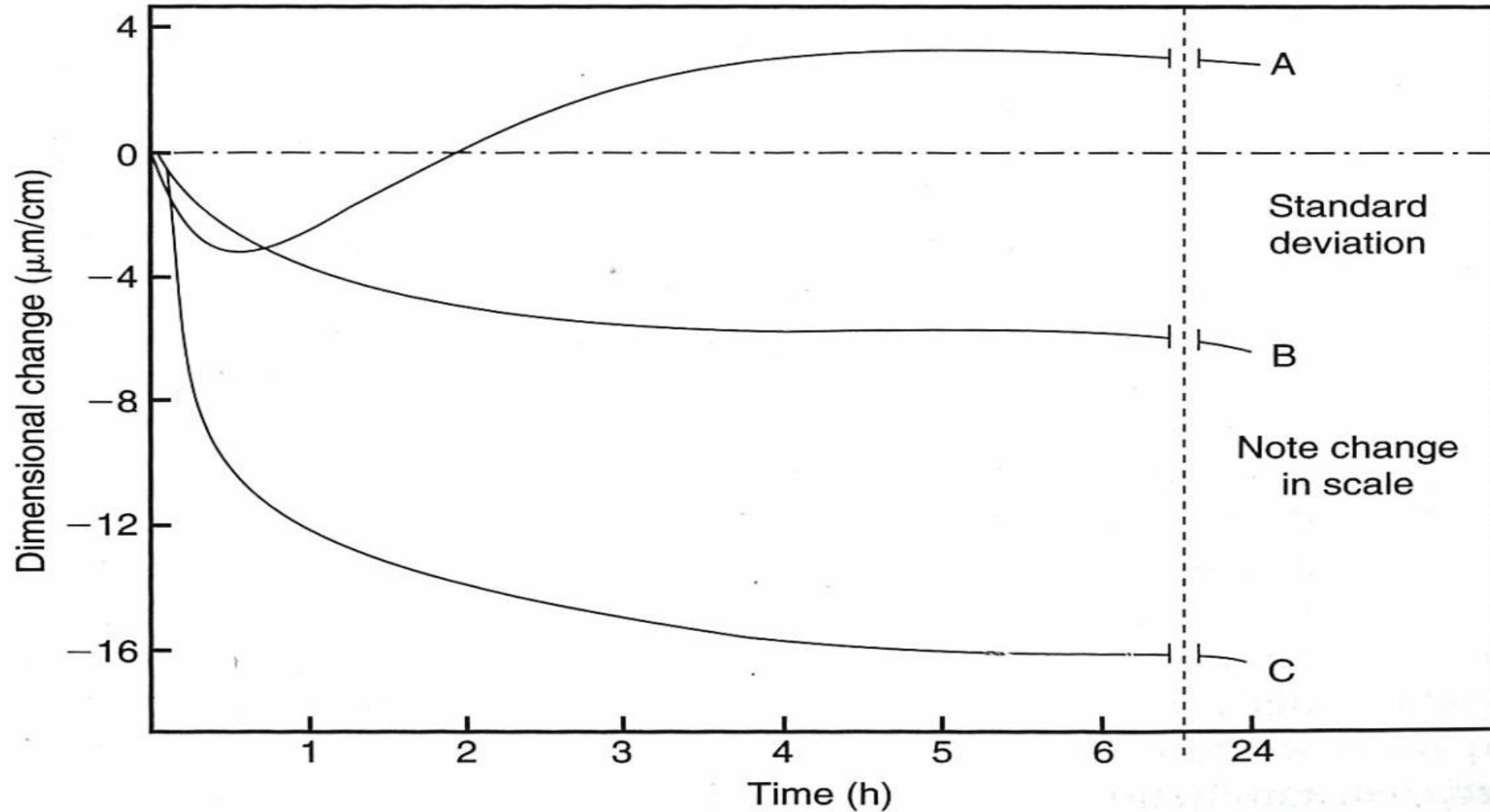
## 3. LIMITED CONTRACTION:

Due to reaction of unreacted mercury.

ADA specification no. 1 requires that amalgam neither contract or expand more than  $20\mu\text{m}/\text{cm}$ , measured at  $37^\circ\text{C}$ , between **5 min and 24 hr** after being triturated.



Modern amalgams mixed with mechanical amalgamators usually have negative dimensional changes



**Fig. 17-10** Dimensional change curves for three amalgam alloys. **A**, A high-copper admixed amalgam. **B**, A high-copper single-composition amalgam. **C**, A lathe-cut low-copper amalgam.



## **CONTRACTION**

- 1) Initial dissolution of alloy particles.**
- 2) Low mercury: Alloy ratio**
- 3) High condensation pressures.**
- 4) Smaller particle size alloys**
- 5) Longer trituration time and mechanical trituration.**

## **EXPANSION :**

- 1) Continued growth of  $\gamma_1$  crystals**
- 2) Excess Mercury**
- 3) Hand trituration**
- 4) Larger particle size alloys (used in past)**

## **Severe contraction –**

Microleakage,

PAIN AND SENSITIVITY

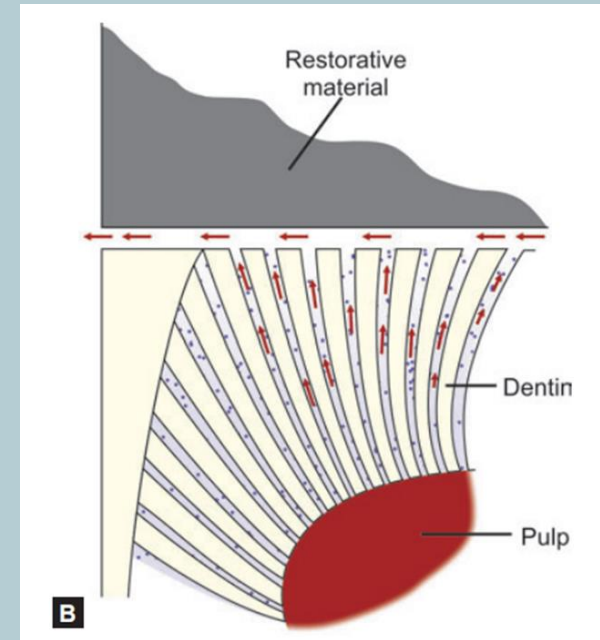
SECONDARY CARIES

- ❑ Evidently the detrimental effect of shrinkage occurs only when the amalgam mass shrinks  $> 50 \mu\text{m}$ .

**Expansion** – Pressure on pulp,

Post operative sensitivity,

FRACTURE



## Mercuroscopic expansion :

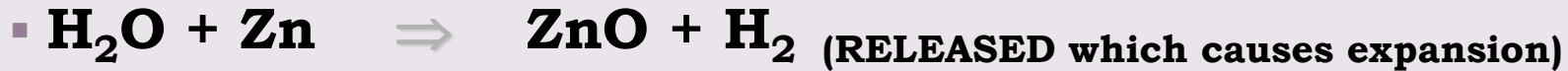
**Extrusion at the margins are promoted by electrochemical corrosion , during which Hg from Sn-Hg re-reacts with Ag-Sn particles and produces further expansion during new reaction. This mechanism is called *Mercuroscopic Expansion*.**



- Proposed by Jorgensen.
- The most common evidence of degradation of low copper amalgams is marginal fracture.

# DELAYED EXPANSION

- Due to moisture contamination of ZINC containing amalgam.
- It occurs during: TRITURATION OR CONDENSATION STEPS.



Causes expansion upto 4% by volume (400  $\mu\text{m}/\text{cm}$ )

- Starts 3-5 days after condensation

## EFFECTS

- **Protrusion of restoration.**
- **Corrosion and pitted surface.**
- **Pain on chewing.**
- **Fractured restoration.**



## 1. COMPRESSIVE STRENGTH:

Amalgam is strongest in compression and weaker in tension and shear.

The compressive strength of a satisfactory amalgam restoration should be at least **310 Mpa after 24h.**

## 2. TENSILE STRENGTH:

- ❑ Amalgam is much weaker in tension.
- ❑ High early tensile strengths are important – resist fracture by prematurely applied biting forces

**TABLE 15-2** Compressive Strength, Creep, and Tensile Strength of Low-Copper and High-Copper Amalgams

	COMPRESSIVE STRENGTH (MPa)		Creep (%)	Tensile Strength at 24 Hours (MPa)
	1 Hour	7 Days		
Low copper*	145	343	2.0	60
Admix (high copper) <sup>†</sup>	137	431	0.4	48
Single composition (high copper) <sup>‡</sup>	262	510	0.13	64

\*Fine Cut; <sup>†</sup>Dispersalloy; <sup>‡</sup>Tytin



**ADA SPEC. → MIN COMPRESSIVE STRENGTH  
80 MPA AT 1 HOUR**

80 MPA AT 1 HOUR

- **Patients should be cautioned not to subject the restoration to high biting stresses for at least 8 hours after placement.**



	<u>Compressive Strength (psi)</u>			<u>Tensile Strength (psi)</u>		
	15-min	1-hr	24HR	24-hr	15-min	1-hr
<b>LOW COPPER:</b>						
Velvalloy	<b>5,400</b>	<b>17,400</b>	<b>56,200</b>	<b>625</b>	<b>1,900</b>	<b>9,000</b>
Spheralloy	5,800	18,500	56,900	450	1,550	8,800
<b>HIGH COPPER:</b>						
Optalloy II	<b>9,100</b>	<b>23,800</b>	<b>55,900</b>	<b>1,000</b>	<b>2,350</b>	<b>7,250</b>
Dispersalloy	6,200	22,400	59,900	575	1,750	6,990
Indiloy	4,600	26,300	64,500	450	2,400	6,500
Sybraloy	23,800	50,000	72,700	2,190	4,700	6,600
Tytin	10,200	40,800	<b>79,100</b>	990	4,000	<b>9,300</b>

## ■ **The factors affecting strength of amalgam are:**

### ■ 1) Temperature:

- □ Amalgam loses 15% of its strength -when its temperature is elevated from room temperature to mouth temperature
- loses 50% of room temperature strength when temperature is elevated to 60 degree C e.g. hot coffee or soup.

### ■ 2) Trituration:

- Either, under trituration or over-trituration decreases the strength for both traditional and high copper amalgams.



### •3) Mercury Content:

**Inadequate Hg** leads to a dry, granular mix → rough, pitted surface → corrosion

**Excess Hg** left → reduction in strength

If mercury content more than 53 to 55% – **drop in strength to about 50%**

### 4) Effect of condensation:

For lathe-cut alloys

Greater the condensation pressure, the higher the compressive strength

For spherical alloys

Amalgams condensed with lighter pressure produce adequate strength.

### **Effect of Porosity**

Voids and porosity are factors that may reduce the compressive strength of set amalgams.

Insufficient pressure on lathe-cut alloys result in more porosity.



## **TRANSVERSE STRENGTH ( MODULUS OF RUPTURE )**

**Amalgam is brittle material - withstand little deformation**

**High copper amalgam with low Creep should be supported by bases with high moduli to minimize deformation and transverse failure.**

# FLOW AND CREEP

- Creep is the time-dependent inelastic deformation of materials that are used at temperatures that are close to their melting points under static load.
- **Single Composition High Copper Amalgam has low creep rates due to:**
  - ✓ 1. **Absence of  $\gamma_2$  phase.**
  - ✓ **Presence of  $\text{Cu}_6\text{Sn}_5$  rods, which acts as barrier to deformation of the  $\gamma_1$  phase**
- The term *flow*, rather than *creep*, has generally been used in dentistry to describe the rheology of amorphous materials

## □ Effect of manipulative variables on Creep:-

- *Mercury :alloy ratio* should be **minimum**.
- *Condensation pressure* should be **maximum**.
- *Undertrituration or overtrituration* or delayed condensation tends to **increase creep**.



