Back

Ball Mill Systems

This section contains:

1. A “system specific” Chemco Specification.
2. A typical arrangement drawing for the type of system you require.

If you have a requirement for a system not shown here, please contact our local representative, or our Monongahela, PA office at:

724-258-7333
fax: 724-258-7350
toll free: 1-800-501-5113
e-mail: sales@chemcoequipment.com

Chemco Vertical Ball Mill Slaking System
(Dry FGD)

Since 1993, Chemco has been providing ball mill slaking systems to “Dry” Flue Gas Desulfurization system suppliers. Chemco’s system features the vertical ball mill by Union Process and is shown in Figure 1. The system is designed to automatically slake commercial grade pebble quicklime at feed rates of 5,000 to 27,000 pounds per hour (based on a material bulk density of 55 lb/ft^3) and prepare a 20-30% by weight slurry concentration. The system consists of the following major components:

- Volumetric or gravimetric feeder
- Premix chamber
- Vertical ball mill (also called an attritor) slaker
- Dust and vapor removal system
- Separation tank
- Slurry recirculation pump
- Grit separation screen (optional)
- Grit removal conveyors (optional)
- Slaking system control panel

The volumetric screw feeder, mounted above the vertical ball mill slaker, is typically used for the metering of dry solids into the wetting cone. An optional gravimetric belt feeder can be furnished if desired. Either type of feeder can be supplied with AC or DC motors along with associated variable frequency drive or dc motor controller. When the drive control is set at 100% the feeder delivers quicklime at its maximum feed rate (based on a material bulk density of 55 lb./ft^3) into the premix chamber. Typically, a proximity switch or weight transmitter delivers a signal to the programmable logic controller (PLC) that indicates feeder speed or delivery rate. This signal is used to adjust the amount of slaking water delivered to the premix chamber in order to maintain constant 3.3:1 water to lime ratio at startup until normal operating temperature is reached. Upon reaching operating temperature, the slaking system control panel temperature controller regulates slaking water flow, to maintain temperature to ±2 F setpoint.

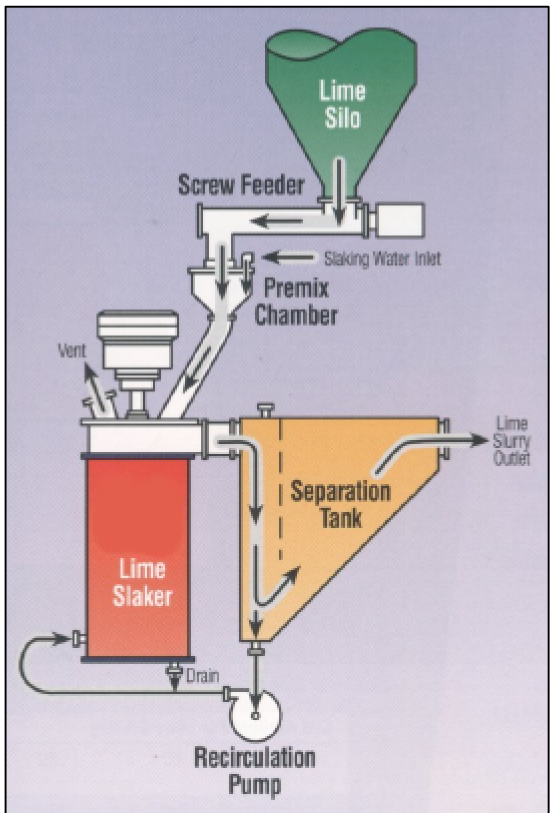


Figure 1. Typical Ball Mill Slaking System.

Quicklime enters the premix chamber from the feeder discharge by way of a fabricated steel chute. The premix chamber is provided with four water inlet connections. Slaking water, delivered by a control valve, enters the premix chamber top cover and is dispersed within the cone such that there is total coverage on the internal wall of the funnel and the discharge chute to the vertical ball mill slaker preventing buildup of dry quicklime. The wetting cone is provided with a hinged hatch that is used for periodic inspection and adding grinding media to the vertical ball mill.

