



# Applied Performance Tests and Characterization of Silica Refractories for Accurate Selection in Designing Glass Furnaces

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MATERIAL ANALYSIS AND CHARACTERIZATION MANAGEMENT**

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# 1. Introduction

**Refractory testing:** To choose the most suitable refractory from various type according to the performance tests.

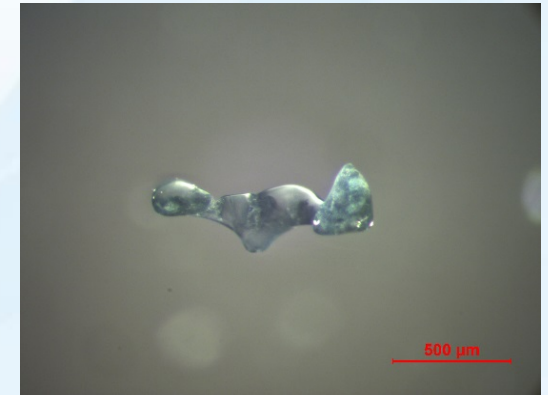
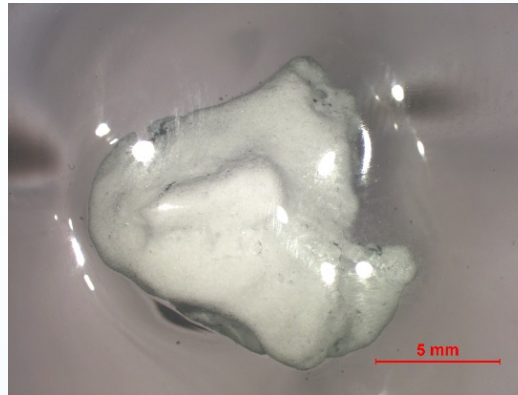
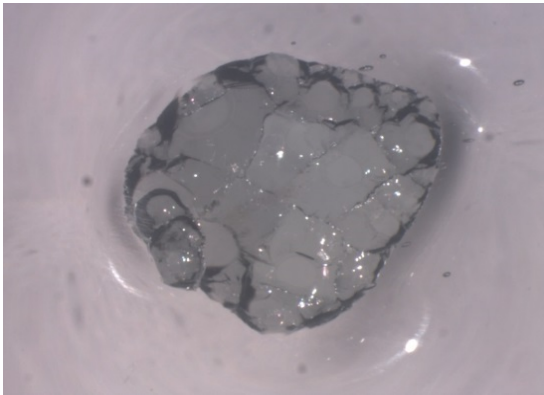
Making a suitable refractory selection,

- Total cost of cold repair/new construction of a new plant can be saved up to %15
- Long lasting campaign



# Material selection : Quality /

Wrong refractory selection may cause glass defects more often as shown below that means; loss of **energy**, loss of **productivity** and loss of **money**



## 2. Silica Refractories in Glass Production



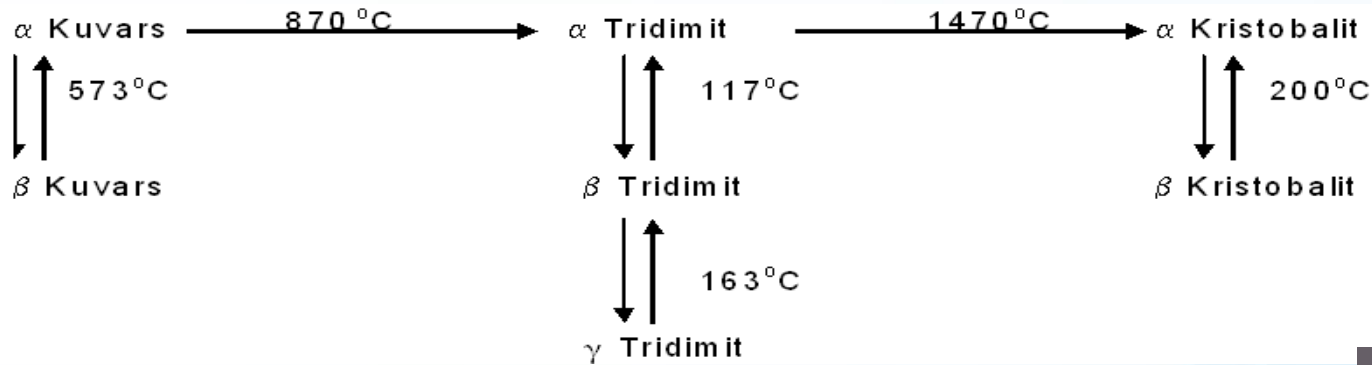
- Melter crown
- Refiner superstructure
- Curtain walls (A Wall top – B Wall )
- Working End crown / superstructure / curtain walls
- Regeneretor crown

# 3. Silica Facts

Silica is the most confusing oxide in glass production.

