

ERIEZ

FLOTATION DIVISION



• FERTILIZER •

CrossFlow Separator • HydroFloat Separator
SlamJet Sparging System
Cavitation Tube Sparging System



FERTILIZER

Eriez Flotation Division has developed several technologies that can improve the separation of fertilizer minerals through flotation.

These technologies incorporate improved methods of air sparging and particle contacting for coarse, fine, and ultra-fine particles. For the coarsest particles, the Eriez HydroFloat® is a proven process for the recovery of particles up to and exceeding 4-mm. Fine particles are best treated using EFD's proprietary SlamJet sparging system. For ultra-fine particles or where more intimate contacting is required, the CavTube™ sparging system can be employed.

The recovery and upgrading of fertilizer minerals can be accomplished using an array of advanced separations technology. Some of the basic components include:

① **CrossFlow Separator** - A teeter-bed separator with a novel feed presentation system which helps to improve classification efficiency, capacity, and operation especially at low feed percent solids. This device complements EFD's flotation systems as it helps to ensure superior flotation performance by reducing misplaced material.

② **HydroFloat Separator** - This patented flotation device carries out flotation in the presence of a teeter or fluidized bed. In this device, bubbles attach to the hydrophobic species which ultimately changes the effective density of the bubble-particle aggregate allowing for the recovery of coarse particles in excess of 4-mm.

③ **SlamJet Sparging System** - Utilized in column flotation cells, this method of aeration includes a self-closing air lance which is custom tailored for each application. These sparging devices use a single, large bore orifice to prevent plugging and fouling. In addition, the nozzles are ceramic-lined and provide nearly maintenance-free operation.

④ **CavTube Sparging System** - This alternate column flotation sparging system offers increase particle-bubble contacting and improved collection based on the creation of pico-bubbles during hydrodynamic cavitation. In this method, barren slurry is pumped from the base of the column, aerated and then routed through a calculated number of spargers where a fine bubble dispersion is created. CavTubes are manufactured using a wide variety of materials to ensure a long wear life.

PHOSPHATE

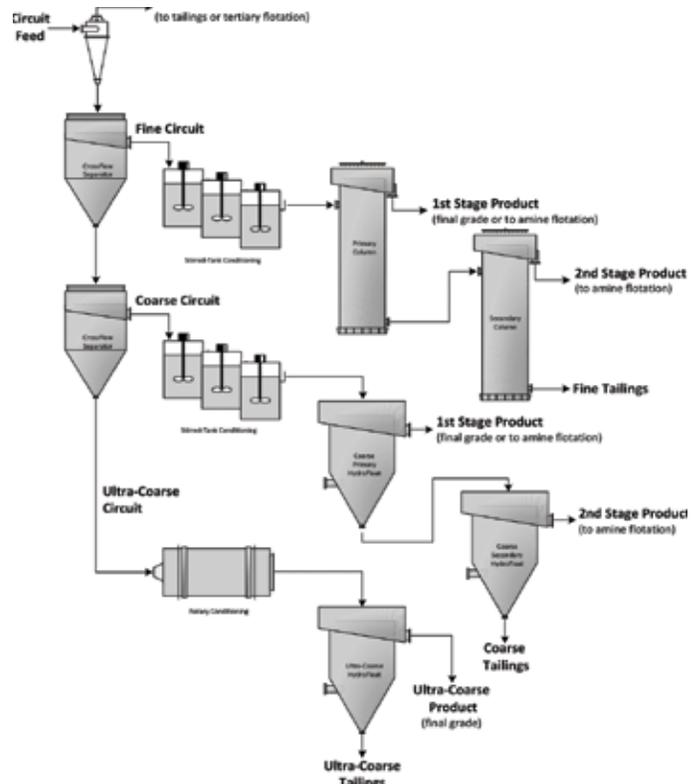
Compared to other minerals, phosphate tends to liberate at a very coarse size. This is quite obvious when treating sedimentary deposits. Traditionally, flotation is considered efficient up to about 0.250-mm; however, given the proper equipment and flow sheet, there is an opportunity to conduct flotation at sizes coarser than 0.250-mm and up to and exceeding 1-mm.

Igneous deposits can benefit from coarse flotation, but they are also amenable to very fine flotation. Typical Brazilian ores are treated down to approximately 5 microns. In contrast, phosphatic slimes finer than 100 micron are discarded in the United States due to high process costs and poor selectivity.

