Filling materials are used to replace missing parts of the tooth.

**Factors causing loss of the tooth substance:**

1. Dental caries.
2. Trauma.
3. Abrasion.

Parts of teeth which require replacement by restorative materials vary in size of cavity, shape, and location in the mouth; no single restorative material is suitable for all cases. For some situations, the strength and abrasion resistance of material may be the prime consideration, in other situation appearance and adhesive properties may become more important.

**Requirements of an ideal filling material**

1. Working time should be sufficiently long, to enable manipulation and placement of material before setting.
2. Setting time should be short for comfort of both the patient and clinician.
3. The material must withstand large variation in pH and a variety of solvents which may be taken into mouth in drink food stuffs and medicaments.
4. Metallic materials should not undergo excessive corrosion, or be involve in the development of electrical currents which may cause "Galvanic pain".
5. Filling should be good thermal insulator, protecting the dental pulp from the harmful effect of the hot and cold stimuli (low thermal diffusivity).
6. Materials should have values of coefficient of thermal expansion similar to those of enamel and dentin.
7. Materials should have satisfactory mechanical properties to withstand the force applied, e.g. abrasion resistance, compression and tensile strength, modulus of elasticity.
8. They should adhere well to the tooth walls and seal the margin prevent ingress of fluid and bacteria. Also reduces the amount of cavity preparation required in order to achieve retention of the filling.
9. They should be harmless to the operator and to the patient and should not irritant to dental pulp and soft tissue.
10. Easily polished.
11. Should be bacteriostatic and anticariogenic.
12. It should be radiopaque to diagnose the marginal caries.
CLASSIFICATION OF FILLING MATERIALS

I- Metallic filling materials
- Amalgam.
- Direct gold filling.

II- Non-metallic filling materials
- Polymeric
  - Filled resin (composite).
  - Unfilled resin (acrylic).
- Non-polymeric:
  - Silicate cement.
  - Glass ionomer cement.

OTHER CLASSIFICATION

I- Anterior filling materials (tooth colored filling).
- Silicate cement.
- Acrylic.
- Composite.

II- Posterior filling materials.

AMALGAM

It is a special type of alloy in which mercury is one of the components. Mercury is able to react with other metals to form a plastic mass, which is conveniently packed into a prepared cavity in a tooth, and then this mass is hardened. It is the most widely used filling material for posterior teeth.
Applications

1- As a permanent filling material in:
   a- Class I and class II cavities.
   b- Class V cavities where esthetic is not important.
2- In combination with retentive pins to restore a crown.
3- For making a die.
4- In retrograde root canal fillings.
5- As a core material.

Classifications

I- Based on copper content
   1- Low copper alloys: contain less than 6% copper (conventional alloy).
   2- High copper alloys: contain more than 6% copper.

II- Based on shape of alloy particles
   1- Lathe-cut alloys: (irregular shape often needle-like either coarse grain or fine grain which is preferred because ease of carving).
   2- Spherical alloys.
   3- Blend of lathe-cut and spherical particles.

III- Based on size of alloy particles
   1- Microcut.
   2- Macrocut.
Figure (6-2): Dental amalgam alloys (Lathe-cut alloy particles).

Figure (6-3): Spherical alloy particles.

Figure (6-4): Lathe-cut particles of conventional alloy and spherical particles.
Supplied as

1- Bulk powder and mercury.
2- Alloy and mercury in disposable capsules mixed by amalgamator machine; figure (6-5).

Composition

1- SILVER (It is the 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 amalgam filling.

2- TIN
   - Control the reaction between silver and mercury, without tin the reaction is too fast and the setting expansion is unacceptable, but it decrease strength and hardness, and reduce tarnish and corrosion resistance, so the amount of tin should be controlled.
3- COPPER

- Increase hardness and strength.
- Increase setting expansion.

4- ZINC

- It is not affect the reaction and properties, but it is added in small amount to act as deoxidizer thus prevents oxidation of major elements during manufacturing.

5- MERCURY

**Setting reaction**

When alloy powder and mercury are triturated, the silver and tin in the outer portion of the particles dissolve into the mercury. At the same time mercury diffuses into the alloy particles and starts reacting with silver and tin present in it, forming (*silver-mercury*) and (*tin-mercury*) compounds.

- The silver-tin compound (unreacted alloy powders) known as gamma phase (γ).
- The silver-mercury compound is known as gamma one phase (γ1).
- The tin-mercury compound is known as gamma two phase (γ2).

\[
\text{Ag}_3\text{Sn} (\gamma) + \text{Hg} \rightarrow \text{Ag}_2\text{Hg}_3 (\gamma 1) + \text{Sn}_2\text{Hg} (\gamma 2) + \text{Ag}_3\text{Sn} \\
\text{(unreacted } \gamma)\\
\]

**Microstructure of set amalgam**

- Gamma (Unreacted particle)
- Gamma 2 (Tin-Mercury)
- Gamma 1 (Matrix)
Properties of set amalgam

1= **Microleakage:**
With age the amalgam has self-sealing property that decreases the microleakage due to the corrosion products that forms in the tooth-restoration interface.