Amalgam Type	% Creep
Low Copper	2.0
Admixture	0.4
Single Composition	0.13

According to ADA specification no.1, creep rate of amalgam alloy should be below 3%.

Low Cu:- HIGH CREEP - principle failure mode- MARGINAL FRACTURE  
HIGH Cu Low creep but BRITTLE Principle failure mode- - BULK FRACTURE

# Tarnish and Corrosion:

- **TARNISH:** Surface discoloration on a metal or even a slight loss or alteration of the surface finish or luster.
- **CORROSION:**
- Not a surface discoloration but actual deterioration of a metal by the reacting with oral environment.



- **Rate of corrosion attack may increase especially with :**

- i. Surfaces subjected to stress.
- ii. Impurities in the metal.

➤ **Types:**

1. Chemical corrosion
2. Electrochemical corrosion
  - a. Galvanic corrosion
  - b. Crevice corrosion
  - c. Stress corrosion



## CHEMICAL CORROSION :

- Occurs most notably on the occlusal surface and produces a black amalgam silver tarnish film.
- Corrosion products are mainly oxides and chlorides of tin.

## ELECTROCHEMICAL CORROSION

Chemically different sites act as anode or cathode.

Electrolyte (saliva)

The anode corrodes, producing soluble and insoluble reaction products.

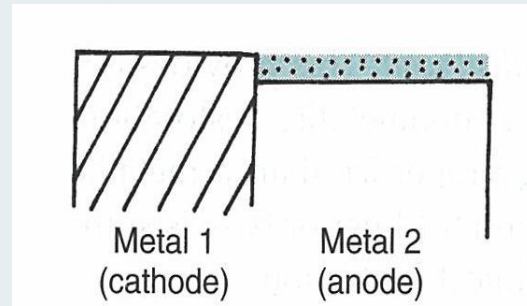
$\text{Ag}_2\text{Hg}_3$  phase has the highest corrosion resistance, followed by  $\text{Ag}_3\text{Sn}$ ,  $\text{Ag-Cu}$ ,  $\text{Cu}_3\text{Sn}$ ,  $\text{Cu}_6\text{Sn}_5$  and  $\text{Sn}_{7-8}\text{Hg}$ .

# GALVANIC CORROSION

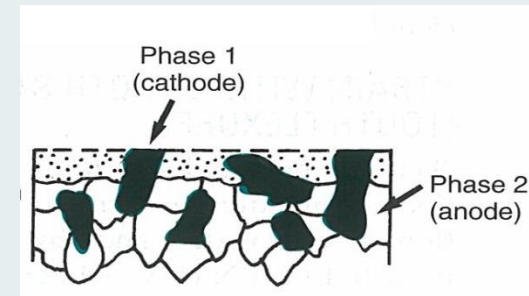
If dental amalgam is in direct contact with an adjacent metallic restoration such as gold crown, the dental amalgam is the anode in the circuit.

SILVER WILL GET CORRODED AWAY

GOLD will get DISCOLOURED due to deposition of corrosion products



Galvanic corrosion



Local galvanic corrosion

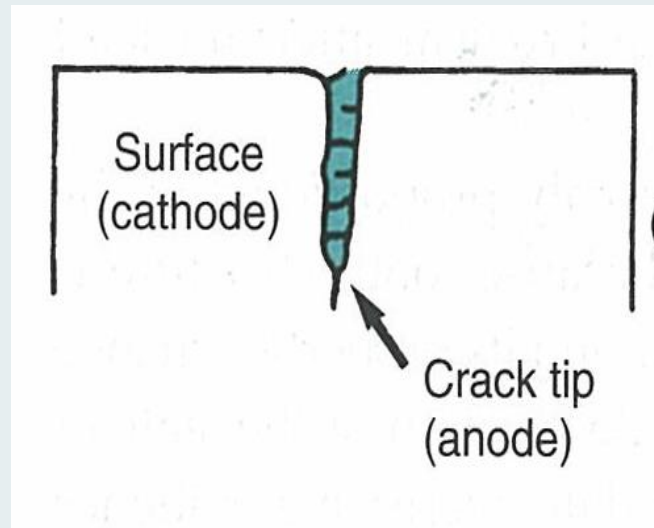
According to one study an electrically insulating layer forms gradually between galvanic couples which could reduce the galvanic corrosion rate.

Amalgam/noble metal couples,  
Amalgam/amalgam and  
Noble metal/noble metal couples

The layer is probably composed of non-metallic corrosion products, biofilms, and possibly, dental calculus

## CREVICE CORROSION:

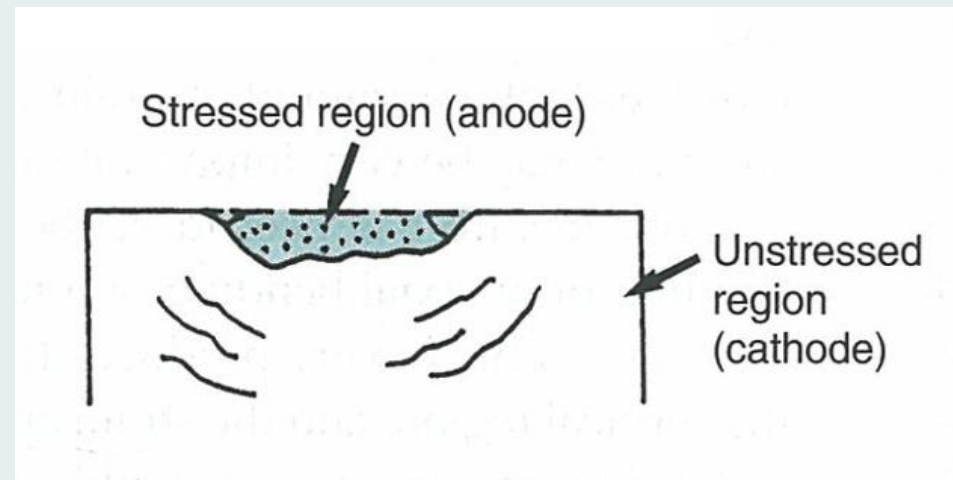
Local electrochemical cells may arise whenever a portion of amalgam is covered by plaque. It behaves anodically and corrodes. If these occur in cracks or crevice, it is called crevice corrosion.



Result in DEEPENING  
OF CREVICE

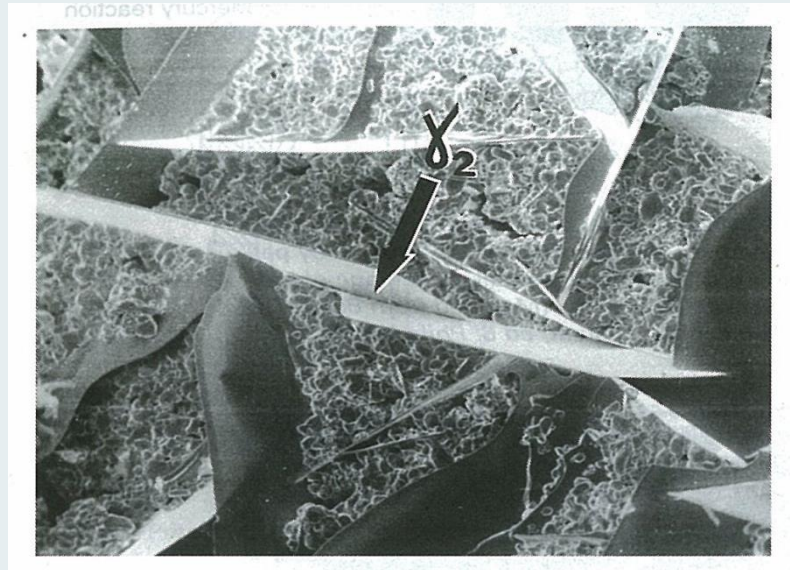
## STRESS CORROSION:

- Regions that are under stress display a greater probability for corrosion, thus resulting in stress corrosion.
- For occlusal dental amalgam greatest combination of stress and corrosion occurs along the margins.



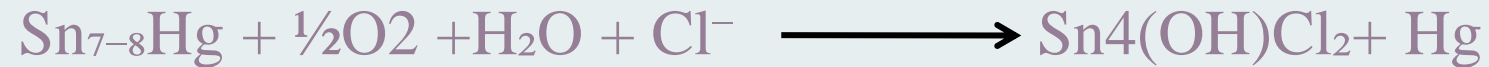
- *Ag-Hg( $\gamma_1$ ) crystals* are generally small and *equiaxed*. Most of the matrix is Ag-Hg . This phase has *intermediate corrosion resistance*.
- *Sn-Hg( $\gamma_2$ ) crystals* are *long and blade like*, penetrating throughout the matrix. This phase is *prone to corrosion*.

Produces *penetrating corrosion* that results in spongy and porous amalgam with minimal mechanical resistance



## Low Cu amalgams –

- Sn<sub>7-8</sub>Hg phase (γ<sub>2</sub>) more prone phase.
- Sn-Hg phase is oxidized into Sn-O (oxides) and Sn-o-Cl (oxychlorides)



**Sn-O-Cl brush Heap**

**crystals**

**Sn-O polyhedral**

**Amalgam surface after corrosion**



**crystals**

## High Copper Amalgam:

- **Sn-Hg reactions is suppressed by the preferential formation of Cu-Sn phases.**
- **Cu-Sn phases are less prone to corrosion as it is not a interconnected phase.**
- **So,** High copper seal late (approx. 6 months) so require initial sealing with varnish.

# Techniques for Amalgam restoration

## ▪ Choice of the alloy

- Alloy : The selection of alloy involves a number of factors-
  - Particle size and shape.
  - Composition.
  - Setting time
- Majority of alloys selected are high copper unicomposition and admixed types.

## **Selection of alloy mainly aims at:**

- High one hour strength
- Minimum dimensional change
- Lowest creep value
- Good condensing property
- High corrosion resistance
- Good polishing and finishing abilities



# Mercury and alloy

## Mercury alloy ratio(propportioning)

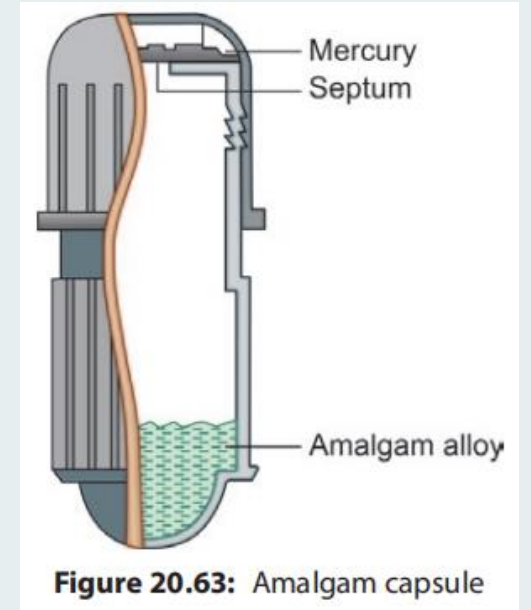
- **For conventional amalgams**, two techniques were used:
  - i. Removal of excess mercury by **squeezing** the mixed amalgam in a squeeze cloth before insertion in prepared cavity.
  - ii. Additional mercury was worked on top during condensation of each increment, this excess was removed as the amalgam mix was built up to form a restoration.
  
