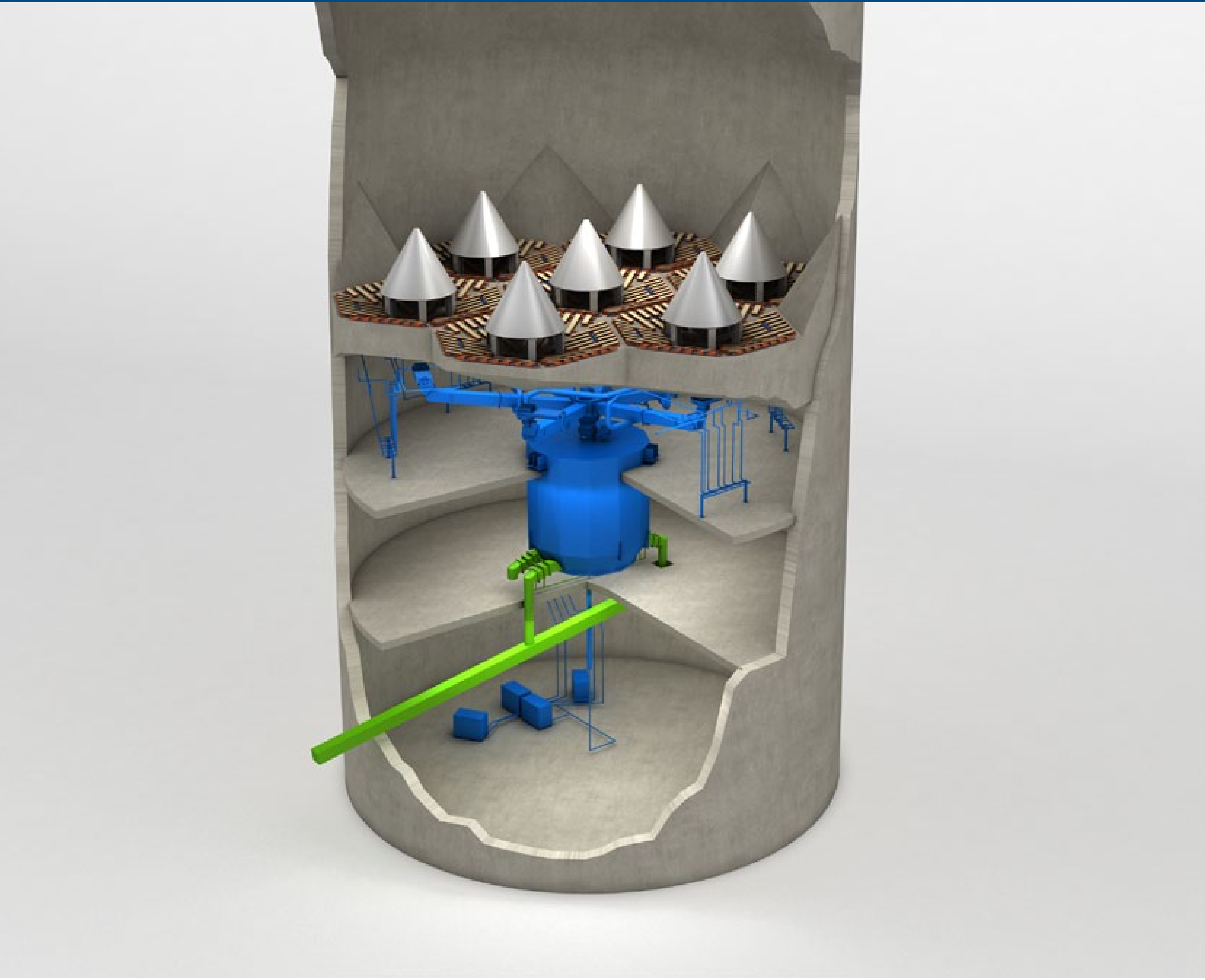
One Source

CF raw meal silo



FLSmidth

Well-proven homogenizing and storage system

Key benefits

- **High kiln feed consistency ensures stable kiln operation and improves run factor**
- **High homogenizing efficiency**
- **Low maintenance costs**
- **Aeration filters, prevent material from blocking the system**

How it works

The CF (Controlled Flow) silo is a continuously operating system for homogenization and storage of cement raw meal, where the material is extracted simultaneously at different flow rates from a number of outlets in the silo bottom. The CF system, including suitable kiln feed equipment, ensures stable kiln feed composition at minimum power consumption and investment cost.