- In the batch
- On the refractories

Although it is easy to identify the silica defects, it is difficult to identify the source.



Silica stone source:

1. Silica agglomeration or segregation of sand
2. Single quartz
3. Silica Refractories which are use crown or SS
4. Mortars which consist of silica
5. Devitrification



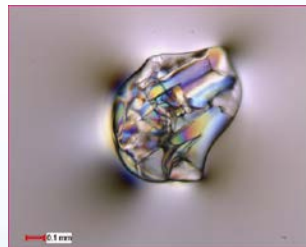
# 4. Determination & Application of Performance Tests

## a. Conditions in Use

	Usage Area/s (Main)	Condition/s in Use	Risks	Problems / Defects
<b>Silica</b>	<ul style="list-style-type: none"> <li>• Crown</li> <li>• Refiner</li> <li>• Superstructure</li> <li>• Regenerator crown</li> </ul>	<ul style="list-style-type: none"> <li>• Flame</li> <li>• Batch dusting</li> <li>• Furnace Atm.</li> </ul>	<ul style="list-style-type: none"> <li>• Alkaline Attack</li> <li>• Sulphate Attack</li> </ul>	<ul style="list-style-type: none"> <li>• Rathole</li> <li>• Collapse</li> <li>• Drip</li> <li>• Frost</li> </ul>



Crown refractory



Silica Frost defect



Curtain Wall of a float furnace



Silica Drip defect

## b. Characterization

### XRF / XRD / SEM / Thin section on optical microscope

Numunenin Niteliği	% SiO <sub>2</sub>	% Al <sub>2</sub> O <sub>3</sub>	% Fe <sub>2</sub> O <sub>3</sub>	% TiO <sub>2</sub>	% CaO	% MgO	% Na <sub>2</sub> O	% K <sub>2</sub> O	% MnO	LOI
SAMPLE 1	96,50	0,55	0,14	0,06	2,29	0,11	0,01	0,11	0,007	0,22
SAMPLE 2	96,45	0,48	0,18	0,03	2,47	0,12	0,02	0,09	0,008	0,15
SAMPLE 3	97,12	0,44	0,26	0,02	1,84	0,03	0,01	0,09	0,002	0,19
SAMPLE 4	96,79	0,31	0,59	0,01	1,98	0,11	0,00	0,06	0,012	0,14

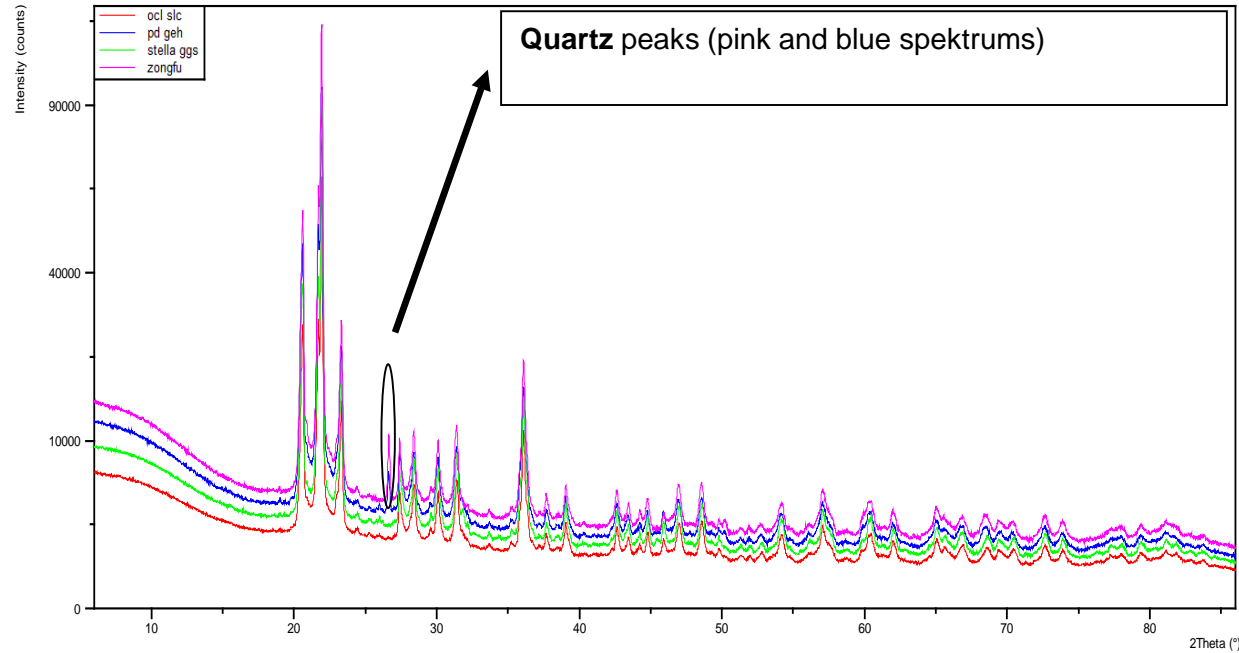
	Al <sub>2</sub> O <sub>3</sub> +TiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub> +2R <sub>2</sub> O (Flux Factor)
SILICA 1	0,597	0.79
SILICA 2	0,141	0.2