- The **best method** of reducing mercury content is to reduce the original mercury:alloy ratio. This method is known as **Emaes Technique(1:1) or Minimal Mercury Technique.**

## Mercury /alloy ratio

- Historically the only way to achieve smooth and plastic amalgam mixes was to use excess of mercury but this was discarded later considering health hazard.
- The recommended mercury/alloy ratio for the lathe cut alloys is approximately 1:1 or 50% mercury, in case of spherical alloy mercury should be 42% because spherical particles have lower surface/volume ratios.
- Use of little mercury results in dry mix, impairs the strength of high copper amalgam and also reduces corrosion resistance. •
- Dispenser should be held vertically to ensure consistent spills of the mercury, tilting the bottle 45-degree results in unreliable mercury/alloy ratios and the dispenser should be half full when used.

**Semi automatic dispensers** are commonly employed which also carry out trituration.

- These dispensers have two containers containing alloy and mercury.
- The ratio is set by the operator.



### **Encapsulated alloy/mercury material:**

The required proportion of alloy and mercury is separated by a thin membrane.

In a mechanical mixer, the membrane is broken as the mixer starts vibrating

- SIZE OF MIX Capsules containing 400, 600 or 800mg of alloy
- 400mg - single mix/ Spill
- 600mg – single mix.
- 800mg – double mix
- 1200mg – for amalgam core



**DPI Amalgam Permanent Filling Material Capsules**

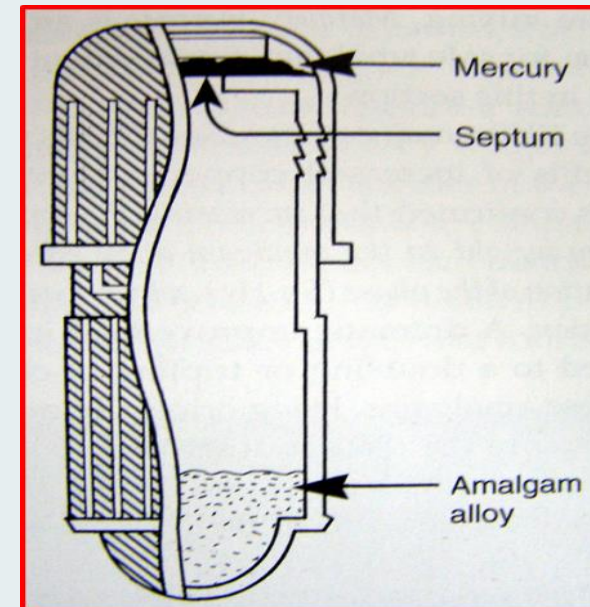
# Trituration

- The objective of trituration is to provide proper amalgamation of the mercury and the alloy. The alloy particles are coated with a film of oxide which is removed by abrasion when alloy particles and mercury are triturated •

## ○ Modern:



Reusable mixing capsules and piston



Preproportioned capsule

# Trituration:

- Trituration can be achieved by:

1. Hand mixing
2. Mechanical trituration.

- ❖ Hand mixing:

- A glass mortar and pestle are used.

- Mortar has rough inner surface to increase friction between amalgam and a glass surface.



- Usually a period of 25 to 45 second is sufficient for hand mixing.

## Mechanical trituration:



- ✓ The disposable capsule serves as a mortar and the cylindrical metal placed in the capsule serves as the pestle.
- ✓ The alloy and mercury are dispensed into the capsule, it is secured in the machine and the machine is turned on. There is an automatic timer for controlling the mixing time. •
- ✓ Modern amalgamator has two or more operating speeds. •

- ✓ The mulling process generally causes the mix to cohere so that it can be readily removed from the capsule. •
- ✓ Spherical alloy require less amalgamation time than lathe-cut alloys, amalgamation time also depends on the quantity.
- ✓ For a given alloy/mercury ratio increased trituration time and speed shortens the working and setting time.



Advantages of mechanical trituration:

1. Shorter mixing time

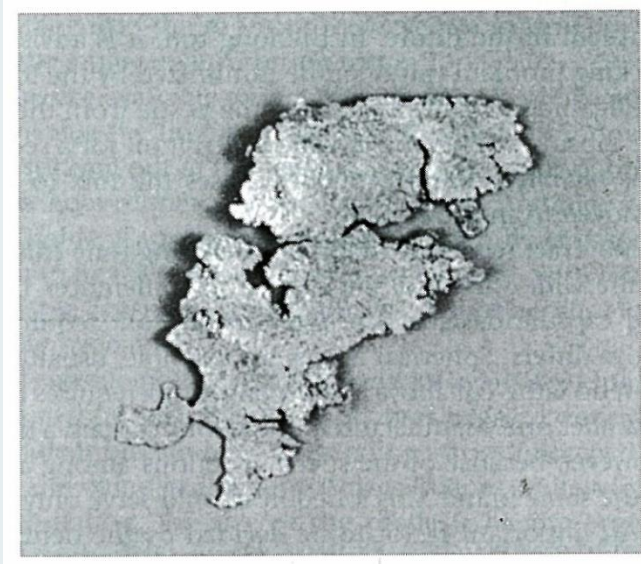
2. More standardized procedure

3. Require less mercury when compared to hand mixing technique

## Consistency of mix:

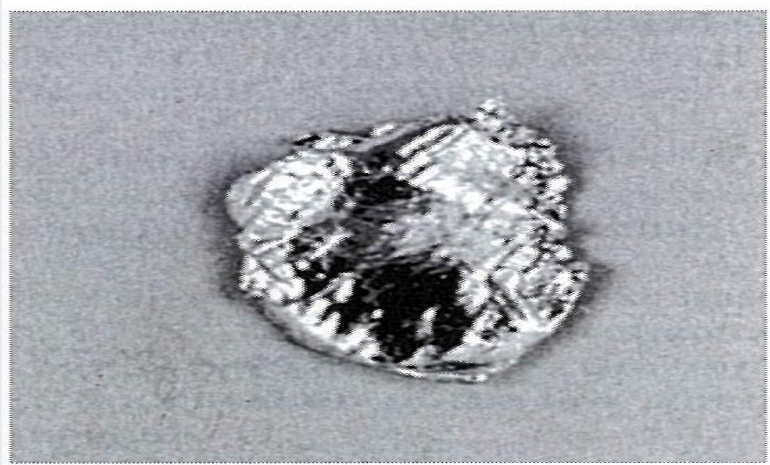
### ❖ Undertriturated mix:

- **Rough and grainy.**
- Amalgam restoration will be **weak** and **rough surface** left after carving which increases the restoration **susceptibility to corrosion.**
- Both **compressive** and **tensile strengths** are **reduced.**



❖ Normal mix:

- Shiny with **smooth and soft consistency**.
- Has **greatest compressive and tensile strength**.
- Smooth carved surface **retain luster after polishing** .



❖ Over triturated mix:

- Too **soupy** and tends to **stick inside the capsule.**
- Compressive and Tensile strength of lathe cut alloys are increased.
- Working time decreases.
- **Creep is increased.**



# Consistency

- Proper combination of the alloy and mercury is a prime manipulative consideration, the composition of the final amalgam is the major determinant of the physical properties.
- Proper mix retains its luster longer after polishing and also remains warm when it is removed from the capsule.

# Mulling

- **Continuation of Trituration.**
- **To improve the homogeneity of the mass and get a consistent mix.**

## Ways:

- i. **Mix is enveloped in a dry piece of rubber dam and rubbed vigorously for 2 to 3sec.**
- ii. **By hand, it can be done by squeezing the freshly mixed amalgam collected in the chamois skin.**
- iii. **After trituration, pestle is removed from capsule, and mix is triturated in the pestle free capsule for 2 to 3 sec**

# Condensation

- **It is process of compressing and directing the amalgam into the tooth preparation with amalgam condensing instruments until the preparation is completely filled.**

## Objective:

- **Squeezes un-reacted mercury out of the increments building up the restoration.**
- If the time lapse between trituration and condensation is more than 3 to 4 minutes, then the mix should be discarded.

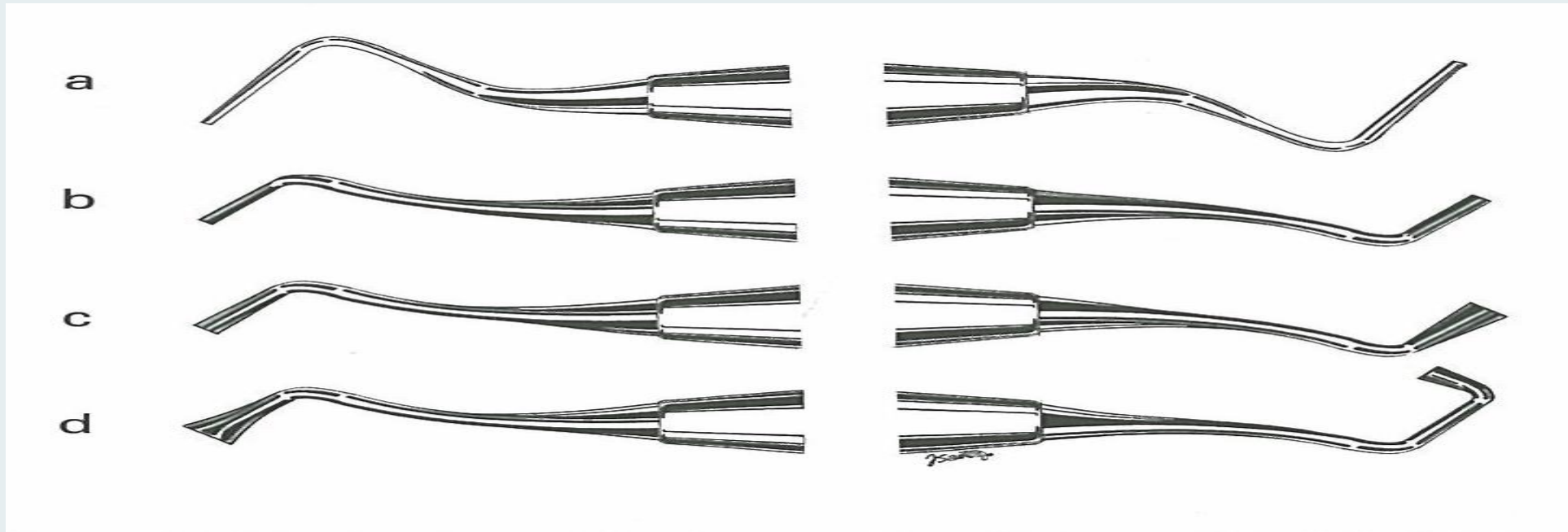
## Aims of condensation

- 1. to secure adaptation of the amalgam to the walls and the margins
- 2. to get compactness and homogeneity of the amalgam in the restoration with minimal voids Introduction
- 3. Remove the excess mercury

## Modes of condensation

- Manual condensation
- Mechanical condensation
  - 1 Pneumatic 2. Electrical
- Ultrasonic condensation.

- Types of condensers:
  - ❑ Round
  - ❑ Parallelogram
  - ❑ Diamond.