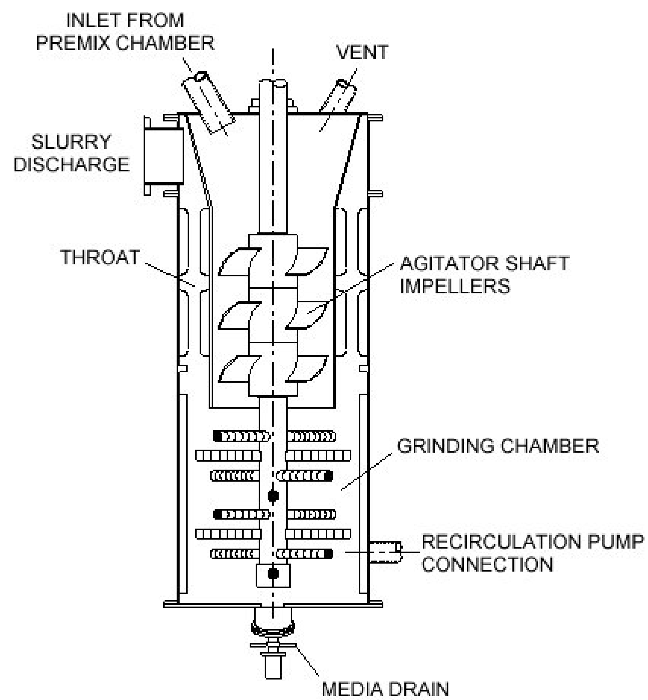


Figure 2. Typical Ball Mill Slaker Section.

Referring to Figure 2, lime slaking takes place within the vertical ball mill slaker grinding chamber. There, the mixture of water and quicklime are introduced from the premix chamber through the top of the unit combined at specified amounts to form approximately 20-23% concentration slurry. The solids and liquid are drawn through the internal mill throat down into the mill by impellers mounted on the mill agitator shaft. Course particles remain in the agitated media bed and finer particles rise on the outside of the throat. These particles are carried up and discharged at the top of the mill into the separation tank. Within the vertical ball mill calcium oxide reacts exothermically with water to produce calcium hydroxide [Ca(s) + $H_2O(l) \rightarrow Ca(OH)_2(s)$; $\Delta H^\circ = -65.7$ kJ]. Friction of the grinding media also generates heat and contributes to the heat generated by the chemical reaction. Normal operating temperature within the vertical ball mill slaker is set at 185-190° F. Approximately 85-95% of the slaking process takes place within the vertical ball mill slaker. Coarse particles and unslaked lime that may be carried into the separation tank settle to the tank bottom were they are pumped back to the ball mill grinding chamber by the recirculation pump. There the larger particles are re-ground as they rise through the agitated media bed. The ball mill is equipped with a two-speed motor. The ball mill agitator runs at high speed while the feeder is running. When the feeder is de-energized the agitator motor shifts to low speed.

Vertical ball mill slaker is equipped with a RTD at the slurry discharge point, before entering the separation. The RTD provides a 4-20 mAdc temperature signal to the system's temperature controller. This signal is used to ensure proper amounts of water are supplied to maintain normal operating temperature. The signal also provides a high temperature alarm which will activate should the chamber operating temperature exceed 195°F. A high temperature alarm will result in the feeder being de-energized and open a cooling water solenoid valve allowing water to be added directly into the premix chamber and ball mill until the temperature falls below 190°F. Upon reaching normal operating temperature the slaking system will resume normal operation.

Vertical ball mill is also equipped with a low grinding media sensor. Should the power draw of the agitator motor fall below a preset level an indicating light at the control panel is illuminated and an audible alarm is sounded. Grinding media should be added at the ball mill or premix chamber.

The slaking system is equipped with a dust and vapor (D&V) removal system that is on at all times while lime slurry is being prepared. The system consists of a D&V and exhaust fan. Steam and entrapped particles originating within the vertical ball mill slaker are evacuated through a vent connection located on top of the mill. From there it enters the D&V canister where cone-type water sprays condense the steam and remove particles. The water and entrapped particles settle at the bottom of the canister where it drains to the separation tank through a 2-inch pipe. The sprays are on at all times while the feeder is energized and will remain on for a period of time after the feeder has been de-energized. The exhaust fan will remain on at all times while it is in auto mode. The exhaust fan serves to create a negative pressure within the vertical ball mill. If an inspection hatch is opened during operation air will be drawn into the system preventing release of steam.