The efficient performance of the CF homogenizing silo results in stable kiln operation so that changes in kiln speed or firing rate are rarely needed and stable coating in the kiln is maintained.

In order to ensure high homogenization efficiency, all the raw meal in a silo must be kept in constant movement towards the outlets. Furthermore, the raw meal must pass through the silo in flow zones with different residence time.

The CF silo complies with these demands. It extracts raw meal at different rates from several outlets in the silo bottom and mixes the stream from these outlets.

The CF silo's extraction system is governed by a programmable control unit. This enables the selection of optimum flow rate distribution based on local requirements and conditions.

The silo design as shown in figure 3 is based on the same configuration for silo diameters up to 31.5 m.

The silo bottom is raised above the ground with the kiln feed or tank placed underneath. The silo bottom has seven extraction points, and material is supplied continuously to the silo.

The standard features of the silo top include manholes, over- and underpressure valves, and level indicators.

Unique design

The unique characteristic of the CF silo is the design of its bottom. As shown in figure 1, the silo bottom is divided into seven identical hexagonal sections. At the centre of each hexagonal section is an outlet with a large conical cover made of steel. These steel cones are designed to maintain an optimal flow pattern during extraction of the raw meal, which influences homogenizing efficiency.

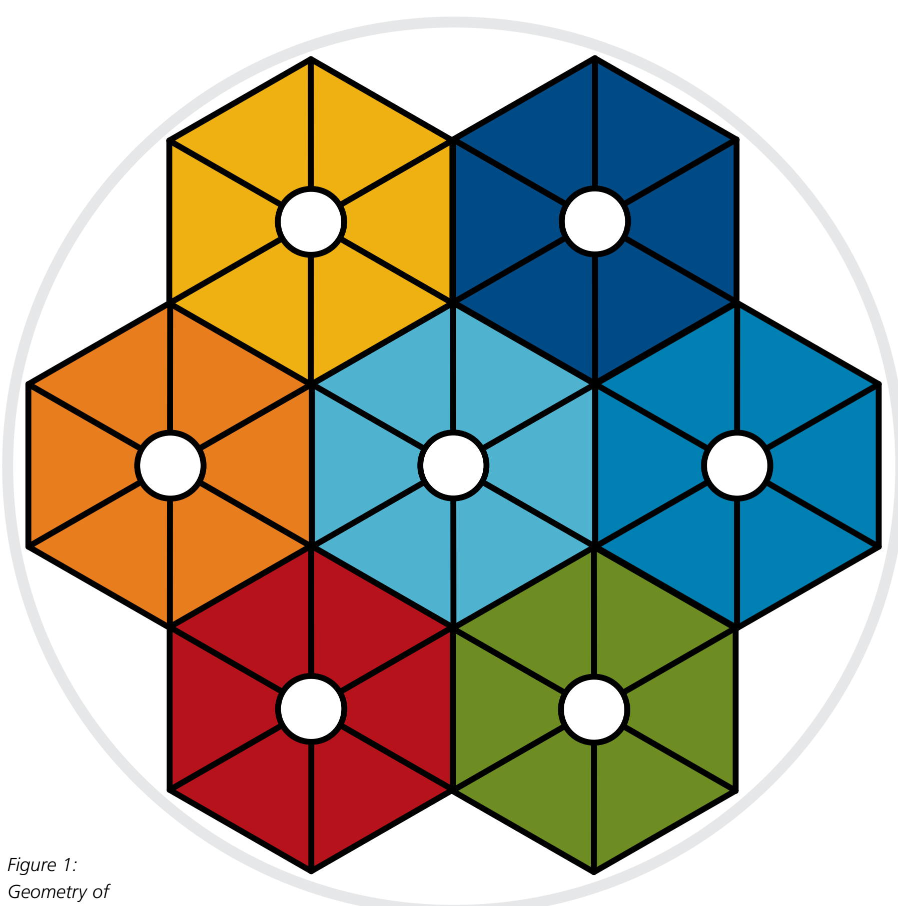


Figure 1: Geometry of silo bottom

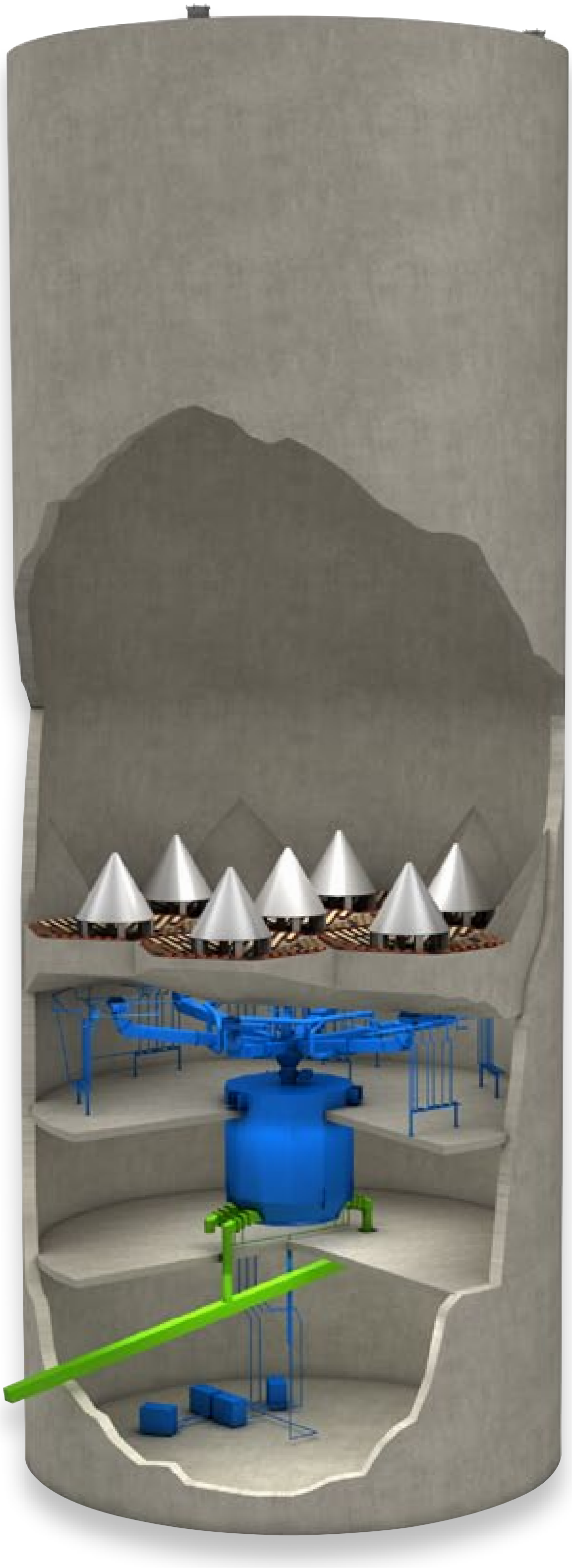
In addition, the cones are designed to relieve the pressure above the outlets and to ensure extraction from the aerated part of the silo bottom (see figure 2).

Each of the seven sections is divided into six triangular segments. So the bottom consists of a total of 42 segments, all of which are provided with aeration units. These 42 separate segments represent 42 individual areas from which the material is extracted in a preset sequence of shorter duration than the residence time in the tank below the silo. Wide flow zones with varying material sinking velocity are formed above the cones covering the outlets, and this further improves homogenization.