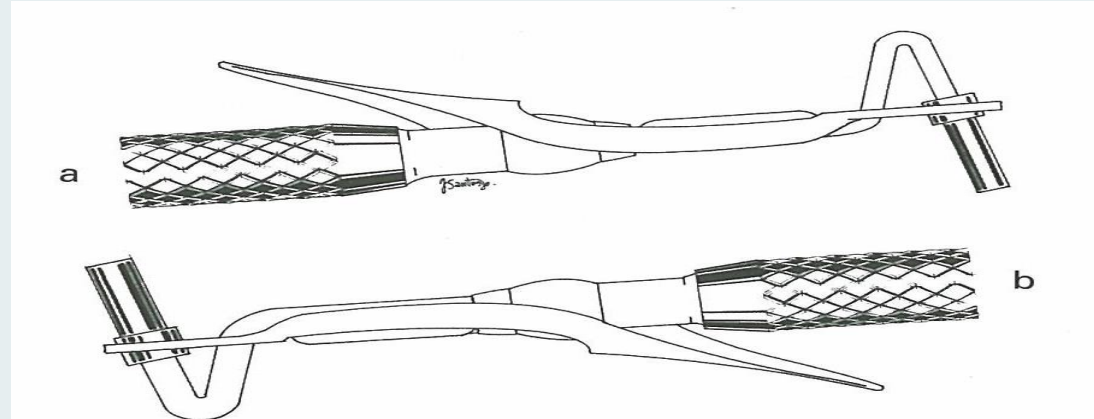


## Condensers

❖ Pressure applied by condenser nib  $\propto \frac{1}{(\text{surface area})^2}$

## □ Hand condensation

○ *Amalgam carrier* is used.



○ Increment should be condensed (not more than 3-4min between trituration time and condensation) immediately with *sufficient pressure*.

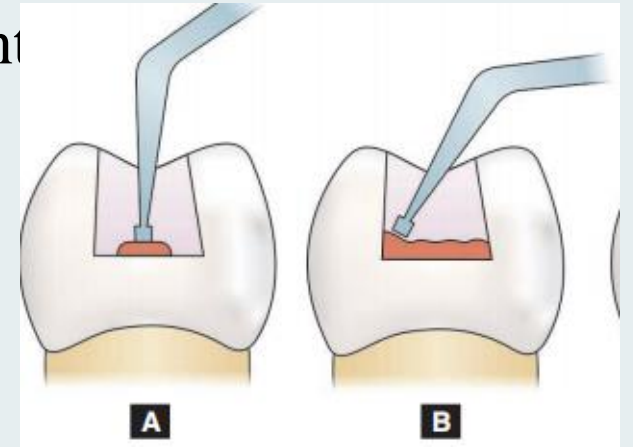
$$\text{Pressure 'p'} = \frac{\text{force}}{\text{Area of cross-section}}$$

## Condensation pressure:

- Condensation pressure should be *3-4lb (13.3N – 17.8 N)*
- Smaller the condensor, greater the pressure exerted on amalgam.
- The increments should be small at one time. Large bulk of increments leads to air entrapment and leads to a porous and a weak restoration.
- After proper condensation- surface will look shiny due to residual mercury.

<i>Type of alloy</i>	<i>Type of condenser</i>
Lathe-cut alloy	Small condenser
Blended alloy	Small condenser
Spherical alloy	Large condenser

- Condensation is usually started **at the center**, then point stepped towards the cavity walls.



# Mechanical condensation:

- Mechanical condensers are available which provide vibration or impact type of force.
- More *useful for condensing irregularly shaped alloys* with high condensation pressure.
- ULTRASONIC CONDENSATION:
- Not recommended as it causes heating of amalgam.



## Pre carve burnishing

- After condensation amalgam is further condensed and *shaping of occlusal anatomy* begun with *large burnisher*. this is **precarve burnishing**.

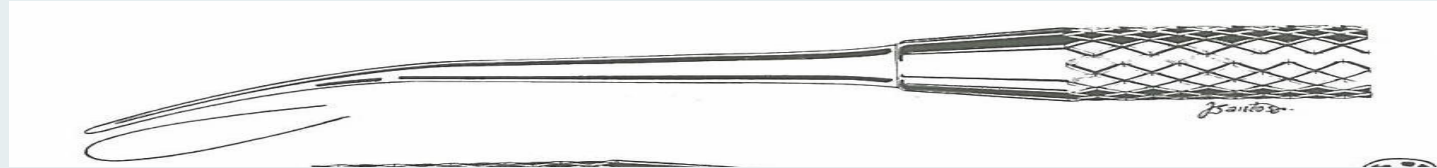
### Objective :

- Reduce number and size of voids.
  - Brings any excess mercury to the surface, to be discarded during carving.
  - Adapt amalgam to cavosurface anatomy for better marginal integrity.
- 
- Burnisher should be used with heavy strokes.

➤ Types of burnishers



Round cone shaped burnisher

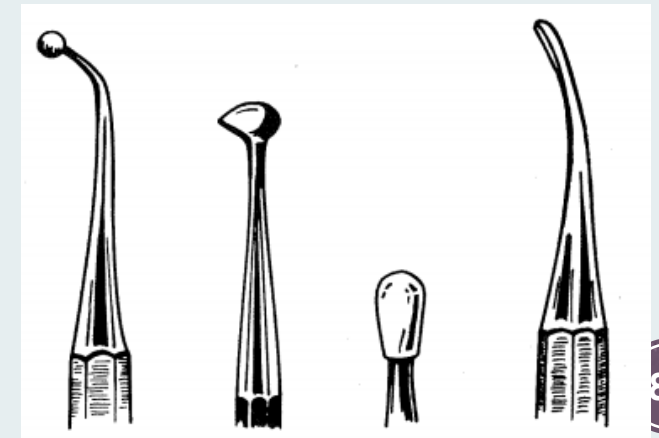


Beavertail burnisher



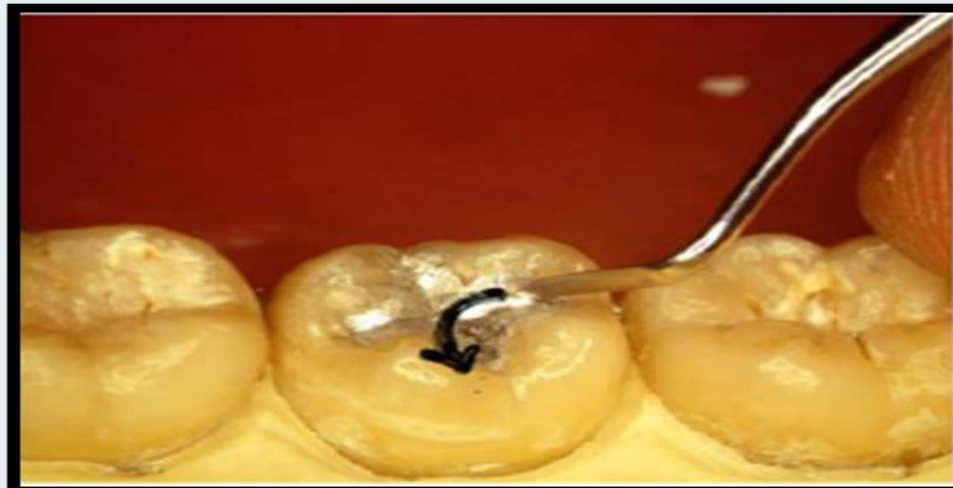
Egg shaped / football shaped burnisher

- Ball shaped burnisher
- Apple shaped burnisher
- Conical B.
- Hourglass B.



# Carving

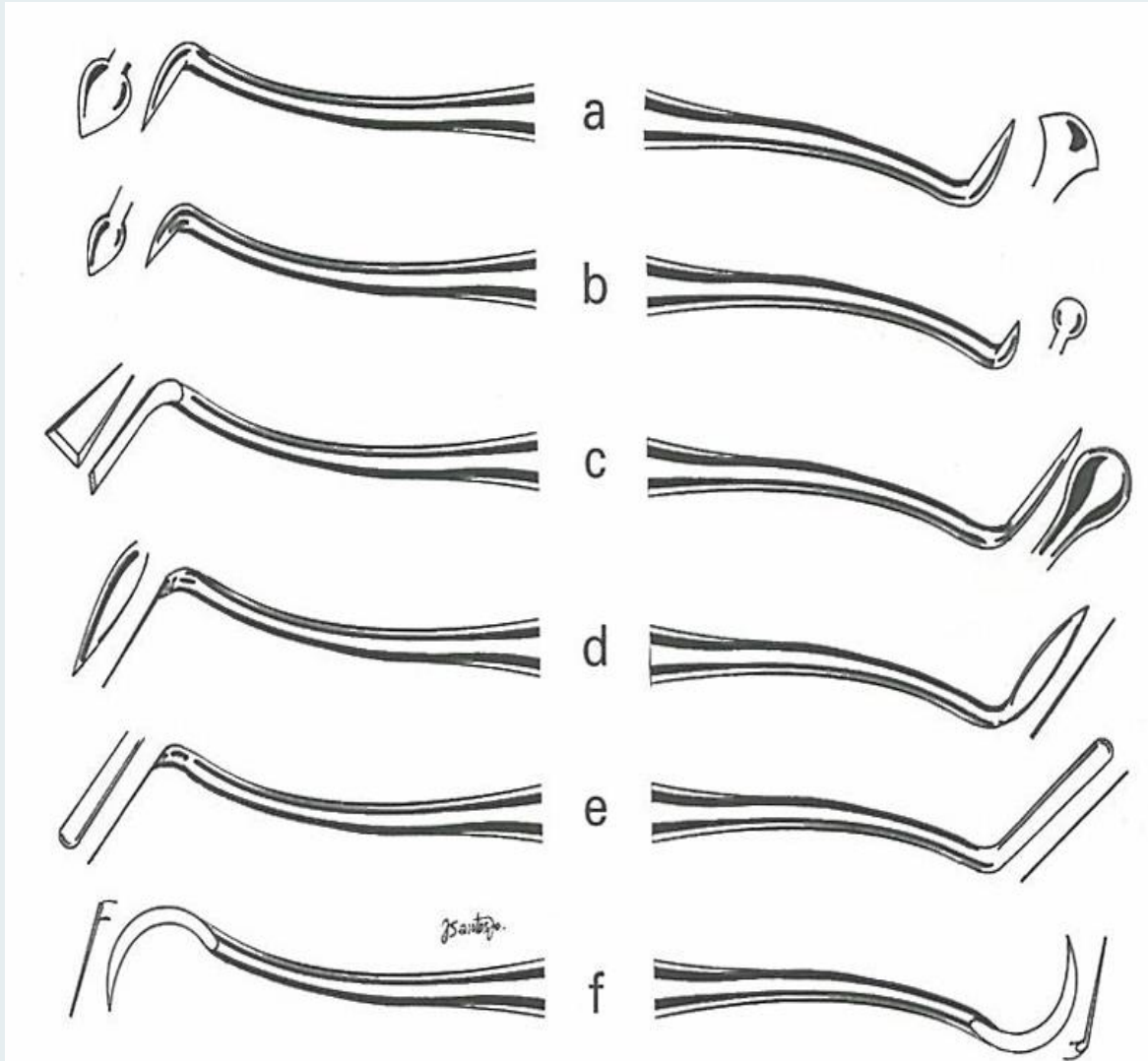
- Objective -To *simulate the anatomy*, rather than to reproduce extremely fine details.
- If the carving is *too deep*, the bulk of amalgam, particularly at the marginal areas ,is reduced ,it may *fracture under masticatory stress*.
- Carving should not be started until the amalgam is hard enough to *offer resistance to carving instrument*.



