General

The function of a grinding mill is to reduce the particle size of a material to a size necessary for a given process. The grinding is accomplished by rotating a large cylinder that is partially filled with the material to be ground and grinding media. As the cylinder rotates, its contents is lifted until it falls or tumbles over itself back down to the bottom of the cylinder. The impact of the grinding media and the tumbling action crush and grind the material down to the desired particle size.

Grinding mills are classified by the media used for grinding. The more common types of mills are:

Ball mills - These mills use forged steel balls up to 5 inches (127 mm) in diameter to crush and grind the material. Mill length is two or more times its diameter.

Rod mills - Steel rods up to 4.5 inches (114 mm) in diameter and slightly shorter then the mill length are used for the grinding process. Mill length is two or more times its diameter.

Pebble mills - These mills use small cylinders, balls, or other chunks of silica, porcelain, aluminum or zirconium oxides for grinding. This type of mill is used when the product must be free of metallic contamination.

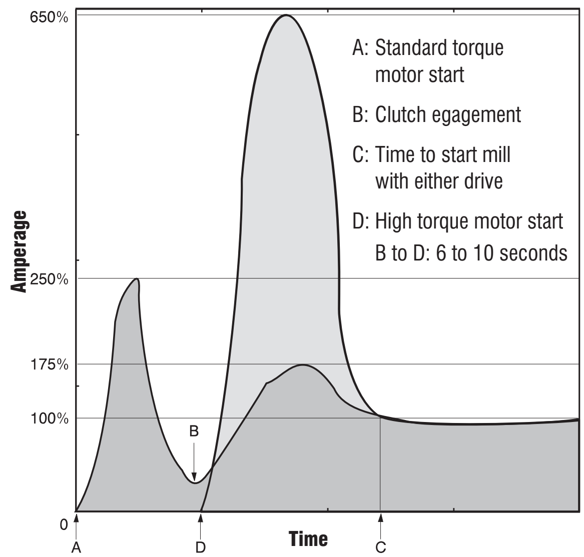
Autogenous mills - These mills use coarse ore particles of the material to grind itself. Grinding is by attrition. An autogenous mill's diameter is larger compared to its length.

Semi-Autogenous mills - Forged steel balls in addition to the coarse ore perform the grinding. Mill diameter is larger compared to mill length.

Use of a clutch permits the mill motor to be started in the unloaded condition, keeping current demand and power factor within limits agreed upon with local utilities. The result is a substantial savings on power costs. The following amperage curves compare peak current demands of high torque - direct drive systems and drive systems using standard torque motors with Airflex clutches which replaced them.

Because of the large thermal loads associated with mill start-up, the use of VC clutches are recommended.

Mill Motor Current Demand



Clutch Selection

The required clutch torque is calculated from the power rating of the mill motor, clutch shaft rpm and an appropriate service factor.

$$M_c = \frac{Pp \cdot 63025}{n} \cdot SF(lb \cdot in)$$

$$M_c = \frac{Pp \cdot 9550}{n} \cdot SF(N \cdot m)$$

Type of Mill	SF
Ball and Rod	2
Pebble and Semi-Autogenous	2.5
Autogenous	3

A type VC clutch element is selected using the procedure outlined in Section B. For good friction lining life, it is desirable to limit the maximum clutch engagement speed to 4500 fpm (22,8 mps). If the clutch is used for inching of the mill, engagement speed should not exceed 3500 fpm (17,8 mps). Gap mounted arrangements, Forms VC506 thru VC510, are recommended.

A preliminary clutch selection guide is given on the following pages. The selections are valid for the operating parameters stated on the guide.

For motor ratings up to 3000 HP (2240 kW) and clutch shaft speeds up to 277 rpm, the clutch element selected should have sufficient thermal capacity and in most cases can be used for inching or spotting of the mill.

For larger power motors and higher clutch shaft speeds a more thorough analysis of the mill is required. Various mill starts can be simulated by computer modeling to determine the proper clutch size and starting time. The various starts are obtained by changing the rate of pressure build-up, and hence the rate of torque build-up in the clutch.