Provided in this process diagram (see right) is a flow sheet recommended by EFD. This flow sheet requires efficient sizing in order to produce up to 4 different size classes. This classification step ensures that each size class is properly treated in a manner that is most effective for its recovery. This flow sheet can be modified as necessary to better suit ores of varying size distributions.

Classification - For the classification of the finest material, hydrocyclones are necessary. This well proven and accepted technology can provide an efficient size cut while treating a vast amount of ore. For the coarser size cuts, the CrossFlow teeter-bed separator is recommended. These units consume much less plant area than an equivalent screen and can process large feed tonnages with little misplacement. The efficient size cut afforded by teeter-bed (or fluidized-bed) technology ensures that oversize is not introduced into finer circuits while flotation entrainment is reduced with minimal misplacement of fines into coarser circuits.

Conditioning - The fine ore can be conditioned in typical stirred-tank conditioners. With proper engineering, this approach can be utilized for ore exceeding 0.600-mm. However, a rotary drum conditioner is recommended for the coarsest ore. This approach has several benefits including a lower installed horsepower, plug flow contacting and minimal generation of slimes which can increase reagent consumption.



Proposed Phosphate Flow Sheet for Sedimentary & Igneous Matrix

HydroFloat - Coarse and ultra-coarse material is generally too massive for traditional column flotation. In conventional cells, the energy required to maintain the particles in suspension leads to a large degree of detachment. As a result, these cells are operated with little or no froth and no guarantee of recovery. The addition of a teeter bed ensures recovery by providing an extremely high bubble/particle collision rate and a high-density teeter zone, impervious to bubble-particle aggregates.

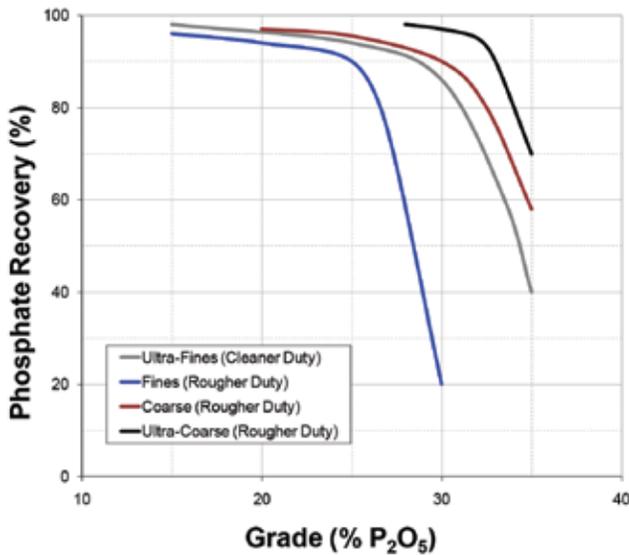
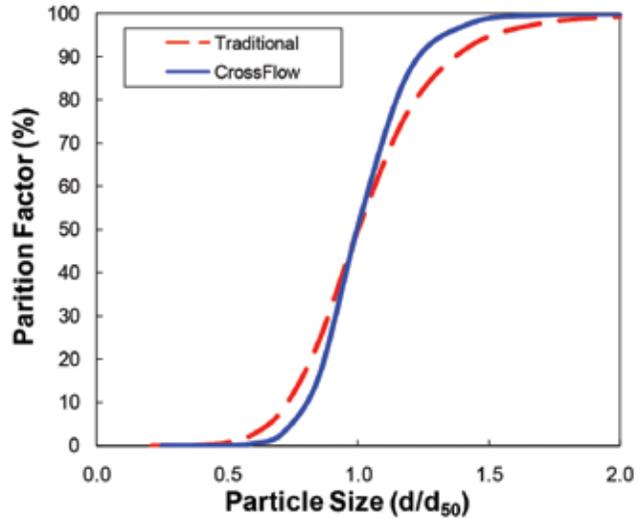
Column Flotation - Ultra-fine and fine phosphate is best upgraded utilizing column flotation which provides for a relatively deep froth in order to produce a high-grade flotation product. A two-stage approach can be utilized where the higher-grade rougher concentrate can be used as final product or further upgraded in a cleaner circuit along with the scavenger concentrate. Sparging for these devices can be accomplished using the SlamJet, CavTube, and even the HydroFloat sparging systems.