## Guidelines for carving

- Pulling strokes – mostly
- Pushing stroke - developing occlusal anatomy
- Occlusal anatomy should be kept reasonably (shallow) to preserve a bulk of amalgam at the margin
- 75 – 90 angle at the margin of occlusal amalgam
- Mesial and distal pit areas should be carved slightly deeper than the proximal marginal ridge

# Types of carvers



Large cleoid-discoid carver

Small cleoid- discoid carver

Walls No. 3 carver

Hollenback carver:  
Most universally used.

Interproximal carver

Sickle-shaped carver

## Post carve burnishing

- Post carve burnishing is the light rubbing of the surface of a carved amalgam restoration with a burnisher.
- Purpose: to smooth the surface of the restoration.
- Burnishing is done with a ball burnisher using light stroke proceeding from the amalgam surface to the tooth surface
- Heavy forces should not be used
- Brings excess Hg to surface – discarded

## Finishing and polishing

- Objective - To remove superficial scratches and irregularities.
- Minimizes corrosion and prevent adherence of plaque.
- Should be done after 24hrs of condensation.
- Wet polishing is advised over dry polishing.



- ✓ Finishing & Polishing is necessary to complete the carving, to refine the anatomy, contours, and marginal integrity and enhance the surface finishing of the restoration .

BEFORE starting evaluate restoration:

### 1. **Surface and margins:**

Margins Using the explorer (or a periodontal probe with a small tip) in a zigzag motion, determine if the cavosurface margins have any excessive discrepancies.

### 2. **Occlusion:**

- lateral slide is used to develop the desired eccentric occlusion
- Articulating paper may be used to check the occlusion

### 3. **PROXIMAL CONTACTS:**

High Cu single composition spherical alloy: 8 min after trituration

- ✓ Always - low speed, low pressure-velvet finish
- ✓ AVOID UNDUE PRESSURE

# FINISHING AND POLISHING INSTRUMENTS



Fig. From the left: five plain-cut plain steel finishing burs, two mounted stones, three mounted abrasive rubber points from coarse to fine, and a mounted abrasive rubber cup

# Finishing Discs Technique

- Gingival and proximal margins to remove overhangs.
- Use short, overlapping strokes and move diagonally across the cavosurface margins.

## Sequence

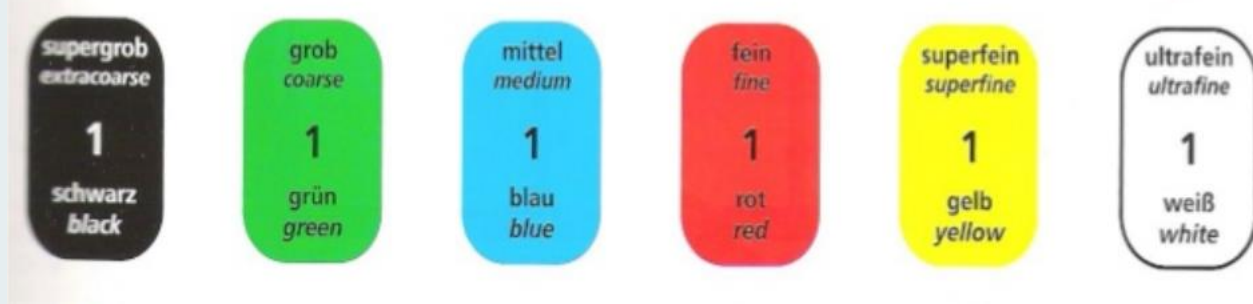
- Discs are used in a sequence of more abrasive to less abrasive grits.
- When using discs in embrasure areas, care must be taken not to damage the contact area or papilla.



# Finishing strips

- a) Types : fine or medium
- b) Placed on both the tooth and the amalgam, and move in a back-and-forth motion.
- c) Avoid the contact area when using finishing strips, and use caution in areas of the inter dental papilla and surrounding tissue





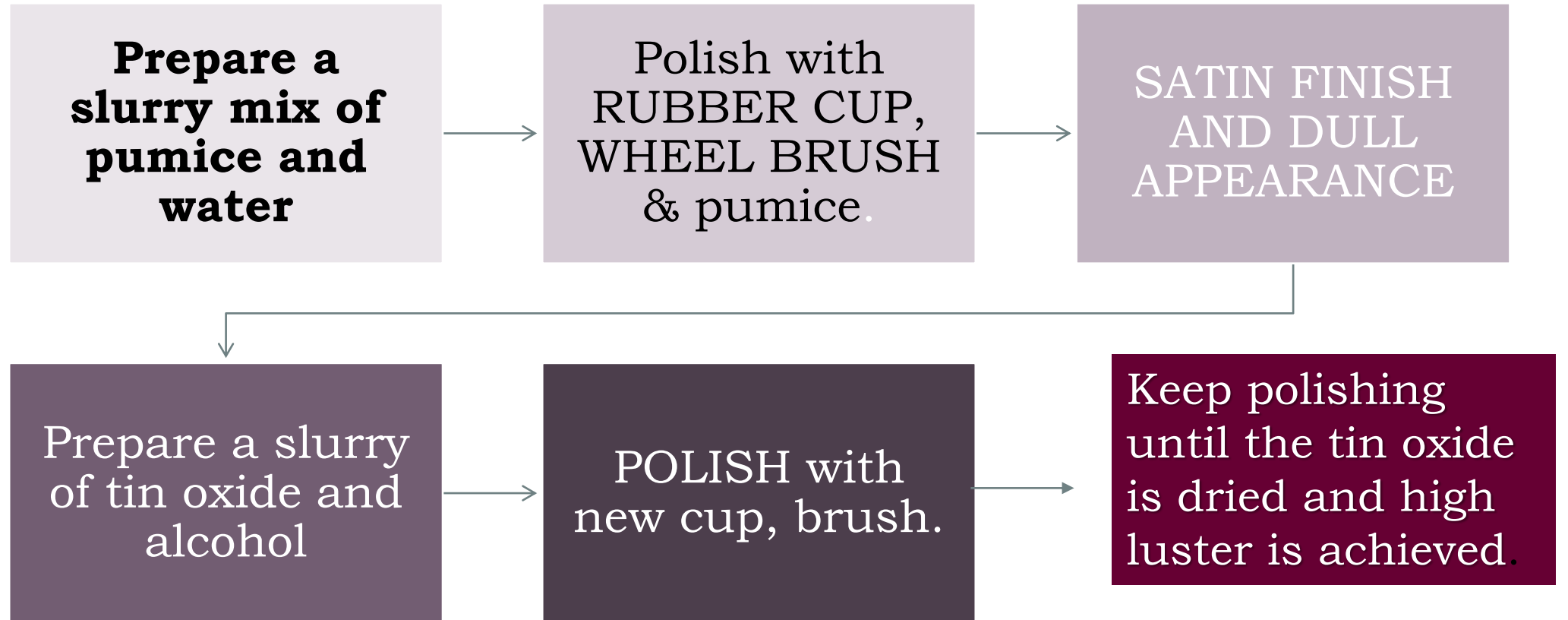
## Finishing burs/stones

1. Green stone to remove excess material and irregularities
2. Sequence
  - largest bur →→ smaller and less abrasive burs
3. Technique
  - Adapt the side of the bur or stone along the margin, contacting both tooth and amalgam.
4. Direction of stroke

Rotate the bur or stone from the amalgam to the tooth to avoid fracturing the amalgam margins.
5. Direction of work Always begin at the centre of the restoration and work toward the cavosurface margin

# AMALGAM POLISHING;

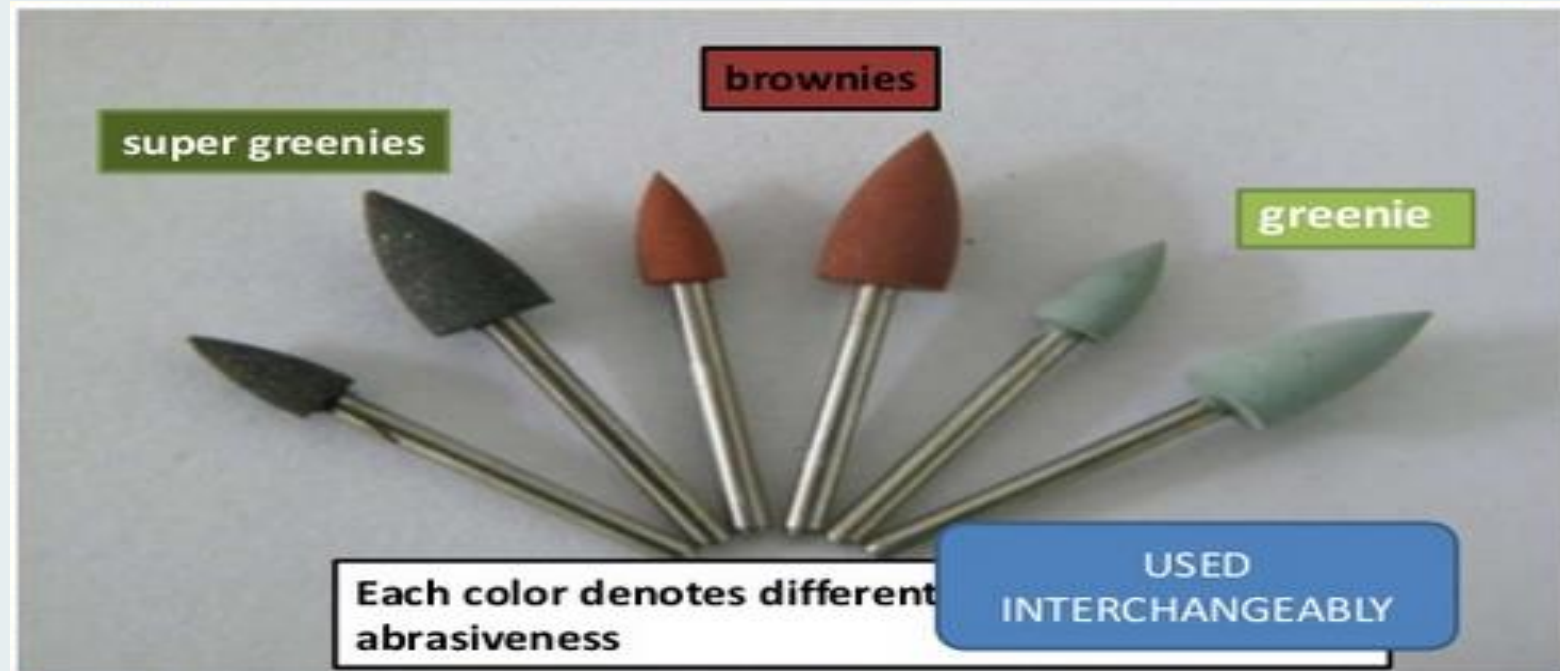
## 1. PUMICE AND TIN OXIDE SLURRY



**Rinse  
and  
Dry the  
mouth**



## 2. Rubber cups and points impregnated with Abrasive particles



BROWNIE: PREPOLISHING  
Greenie: POLISHING

SUPERGREENIE: HIGH GLOSS

They should be operated at a relatively low speed, using light, intermittent strokes under wet conditions

# Advances in Dental amalgam

1. Bonded amalgam.
2. Gallium based alloys.
3. Direct filling silver.
4. Powder coated technology.
5. Alloying additions.
6. Fluoride releasing dental amalgam



# Bonded Amalgam

- Disadvantage of amalgam “inability to bond to the tooth structure.
- Traditional amalgam restorations are retained by mechanical retention features that incorporate:
  - Parallel or undercut walls.
  - Dove tails.
  - Box forms.
  - Retention grooves, which often require removal of healthy tooth structure.