For a given clutch size, the mill starting times are plotted against the resulting clutch thermal load. A typical overview of the starts are shown below. The preferred starting time is when the peak loading is at a minimum.

For any given starting time, the entire clutch profile can be projected for the complete start. By comparing the profile to the rated capacity, the clutch's suitability for the drive can be determined.

The information required for simulation must include:

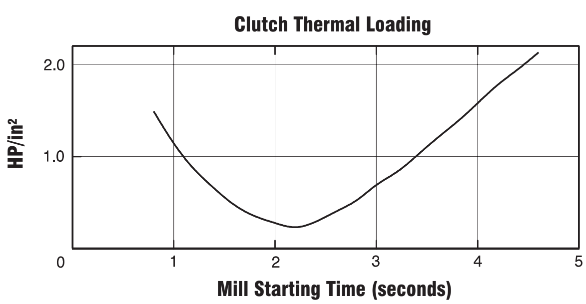
- Type of mill
- Mill inertia
- Mill rpm
- Inside diameter of shell liners
- Total weight or mass of charge including grinding media
- Normal percent mill fill
- Material cascade angle
- Method of material discharge (overflow, grate or batch)
- Motor power rating
- Motor pullout torque
- Clutch shaft rpm
- Maximum air pressure available

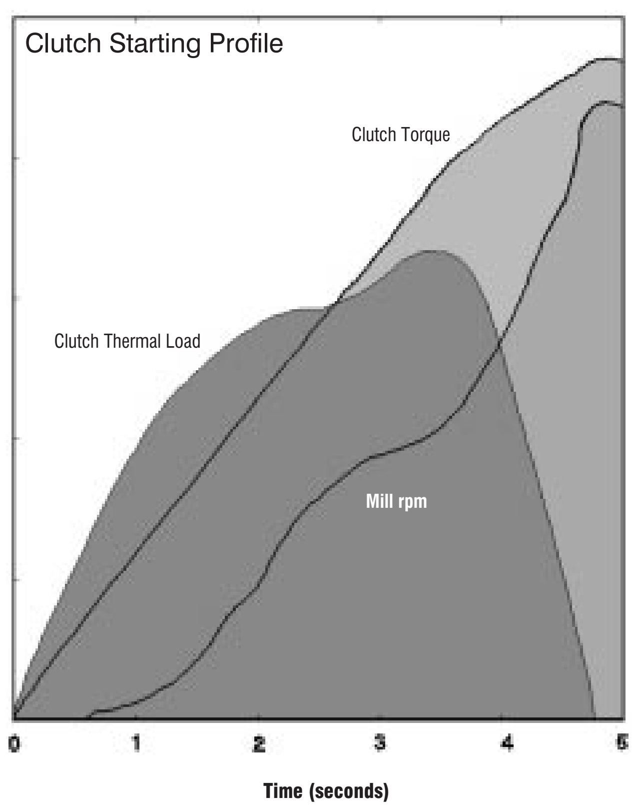
Clutch Control

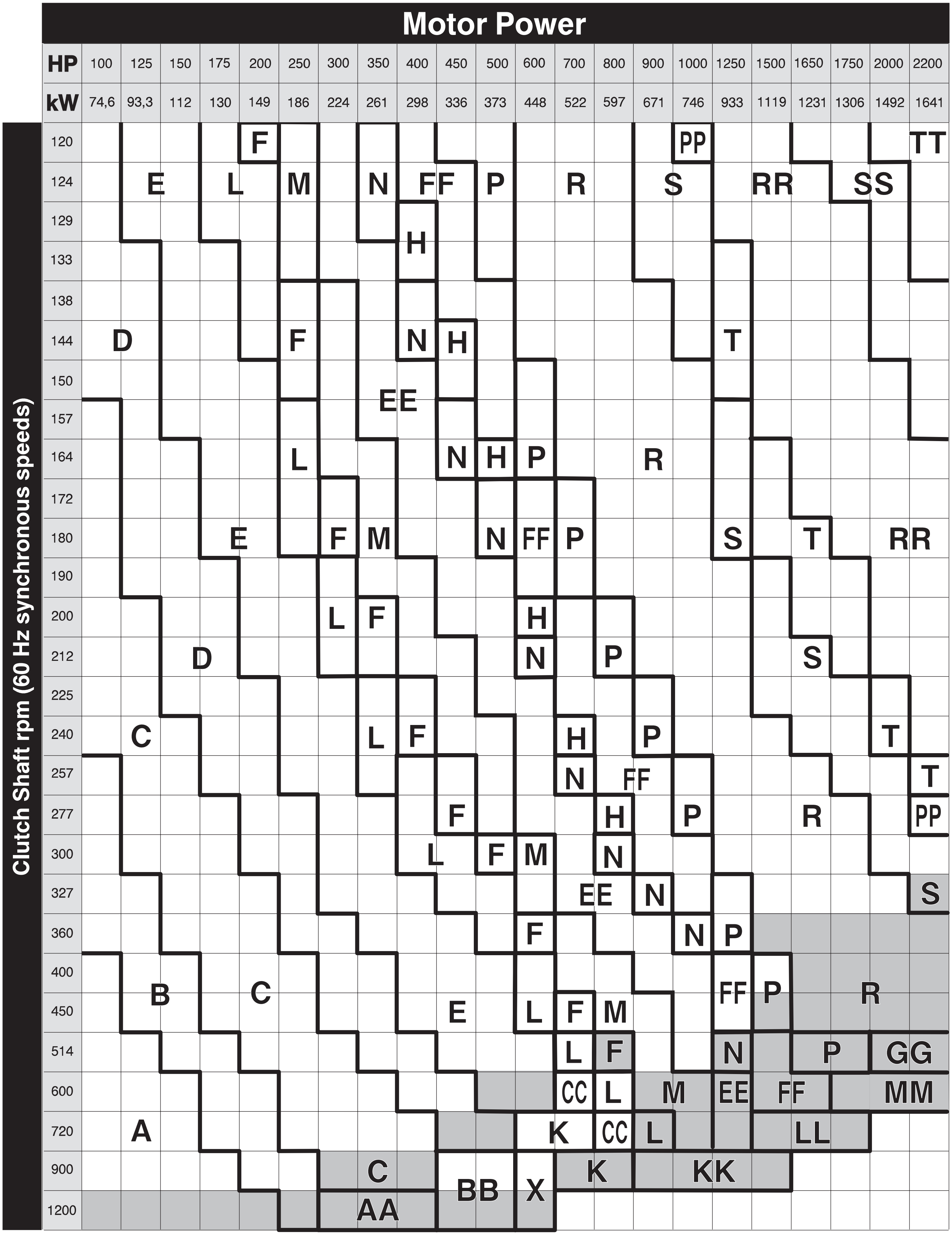
Normal mill starting procedure is to bring the motor up to operating speed and then engage the clutch to accelerate the mill. Airflex offers a simple, but reliable, system for clutch control. The system consists of two parts: the pneumatic and electrical portions.