SiO<sub>2</sub> > %96

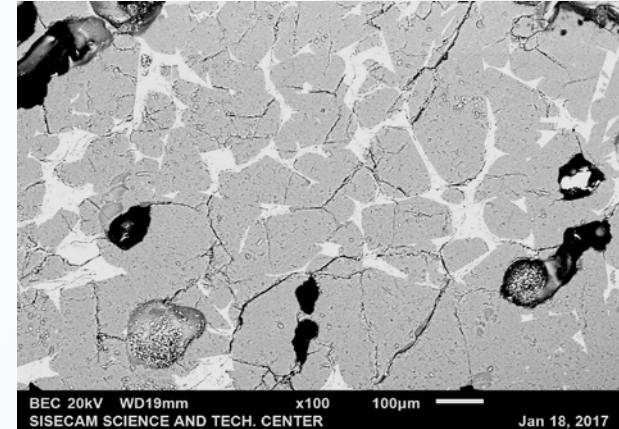
Al<sub>2</sub>O<sub>3</sub>+TiO<sub>2</sub> < %0,58

Al<sub>2</sub>O<sub>3</sub>+2R<sub>2</sub>O < %1

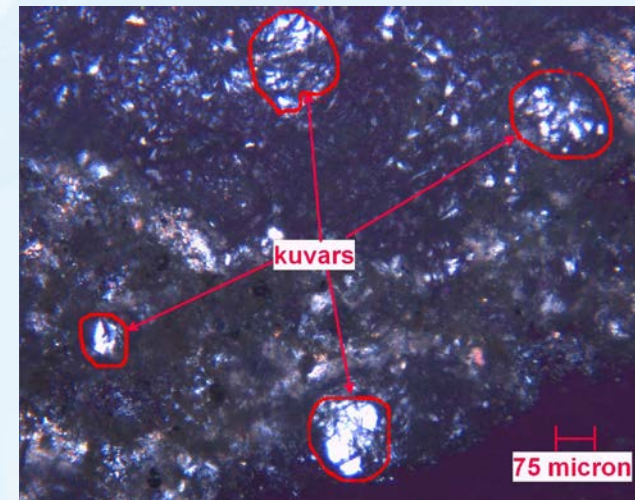
# XRF / XRD / SEM / Thin section on optical microscope



XRD Spektrums



SEM photo

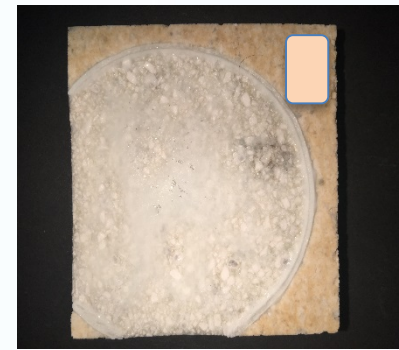


Thin section photo

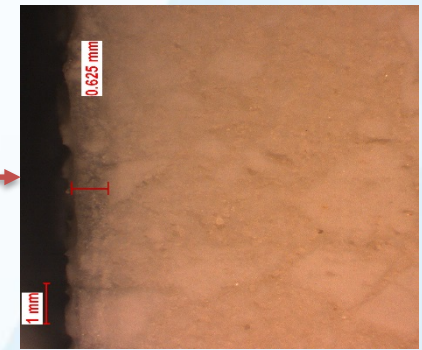
## c. Alkaline Penetration Test for Silica Refractories