- clinical technique that bonds amalgam to enamel or dentin was introduced by “**Baldwin**” in **1897**.
- Earliest method was to paint the walls with Zinc Phosphate cement and condensing amalgam on the wet surface.
- ‘*selective interfacial amalgamation liner*’ Combining polycarboxylate cement and amalgam alloy particles.
- Further improvement in amalgam bonding became possible with the introduction of adhesive resins meant for the ‘*Maryland bridge*’ technique.
- adhesive resin systems, Superbond (Sun Medical) and Panavia (Kuraray) which contained monomers and enhanced bonding to metal surfaces **after air abrading or tin plating these surfaces**



- Dental amalgam is hydrophobic and enamel is hydrophilic → bonding agent must be modified with wetting agents (i.e., co-monomer) that has a capacity to meet both hydrophilic and hydrophobic surfaces.
- **4 META (4-methacryloxyethyl trimellitic anhydride) is used.** This monomer molecules has both hydrophilic and hydrophobic ends.



- Shear bond strengths of amalgam to dentin as high as 10 MPa have been reported using these adhesives.
- The fracture resistance of teeth restored with amalgam-bonded mesio-occlusal-distal (MOD) restorations was more than twice that of restorations containing unbonded amalgams.
- In spite of the lower shear-bond strength of amalgam bonded to dentin as compared to that for composites, the fracture strength of MODs in teeth restored with bonded amalgams was as high as that for composites.



## ■ **Mech of retention:**

- Due to the method of condensing amalgam onto unset adhesive resin liner, there is an intimate mechanical interlocking created.
- The mechanism responsible for bonding amalgam to resin is predominantly MECHANICAL in nature. It is produced by condensing the plastic amalgam mass into a plastic resin layer, producing MACRO RETENTIVE areas within the resin after the resin has polymerized.

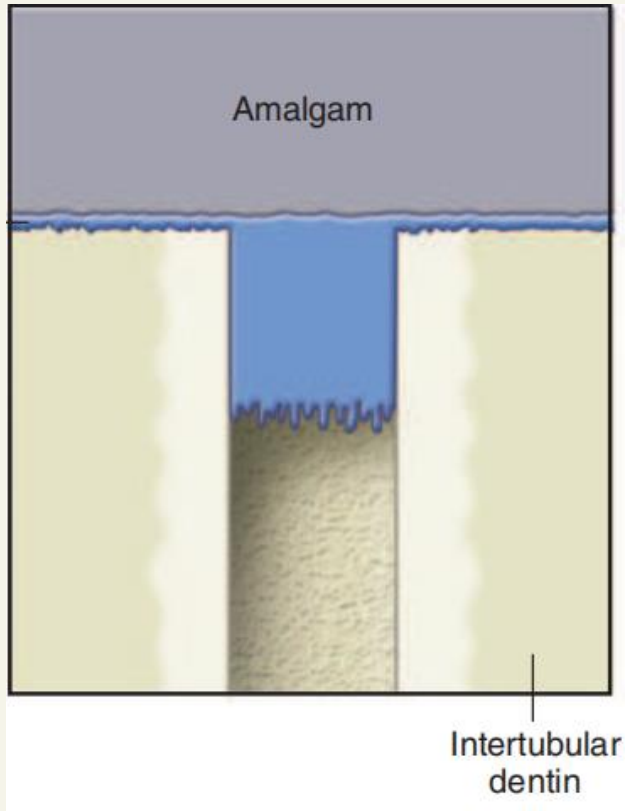


## ■ **AMALGAM BOND:**

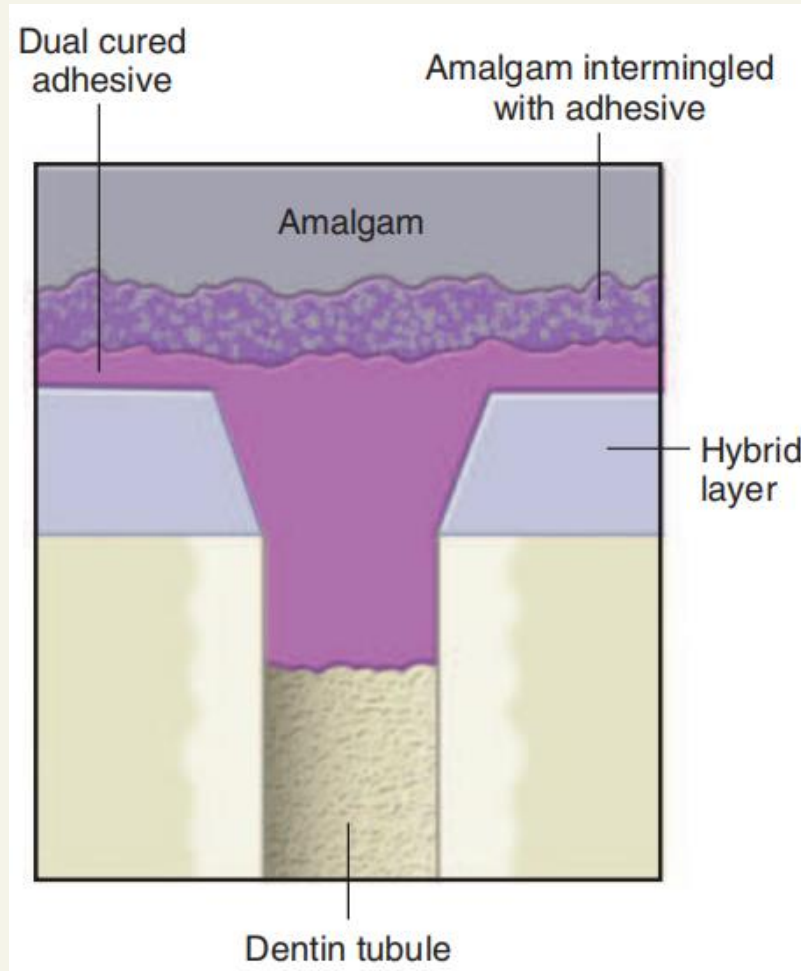
- It is based on a dentinal bonding system developed in JAPAN by NAKABAYASHI.
- It uses a solution of 10% CITRIC ACID and 3% FERRIC CHLORIDE to remove the smear layer and demineralize the dentine surface.
- Finally, a self-curing methacrylate resin is applied to impregnate the primed dentine.
- The resin contains an adhesive monomer called 4-META. (4-methacryloxyethyl trimellitic anhydride)

■ .

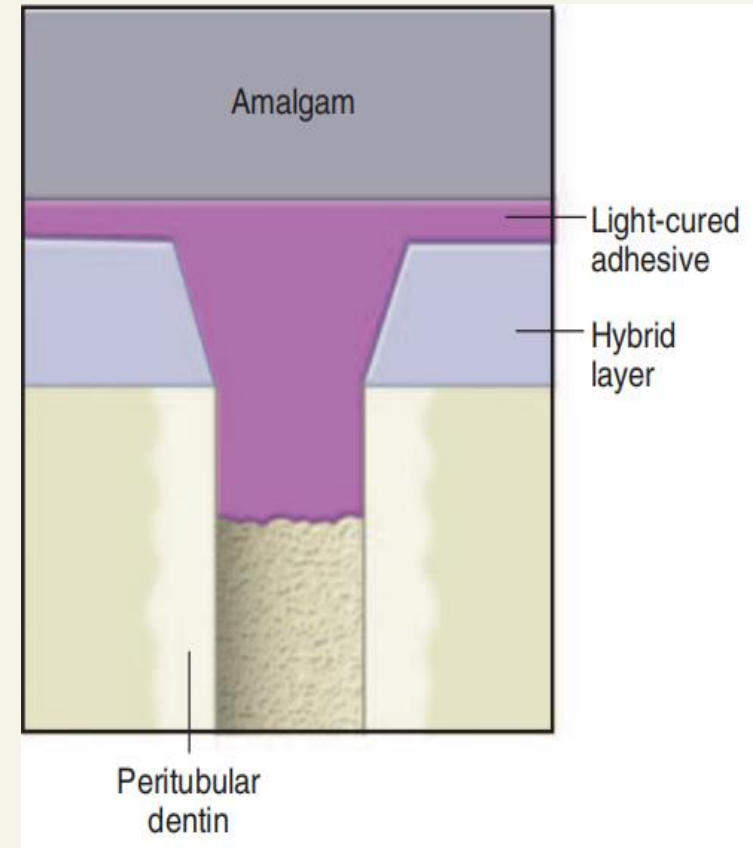




**Dentin desensitization**



**Amalgam bonding (amalgam intermingled with adhesive resin).**



**Amalgam bonding (amalgam intermingled with adhesive resin).**



- Examples → ALL BOND 2 (BISCO).
- -AMALGAM BOND PLUS WITH HPA (High Performance Additive) powder, contains polymethylmethacrylate fibers to form a thick, viscous layer when mixed with the Amalgam bond Plus base and catalyst liquids
- OPTIBOND 2 (KERR).
- PANAVIA EX AND PANAVIA 21 (Kuraray).



# Indications

- Large compound restorations: In every extensive cavities with gross tooth loss.
- Repair of restorations (to bond new to old amalgam and to seal cavity margins in the old restorations).
- Preparations without retention.
- Repeated fracture of amalgam restorations.
- Geriatric and debilitated patients – Bonded amalgam is preferred over more expensive and time consuming cast restorations.
- Repairing marginal defects.



# Advantages

- Conservative cavity preparation → does not always require additional mechanical retention (unlike amalgam) and resistance form, thus conserving sound tooth tissues.
- It eliminates the use of retentive pins and their inherent risks
- It reduces marginal leakage to minimum.
- Reduces the incidence of marginal fracture.
- Reduces the incidence of secondary caries.
- It allows the biologic sealing of pulpodentinal complex.



# Limitations and disadvantages

- It is time consuming:
- Technique sensitive.
- It requires practitioners to adapt to the new technique.
- It increases the cost of restoration.
- It has not been in use long enough to allow a proper evaluation of its clinical performance.
- Failures may occur at the amalgam-bonding agent interface because of poor micromechanical bonding.



# Gallium alloy

- Suggested by **Puttkamer** in **1928**.
- **Waterstrat** formulated **Ga-Pd-Sn alloy**.
- **ADA seal** of acceptance in **1995**.

## ➤ Types of gallium alloy:

1. Gallium alloy GF (palladium 9%) or 2% gallium GFII.
2. Galloy (palladium free alloys)

# Composition

## **Galloy (non-palladium gallium alloy)**

### ❖ *Spherical High copper alloy powder*

- Silver - 60.1%
- Tin - 28.05%
- Copper - 11.8%
- Platinum - 0.05%

### ❖ *Galloy liquid*

- Gallium - 62%
- Indium - 25%
- Tin - 13%
- Bismuth - 0.05%

## Properties :

- ***Compressive strength*** = dispersalloy  
(can be given in stress bearing areas)
- Creep : ***negligible creep value.***
- ***Excessive setting expansion*** compared to conventional amalgam.
- ***High corrosion***  
(Venugopalan et al study showed corrosion potential 3 ***times greater than amalgam***).