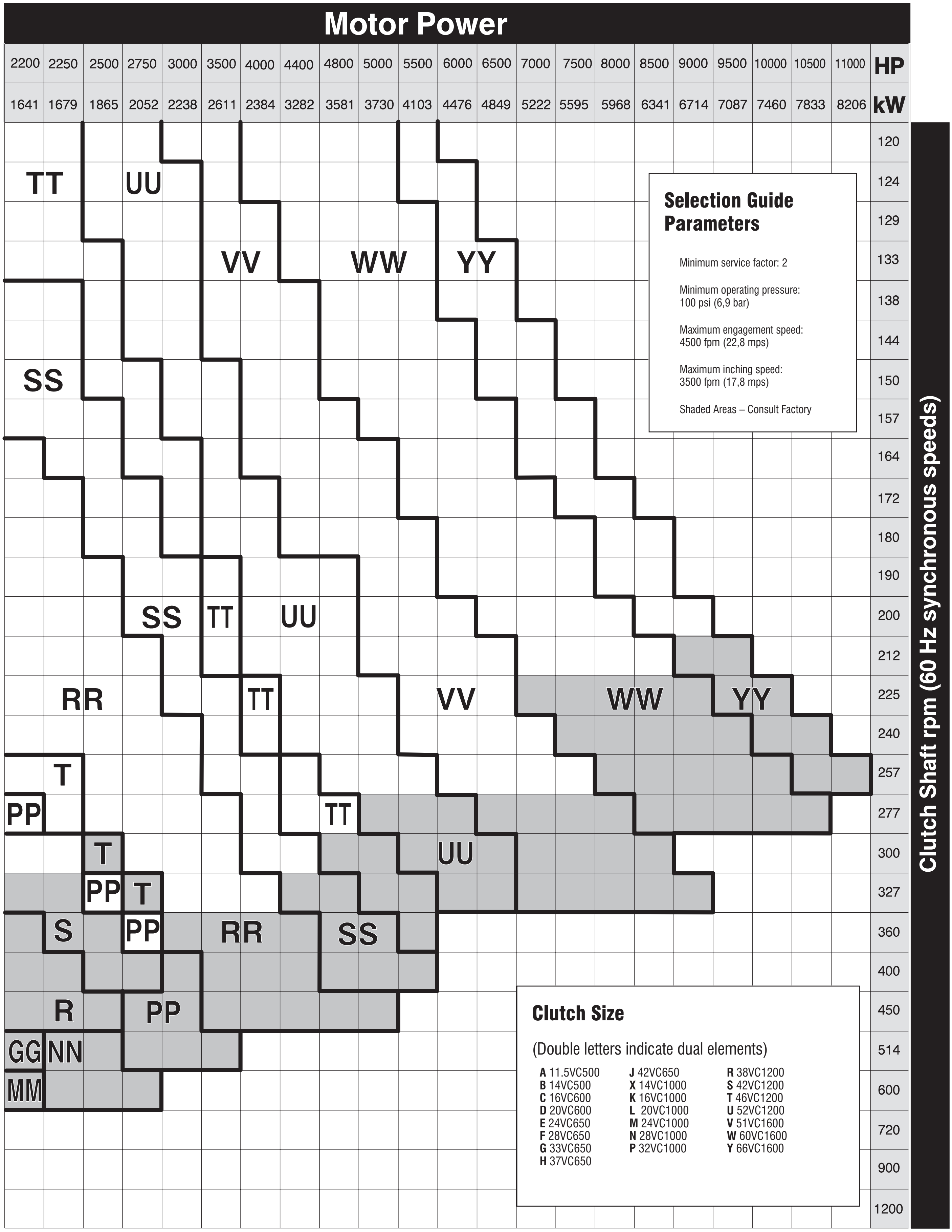
The pneumatic portion is basically that shown in Section Y, with the addition of a three-way normally closed solenoid valve, a manually adjusted flow control valve and pressure switch, all plumbed in the air line to the clutch. The pressure switch in the clutch air line prevents motor starting if the clutch is pressurized. The pressure switch on the air tank insures that sufficient air volume and pressure is available before a start can be made. Rate of clutch torque build-up and mill acceleration is determined by the flow control valve setting.

The pressure switches are tied in electrically to the motor and clutch control circuits. The electrical clutch control furnished by Airflex regulates the electrical signal to the solenoid valve. The standard control permits starting, stopping and where applicable, inching of the mill.






Motor Power
HP 100 125 150 175 200 250 300 350 400 450 500 600 700 800 900 1000 1250 1500 1650 1750 2000 2200
kW 74,6 93,3 112 130 149 186 224 261 298 336 373 448 522 597 671 746 933 1119 1231 1306 1492 1641
Clutch Shaft rpm (60 Hz synchronous speeds)
120 124 129 133 138 144 150 157 164 172 180 190 200 212 225 240 257 277 300 327 360 400 450 514 600 720 900 1200
F PP TT
E L M N FF P R S RR SS
H
D F N H T
EE
L N H P R
E F M N FF P S T RR
L F H
D N P S
C L F H P T
N FF T
F H P R PP
L F M N
EE N S
F N P
B C FF P R
E L F M
L F N P GG
CC L M EE FF MM
A K CC L LL
C K KK
BB X
AA



