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Preparation of Work Pieces for Brazing

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Agenda Items



- Fundamentals of Brazing and Joint Design
- Assembly Gap, Brazing Gap, and Influencing Factors
- Selection and Influence of Brazing Filler Materials
- Influence of Parent Materials and Dissimilar Materials
- Surface Preparation: Wettability, Capillary Action, and Cleaning
- Atmospheres and Fluxes in Brazing
- Parent and Filler Materials Used in Aerospace and Defence
- Additional Considerations for Brazing Processes



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Fundamentals of Brazing and Joint Design

Principle of the Brazing Process



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Capillary Flow Mechanism

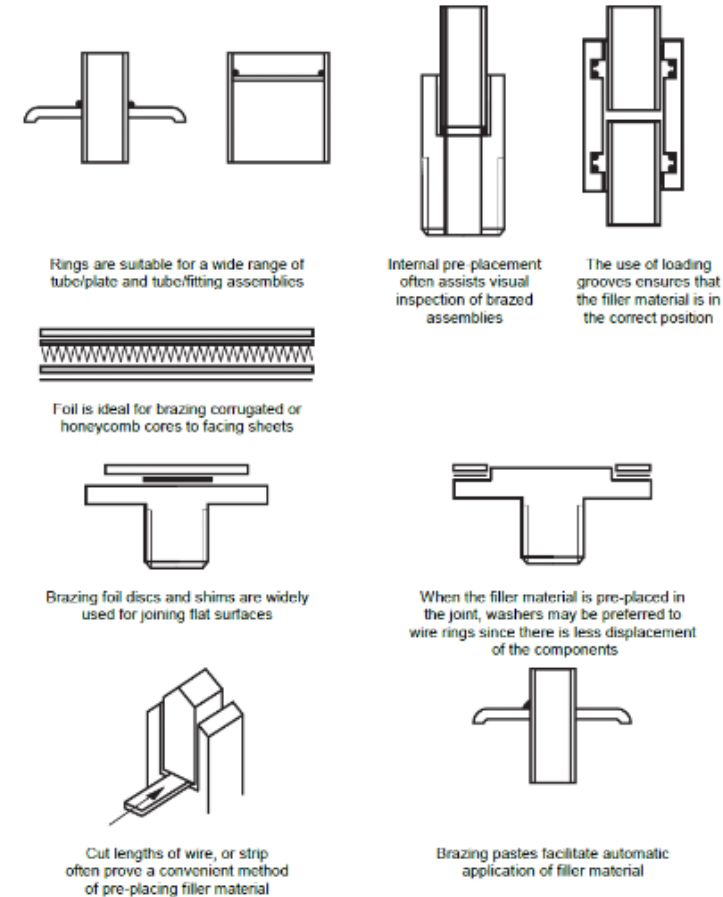
Brazing uses capillary action to draw molten filler metal into narrow gaps between components for joining.

Filler Material Composition

Filler metals differ in composition from base metals, affecting performance in heat, corrosion, and fatigue.

Impact on Parent Metals

The brazing cycle can alter material properties of the base metals being joined, influencing the final assembly.



Type of Joints

- **Lap Joints:** Preferred for ease of fabrication and higher mechanical strength.
- **Butt Joints:** Selected when the required strength is achievable, especially if base materials are weaker than the brazed joint or when lap joint dimensions are unsuitable.
- **Shear Strength in Lap Joints:** Effective overlap length should match the thickness of the thinner component; extra overlap adds little benefit.



a) Lap



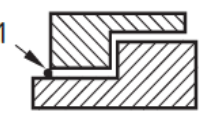
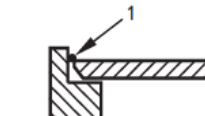
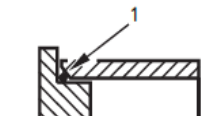
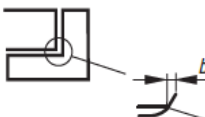
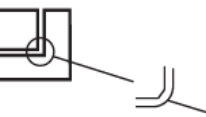
b) Butt

Assembly Gap and Brazing Gap



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- Different filler materials may require different gap sizes.
- Optimum gap can also be influenced by several other joint parameters, including:
 - The **type of parent material** or materials being joined
 - The **geometry** of the joint
 - The **surface finish** of the faying surfaces
 - The use of **flux or a protective atmosphere** during brazing
 - Careful control of both the **brazing temperature and the heating rate**
 - The **specific brazing process** employed

