Silica Refractories

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Topics

- Basics:
  - Silica refractories
  - What are the alternative refractories?

- Testing of worker PEL

- What can we do?
Common Refractory Aggregates

Magnesia (MgO) 2700–3300°F
  Steel Coreless
  Channel Inductors

Alumina (Al₂O₃) 800–3300°F
  Channel Furnaces, Ladles,
  Coreless (Steel, Cu, Al, Zn)

Silica (SiO₂) 1800–3000°F
  Coreless Furnaces (Iron, Cu)
Most widely used and discussed:

Quartz–based dry vibratables

Nom. 99% SiO₂ content

0–2% addition of boron based binder
Why is silica used?

- Total Cost (mineral cost and lower density)
- Excellent thermal shock resistant
- Non-wetting to iron and slags
- Glass forming properties impede zinc and other vapors
- Lower thermal conductivity
Reversible Expansion Properties

Temperature (°F)

Linear Expansion (%)
Dilatometer Data

![Graph showing dilatometer data for Standard Quartz Dry Vibratable and Quartz Dry Vibratable + 30% Fused Silica. The graph plots EXPANSION (%) against TEMPERATURE (°C).]
Dilatometer Curve – Spinel

% Change in Length

Temperature (°F)
Silica Forms

Quartz Form

- Polymorphs
  - Alpha-quartz – <1000°F
  - Beta-quartz – 1000° – 1600°F
  - Tridymite – 1600°–2700°F
  - Cristobalite – 2700°–3100°F

- Fused silica >3100°F
Other refractories that contain SiO$_2$

- Clay-ganister gun mixes (cupola and arc furnace)
- Cupola bottom materials (silica and fireclay blend)
- All clay-alumina refractories contain some portion of silica.
Other Minerals

Clay gannister and fireclay deposits
- 50 - 85% SiO₂

Clay used in plastics, castables, rams, gunning materials
Refractory Minerals

- Tabular Alumina
- White Fused Alumina
- Brown Fused Alumina
- Fused Magnesia

Castables/Plastics/Gun

- Bauxite 10 – 15% SiO$_2$
- Mullite 30 – 35% SiO$_2$
- Andalusite

Steel DRI–VIBEs < 1.0% SiO$_2$
What are the alternatives to reduce silica exposure in refractory applications?

- **Reduce or eliminate silica from source**
  - Change refractory types
    - Spinel forming
    - Andalusite/mullite

- **Dust collectors**

- **Dust suppressants**

- **Packaging**

- **Automated installation equipment**
Can we use alternative (non-quartz) lining materials?

- High alumina spinel forming materials are used extensively in steel foundries (Cost is about 5 – 10 times that of SiO₂ lining)

- In some high volume ductile iron applications (heel melting, 24/7 operations) andalusite lining is utilized in a cost effective manner.
Andalusite, The Mineral

- Silicate
- $\text{Al}_2\text{SiO}_5$
- Same composition
  - Kyanite
  - Sillimanite

- First samples thought to be from Andalusia, Spain
Advantages of this mineral

- Best thermal shock resistance of aluminosilicates
- Excellent creep resistance
- Low residual tramp elements
Comparison of Grain Structure

Cross section of traditional Silica-based lining

Cross section of andalusite-based lining
Cracking/Finning
Concern with Cracking/Fins
What are the regulations?

Exposure to employees over a full shift (time weighted average)

Testing is for overall dust as well as crystalline silica
Regulations

- Overall limit for dust is 5.0 mg/m$^3$

- Crystalline Silica
  - 0.05 mg/m$^3$, down from 0.10 mg/m$^3$

- Into effect June 23, 2018
Testing

- Employees wear monitoring device during their entire shift.
- Device samples are cyclonic and designed to filter out large particles and to capture the remaining smaller particles.
- The remaining dust is then tested by XRD (X-Ray diffraction) to determine the portion of crystalline silica.
Testing

- Testing should be completed to establish baseline and what actions to be taken

- Cannot assign administrative controls until engineering controls have been utilized.
Other Actions

- Dust collectors
- Dust suppressants
- Packaging
- Automated installation equipment
Administrative Controls

- Half mask respirator – 10 X the effectiveness of no respirator
- Full face respirator – 50 X the effectiveness of no respirator
- Supplied air respirator – > 50 X the effectiveness of no respirator
Summary

- Alternatives exist to replace silica refractories, but total cost will be higher.
- Improvements to the process can be made with changes/optimization.
- Testing for baseline is the first step.
Stay Safe!