DESIGN CRITERIA (TYPICAL)	CLASSIFICATION CROSSFLOW	ULTRA-FINES COLUMN	FINES COLUMN	COARSE HYDROFLOAT	ULTRA-COURSE HYDROFLOAT
Size Class	3.0mm x 0	0.150x0.005mm	0.425x0.150mm	0.850x0.425mm	1.420x0.600mm
Feed Rate	30-50 tph/m ²	-	-	15-20 tph/m ²	15-20 tph/m ²
Product Rate	-	0.7-1.2 tph/m ²	1.0-3.0 tph/m ²	-	-
Air Requirement	-	1.0-1.5 cm/s	1.5-2.5 cm/s	0.2-0.6 cm/s	0.2-0.6 cm/s
Retention Time	-	7-10 min.	7-10 min.	-	-

PHOSPHATE

Typical Sizing Performance - The importance of proper sizing of phosphate ore prior to flotation cannot be underestimated. Oversize material reporting to fine circuit will have a lower probability of recovery. In contrast, fine material reporting to a coarser circuit may be unselectively recovered. In general, flotation cells are typically most efficient when tuned for a specific size fraction.

Classification performance for the EFD CrossFlow teeter bed separator is shown in the adjacent plot. The patented feed presentation system provides a more efficient use of separator volume leading to improved efficiencies and higher capacities of traditional hindered-bed separators. In side-by-side testing, the CrossFlow Separator was able to provide a sharper size cut which outperformed a traditional classifier by over 30%.



Typical Flotation Performance - Provided are the typical performance curves for treating a range of phosphate ores at various size fractions.

Efficiently sized ultra-coarse feed provides the highest P₂O₅ grade given that this feed contains the least amount of clays and silicates that can unselectively report to the flotation concentrate due to entrainment.

For both the coarse and ultra-coarse feeds, the aerated teeter-bed found in the HydroFloat Separator ensures high phosphate recoveries. In a typical installation, recovery is generally in excess of 95%.

Fine and ultra-fine feed is easily processed using column flotation and returns recoveries exceeding 90%. Depending on the application (i.e., rougher or cleaner), the products can either be of final grade or tailored for the various downstream processes such as amine flotation, depending on plant operating conditions.

UNIT SIZE METER (FT)	CROSSFLOW (TPH FEED)	ULTRA-FINES (TPH PRODUCT)	FINES (TPH PRODUCT)	COARSE (TPH FEED)	ULTRA-COARSE (TPH FEED)
1.25 (4.0)	45-80	0.9-1.5	1.2-3.7	18-25	18-25
1.80 (6.0)	95-160	1.7-3.0	2.5-7.6	38-50	38-50
2.50 (8.0)	180-315	3.4-5.9	4.9-14.7	73-98	73-98
3.00 (10.0)	270-450	5.0-8.5	7.0-21.2	105-141	105-141
3.66 (12.0)	400-670	7.4-12.6	10.5-31.0	157-210	157-210
4.00 (13.0)	-	8.8-15.0	12.5-37.0	-	-
4.25 (14.0)	-	9.9-17.0	14.2-42.5	-	-

POTASH

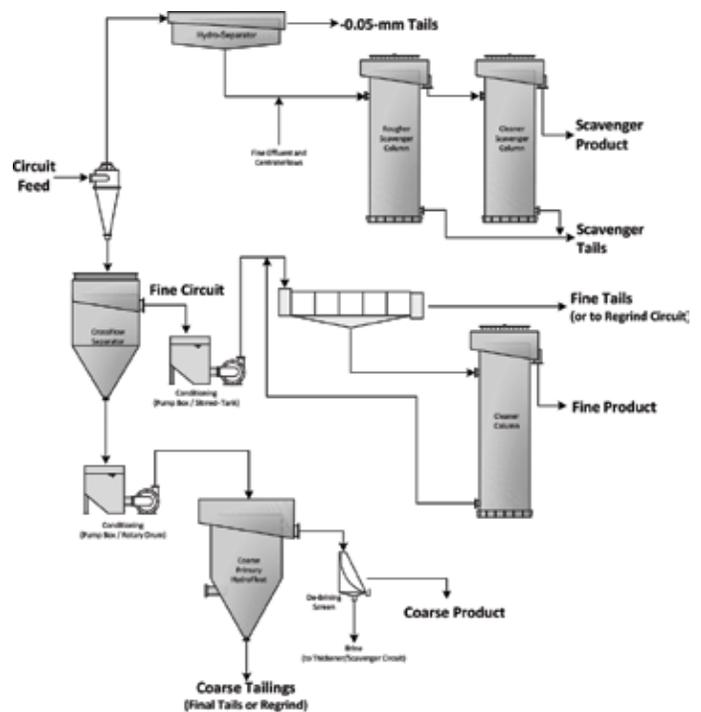
The liberation of potash is site-specific. In some cases, potash particles liberate with very high grade at over 3-mm. In other cases, good liberation is achieved at finer sizes (i.e., 100% passing 0.500-mm). As a result, plant circuitry can vary to a large degree. Plants may or may not include a coarse flotation circuit depending on the ore characteristics. In addition, most plants incorporate a regrind flotation circuit for the recovery of ore from freshly ground rougher circuit tails.

