

Determination of humidity content

Date of testing: August 10, 2017

The results are related to delivered material

| Sample | Humidity [wt-%] |
|----------------------|----------------------------|
| Granulite-160 | 0,09 |
| Granulite-300 | 0,07 |



Chemical analysis of refractory products by XRF

fused cast bead method
determined according DIN EN ISO 12677*

Date of testing: August 10, 2017

The results are normalized to 100 wt.-% and related to ignited material

| | Granulite-160 | Granulite-300 |
|---|----------------------|----------------------|
| Al₂O₃ | 35,54 | 36,31 |
| SiO₂ | 59,54 | 58,48 |
| Fe₂O₃ | 1,27 | 1,45 |
| TiO₂ | 1,07 | 1,11 |
| CaO | 0,68 | 0,72 |
| MgO | 0,32 | 0,42 |
| K₂O | 0,66 | 0,61 |
| Na₂O | 0,38 | 0,34 |
| Mn₃O₄ | <0,01 | <0,01 |
| Cr₂O₃ | <0,01 | <0,01 |
| P₂O₅ | 0,31 | 0,35 |
| ZrO₂ | 0,03 | 0,03 |
| SrO | 0,05 | 0,05 |
| BaO | 0,15 | 0,14 |
| change in weight by ignition (1025 °C) | -0,15 | -0,12 |

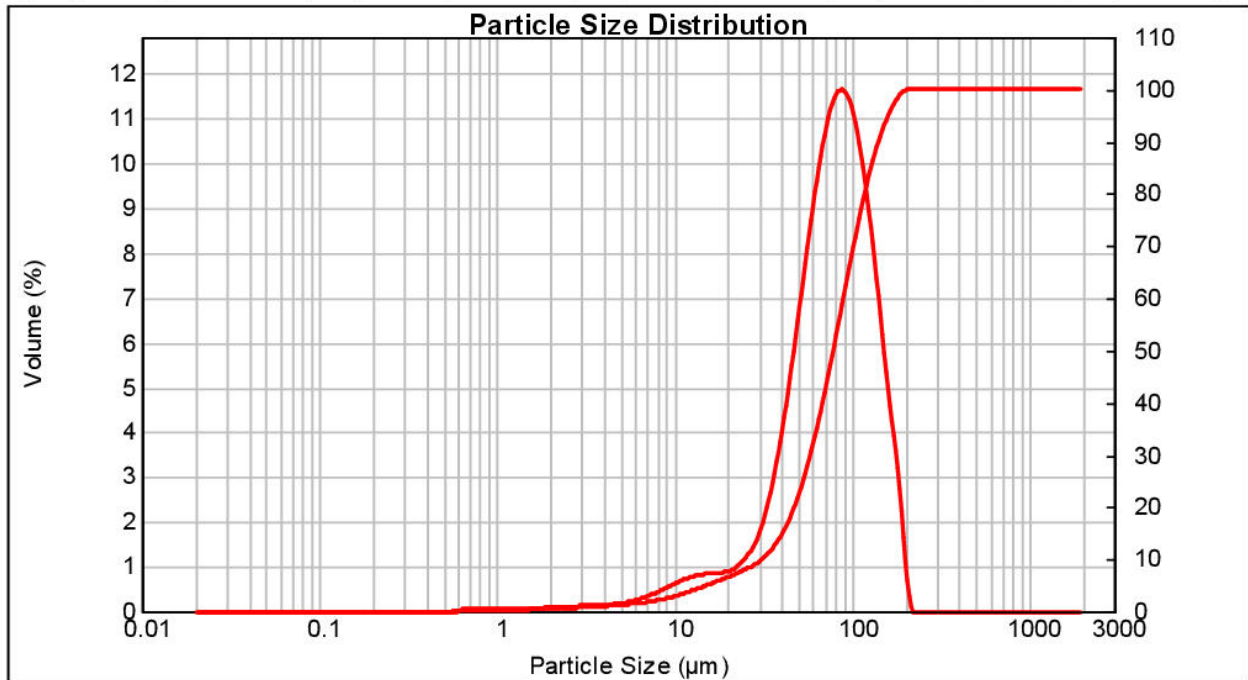
Determination of particle size distribution