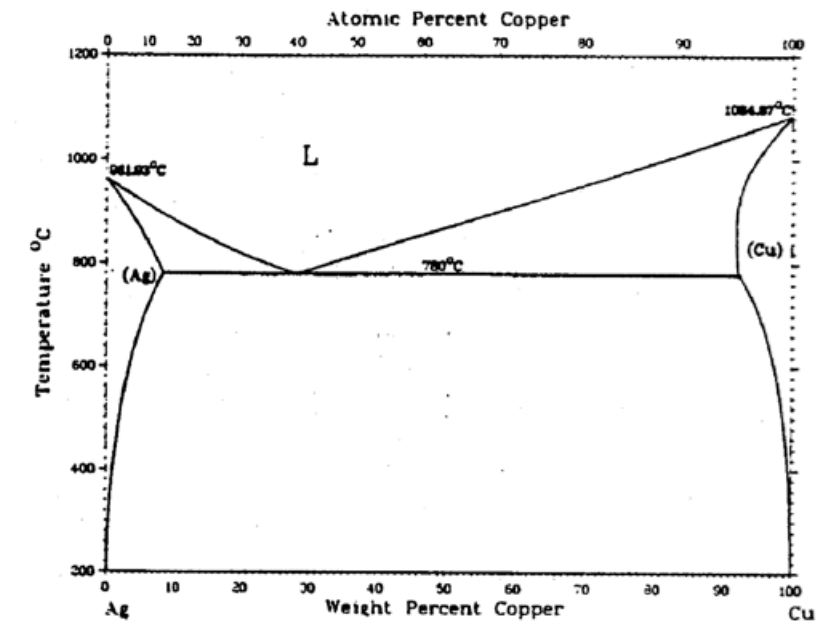
No.	Basic design	Improved design	Comments
1			1 – Filler material Where the gap varies, the filler material should be fed from the wider end.
2			1 – Filler material
3			2 – Barrier to flow 3 – Chamfer Chamfer added to aid filler material flow. This may also be aided by positioning filler material as shown in No. 2 of this table

Influence of Brazing Filler Materials



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Influence of Parent Material



- The type of parent material significantly affects the ideal brazing gap.
- If parent materials do not dissolve into the filler or form alloy layers, tighter gaps are recommended for better filler flow.
- Significant inter-alloying between filler and parent materials reduces filler fluidity.
- When inter-alloying occurs, a larger brazing gap is needed for complete filler penetration.
- The required gap size depends on the degree of alloying interaction between the filler and parent materials.

Influence of Dissimilar Parent Materials



- When brazing dissimilar parent materials, differences in thermal expansion must be carefully considered in joint design.
- Improper calculation can cause the joint gap to close or open excessively during heating, affecting filler metal penetration.
- The assembly setup should be based on the thermal expansion coefficients, component dimensions, and brazing temperature.
- These factors become increasingly important for larger assemblies, higher brazing temperatures, or greater expansion differences.
- Accurate joint design and calculation are crucial for reliable, high-integrity brazed joints when using dissimilar materials.



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Surface Preparation



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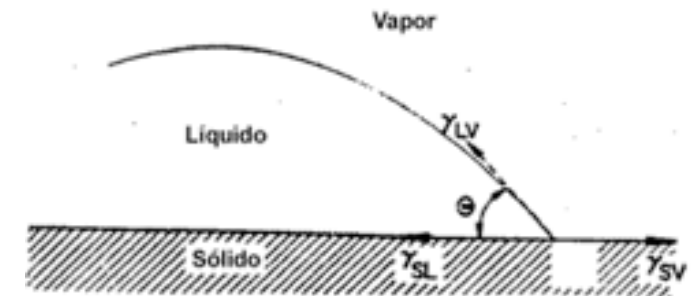
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Surface Preparation: Wettability

- Wettability is the ability of molten filler metal to spread and adhere to base materials, crucial for strong brazed joints.
- High wettability ensures even filler flow, strong bonds, and fewer joint defects.
- Wettability is assessed using the meniscodiagram (observing meniscus shape/contact angle) and the variable clearance test (measuring filler penetration in different gap widths).
- Surface tension and flux play key roles: flux removes oxides, lowering interfacial tension and improving wetting.
- Proper surface preparation—removing contaminants, roughening surfaces, or applying coatings—enhances wetting and joint quality.