Lime slurry enters the separation tank from the vertical ball mill slaker. The separation tank is designed such that heavier particles settle to the bottom of the inclined walls and are recirculated through the recirculation pump back to the vertical ball mill slaker for additional grinding. Two axial-turbine type agitators are provided on the inlet and discharge chambers of the separation tank force slurry down and up the tank chambers. Agitators are equipped with abrasion resistant alloy steel impeller blades and are continually energized during normal operation and while slurry is contained with the tank. The recirculation pump is equipped with a low-pressure switch on the discharge piping. Should the discharge pressure fall to preset limit, an indicating light at the control panel will be illuminated and an audible alarm is sounded. The pump motor is typically equipped with a power-monitoring device located in the control panel that will illuminate an indicating light if the power draw is outside a band set at startup. In either case, some sort blockage has occurred in the suction or discharge piping of the pump or the conveying pipeline has broken and must be corrected for the system to resume normal operation.

Slurry overflows out of the separation tank through a discharge pipe and flows onto the (optional) vibrating grit screen or directly to the slurry storage tank. The grit screen motor is energized when the feeder is running and remains energized for 15 minutes after the feeder stops. A velocity diffuser is typically provided and serves to disperse slurry before it falls onto the screen preventing the screen from becoming prematurely worn. There, slurry passes over a 16-mesh screen. The screen vibrating motor ensures a constant movement of particles around the screen material and cone-type water sprays provide continuous washing of material. Finer calcium hydroxide particles pass through the screen and are discharged to a lime slurry storage tank. Any larger grit particles, which cannot pass through the screen, are discharged into the grit conveyor. The conveyor operates continuously while the feeder is energized and for 20 minutes after the feeder stops. It typically passes through the silo skirt where grit is discharged into disposal containers. A proximity switch mounted on the discharge end of the conveyor provides a signal during conveyor operation. Should the shaft stop rotating, indicating some sort of blockage or broken shaft, the conveyor motor is de-energized and an indicating light at the control panel will be illuminated and an audible alarm sounded.

The slaking system control panel contains all indicating lights, hand switches, control devices and alarms to ensure proper operation on the slaking systems. System process is controlled through a PLC. The panel can also be equipped with 6", 10" or 12" graphical interface touch screen, similar to that shown in Figure 3. Using a touch screen will increase system flexibility and options. The screens contain all selectors and indications needed for proper system operation.

Figure 3. Typical Graphical Interface Screen.

The heart of the Verticall ball mill (also called an attritor) slaking system, of course, is the ball mill. In 1993, Chemco Equipment Company agreed to team with Union Process of Akron, Ohio in providing an vertical ball mill for quicklime slaking (dry FGD) as well as limestone grinding (for wet FGD).

Chemco Vertical Ball Mill Limestone Grinding System (Wet FGD)

It was a natural progression from dry flue gas desulphurization to wet flue gas desulphurization. With CHEMCO's 17 years of experience in lime handling, processing and slaking, and Union Process' 40 years of experience in fine grinding, we are in an excellent position to provide our customers with not only good equipment but also technical expertise in this field.

We have extensive laboratory facilities available to test slaking as well as grindability of different quick lime and limestones.

Due to the unique design of the attritor vertical ball mill, this system is very competitive and in general consumes 40% less power compared to systems using horizontal ball mills of similar capacity.

For large Wet Flue Gas Desulphurization systems with ball mill capacities over 30 metric tons per hour, CHEMCO supplies standard horizontal ball mills as part of the limestone grinding systems.

The Chemco/Union Process vertical attritor ball mill is used for quick lime slaking in dry FGD as well as limestone grinding in wet FGD systems.

UNION PROCESS/CHEMCO
CL ATTRITOR

TECHNICAL SPECIFICATIONS

The patented CL Attritor is an energy efficient, compact, internally agitated vertical ball mill. The system is composed of a support frame with drive pivot assembly, grinding tank assembly, agitator shaft assembly, and motor/gear reducer drive system.