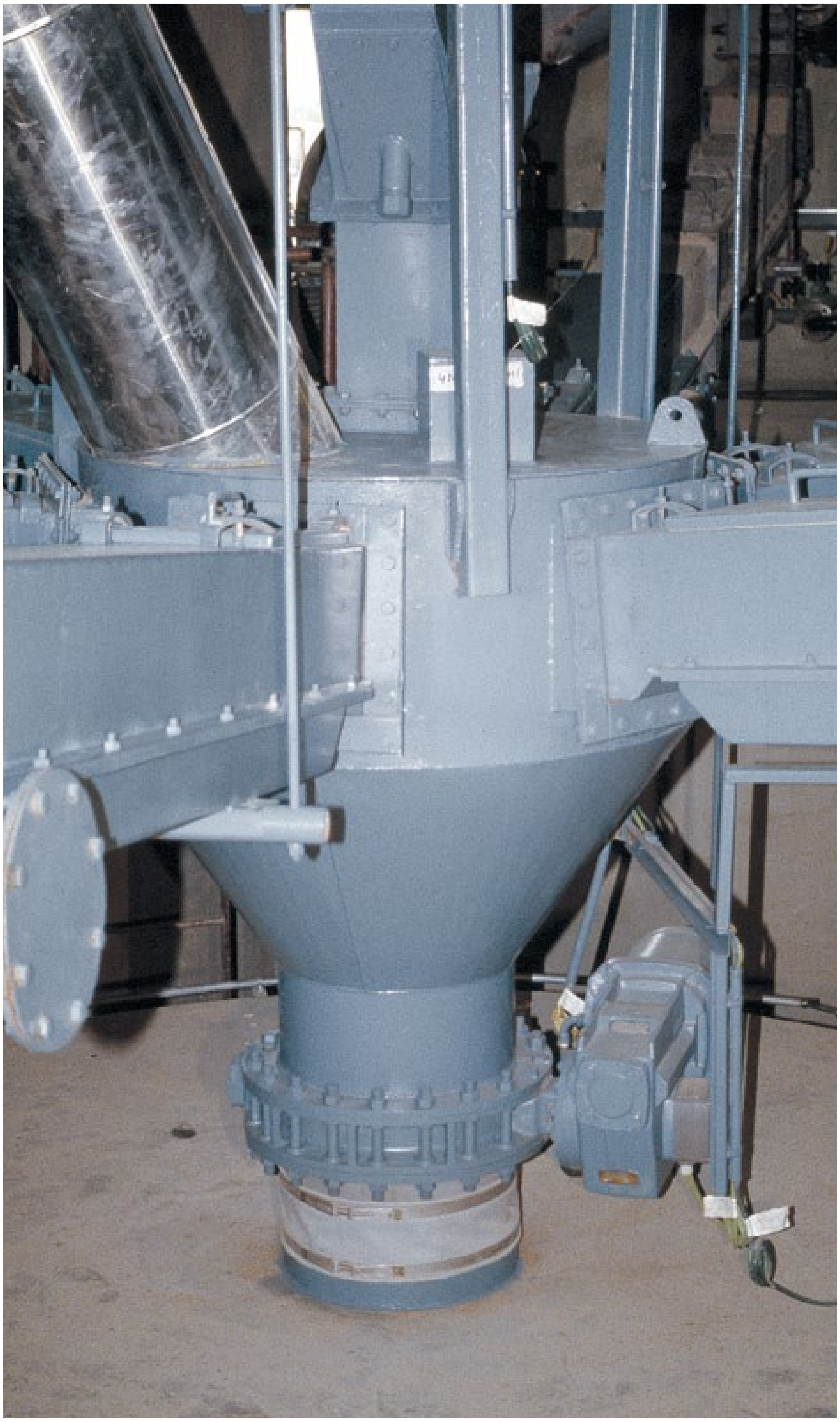
Layers of raw meal of varying chemical composition are fed to the silo. The variations in extraction rate/residence time mean that these layers are broken up as they proceed down through the silo. The resulting raw meal product, extracted from the silo during any stage of the extraction sequence, will therefore be a mixture of raw meal components of different chemical composition.

