

# Silicon metal production

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# Introduction

Carbon electrodes are applied for the production of silicon metal as they have peculiar characteristics. Carbon electrodes are used as electric current conductors in electric furnaces where silicon metal, elemental phosphorus or - to a small extent - other specialties are produced. The production of silicon metal and phosphorus is quite a specialised process and therefore only a small number of companies is engaged in this business world-wide. Most of the silicon metal produced is used in two main industrial fields: in metallurgy as an alloying element for aluminium and in the chemical industry for the production of a large family of plastics called silicones. Silicon metal is also employed, after a long processing chain, in the electronic field.



# Carbon electrodes for silicon metal production

Amorphous carbon electrodes are produced with electrographite and/or anthracite, bound with coal tar pitch. The production cycle includes: raw materials, crushing and selection of granulometry, mixing with pitch as binder, forming, baking and final machining. Click here for [the production scheme](#).

Carbon electrodes are produced with several types of joints: conical (male-female) or pin type joint. The choice between the two types depends on the characteristics and operative conditions of the electric furnace.



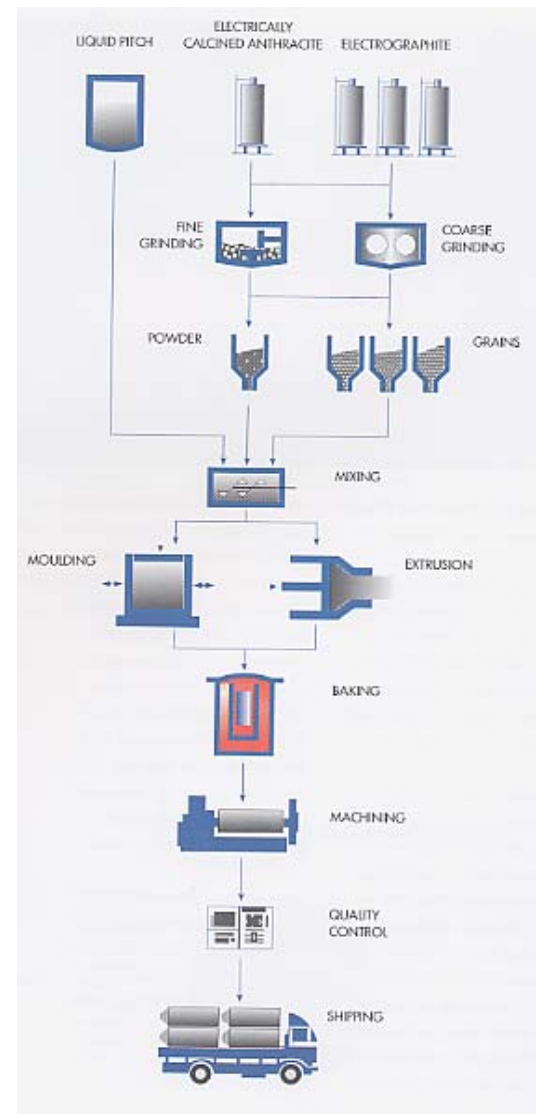
# Requirements for carbon electrodes

Requirements for carbon electrodes are:

- good electrical conductivity: in order to withstand the high current density required by the metallurgical process;
- good thermal conductivity: to minimise the temperature differences inside the electrodes when in use and , consequently to reduce internal stresses;
- good mechanical strength: to withstand the stresses when in use;
- high level of chemical purity: to avoid polluting the end product;
- reliable joint: to ensure current flow continuity in the electrode column;
- easy mounting: to facilitate and speed up operations for the lengthening of the electrode column;
- accurate machining on the external surface on the joints: to avoid problems when the joint passes through the holding clamps and the contact shoes and to facilitate the current flow from one electrode to the following one.



# Production scheme for carbon electrodes



# Peculiar characteristics of carbon electrodes for silicon metal production

- carry large amounts of electrical current
- withstand very high temperatures
- keeping good mechanical properties under above-described circumstances

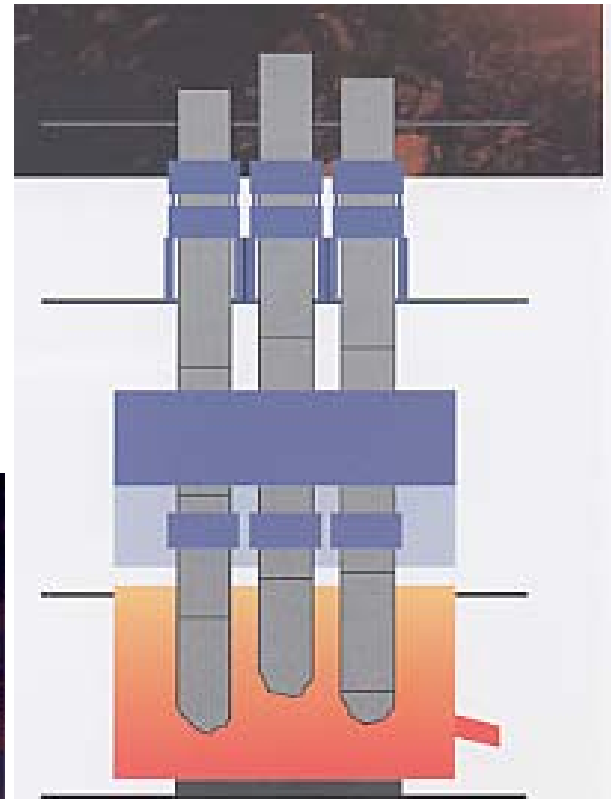


# Production of silicon metal

Carbon electrodes play a main role in the production processes in submerged arc furnaces. Carbon electrodes are most largely used for the production of silicon metal. The process consists in the continuous reduction of quartz ( $\text{SiO}_2$ ) into silicon by a reducing mixture according to the simplified relation  $\text{SiO}_2 + 2\text{C} \rightarrow \text{Si} + 2\text{CO}$ . As components of the mixture, carbon in the form of mineral carbon, petroleum coke, charcoal, wood-chips can be used. The choice and proportions of these materials vary depending on the local availability and cost. The electric current runs through the electrode between the contact plates and the tip of the electrode causing the ignition of the electric arc with its extremely high temperatures ( $> 2000^\circ\text{C}$ ) necessary for the reduction of quartz into silicon. The silicon is then tapped from the bottom of the furnace. Every day, 15 to 50 tons of silicon are produced according to the power applied to the furnace. During the process the tips of the columns submerged in the reaction area are gradually consumed. Each of the three electrode columns is built with 5-6 electrodes. [Drawing of a silicon furnace.](#)



# Silicon furnaces



A medium size submerged arc furnace has a crucible diameter of approx. 7m. It is fed by three carbon electrode columns about 15m high and weighing approx. 20 tons each.