Most plants typically employ conventional mechanical cells for rougher flotation. The product is traditionally put through several stages of cleaning. In addition, the rougher tails are reground and reprocessed in flotation. Finer effluents and material passing 100 micron are typically treated in a scavenger circuit. A coarse flotation circuit is employed if applicable.

Several benefits can be achieved by utilizing the process flow sheet recommended by Eriez (see right). Test work has shown that efficient sizing can improve the flotation response of each of these circuits allowing each size class to be treated in a manner that is most effective for its recovery. In addition, the use of column flotation, complete with froth washing, can significantly reduce the number of unit operations when compared to a plant utilizing only conventional, mechanical cells.

Classification - Hydrocyclones are typically utilized to produce an initial size cut at approximately 100 micron. This material is further deslimed in large hydro-separators which create a feed for a finer scavenger circuit. While typical industry practice utilizes vibratory screens for creating both a fines and coarse stream, this proposed circuit utilizes teeter bed technology which can provide an efficient size cut with less misplacement and while consuming little floor space.

Conditioning - The amine chemical reagents are typically contacted for short periods of time in simple pump boxes. Stirred-tank conditioners may improve conditioning characteristics of the fine material. Coarse material generally responds well using pump boxes, though test work has shown that contacting is improved within tumbling drum conditioners or even rotary screw conveyors.



Proposed Potash Flow Sheet

HydroFloat - Coarse material is generally too massive for traditional column flotation. In conventional cells, levels are typically maximized and the cells are flooded to improve recovery. The HydroFloat cell offers the ability to recover these coarse particles with little turbulence through the use of an aerated teeter bed. The teeter bed provides a zone of extremely high bubble/particle collisions which ultimately improve the flotation rate of the coarse material. In fact, the HydroFloat has been successful in floating potash particles in excess of 4-mm.

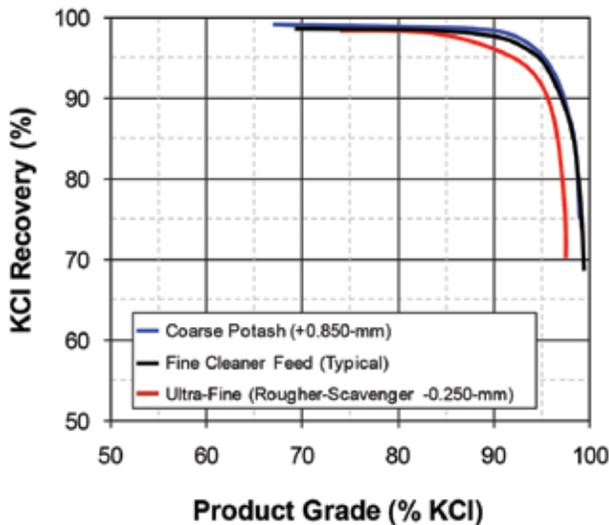
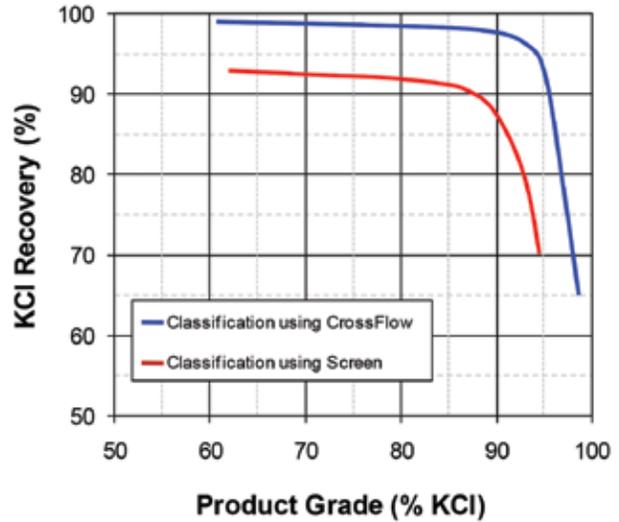
Column Flotation - Fine potash is typically recovered in conventional, mechanical cells. It is recommended that the float product from these rougher cells be then reprocessed in CavTube Sparged columns complete with froth washing to ensure both recovery and grade. This technology can also be used to treat fine regrind material or scavenger material. Scavenger material is made up primarily of screen effluents (-100 micron particles) all of which contain ultra-fine clays which can be efficiently rejected via froth washing. Scavenger circuits are typically made up of either one column or two columns operating in parallel, or in a rougher cleaner configuration which maximizes product grade.