Figure 2: Steel cone to relieve pressure above outlet

Figure 3: The CF silo



Optimal flow and homogenizing efficiency



Each of the seven outlets is provided with a shut-off valve by which extraction from a given outlet can be started and stopped together with the aeration of the appertaining segments. Slide gates are provided to facilitate the maintenance of the shut-off valves.

As a part of the kiln feed system, a mixing tank is installed after the silo outlets. The material is transported via airslides to this tank, which is mounted on load cells (see figures 4 and 5). The load signal from the load cells starts and stops the extraction process so the material level in the tank is kept within preset limits. The load signal is used in the FLS-LOW (Loss-Of-Weight) kiln feed system.

The FLS-LOW system controls the kiln feed flow rate based on the following principle: Whilst no raw meal is entering the tank from the silo, the resulting loss in tank weight per time unit is used to measure the true extraction rate of kiln feed. This measurement controls the position of the flow gate in order to maintain the preset rate of kiln feed whilst the kiln feed tank is being filled.

Figure 4: LOW kiln feed tank inlet

The fluidizing air is supplied to the silo bottom by rotary blowers and distributed by means of valves, one for each segment. Furthermore, the air supply system to each section (or optionally each segment) is provided with a filter that cleans the air and prevents material from entering in case of leaks in the aeration system inside the silo (see figure 6). In practice, homogenization is accomplished by using three of the seven outlets simultaneously, each blower aerating only one segment at a time. This means that only 3 of the 42 segments are aerated at the same time, which reduces air and power consumption.

The CF silo is also provided with a rotary blower for the tank and a fan for the airslides. Compressed air for the operation of the seven shutoff valves and the cylindrical flow-rate controllers is normally taken from the central compressor at the plant.