Date of testing: August 09, 2017

Determination of grain size with Malvern Mastersizer 2000

| | Granulite-160 |
|-----------------------------|----------------------|
| D10 – value [µm] | 30,74 |
| D25 – value [µm] | 52,60 |
| D50 – value [µm] | 78,10 |
| D75 – value [µm] | 109,24 |
| D90 – value [µm] | 141,13 |

D(0.10) : 30.74 µm D(0.25) : 52.60 µm D(0.50) : 78.10 µm D(0.75) : 109.24 µm D(0.90) : 141.13 µm



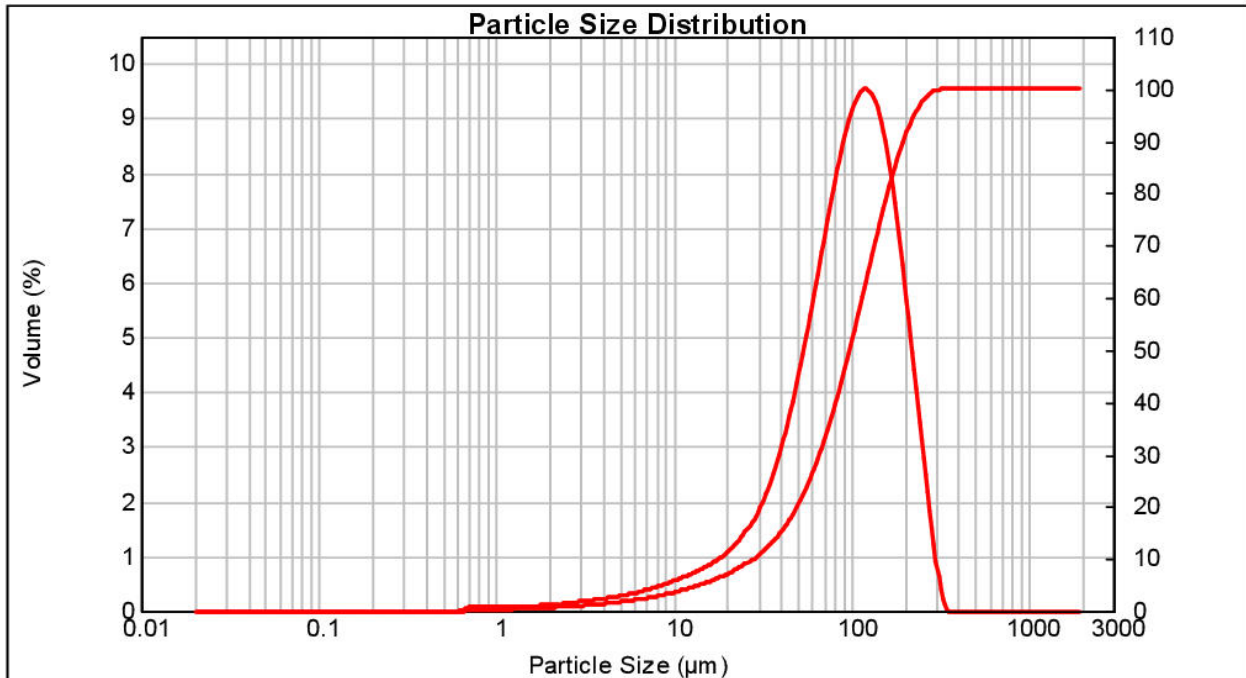
Determination of particle size distribution

Date of testing: August 09, 2017

Determination of grain size with Malvern Mastersizer 2000

| | Granulite-300 |
|-----------------------------|----------------------|
| D10 – value [µm] | 28,07 |
| D25 – value [µm] | 57,86 |
| D50 – value [µm] | 97,90 |
| D75 – value [µm] | 147,28 |
| D90 – value [µm] | 197,83 |

D(0.10) : 28.07 µm D(0.25) : 57.86 µm D(0.50) : 97.90 µm D(0.75) : 147.28 µm D(0.90) : 197.83 µm



