

# Quality control during the installation of carbon-based cold ramming paste

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## INTRODUCTION

Elkem Carbon produces a range of refractory materials, including type-K paste, a carbon-based cold ramming paste (Prins, 2011). Type-K paste was installed in one of Mintek's pilot plant furnaces as working lining in the bottom and sidewalls of the furnace (see Figure 1a and 1b). The aim of this paper is to report on the quality control measures implemented during the installation of the type-K paste.

## PROCEDURE

The type-K paste was rammed onto a magnesia-based ramming material that formed the back lining of the hearth and magnesia bricks that formed the back lining of the sidewalls. Care was taken to ensure that water did not enter the magnesia-based material, as the furnace is located within a covered building and was covered by a tarpaulin before the type-K paste was added as a protective layer. The type-K paste was rammed in layers 1–6 in the hearth and 7–15 on the sidewalls.

The type-K paste was rammed in individual layers, each with its own specification (see Table I). The specifications were provided by the supplier. The type-K paste lining installation required two quality control tests to verify the integrity of the installation: a core sample test and a penetrometer test were conducted on each hearth layer (from 1 to 6) before the next layer was installed, whereas only the penetrometer test was used on sidewall layers 7–15 to optimize installation time. The property of interest was the density to which the type-K paste was rammed, which influences infiltration of the refractory by liquid process materials.

In the core sample test, a core sample was removed from the rammed paste with a pipe-like tool. The core sample had a cylindrical shape with dimensions of  $\phi 20 \times \pm 100$  mm. The sample density was determined by weighing the suspended sample in air and when immersed in water. Assuming the density of water was  $1 \text{ g/cm}^3$ , the density of the sample was determined by dividing the weight in air by the difference between the weight in air and weight immersed. The penetrometer is an instrument that determines the hardness of the rammed paste by measuring the penetration depth of a steel rod with a sharpened end, driven into the rammed paste under a given force. Once the depth of the hole is determined (using a vernier calliper) a graph is used, together with the temperature of the material, to derive the density of the paste. The penetrometer gives an accurate and speedy indication of the density of each layer quicker than measuring the density from a drill sample. For repeatability, two penetrometer measurements are done in close proximity to obtain a good average density.

Figure 1 illustrates the calibration curves of the penetrometer and the type-K paste at different temperatures. During installation the calibration charts between 20 and 25°C were used, depending on the room temperature thermometer reading.

When the density measured was below 1.53 g/cm<sup>3</sup>, the ramming time was extended for a further 30 minutes and a new test was conducted. Figure 1b illustrates the number of layers in the hearth (1–6) and the side walls (7–15). Table I relates the layers in Figure 1b to a more detailed specification for layers 1–6. The specification table shows the important information, such as the height and diameters of the layers, the weight and ramming time required.

Table I.: Type K-paste installation details for lining at bottom of furnace.

Layer	Outer diameter [cm]	Layer thickness[cm]	Volume of layer [L]	Density [kg/L]	Mass of layer [kg]	Cum. height [cm]	Duration of ramming [min]
6	224.2	6.3	249	1.56	388	40	52.0
5	224.2	6.9	272	1.56	425	34	57.0
4	224.2	6.9	272	1.56	425	27	57.0
3	224.2	6.9	272	1.56	425	20	57.0
2	224.2	6.9	272	1.56	425	13	57.0
1	224.2	6.1	241	1.56	375	6	50.0
Total	224.2	40	1578	1.56	2462		330.0

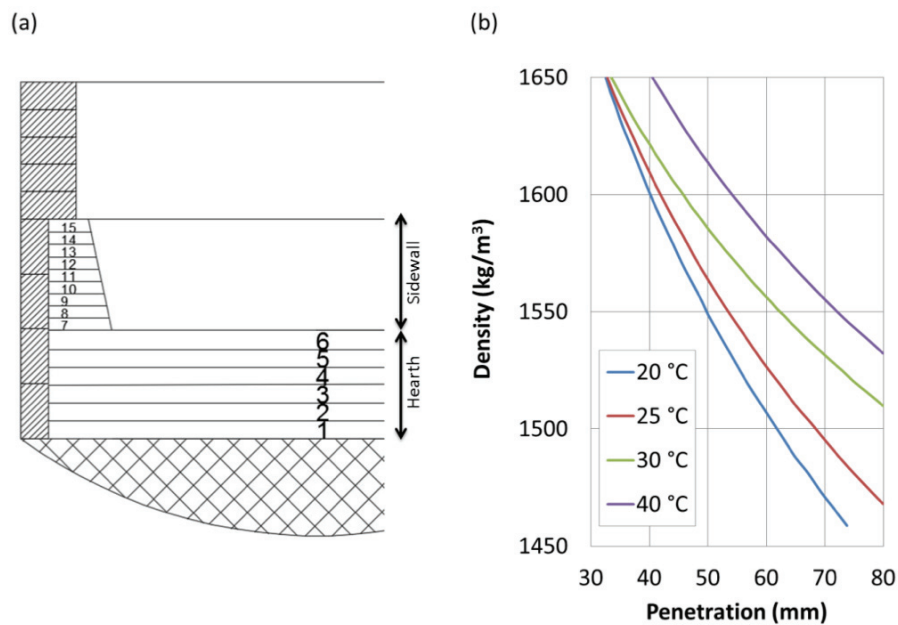


Figure 1. (a) Correlation between penetrometer and density measurements, (b) vertical section through the furnace showing layers 1–6 in the hearth and 7–15 in the sidewalls.

## **CONCLUSION**

The quality of the installation of the type-K paste in a pilot furnace installation at Mintek was monitored by applying core sample tests and penetrometer tests. Results from these procedures provided assurance that each ramming layer met the supplier's specifications of a density of 1.53 g/cm<sup>3</sup> in all areas. Both procedures are transferrable to the quality control of industrial-scale furnace refractory installations in South Africa.

## **REFERENCE**

Prins, F. (2011). Personal communication: Elkem Carbon Furnace Lining Materials.



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