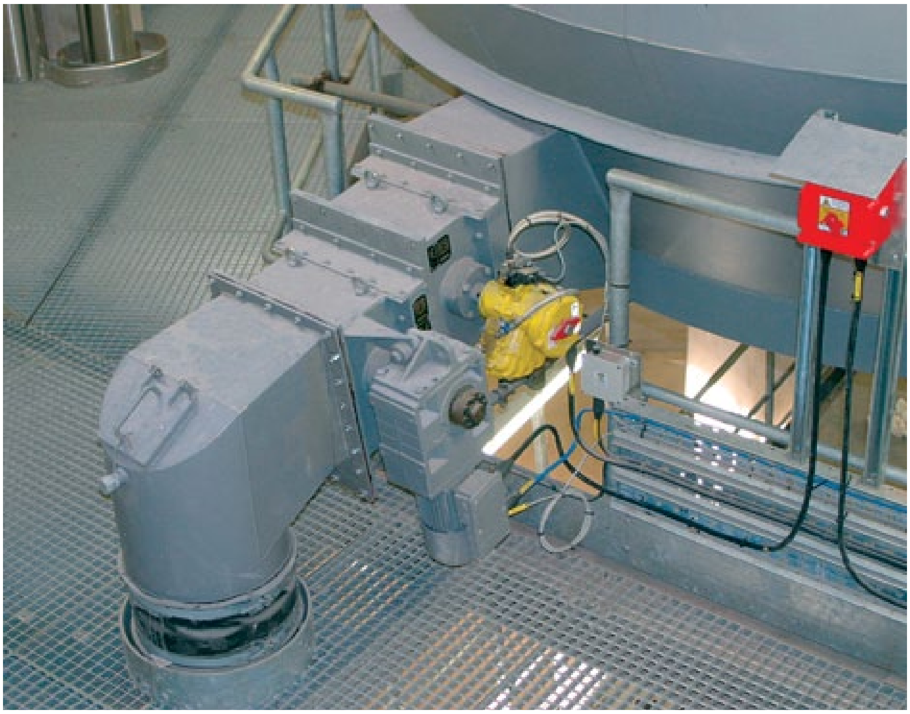


Figure 5: LOW kiln feed tank outlet

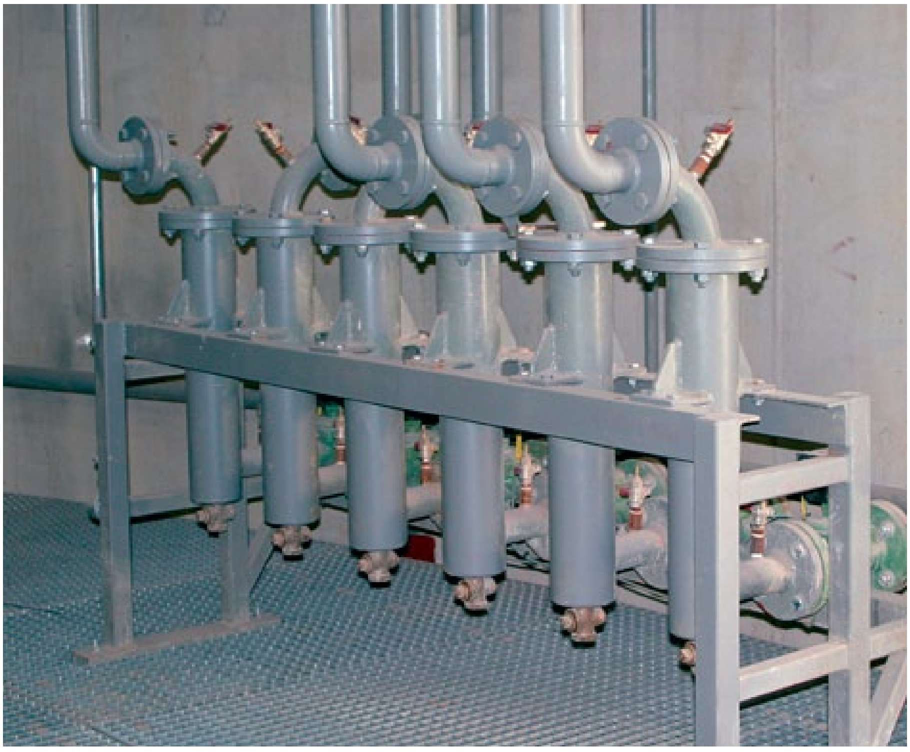


Figure 6: Filter battery for a single sector (optional)