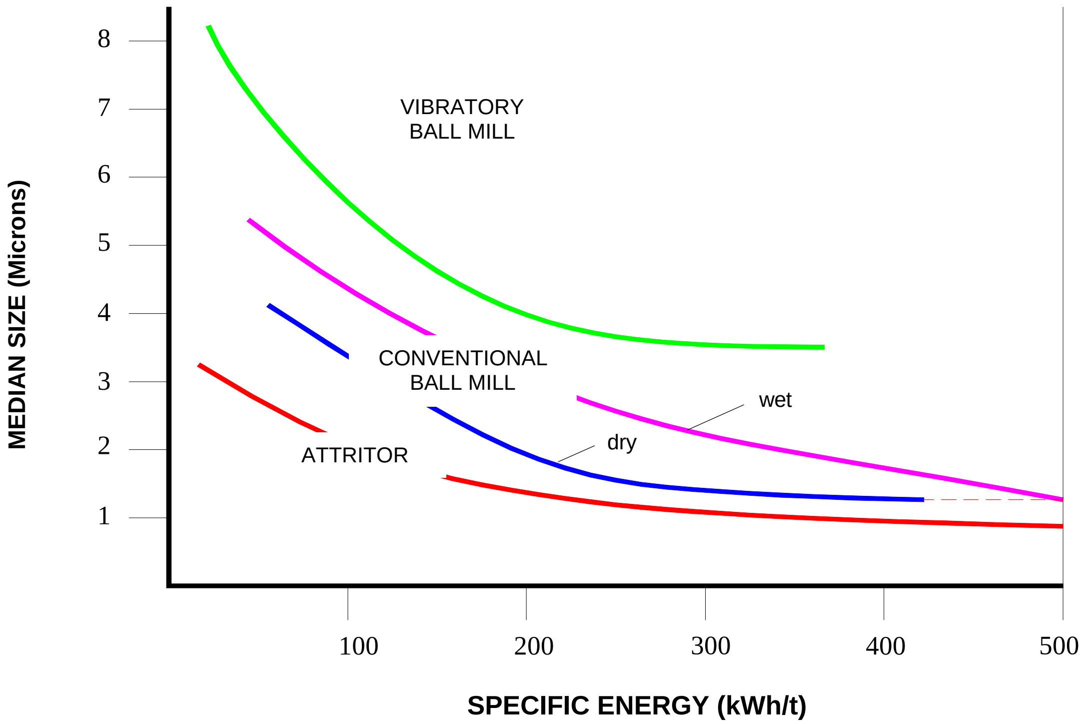
The grinding tank, which can be removed from the frame for maintenance, contains an internal funnel and throat through which with raw materials are added. The funnel and throat separate the incoming raw material from the discharging ground material. A vertical agitator shaft passes through the throat with shaft mounted impellers in the throat area and shaft mounted agitator arms below the throat in the bed of grinding media. Grinding media consists of steel balls ranging from ¼" to ½" in diameter. The bottom of the grinding tank has a media discharge assembly for discharging grinding media.

The frame supports the motor and gear reducer. The frame has a special drive pivot assembly, which allows the motor and gear reducer to be pivoted 90º away from the grinding tank assembly. A coupling connects the reducer shaft to the agitator shaft. Once the drive pivot assembly has been rotated, the funnel, throat, and agitator shaft assembly can be removed up out of the grinding tank. The motor and gear reducer are connected by sheaves and belts. The drive system is equipped with a special 450% high starting torque motor, designed to overcome the inertia of the stationary media bed when starting the mill.

The CL Attritors are top-feed/top-discharge machines. The solids and liquid are charged at the top of the mill and pumped through the throat down into the media bed by the rotating impellers. The media bed is agitated by the rotating shaft arms. The solids are ground in the agitated media bed. Coarse particles remain in the media bed, whereas the fine particles are carried up by the slurry flow on the outside of the throat and funnel, and are discharged at the top of the mill into a settling tank. Coarse particles that may be carried over into the bottom of the Attritor's grinding tank where they are further ground as they rise through the agitated media bed.

ATTRITORS – THE MOST ENERGY EFFICIENT GRINDING MILL

The Attritor mill has proven to be the most efficient in grinding several kinds of minerals. As an example, a comparison of the effectiveness of various grinding devices for producing ultra-fine products from a Pima chalcopyrite concentrate, has shown that the ***Attritor is capable of producing the finest product for a fixed specific energy input of all the different devices tested.*** (Figure below). It can be observed in the Figure that, for energy inputs exceeding 200 (kWh/t) Attritors continue to grind into the submicron range when size reduction in other devices has almost stopped. In addition, in the micron range, the capacity of the Attritor is high relative to the other devices because of the exceptionally high power input per unit volume of the vessel which gives a much higher grinding potential. For example, the power input per unit volume of the S-1 Attritor operated under typical conditions is 0.33 kW/gallon compared to the value of 0.016 kW/gallon obtained from a 10-inch diameter by 11.5-inch long tumbling ball mill. As a consequence, time required for grinding in the Attritor is shorter than that required to grind in the ball mill for a fixed specific energy input or to a certain desired median particle size.



