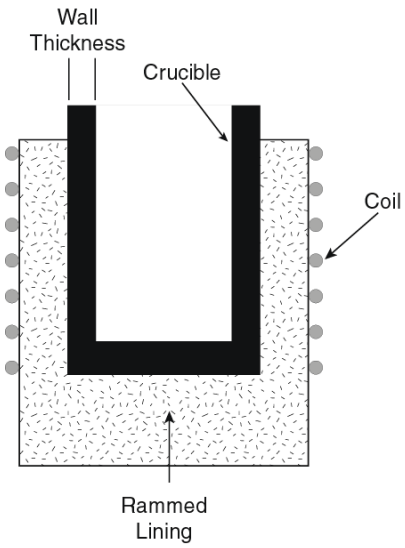
Crucible and Ram Selection for Induction Melting

SELEE® Advanced Ceramics™ Technical Service

"The selection of the proper crucible and ram forms the basis for extending crucible life and performance."

Five Important Aspects of Crucible Selection:



1. Proper fit into furnace

- Fit into furnace is essential to crucible performance.
- As a guideline, use 1 to 1.5" of ram for every 1" of wall thickness.
- Minimum of ½" ram on side walls.
- Minimum of 3" of ram on the bottom floor.
- The bottom of the crucible should be even with the bottom coil.
- To prevent thermal shock, a minimal amount of the crucible should extend above the furnace.

2. Physical Properties

- Crucibles with higher hot strengths tend to erode less.
- Hot strength is the best physical measure for determining crucible life.

3. Chemical Considerations

- During induction melting, an acid and a base react to form slag.
- Refractories, additives, and rams are classified as acidic, neutral, and basic and should be matched with the melt chemistry to prevent slag. (Table 1)
- The 90% alumina crucible is most widely used since it is neutral and provides minimal reaction across a large array of alloys used today.
- High manganese steel and nodular irons are very basic and react with silica to erode a crucible. To combat this, a higher alumina refractory or a more basic refractory like spinel ($MgAl_2O_4$) can be used.

Table 1. Refractory Chemical Compatibility

Condition	Recommended Material
Acidic	Zircon ($ZrSiO_4$) Silica (SiO_2) Mullite ($Si_2Al_6O_{13}$)
Neutral	Alumina (Al_2O_3) Spinel ($MgAl_2O_4$) Zirconia (ZrO_2)
Basic	Magnesia (MgO)

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4. Thermal Characteristics

- Melt Temperature

  -A high melt temperature decreases crucible strength and allows for more erosion.

- Thermal Expansion

  -Thermal expansion impacts both a materials thermal shock resistance and the ability of a material to withstand thermal cycling.

  -High expansion materials such as magnesia, zirconia and alumina need to be held in compression so they do not expand and crack.

  -Fused silica is a low expansion material and can be used freestanding generally for transfer ladles and lift coil furnaces.

- Thermal Conductivity

  -Highly conductive materials will transfer heat quickly for improved thermal shock resistance.

5. Ram Selection

- Dry Vibratable Rams Must:

  -Have a high thermal expansion to hold crucible tightly in compression.

  -Have an optimized grain size distribution for maximum packing density, minimal shifting, and easy packing.

  -Sinter upon contact with metal.

- Chemical Considerations

  -Matching ram materials with the melt chemistry will provide a working back up lining if metal penetrates through the crucible. (Table 2)

- Wet Rams Must:

  -Be of a high purity material and should closely match the melt chemistry to resist slag and metal penetration.

  -Come with the proper moisture content for easy forming.

Table 2. Chemical Compatibility of Ram Materials.

Condition	Recommended Material
Acidic	Silica (SiO_2)
Neutral	Spinel ($MgAl_2O_4$)
Basic	Magnesia (MgO)

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