Controlling efficiency

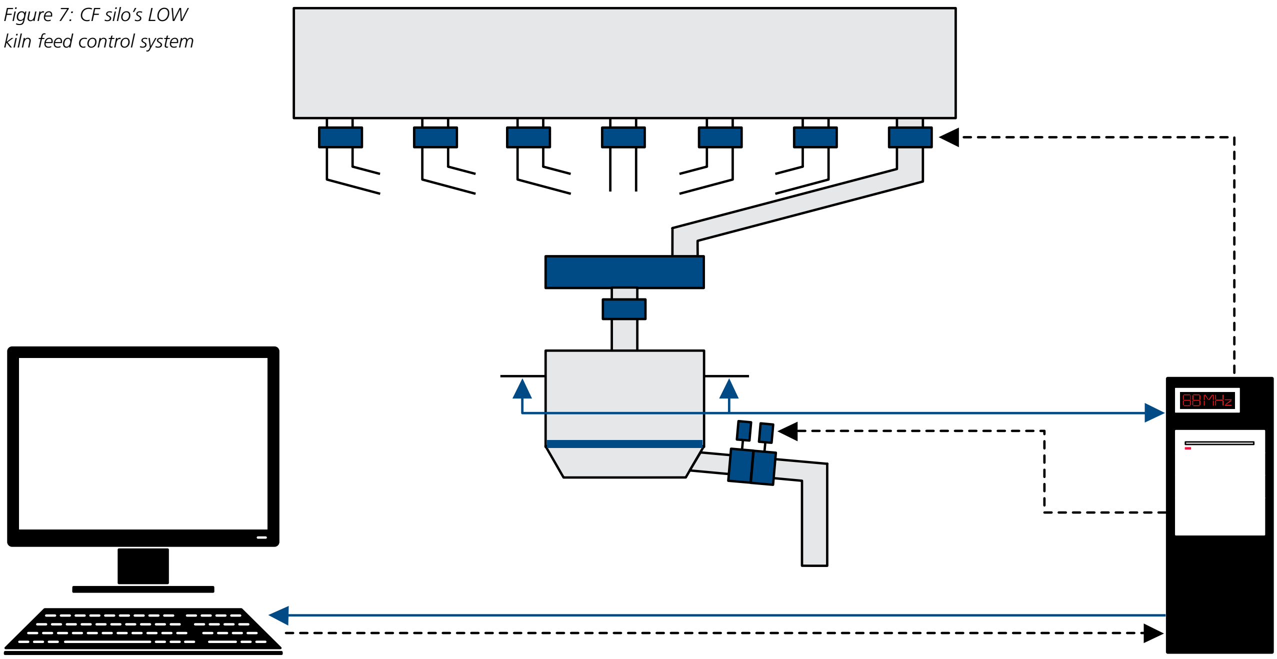


Figure 7: CF silo's LOW kiln feed control system

Controlling the CF silo
CF silo control is maintained either via a locally installed programmable control unit or by a central programmable control unit (see figure 7). The sequence of extraction from the seven outlets, the opening of the shut-off valves and the aeration of each segment is programmed in the control unit. The desired extraction pattern is attained by inserting throttle plates with different apertures in the seven outlets. When the kiln feed tank reaches its maximum level, the program is interrupted. When the tank level decreases to a certain point, the program continues from the point of interruption.

As an additional advantage, the CF silo's programmable control unit can be configured to include the FLS-LOW system and vice versa.

Homogenising factor
The homogenizing factor H is the most commonly used term to describe the efficiency of a homogenizing silo.

H represents the ratio between the inhomogeneity before and after the silo. The homogenizing factor H is defined as:

$$H = \sqrt{\frac{S^2_{in} - S^2_{an}}{S^2_{out} - S^2_{an}}}$$

S_{in} = The standard deviation of one chemical parameter in the feed to the silo

S_{out} = The standard deviation of one chemical parameter in the discharge from the kiln feed system

S_{an} = Standard deviation attributable to analysis errors

It is generally acknowledged that when the true inhomogeneity of the kiln feed is less than 1% LSF, corresponding to 3% C3S, 0.2% CaCO3 or 0.1% CaO, no further improvement in kiln operational stability, refractory life or cement quality can be achieved through additional homogenization.

$$\sqrt{S^2_{in} - S^2_{an}}$$

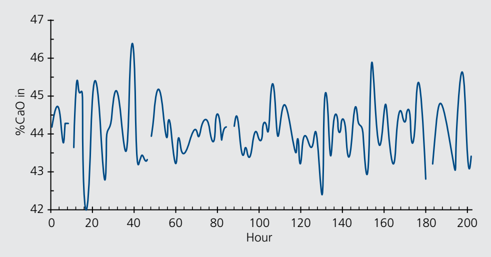
In order to meet a level of less than 1% LSF inhomogeneity, an H factor within the range of 5:1-10:1 is usually required.

CF silo in practice
The first CF silo went into operation in 1981. Ever since, it has been thoroughly tested and has demonstrated significant contribution to the smooth operation of a cement plant.

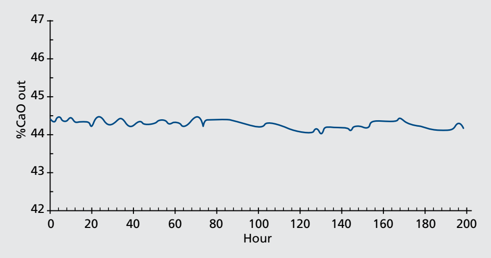
Determining homogenizing factor

The following calculation shows how the homogenizing factor is determined at a CF silo in operation.

The first graph shows the chemical variation of the material entering the silo; the second graph shows the variation of the material at the silo output.