Determination of loose bulk density
determined according to DIN EN 1097-3

Date of testing: August 14, 2017

| Sample | Loose bulk density [Mg/m³] | Average loose bulk density [Mg/m³] |
|----------------------|--|--|
| Granulite-160 | 0,402 0,399 0,403 | 0,402 |
| Granulite-300 | 0,404 0,403 0,405 | 0,404 |



Determination of solid state density by Gaspycnometry with Helium gas
determined according to DIN 66137-2

Date of testing: until August 15, 2017

| True density [g/cm ³] | | | | |
|--------------------------------------|--|--|--|---|
| Sample | Single value 1 [g/cm ³] | Single value 2 [g/cm ³] | Single value 3 [g/cm ³] | <u>Mean value</u> [g/cm ³] |
| Granulite-160 | 0,827 | 0,825 | 0,824 | <u>0,825</u> |
| Granulite-300 | 0,837 | 0,845 | 0,842 | <u>0,841</u> |



Particle size analysis (dry)

Determined according to DIN 66165 part 1+2

Date of testing: August 14, 2017

| | | Granulite-160 | Granulite-300 |
|-------------------------|------------|----------------------|----------------------|
| dried sample: | [g] | 100,07 | 100,02 |
| > 0,5 mm | [%] | - | - |
| 0,5 – 0,25 mm | [%] | - | - |
| 0,25 – 0,125 mm | [%] | 65,68 | 82,94 |
| 0,125 – 0,063 mm | [%] | 29,19 | 14,68 |
| < 0,063 mm | [%] | 5,13 | 2,38 |

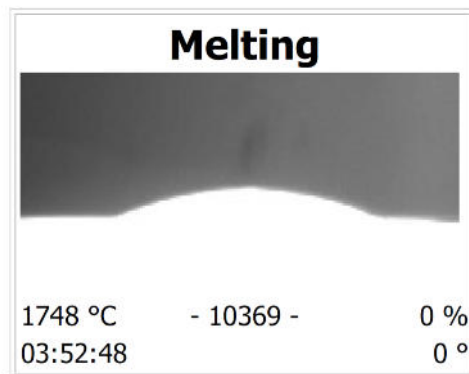
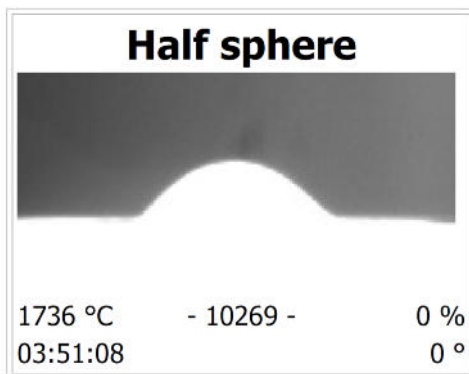
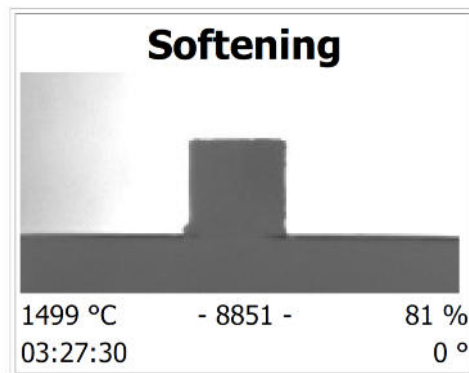
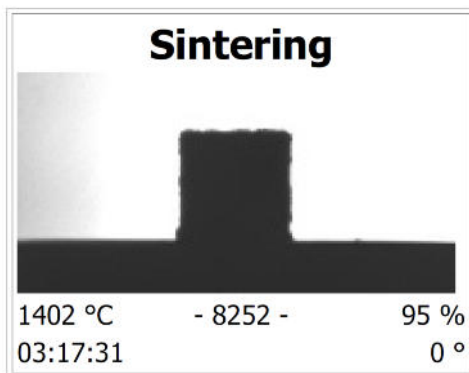