Selection Guide Parameters

Minimum service factor: 2

Minimum operating pressure:
100 psi (6,9 bar)

Maximum engagement speed:
4500 fpm (22,8 mps)

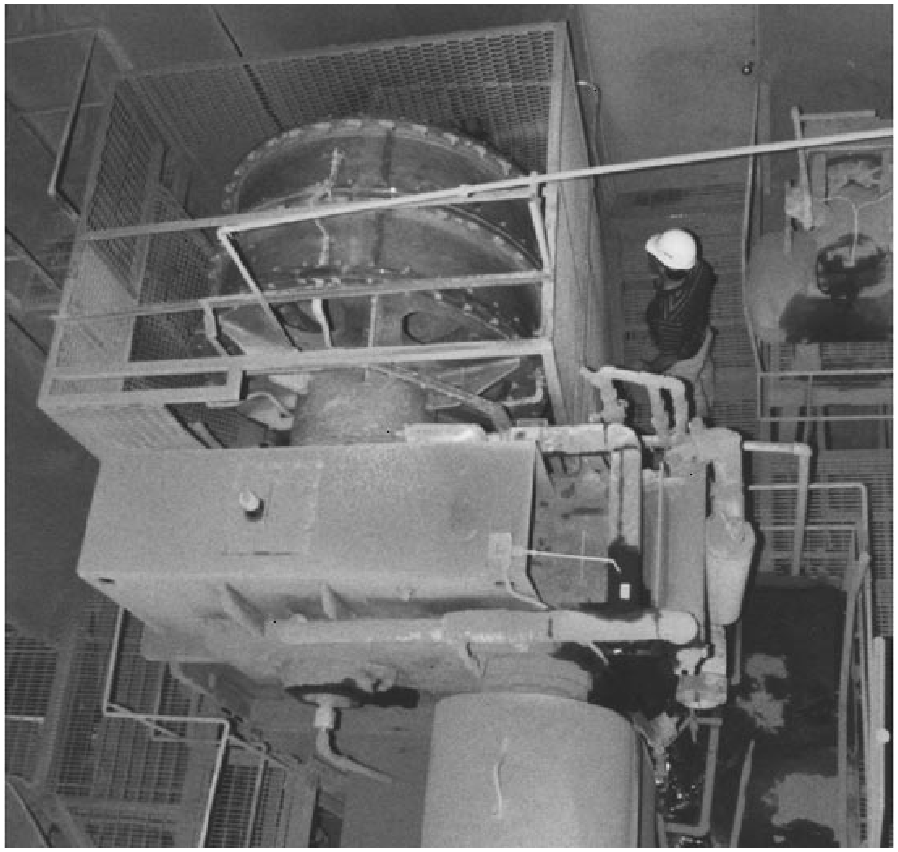
Maximum inching speed:
3500 fpm (17,8 mps)