How to simulate:

- An aggressive batch is prepared
- Pour it into a pot,
- Mount the refractory sample onto the pot,
- Refractory sample dimensions are 1x8x8cm<sup>3</sup>
- Set the temperature 1450°C for 5-24 hours



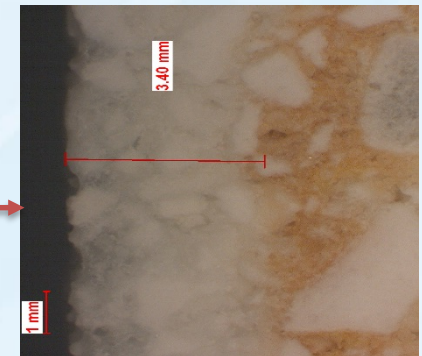
Surface Image A



Cross Section Image A



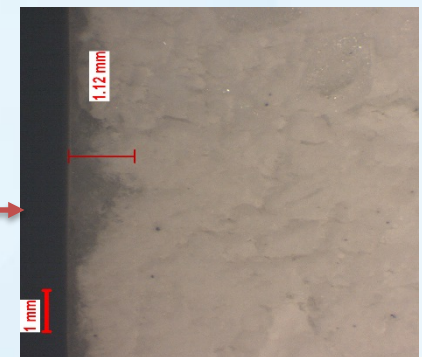
Surface Image B



Cross Section Image B



Surface Image C

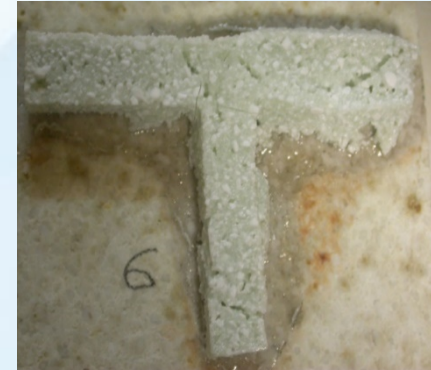
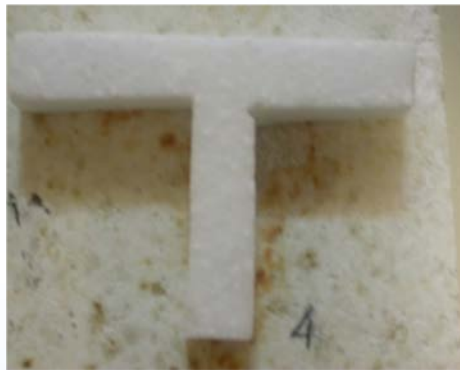


Cross Section Image c

## d. Sulphate Attack Test for Silica Refractories

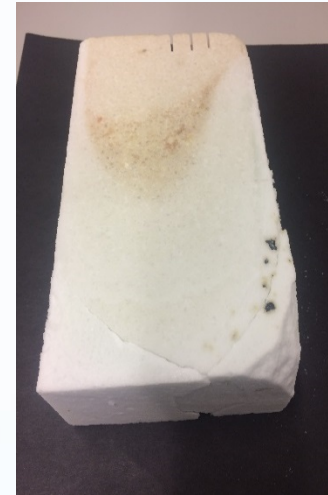
How to simulate:

- Batch is %100  $\text{Na}_2\text{SO}_4$  in a pot,
- Melt it in the furnace which is set to 1100 °C,
- Then put the T samples into the platinum pot for 5 min.,
- Set the furnace again 1450 °C for 5 hours.