Comparison of the effectiveness of various grinding devices for the ultrafine chalcopyrite concentrate.
Herbat and Sepilvede, Fundamentals of Fine and Ultrafine Grinding ia a Stirred Ball Mill. Proc. Powder & Bulk Solids Conf., Chicago, IL, May 1978.

Lime Grinding System Description

The Chemco Limestone Grinding System consists of _____ independent trains. Either train can satisfy the requirement to process _____ MPTH of 20 mm X 0 limestone, and to produce 95% (by weight) minus 44 µm (325 mesh) limestone slurry. The system consists of the following components:

- Limestone Silo
- Silo Discharge Knifegate Valve
- Weighbelt Feeder
- Crusher (if required)
- Reversing Screw Conveyor (if required)
- Wetting Cone
- Attritor (Vertical Ball Mill)
- Attritor Recirculation Pump & Piping
- Separation Tank
- Mill Product Tank
- Hydrocyclone Cluster
- Reactor Slurry Storage Tank
- Reactor Feed Pumps

The components are interconnected by a series of chutes and pipe, some lined with a hardened steel alloy, others with rubber.

The process flow stream is shown in the Process flow Diagram, Chemco drawing 42805. Values for the relevant parameters at the design tonnage rate 9.75 MTPH (10.75 STPH) are given in the accompanying table as an example.

Redundancy

As noted from the flow diagram, the reversible screw conveyor allows the silo, feeder and crusher in either train to feed either attritor. Therefore, when either attritor, or any component downstream is inoperable due to maintenance or repairs, the remaining attritor, and downstream equipment can be used without alternating to the other silo.

Maximum System Capacity

Each component of the system has been designed to process a maximum of _____ MTPH.

Equipment & Component Descriptions

The following descriptions are to briefly familiarize you with the components of the system.

Attritor Recirculation Pump *(Optional – Used only if separation tank is used)*

The recirculation pump consists of a horizontal, centrifugal pump with a cast iron casing and No. 566 Urethane rubber replaceable liners. The liners cover all of the pump's internal slurry-wetted surfaces. Pump bearings are roller-type and are oil lubricated. Impeller adjustments are made at the bearing pedestal without having to disassemble the pump. The pump stuffing box carries 4 rings of TFE impregnated graphite packing, a Hastelloy "C" shaft sleeve, Hastelloy "C" gland bushing, and 316 stainless steel half glands. The stuffing box requires 1-2 gpm of service water.

The pump speed of ____ rpm will result in ____ m^3/hr. against ____ meters TDH. The head versus flow curve has a characteristic shallow rise to shutoff head, however, so that small changes in discharge head will result in relatively large changes in flow rate.

The pump motor is mounted overhead: TEFC, Mill and Chemical Duty, and drives the pump via V-belt.

Separation Tank *(Optional – May be substituted by mill product tank)*

The separation tank is a two-chambered A-36 carbon steel, 6.4 mm (¼") thick rubber-lined fabrication, trapezoidal in shape to encourage separation of the coarse and fine limestone particles. The ground limestone enters the tank from the attritor and is forced to the bottom of the primary chamber by the cover-mounted turbine mixer. The coarse particles settle to the bottom, and are drawn up by the attritor recirculation pump. The fine limestone particles flow up the sloped surface of the secondary chamber, aided by the second mixer, exit the tank, and enter the mill product tank. The rubber-coated baffle plate separating the two chambers is fitted with an overflow weir to allow the primary chamber contents to spillover into the secondary chamber instead of backing up in the attritor.

The mixers are driven by a severe duty, _____ Kw, 54 RPM, gear motors. The mixer impellers are hardened steel for abrasive wear resistance; the balance of the mixer is rubber coated. Smaller mixer blades are also provided to replace the installed ones, if less agitation is desired in each chamber.