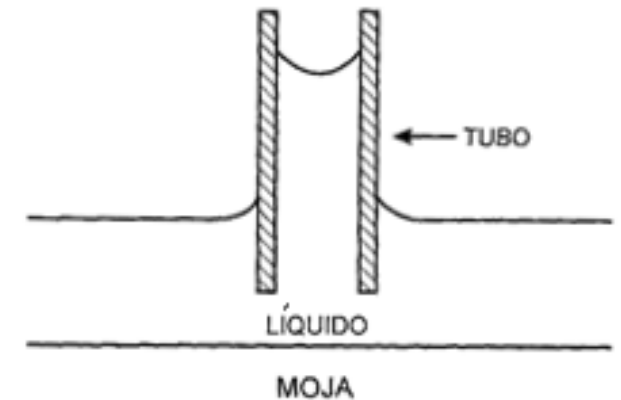




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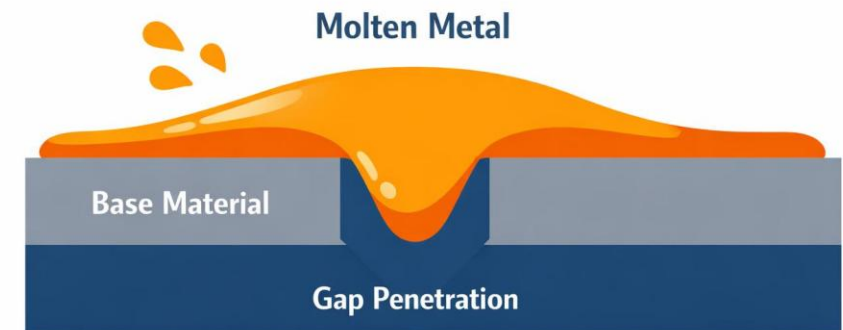
Surface Preparation: Capillary Action

- Capillary action drives molten filler metal into narrow gaps between base materials, ensuring complete and uniform joint filling.
- This phenomenon relies on surface tension and adhesive forces, as described by Jurin's law: narrower gaps enhance filler penetration.
- The meniscus shape at the interface indicates wetting quality—concave meniscus means effective capillary action and strong joints.
- Precise joint geometry and appropriate filler metal properties are crucial for optimal capillary flow and metallurgical bonding.
- Use of a 'stopping-off' agent helps control filler flow but must not enter the joint gap to avoid compromising joint integrity.



Surface Preparation: Optimal Conditions for Wettability and Capillary Action in Brazing

- Clean base metals thoroughly to remove oxides and contaminants for optimal wettability and capillary flow.
- Apply appropriate flux to maintain a clean interface and promote even spreading of molten filler metal.
- Design joints with consistent, narrow clearance (0.05–0.2 mm) tailored to materials for strong capillary action.
- Choose filler metals with suitable surface tension and melting characteristics; control temperature for uniform heating.
- Select joint type, filler, and brazing technique to ensure mechanical properties meet or exceed the weakest component's requirements.



Surface Cleaning



- Thorough cleaning of base and filler metals is essential for strong brazed joints, ensuring effective capillary action and wetting.
- Contaminants like oxides, grease, and oil must be removed just before brazing to prevent recontamination and facilitate optimal metal flow.
- Cleaning methods are categorized as chemical or mechanical, and maintaining correct joint clearance after cleaning is critical for quality results.

Chemical Cleaning Methods

- Chemical cleaning encompasses a variety of techniques and agents tailored to the specific contaminants and materials involved:
 - **Solvents**, such as petroleum-based or chlorinated hydrocarbons
 - **Degreasing vapors**, including stabilized trichloroethylene or perchloroethylene
 - **Alkaline products**, which may be commercial blends of silicates, phosphates, carbonates, detergents, wetting agents, and occasionally hydroxides
 - **Emulsion cleaners** made from hydrocarbons, fatty acids, wetting agents, and activators
 - **Electrolytic cleaners**, both anodic and cathodic types
 - **Acid cleaners**, typically phosphates
 - **Pickling acids** such as sulfuric, nitric, or hydrochloric acid
 - **Salt bath pickling**, which may be electrolytic or non-electrolytic
 - **Ultrasonic cleaning**, using high-frequency sound waves to remove contaminants



Mechanical Cleaning Methods



- Common mechanical cleaning techniques include:
 - Grinding or using abrasive wheels
 - Filing
 - Blasting, which involves projecting clean particles, liquids, or gases onto the surface
 - Brushing

Special Considerations



- Flux-free atmosphere brazing demands strict cleanliness, often requiring assembly in dedicated clean rooms to prevent contamination.
- Coating joint surfaces with highly weldable materials—using methods like hot dipping or electrolytic immersion—can improve brazing quality and eliminate the need for strong acid fluxes.
- Surface coatings are especially helpful for base metals that easily form stubborn oxide layers, ensuring better joint integrity.
- The required cleanliness level is determined by the desired component quality and the specific brazing process.
- The highest cleanliness standards are essential for flux-free, controlled atmosphere brazing at elevated temperatures.



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Influence of Atmospheres and Fluxes on Brazing

- The choice of atmosphere or flux during brazing is crucial for joint quality, allowing for tighter joint gaps and preventing defects.
- Controlled atmospheres and vacuums prevent oxidation and help reduce oxides, ensuring good filler metal flow and strong joints.
- Furnace brazing commonly uses controlled atmospheres; induction and resistance brazing may also apply them.
- Non-noble base metals react with air at high temperatures, forming oxides and other compounds that can weaken joints; fluxes and atmospheres prevent these reactions.
- Flux dissolves and removes oxides during heating, ensuring a clean surface for the filler metal and a reliable bond.