2= **Effect of moisture contamination (delayed expansion):**
If a zinc-containing amalgam is contaminated by moisture during condensation large expansion can take place. It usually starts after 3-5 days and may continue for months. It may reach 4 % that produce pressure on the pulp and cause post-operative sensitivity.

\[
H_2O + Zn \rightarrow ZnO + H_2 \text{ (gas)}.
\]

*Figure (6-7):* An occlusal amalgam filling which has caused the tooth to crack. The most likely cause of this cracking is the expansion of the amalgam during or shortly after setting.

3= **Effect of trituration:**
Under- and over-trituration will decrease the strength.
4- **Effect of mercury content:**
- Low mercury in mixing lead to dry, granular mix resulting in rough pitted surface that invites corrosion.
- High mercury can produce a marked reduction in strength.

5- **Effect of condensation:**
Higher condensation pressure results in higher compressive strength this happen only in lathe-cut alloys. The condensation will decrease porosity, and remove excess mercury from lathe-cut amalgam. If heavy pressure is used in spherical amalgam, the condensation will punch through. However, spherical amalgam condensed with lighter pressure produces adequate strength.

6- **Effect of cavity design:**
- Should be designed to reduce tensile stresses.
- The cavity should have adequate depth, because amalgam has strength in bulk.

7- **Creep value:**
Creep is related to marginal breakdown.
- Low-copper amalgam 0.8-8 %.
- High- copper amalgam 0.4-1 %.

**Figure (6-8):** Creep of amalgam causes the formation of unsupported edges which can fracture.

8- Amalgam does not adhere to tooth structure, so retention is obtained through mechanical locking.
Amalgam restorations often tarnish and corrode in the mouth. This corrosion can be reduced by:

- Smoothing and polishing the restoration.
- Correct Hg/alloy ratio and proper manipulation.
- Avoid dissimilar metals including mixing of high, and low copper amalgams.

**ADVANTAGES**

1- Reasonably easy to insert.
2- Maintains anatomic form well.
3- Has adequate resistance to fracture.
4- After a period of time prevents marginal leakage.
5- Cheap.
6- Have long service life.

**DISADVANTAGES**

1- The color does not match tooth structure.
2- Brittle.
3- Corrosion and galvanic action.
4- They eventually show marginal breakdown.
5- They do not bond to tooth structure.
6- Risk of mercury toxicity.

**MERCURY TOXICITY**

Mercury is toxic, free mercury should not be sprayed or exposed to the atmosphere. This hazard can arise during trituration, condensation, and finishing, and also during the removal of old restorations at high speed. Avoid mercury vapors inhalation and skin contact with mercury as it can be absorbed.
Approximately 80% of the mercury vapor will be absorbed in the lungs, and 5–10% of the mercury (saliva) will be resorbed in the gastrointestinal tract. The hypothesized intake of mercury via oral mucosa or dental pulp, however, seems to be negligible.

There are no scientific studies that show that having dental amalgams is harmful, or that removing your amalgam fillings will improve your health. *(U.S. Food and Drug Administration, consumer information, October 2006)*

It has been determined that the dental amalgam fillings do not pose a health risk, although they do account for some mercury exposure to those having such fillings.

Mercury has a cumulative toxic effect. Dentists are at high risk. Through it can be absorbed by skin or by ingestion; the primary risk is from inhalation.

Mercury accumulates in the kidneys. If the dose exceeds the capacity limit, direct toxic damage of the proximal renal tubules.

The target organ of prime concern is the central nervous system. Tremor and psychological disturbances (ereethism) are classical symptoms of a chronic mercury intoxication caused by extensive occupational exposure. Ereethism is characterized by acute irritability, abnormal shyness, timidity, and overreaction to criticism. Disturbance of memory, loss of appetite, depression, fatigue, and weakness may also occur. Further symptoms of chronic intoxication with inorganic mercury are decreased nerve conduction velocity and gastrointestinal disturbances. Oral symptoms, including metallic taste, swollen salivary glands, disturbed salivation, severe gingivitis, mucosal ulcerations, necrosis, and even tooth loss have also been reported. Clinical symptoms of mercury poisoning that may be found in heavily exposed persons.
Precautions

1- The clinic should be well ventilated.
2- The mercury should be stored in well-sealed container.
3- Amalgam scrap and materials contaminated with mercury or amalgam should not be subject to heat sterilization.
4- Vacuum cleansers are not used because they disperse the mercury.
5- Skin contacted with mercury should be washed with soap and water.
6- While removing the old fillings, a water spray, mouth mask, and suction should be used.
7- The use of ultrasonic amalgam condenser is not recommended as a spray of small mercury droplets is observed.
8- If the mercury contact the gold jewelry the mercury bonds permanently to the gold and ruins, but boiling it in coconut oil can fix it.
9- Annually, a (programme for handling toxic materials) is monitored for actual exposure levels.