Hot stage microscopy
determined according DIN 51730

Date of testing: August 14, 2017

| Code | | Granulite-160 |
|------|-----------------------------|---------------|
| A | Softening temperature [°C] | 1499 |
| C | Hemisphere temperature [°C] | 1736 |
| D | Flow temperature [°C] | 1748 |

Remark: without platinum

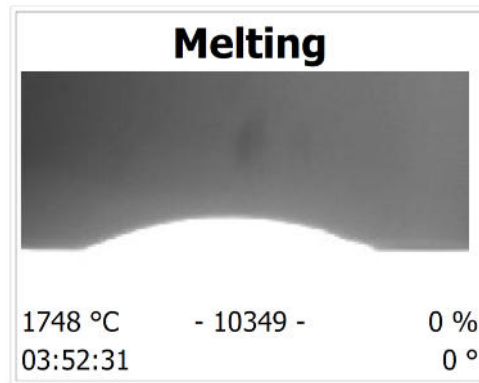
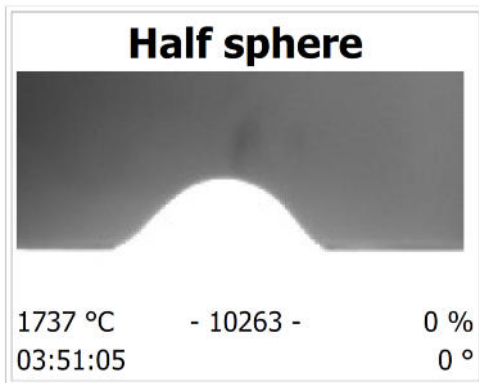
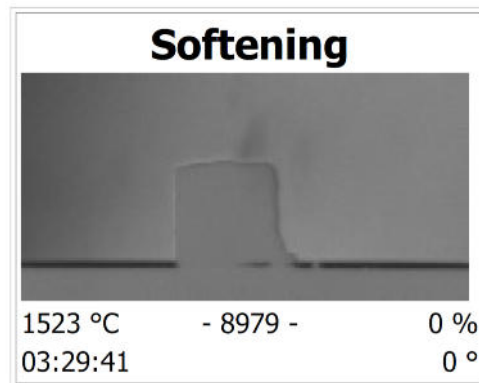
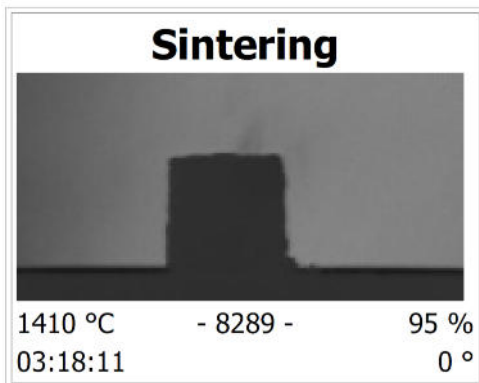


Hot stage microscopy
determined according DIN 51730

Date of testing: August 15, 2017

| Code | | Granulite-300 |
|------|-----------------------------|---------------|
| A | Softening temperature [°C] | 1523 |
| C | Hemisphere temperature [°C] | 1737 |
| D | Flow temperature [°C] | 1748 |

Remark: without platinum



Sinker

internal test method

Date of testing: August 25, 2017

Scope

This test method covers measurement of the relative resistance of granulates to absorption of water

Significance and use

This test method allows to differ the floating and sinking amount of the granulates

Apparatus

Graduated separating funnel 1000 ml

800 ml H₂O

100 g of the sample

Procedure

Weigh in the 100 g of the sample in the measuring cylinder.

Fill in 800 ml of H₂O.

Pivot the separating funnel to horizontal, hold it 10 seconds, then decline it 180° in the other direction. Repeat 20 times.

Wait the settling time of 1 hour.

Let the lower phase out by the plug valve, dry the lower phase 24 h by 110°C

Weigh the amount of the dried sediment.

| Sample | Total Amount [g] | Sediment [g] | Sediment [%] |
|----------------------|-------------------------|---------------------|---------------------|
| Granulite-160 | 100 | 4,8 | 4,8 |
| Granulite-300 | 100 | 2,7 | 2,7 |