- **Properties –**

- **1 hr. Comp. Strength** - **343 MPa**
- **1 day Comp strength** - **533 MPa.**
- **Tensile strength** - **57 MPa/**
- **Creep** - **0.17%**
- **Dimensional change** - **+ 16 urn/cm**

# ADVANTAGES

- ✓ **Rapid solidification.**
- ✓ **Good marginal seal by expanding on solidification.**
- ✓ **Heat resistant.**
- ✓ **The compressive and tensile strength increases with time comparable with silver amalgam**
- ✓ **Creep value are as low as 0.09%**
- ✓ **It sets early so polishing can be carried out the same day**

- Inferior handling characteristics.  
(teflon coated instruments are required)



**The Galloy material and delivery system**

- Second alloy → The liquid Gallium alloy (composed of Ga, In, Sn) replaced mercury and was triturated with a **spherical alloy powder** similar in composition to that used for amalgam restoration, with the addition of 9% palladium.
- Galloy uses a spherical, high copper alloy powder.
- The liquid portion is a Gallium alloy containing Ga-62%, In-25%; Sn-13%; Bi-0.05%.



# Disadvantages

- Extreme corrosion
- Sticky to the carrying instruments
- Excessive expansion
- Increase post-operative sensitivity
- White line formed at restorative margin
- High Cost i.e 16 times the silver alloy.



## Indium containing alloys

- Youdelis (1992).
- Addition of 10-15% In to Ag alloys.
- Properties of new, dispersed-phase amalgam containing admixed indium-
  - Improves strength
  - Resistance to corrosion and creep
  - Low frequency of marginal breakdown

# Direct filling silver

- Mercury-free metallic direct filling material
- discovery of a process called “ACID-ASSISTED CONSOLIDATION”, where these elemental powders could be mixed with an acid to remove surface oxides and consolidated, while submersed in the acid



- 1994, the national institute of Dental Research → called for alternatives to amalgam
- The PRC-NIST (PAFFENBARGER RESEARCH CENTER – NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY)

→ Direct placement

→ Suitable biocompatibility

→ Robust storage and stability

→ Instrumentation and placement similar to amalgam

→ Performance equivalent to amalgam

→ Low manufacturing and processing costs.



- Composition → 98% chemically ppt powder with particle size  $25\mu$
- Powder immersed in 2% fluoboric acid to form slurry → condensed into cavity
- Condensation with 1.5 dia condensor in increments 0.1mm-0.3mm
- Mass achieved max strength immediately upon consolidation
- Finishing and polishing → conventional amalgam
- Main problem is that this alloy strain hardens so it is difficult to compact it adequately to eliminate
- internal voids and to achieve good adaptation to the
- cavity without using excessive force



# POWDER COATED TECHNOLOGY

- developed at the National Institute of Standards and Technology in USA, Maryland.
- a more economic variant of cohesive gold
- powder condensed under pressure to produce solid restorations.
- silver particles are coated with Gold and condensed as pure gold.
- powder particles are packed with Tetrafluoroboric acid, the oxides are dissolved and a restoration is obtained with properties in between cohesive gold and amalgam.



# ALLOYING ADDITIONS

- In 1997, Cherlin reported that (0.5-0.75%) of palladium when added to  $\gamma_1$  phase of amalgam resulted in
  - Decreased corrosion characteristics.
  - Increase in compressive strength.
  - Increase in Creep resistance.
  - Decrease in release rates of mercury vapour and ions.
  - Decreased transition of  $\gamma_1$  to  $\beta_1$ .



# Fluoride releasing amalgams

- 50% of restorations are replaced → secondary caries
- Addition of 1% SnF<sub>2</sub> → F<sup>-</sup> releasing dental amalgams
- Class V cavities in artificial caries model) → inhibition of secondary caries
- Cavities on root surfaces were showed → inhibition of secondary caries below restoration and primary caries in surface enamel adjacent to restoration
- showed better anti-microbial efficacy to strep. mutans and lactobacillus acidophilus.



## **FLUORIDE IN AMALGAM**

A conventional (Minimax), two single-particle high-Cu (Summalloy and Aristaloy CR), and two dispersed-phase (Cluster and Phasealloy) amalgam alloys were each admixed with 0.5 wt% of  $\text{CuF}_2$ ,  $\text{InF}_3$ ,  $\text{SnF}_2$ , and  $\text{CaF}_2$ , and evaluated for  $\text{F}^-$ , Cu, and Sn release

A ranking for  $\text{F}^-$  release was

Cluster (highest) Summalloy Phasealloy Minimax Aristaloy CR

The effectiveness of the  $\text{F}^-$  compounds in releasing  $\text{F}^-$

$\text{CuF}_2$  (highest)  $\text{SnF}_2$   $\text{InF}_3$  (1.0%)  $\text{CaF}_2$

# AMALGAM ALLOYS AVAILABLE IN INDIA

- **1. ANA 2000 NORDISKA DENTAL- Single composition lathe cut.**
- **2.ADMIX AMALGAM ALLOY**
  - Permite - the non-gamma 2 admix alloy
  - **Dentsply Dispersalloy Amalgam**
  - Kerr CONTOUR



# Low initial tensile strength of High Cu Admix Alloy

- **Composition of Admix alloy:**

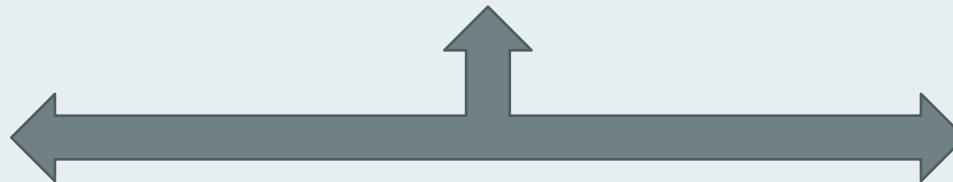
**Spherical AgCu eutectic alloy + Lathe cut Low copper amalgam alloy**



**Ag and Cu are completely soluble in liquid phase and partially soluble in solid phase**



In solid state, Ag and Cu are present in two forms



# Rate of attaining strength

- As long as there is residual mercury ( always present)present in the silver amalgam restoration, the amalgamation process is never complete; but, generally speaking, more than 90% of the amalgam strength is attained within 24 hours.
- The rate of attaining strength is dependent on two major factors:
  - 1.complete crystallization of the matrix phases.
  - 2. Completion of the interphases between matrix phase and original particles.
- Rate can be accelerated by:
  - 1. Reduction of particle size
  - 2. More trituration energy
  - 3. More condensation energy
  - 4. Minimal amount of mercury.
  - 5. Homogenizing heat treatment



# GENERAL CONSIDERATIONS

## ▪ RESTORATION WITH AMALGAM:

The required tooth preparation form must allow the amalgam to

1. possess a uniform specified minimum thickness for strength (so that it will not flex and fracture under load),
  - (2) produce a 90-degree amalgam angle (butt-joint form for maximum edge thickness) at the margin, and
  - (3) be mechanically retained in the tooth
- Amalgam restorations initially leak and therefore require steps to protect from pulpal sensitivity until self-sealing is able to occur.



# Allergy

- LESS THAN 1% OF TREATED POPULATION



- IF ALLERGIC TO AMALGAM → REPLACED WITH COMPOSITES OR CERAMICS
- Many dentists are asked by patients to remove all their amalgam fillings and replace them with alternative material.
- These requests should usually be kindly and gently resisted, with a full explanation of the difference between toxicity and allergy which many patients find difficult to understand.



## Mercury Hypersensitivity: (Type IV hypersensitivity)

Low level allergic reaction which is **Experienced by less than 1% of the treated population.**

- Represents antigen-antibody reaction marked by Itching, rashes, sneezing, swelling
- Contact dermatitis .
- Oral manifestations: Gingivostomatitis.  
Hypersalivation.  
Erosive Lesions.
- Symptoms usually resolve with in few days to 2 wks after removal of amalgam restoration.



- Mercury from dental amalgam is released in 2 forms:

- i. Mercury ions:

- *Circulate* readily in the *blood* but pass the membrane barrier of brain and placenta with difficulty.
    - Released during corrosion.
    - *Play role in allergic reactions.*

- ii. Mercury vapours:

- Carried to lungs from intraoral air (80%) or dissolved in saliva (5-10%) where it is rapidly absorbed into blood stream.
    - Capable of crossing the membrane barrier of brain and placenta, if oxidized within these tissues are removed slowly.

# MERCURY RELEASE



Superficial layer of fresh amalgam specimens.

Released in oral cavity because of low melting point of gamma 1 phase ( 127 deg. cent.)

Gradually gamma 1 phase is converted to a phase with low mercury content, leaving free mercury to be released.

Elevated during tooth brushing, intake of hot beverages, and particularly chewing gum.

## PROPOSED THRESHOLD VALUES;

- Pts with amalgam restoration → 0.7 $\mu$ g/day]
- People without amalgam restoration showed blood levels – 0.3  $\mu$ g/day
- Pts with 8-10 restoration → 1.1-4.4 $\mu$ g/day
- Workers in mercury industry having threshold 350-400 $\mu$ g
- WHO declares an occupational threshold limit value (TLV) of 50  $\mu$ g Hg/m<sup>3</sup> as the maximum concentration of exposure based on a 40-h working week.



According to the WHO, all humans are exposed to some level of mercury.

**Factors that determine whether health effects occur and their severity include**

- ❖ the type of mercury concerned (methyl and ethyl mercury, commonly found in fish, being more serious than elemental mercury)
- ❖ dose
- ❖ age or developmental stage of the person exposed (the foetus is most susceptible)
- ❖ duration of exposure
- ❖ route of exposure (inhalation, ingestion or dermal contact).