Shaded Areas – Consult Factory

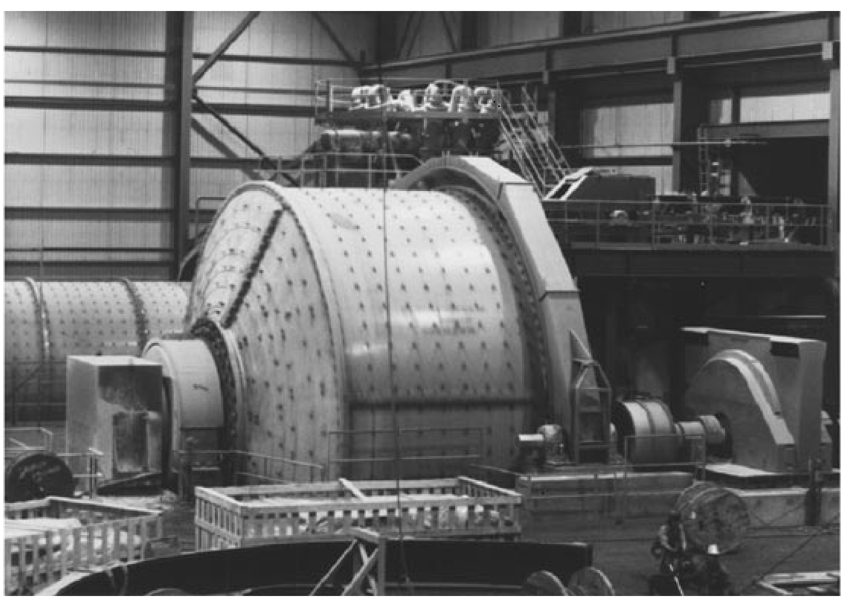
Clutch Size

(Double letters indicate dual elements)

A 11.5VC500	**J** 42VC650	**R** 38VC1200
B 14VC500	**X** 14VC1000	**S** 42VC1200
C 16VC600	**K** 16VC1000	**T** 46VC1200
D 20VC600	**L** 20VC1000	**U** 52VC1200
E 24VC650	**M** 24VC1000	**V** 51VC1600
F 28VC650	**N** 28VC1000	**W** 60VC1600
G 33VC650	**P** 32VC1000	**Y** 66VC1600
H 37VC650		

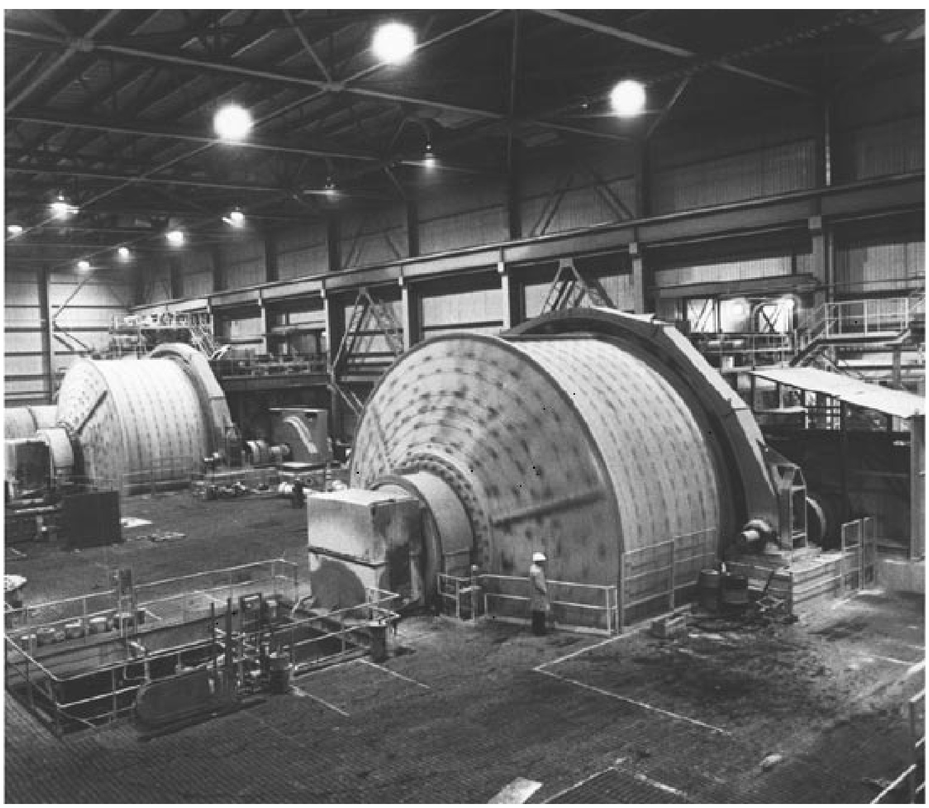


Two compartment cement ball mill driven by a 5000 HP (3730 kW) motor through a gearbox, pinion and a dual VC clutch.



Dual VC clutch on an autogenous grinding mill.

Dual VC clutch application on autogenous mill drive.



Dual VC clutches installed on a twin motor/twin pinion autogenous mill drive.