Hydrocyclone Cluster

The Model _____ Cyclone Cluster is custom-fabricated to produce a maximum of _____ MTPH 95% by weight less than 44 µm (325 mesh) limestone particles in a 30% by weight slurry. Construction is per Warman drawing including Teflon-lined Warman slurry knifegate valves; diaphragm protected pressure transmitter & gage (KPa), stainless steel nameplates, standard paint finish. Overflow and underflow launderers, and feed inlet pipe and distribution piping are rubber coated.

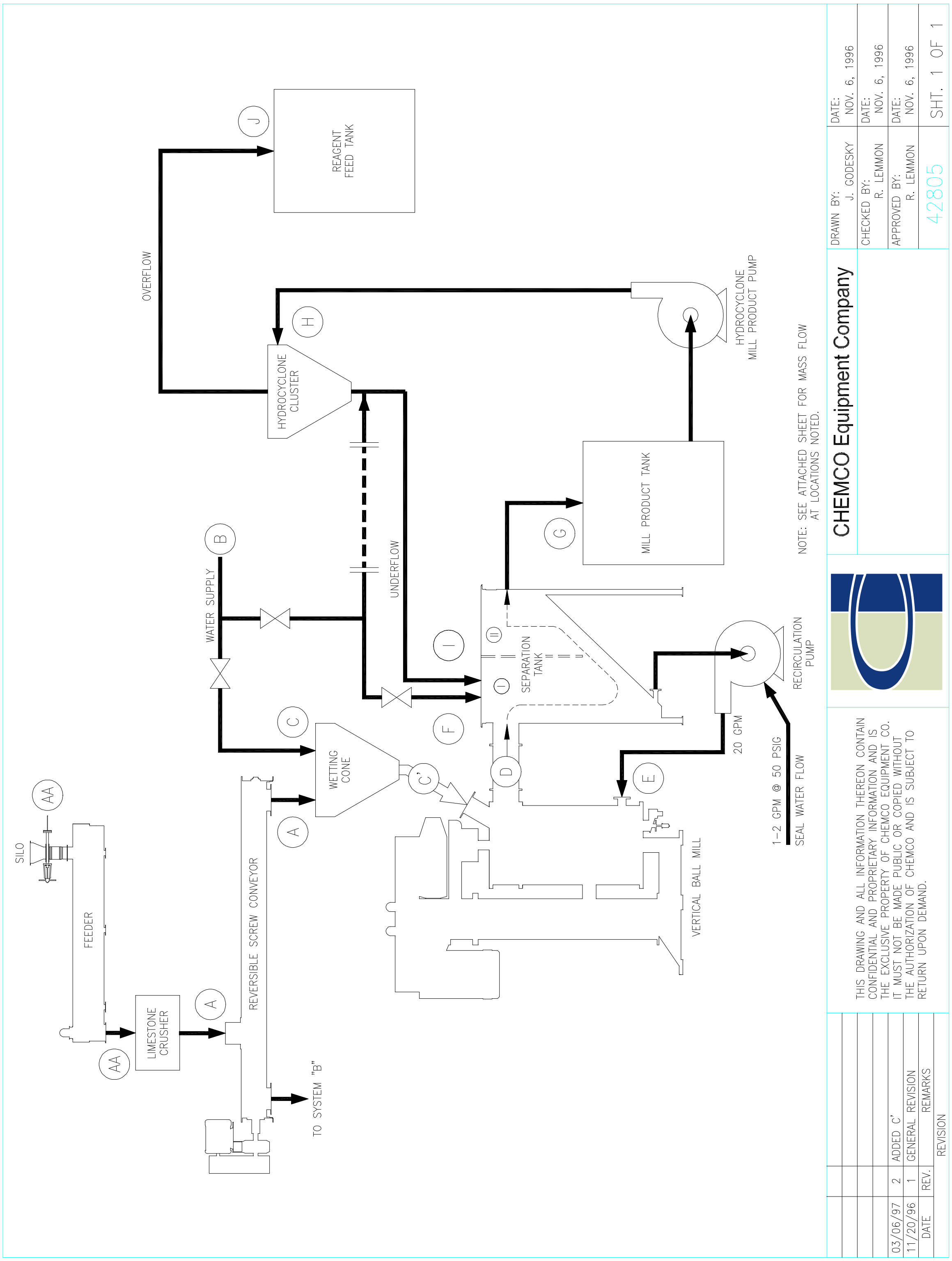
Each cyclone in the cluster is composed of interchangeable vortex finders and spigots so that different sizes can be installed to meet start-up or off-design conditions.