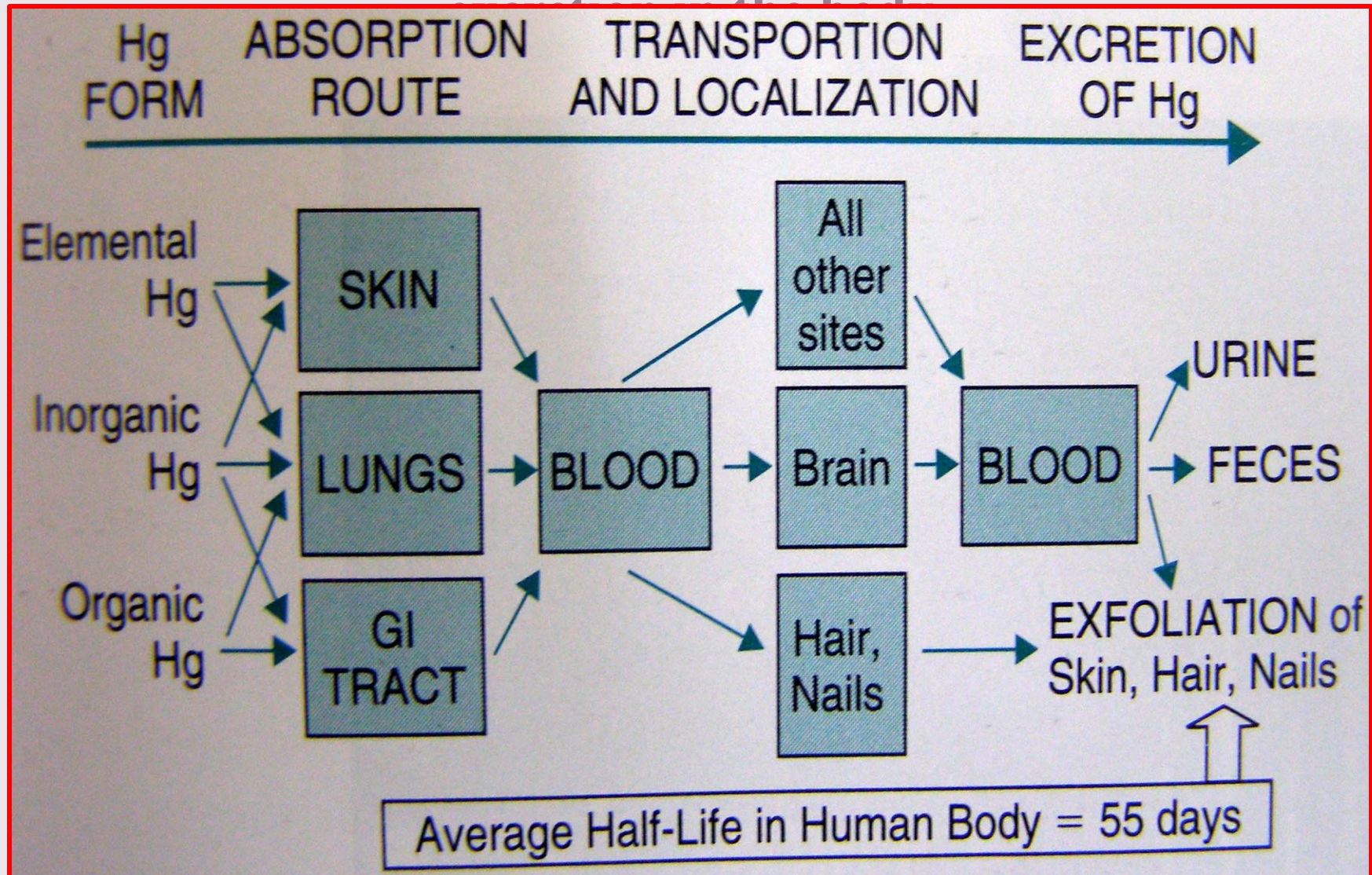
- $1\ \mu\text{g}/\text{m}^3$  is considered as the lowest threshold of mercury vapour in air.
- $15\ \mu\text{g}/\text{l}$  of mercury in urine and  $4\ \text{ng}/\text{ml}$  of mercury in blood is acceptable normal value.



### Mercury Toxicity:

- OSHA maximum TLV =  $50\ \text{mg}/\text{m}^3$  (vapor) per 40 hr work week.
- Transient intraoral release ( $<35\ \text{mg}/\text{m}^3$ ).

## Events occurring during mercury absorption, transportation and



# AMALGAM TATOO

- Accidental implantation of silver containing compounds into oral mucosal tissue or corrosion products leach into surrounding tissue, causing discoloration.
- Grayish black pigmentation
- Most common Site Gingiva, buccal mucosa, alveolar mucosa
- Amalgam tattoos can often be diagnosed because of their opacity under radiographic examination.
- Asymptomatic



# Mercury Monitoring

- Exhalation
  - difficult to perform reliably
- Urine
  - best method for chronic exposure
    - symptoms – 300 ug/L
    - normal < 25 ug/L



# Mercury Monitoring

- Blood
  - normal < 6 ug/L
  - reflects recent exposure
  - reliable measurement of methyl mercury exposure
- Hair
  - not a reliable method



# Biologic Activity of Mercury

- No carcinogenicity
- No Teratogenicity
- No immunotoxicity

Exposure to low concentrations of mercury released from dental amalgam fillings does not pose a risk of adverse neurobehavioral effects to the general population.

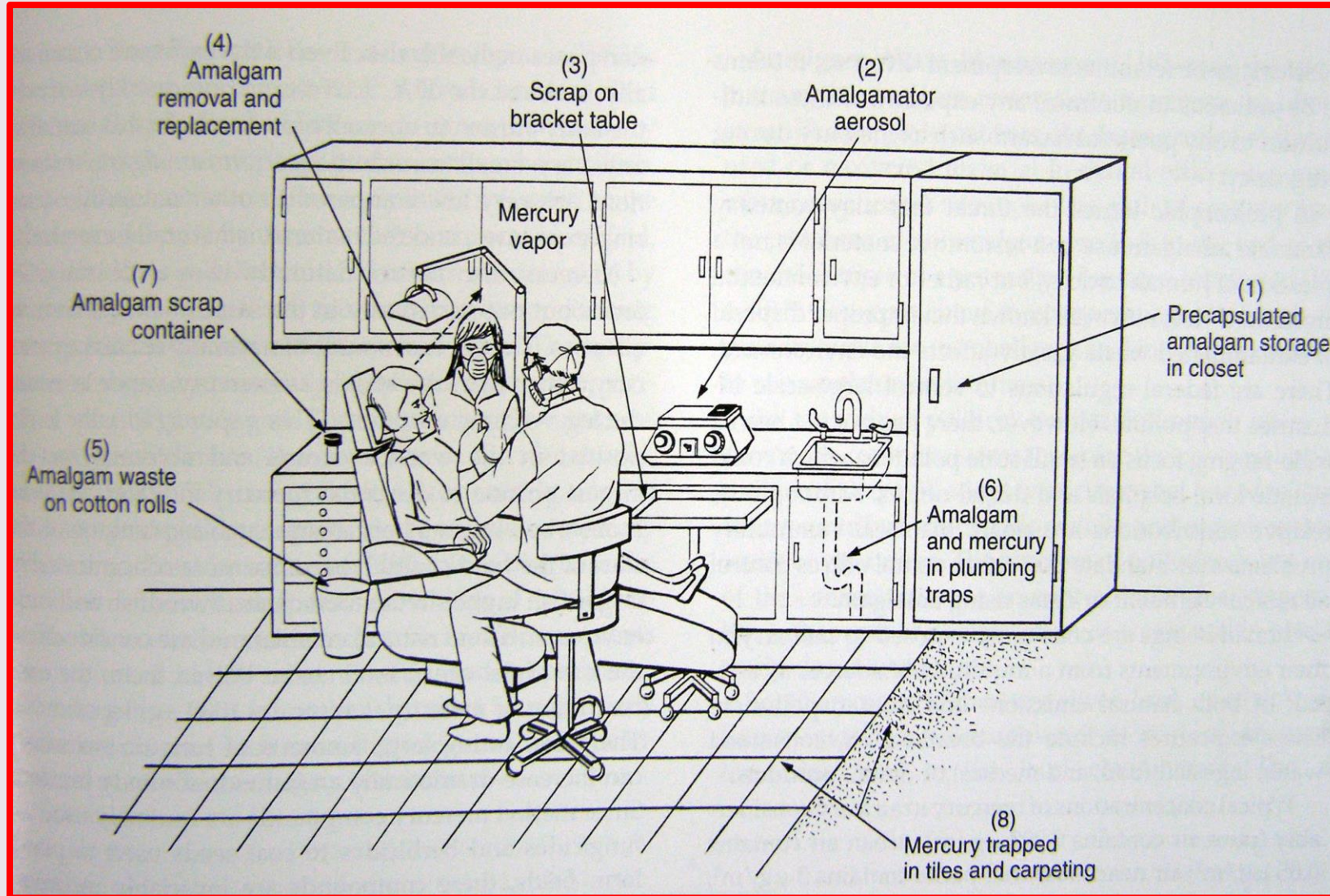


# Symptoms of Toxicity



- Acute high-level exposure
  - hypersalivation
  - cough
  - dyspnea
  - bronchitis
  - Pneumonia
  - vomiting
  - gastroenteritis
- Chronic low-level exposure
  - depression
  - irritability
  - weakness
  - tremor
  - insomnia
  - renal failure
  - memory loss

## Sources of mercury exposure related to amalgam in the dental office



. The [World Health Organization](#) reports that health care facilities, including dental offices, account for as much as 5% of total waste water mercury emissions.

# Minimizing Office Exposure

1. Train all personnel involved in the handling of mercury or dental amalgam.
2. Personnel must be aware of the potential sources of mercury vapors in dental operator.
3. Work in well ventilated spaces with fresh air exchanges and outside exhaust..
4. Periodically check the dental operator atmosphere for mercury vapor. The current limit of mercury vapors established by *OSHA is  $50\mu\text{g}/\text{m}^3$  in any 8hrs work shift over a 40 hr work week.*

5. Use only pre-capsulated alloys; discontinue the use of bulk mercury and bulk alloy.
6. Use amalgamator with completely enclosed arm.
7. Use care in handling amalgam. Avoid skin contact with mercury or freshly prepared amalgam.
8. Properly dispose of the pre-capsulated alloy after use according to applicable waste disposal laws.

9. Use high volume evacuation when finishing or removing amalgam.
10. Salvage and store all scrap amalgam in a tightly closed container, either dry or under radiographic fixer solution.
11. Dispose of mercury contaminated items in sealed bags according to applicable regulations.
12. Remove professional clothing before leaving the workplace

# RECOMMENDATIONS IN HG HYGIENE

Store Hg in unbreakable, tightly sealed containers

Confine and facilitate the recovery of spilled hg or amalgam

Use tightly closed capsules during amalgamation

No-touch technique for handling

Amalgam scrap – under water that contains sodium thiosulfate

Avoid carpeting dental office

Avoid heating Hg or amalgam

Water spray and suction when grinding dental amalgam

Perform yearly Hg checks

# Amalgam Waste

- Non-contact amalgam
  - store in sealed container
- Contact amalgam
  - disinfect and dry
    - non-chlorine disinfectant
  - combine with non-contact amalgam
- Used amalgam capsules
  - recap, if possible
  - store in sealed container



# Amalgam Waste

- Extracted teeth
  - disinfect and dry
    - non-chlorine disinfectant
  - store in sealed container
- Chairside traps
  - disinfect and dry
  - store with used amalgam capsules



# RECYCLING OF MERCURY

- Stock amalgam capsules in a variety of sizes to minimize the amount of mercury generated and use the disposable capsules for recycling.
- Check with your state regulatory and municipality to find out if a bulk mercury collection program is carried out.
- Do not pour bulk mercury in biohazard containers, infectious waste containers or down the drain.
- Do not BLEACH or use CHLORINE based cleaners for line cleaning that might dissolve amalgam.



# Safety of amalgam

- Scientific groups throughout the world have investigated the safety of amalgam, and there is no evidence that the *minute amount* of mercury released from dental amalgams contributes to systemic disease or has any systemic toxicological effects. There is no justification for discontinuing the use of dental amalgam as a filling material or recommending replacement of existing amalgam fillings.

According to a report in 1992 by the United States Environmental Protection Agency showed that in 1989 discarded household batteries accounted for 86 per cent of waste mercury while dental amalgam represented only 0.56 per cent

Human studies show no correlation between the surface area of amalgam restorations and mercury levels in maternal blood, amniotic fluid, milk, or neonatal blood



# REFERENCES

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**THANK YOU**

