Refractories 101 – Refractories for Power Generation

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ZAMPELL REFRACTORIES
Refractories – Why do we need them

- Protect against Corrosion / Erosion
- Protect against Abrasion
- Provide Thermal Insulation and Efficiencies
Refractories 101

❖ Types of Refractories

❖ Key Data Sheet Properties

❖ Refractories for Power Generation

❖ Destructive Conditions
Types of Refractories

- Plastics
- Castables
- Bricks & Shapes (Tiles)
Plastic Refractories

SiC Plastic

High Alumina Plastic
Castable Refractories - Pouring
Castable Refractories - Gunning
Castable Refractories - Shotcrete
Brick & Shape Refractories
Brick & Shape Refractories
Key Data Sheet Properties of Refractories

- Chemical Analysis
- Density
- Strength
- Abrasion Resistance
- Thermal Conductivity
Refractory Properties

- Technical Data *Is*:
  - Average Production / Lab data
  - List of Important Physical Properties for use in Comparing Similar Products and Predicting Performance

- Technical Data *Is Not*:
  - To be used for specification values Min – Max
  - Duplication of all service conditions
  - Everything there is to know about a product.
Product Description –
  - Describes General Terms on Product

Service Temperature

Material Required.

Recommended Water Addition
  - Castables

Service Temperature: 3000 °F
Material Required: 155 lb/ft³
Typical Water Required: 5.0 - 6.0 %
Maximum Grain Size: -
## Chemical Analysis - %

<table>
<thead>
<tr>
<th>Chemistry</th>
<th>Fireclay Castable</th>
<th>High Alumina Gun</th>
<th>SiC Plastic</th>
<th>Fused Silica Gun</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{Al}_2\text{O}_3$</td>
<td>38</td>
<td>61</td>
<td>8.3</td>
<td>45.8</td>
</tr>
<tr>
<td>$\text{SiO}_2$</td>
<td>48.5</td>
<td>34</td>
<td>5.8</td>
<td>47.7</td>
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<tr>
<td>CaO</td>
<td>8.3</td>
<td>2.4</td>
<td>-</td>
<td>5.5</td>
</tr>
<tr>
<td>$\text{P}_2\text{O}_5$</td>
<td>-</td>
<td>-</td>
<td>4.1</td>
<td>-</td>
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<tr>
<td>SiC</td>
<td>-</td>
<td>-</td>
<td>80</td>
<td>-</td>
</tr>
<tr>
<td>Other / Impurities</td>
<td>5.2</td>
<td>2.6</td>
<td>1.8</td>
<td>1.0</td>
</tr>
</tbody>
</table>
DENSITY – lbs / cu ft

- Fiber: 6 lbs / cu ft
- Lite: 8 lbs / cu ft
- Wate: 40 lbs / cu ft
- Fused Silica: 118 lbs / cu ft
- Fireclay: 120 lbs / cu ft
- High Alumina: 145 lbs / cu ft
- SiC: 165 lbs / cu ft
- Zampell
STRENGTH

- Cold Testing – Measured at Room Temperature *AFTER* firing to a designated temperature.
- Hot Testing – Measured *AT* a designated temperature.

FACTS

- Hot data is more representative of what materials performance in working conditions.
- Cold data properties are more used as controls in the manufacturing and QC process. Data should not be used for specification purposes.
- Hot Data at high temperatures is lower than cold data (*glasses form during the firing and cooling of product giving added strength at room temperature*).
**Strength**

- **CCS** — measure of compressive strength
- **MOR** — measure of flexural breaking strength
<table>
<thead>
<tr>
<th>Strength Test</th>
<th>Fireclay Castable</th>
<th>High Alumina Gun</th>
<th>Fused Silica Gun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold Crushing Strength AFTER firing to 1500 F</td>
<td>3000</td>
<td>6219</td>
<td>7435</td>
</tr>
<tr>
<td>Cold Modulus of Rupture AFTER firing to 1500 F</td>
<td>600</td>
<td>1837</td>
<td>1422</td>
</tr>
<tr>
<td>Hot Modulus of Rupture AT 2500 F</td>
<td>40</td>
<td>425</td>
<td>800</td>
</tr>
</tbody>
</table>
KEY PROPERTIES – Abrasion Resistance

All data is typical and should not be used in specifying products.
Abrasión Resistencia – Material Loss

LW Castable, + 60 CC Loss

SiC Plastic < 12 CC Loss
Thermal Conductivity (Tc) – Btu’s-in/sf-hr-F

- Ceramic fiber = <1
- Fireclay products = 6-8
- High alumina = 10-15
- SiC = 60 – 100

- The lower the number the better an insulator
- The higher the number the better a conductor
All data is typical and should not be used in specifying products.
Summary – What do you do with this info

- Temperature you operating at
- Class and Bond Types
- Material & Water needed
- Heat transfer – thermal conductivity - is Insulation Required as back-up
- Comparing Strengths vs products
  - Cold and Hot
- Comparing Abrasion Resistance vs products
Refractory Material Selection Guide

[Diagram of industrial equipment]
Refractory Selection for Power Generation

- Type of fuel
  - (coal / biomass / refuse / gas / oil / pet coke)
- Boiler Operating Conditions
  - Ox, Reducing, ReOx
- Specific application (required properties)
- Preferred installation method
  - Cost
  - Good, Better, Best
  - Schedule
  - Access to Areas
Utility (PC) Boilers