Reactor Feed Tank and Feed Pumps

A reactor feed tank and pumps can be supplied if required as part of this package.

Controls

Chemco can supply controls including control panels, programmable logic controllers to operate the entire limestone storage, grinding and slurry feed system. If central controls are required, we will provide the necessary interface devices so that the customers DCS will control the entire system. Each system control is custom designed for the particular project.


REAGENT FEED TANK
J
OVERFLOW
HYDROCYCLONE CLUSTER
H
HYDROCYCLONE MILL PRODUCT PUMP
WATER SUPPLY
B
UNDERFLOW
MILL PRODUCT TANK
G
SEPARATION TANK
I
II
I
F
C
WETTING CONE
C'
D
E
20 GPM
RECIRCULATION PUMP
1-2 GPM @ 50 PSIG
SEAL WATER FLOW
NOTE: SEE ATTACHED SHEET FOR MASS FLOW AT LOCATIONS NOTED.
VERTICAL BALL MILL
SILO
AA
FEEDER
AA
LIMESTONE CRUSHER
A
A
REVERSIBLE SCREW CONVEYOR
TO SYSTEM "B"
CHEMCO Equipment Company
DRAWN BY: J. GODESKY
DATE: NOV. 6, 1996
CHECKED BY: R. LEMMON
DATE: NOV. 6, 1996
APPROVED BY: R. LEMMON
DATE: NOV. 6, 1996
42805
SHT. 1 OF 1
THIS DRAWING AND ALL INFORMATION THEREON CONTAIN CONFIDENTIAL AND PROPRIETARY INFORMATION AND IS THE EXCLUSIVE PROPERTY OF CHEMCO EQUIPMENT CO. IT MUST NOT BE MADE PUBLIC OR COPIED WITHOUT THE AUTHORIZATION OF CHEMCO AND IS SUBJECT TO RETURN UPON DEMAND.
03/06/97 2 ADDED C'
11/20/96 1 GENERAL REVISION
DATE REV. REMARKS
REVISION

Rev.⑤
03-07-97

PROCESS FLOW- PARAMETER VALUES AT DESIGN (9.75 MTPH, 10.75 STPH)

Process Location	Solids Flow Rate lb./hr.	② Particle Size	Water Flow Rate lb./hr.	Mass Flow Rate lb./hr.	% Solids	① Slurry Specific Gravity	① Volume Flow Rate GPM	m³/hr.	② Pressure PSIG	BAR	③ Temp °C
AA	21500	20 MM X O	0	21500	100.0%	2.700	15.9	3.6	0	0	Ambient
A	21500	6 MM X O	0	21500	100.0%	2.700	15.9	3.6	0	0	Ambient
B	0	0	50170	50170	0.0%	1.025	97.8	22.2	80	552	Ambient
C	0	0	21500	21500	0.0%	1.025	41.9	9.5	0	0	Ambient
C′	21500	6 MM X O	21500	43000	50%	1.49	57.7	13.1	0	0	Ambient
D	34038	6 MM X O	27401	61439	55%	1.56	78.5	17.8	0	0	46
E	12538	6 MM X O	5901	18439	68%	1.77	19.4	4.4	27	186	46
F	0	0	28670	28670	0	1.025	55.9	12.6	0	0	Ambient
G	51646	65% -325 mesh	63090	114736	45%	1.42	161	36.5	0	0	38
H	51646	65% -325 mesh	63090	114736	45%	1.42	161	36.5	30	207	38
I	30146	40% -325 mesh	12920	43066	70%	1.81	46	10.4	0	0	38
J	21500	95% -325 mesh	50170	71670	30%	1.26	115	26.1	0	0	38

NOTE:

- Above values are design criteria. Actual values may vary.
- Specific gravity of limestone = 2.7
- Sp. gr. of process (sea water) water = 1.025

Mill Grind Test for Limestone

The following are grind test results performed in a scaled down model of a Chemco/Union Process attritor, vertical ball mill with a rated capacity of 12 metric tons per hour.

PARAMETERS	
Material:	Limestone
Material/Feed Size:	0 by 6 mm
Final Grind:	95% > 325 mesh 99.5% > 140 mesh After cyclone separation and recirculation
Final Slurry Concentration:	30% by weight