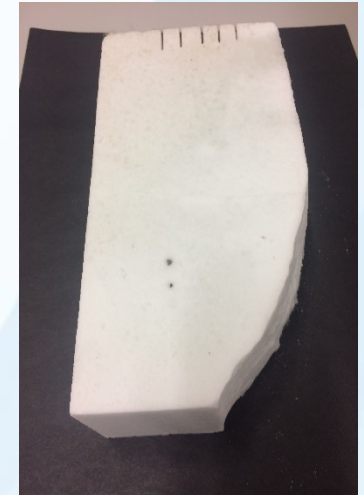


# A Further Step: In -Situ Trials for Silica Refractories

- Using silica bricks itself in furnace peepholes for a couple months,
- Providing them same conditions during In situ test,
- After test, finally slice the brick and measure the  $\text{Na}_2\text{O}$  contents of refractories inward by XRF. Also XRD analysis comparaces help understanding the transformation differences.

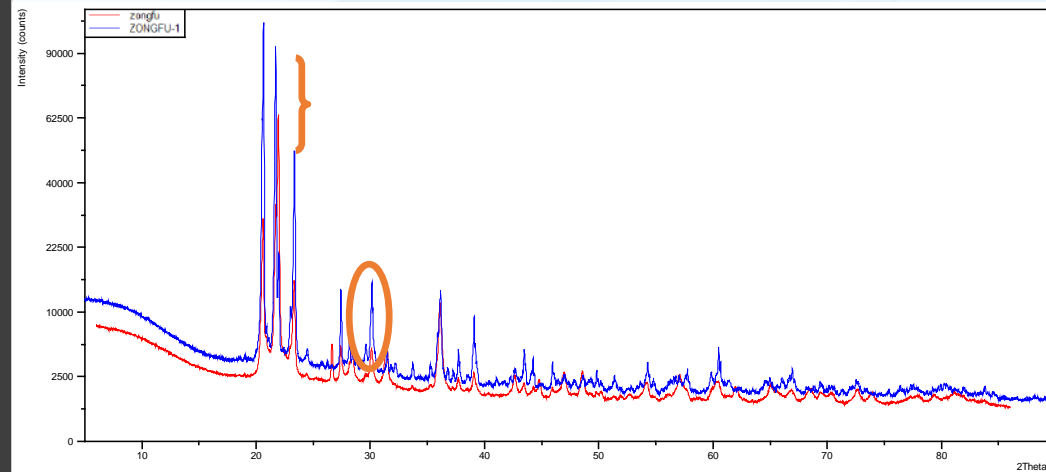
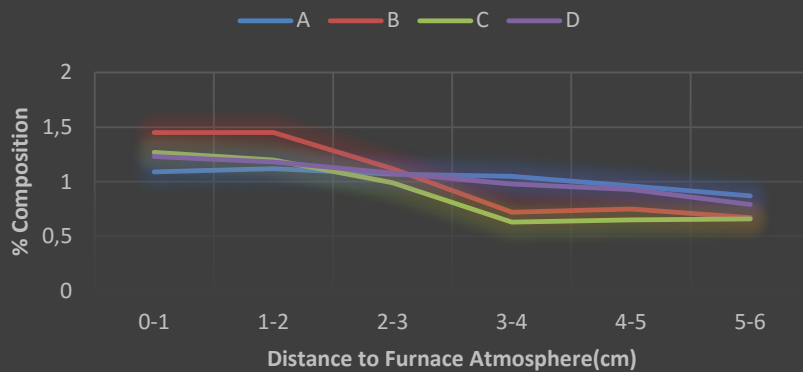


Sample A



Sample B

## $\text{Na}_2\text{O}$ Diffusion



# 5. Results and Discussions

- Chemical analysis (XRF)
- Phase analysis (XRD)
- Microstructure observations (OM & SEM)
- Cold crushing
- Creep test

	Type/s	For	Remarks/Observations
<b>Alkaline Penetration Test</b>	<ul style="list-style-type: none"><li>• Silica</li></ul>	Estimate & compare of alkaline penetration resistance of refractories	Factory trials assist to see alkaline penetration
<b>Sulphate Attack Test</b>	<ul style="list-style-type: none"><li>• Silica</li></ul>	Estimate & compare of sulphate attack resistance of refractories	Represents also batch dusting resistance

# Suggestion

- The refractory test methods on standards are not for glass manufacturers.
- TC11 should determine the standard test method for all types of refractories, especially silica.

So;

- Each glassmaker can make their own refractory tests.
- And refractory manufacturers and glass producers can meet in same plane

# Thanks for Your Attention!!!