Chemical variations of input



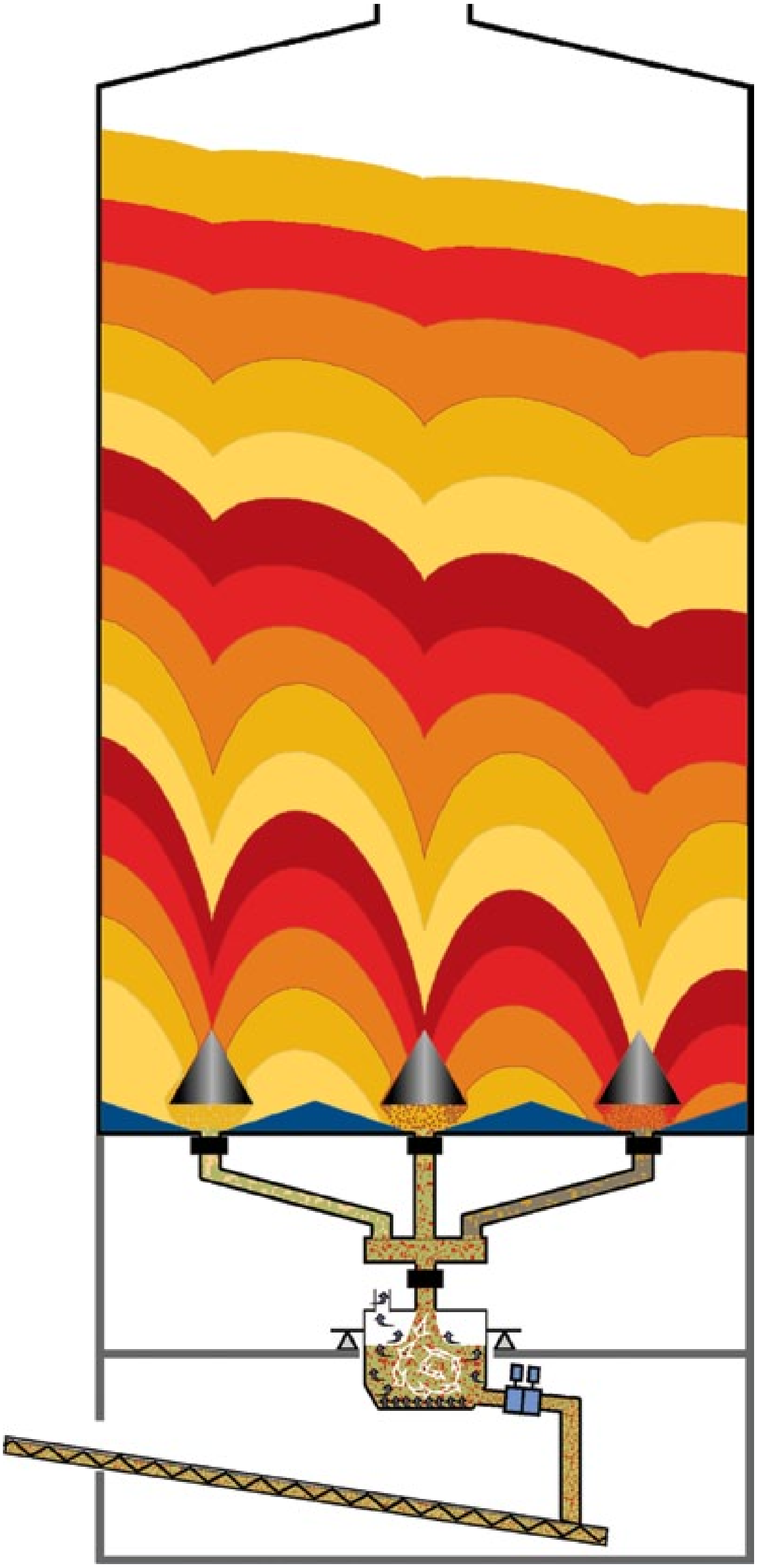
Chemical variations of output

Based on the obtained results:

S_{in} = 0.80% CaO
S_{out} = 0.10% CaO
S_{an} = 0.03% CaO

the homogenizing factor H can be determined:

$$H = \sqrt{\frac{0.80^2 - 0.03^2}{0.10^2 - 0.03^2}} = 8.3$$



12,000 tpd kiln system

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