Utility Boilers

- Insulating Castables
- Fireclay Castables
- Fireclay Gunning Mixes
- Shotcrete Mixes
- Fast Fire Gunning Mixes
- Fused Silica Products
- SiC Products
Wet Ash Hopper - Center Wall
Ash Hopper - Complete
Boiler Tube Walls
Boiler Tube Walls - Gunite
Industrial Boilers

Package Boilers

Black Liquor Boilers

Firetube Boilers

• Fireclay Bricks and Tiles
• High Alumina Plastic
• Rapid Fire Gun Mixes
• Insulation
Waste-to-Energy Incineration

- Plastics
  - SiC
  - Alumina-Chrome

- SiC Tile Back Cast / Mortar

- Fast Fire Gun Materials
  - 60 % Alumina
  - Fused Silica
  - SiC
Plastics
SiC Tiles
Circulating Fluidized Bed (CFB) Boilers

- **Cyclone Roof**
  - Abrasion Resistant Plastics and Gun Mixes

- **Cyclone**
  - Abrasion Resistant Gun Mixes
  - Plastics
  - Brick

- **Return Seal**
  - Abrasion & Thermal Shock Resistant Vibration Castables

- **Outlet Hood**
  - Insulating High Strength

- **Combustor**
  - Abrasion Resistant Plastics
Circulating Fluidized Bed (CFB) Boilers

Cyclone Roof
Fast Fire 60%
Shotcrete 60%
Plastic 70%

Cyclone
FastFire 60%
Shotcrete 60%
Plastic 70%
Special AR

Return Seal
Fused Silica Castable
Fast Fire Fused Silica

Outlet Hood
Castable 50%
Shotcrete 50%
LITE WATE® 25/80

Combustor
Plastic 70%
Plastic SiC
Special AR
Destructive Conditions in Boiler Applications

- Corrosion / Erosion
- Abrasion
- Thermal Cycling
- Thermal Heat Transfer
Material Selection Guide

- Corrosion / Erosion
  - Alkali Attack
    - (Na2O, K2O)
  - Volume Expansion
  - Weaker Material

- Product Type
  - Alkali Resistant
  - High Alumina
  - Ultra / Low Cement
  - Phos-Bonded
Alkali Testing
# Alkali Resistant Refractories

<table>
<thead>
<tr>
<th>Chemistry</th>
<th>High Alumina Plastic</th>
<th>High Alumina Gunite</th>
<th>High Alumina Brick</th>
<th>High-Alumina – SiC Gun</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al₂O₃</td>
<td>70%</td>
<td>61%</td>
<td>63%</td>
<td>48%</td>
</tr>
<tr>
<td>SiO₂</td>
<td>20%</td>
<td>34%</td>
<td>35%</td>
<td>26%</td>
</tr>
<tr>
<td>CaO</td>
<td>-</td>
<td>2.4%</td>
<td>-</td>
<td>2.2%</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>4 %</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SiC</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>21%</td>
</tr>
<tr>
<td>Other &amp; Impurities</td>
<td>4%</td>
<td>3%</td>
<td>2%</td>
<td>3%</td>
</tr>
</tbody>
</table>
Material Selection Guide

- Abrasion / Mechanical
  - High Velocity
  - Impact

- CC – Loss, Measure of Wear
  - Good 12-18
  - Better 8-10
  - Best <6
  - Extreme <3
Abrasion Resistance

CC - Loss

- HA Gun
- HA Plastic
- HA Brick
- SiC Brick
- HA Special

ZAMPPELL
Coal Pulverizer
Material Selection Guide

- Thermal Shock
  - Rapid Heat
  - Rapid Cool
  - Low Coeff. Of Expansion
Thermal Heat Transfer

Heat Flow Calculation

<table>
<thead>
<tr>
<th>Material</th>
<th>Thickness (in)</th>
<th>K-factor (BTU-in/hr-ft²-F)</th>
<th>Temperature (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>85-Ram HS Plastic</td>
<td>12.00</td>
<td>13.72</td>
<td>2000</td>
</tr>
<tr>
<td></td>
<td>12.00</td>
<td>490</td>
<td>54177</td>
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<td></td>
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<td>1726</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Hot Face Temp. (F)</td>
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<tr>
<td></td>
<td></td>
<td>Cold Face Temp. (F)</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Heat Loss (BTU/sq.ft/hr)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat Storage (BTU/Sq.ft)</td>
<td></td>
</tr>
</tbody>
</table>

Ambient Temperature = 80 (F)
Windspeed = 0 (MPH)
Emissivity = 0.95
Construction = Sidewall

Thermal Profile

Thermal Profile

Heat Flow Calculation

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<tr>
<th>Material</th>
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<th>Temperature (F)</th>
</tr>
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<tbody>
<tr>
<td>85-Ram HS Plastic</td>
<td>12.00</td>
<td>11.57</td>
<td>2000</td>
</tr>
<tr>
<td>Griptex Block Insulation</td>
<td>4.00</td>
<td>0.71</td>
<td>1718</td>
</tr>
<tr>
<td></td>
<td>16.00</td>
<td>191</td>
<td>272</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat Loss (BTU/sq.ft/hr)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat Storage (BTU/Sq.ft)</td>
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Thermal Profile

Thermal Profile
Thermal Heat Transfer
Questions / Thank You