DESIGN CRITERIA (TYPICAL)	CLASSIFICATION CROSSFLOW	SCAVENGER COLUMN	FINES COLUMN	COARSE HYDROFLOAT
Size Class	5.0mm x 0.0	0.150x0.020mm	0.850x0.150mm	3.40x0.710mm
Feed Rate	30-50 tph/m ²	-	-	15-20 tph/m ²
Product Rate	-	3.0-8.0 tph/m ²	3.0-10.0 tph/m ²	-
Air Requirement	-	0.75-1.25 cm/s	1.0-1.5 cm/s	0.2-0.6 cm/s
Retention Time	-	2-10 min.	10-12 min.	-

POTASH

Effects of Proper Sizing Performance - Poor classification can easily lead to sub-par flotation performance. This is a direct result of misplaced material that unselectively reports to the wrong process stream. For instance, screens tend to suffer from the misplacement of fine material to the coarse product stream due to inefficient washing or overloaded conditions. Cyclones also suffer from misplacement due to underflow bypass which is a result of the inherent water split within the separator.

Misplacement can greatly affect the flotation process as seen in the adjacent plot. The high efficiency offered by the CrossFlow separator ensures that there is little or no misplaced material which can be detrimental to the final product grade. Efficient classification can improve both recovery and grade.



Typical Flotation Performance - Provided are the typical performance curves for treating a range of potash ores including coarse, fines, and effluent screen fractions.

The HydroFloat separator is recommended for coarse potash streams that may contain particles exceeding 3.5-mm. While this size fraction is not amenable to typical “open cell” flotation, it does respond well to air-assisted density separation regularly achieving KCl recoveries in excess of 95%.

Test work has shown fine material is best upgraded utilizing the CavTube sparging system. The high air rates and stable froth phase formed using these technologies ensures both high recovery and also a high-grade product that may exceed 95% KCl.

Fine effluent streams are also best treated using the CavTube system. Acceptable recovery (95%) and grade have (+90% KCl) been obtained in either a rougher-only or rougher-scavenger configuration.

UNIT SIZE METER (FT)	CROSSFLOW (TPH FEED)	ULTRA-FINES (TPH PRODUCT)	FINES (TPH PRODUCT)	ULTRA-COARSE (TPH FEED)
1.25 (4.0)	45-80	3.0-10	3.0-12	18-25
1.80 (6.0)	95-160	7-20	7-25	38-50
2.50 (8.0)	180-315	14-40	14-49	73-98
3.00 (10.0)	270-450	21-56	21-70	105-141
3.66 (12.0)	400-670	31-84	31-105	157-210
4.00 (13.0)	-	38-100	38-125	-
4.25 (14.0)	-	42-113	42-141	-

TESTING SERVICES

The Eriez Flotation Division operates a full service laboratory and pilot-scale equipment test lab in Erie, Pennsylvania, USA. This newly renovated test facility measures over 1000 square meters and houses a variety of laboratory-scale equipment including CrossFlow Separators, HydroFloat Separators, and a variety of column flotation cells utilizing both SlamJet and CavTube sparging systems.

In addition, Eriez maintains all the necessary materials handling equipment to facilitate testing (e.g., mixing sumps, pumps, feeders, etc.) as well as full assaying capability. Sample size can range from a few kilos of sample to several tons of sample depending on the extent of the testing which may include simple preliminary scoping trials, proof-of-concept evaluations, and complete design evaluations.

Pilot-scale equipment is maintained at several facilities to ensure quick delivery to customer test sites. The equipment ranges from 150-mm test cells to near full-scale 1200-mm column flotation cell complete with instrumentation and sparging systems. These units are sized and outfitted such that installation is straight forward so that equipment can be commissioned and evaluated in the shortest amount of time possible. They are also large enough to provide confidence in their operation for both operators and technical support personnel.

The pilot-scale equipment is typically rented on a month-to-month basis which allows sufficient time for testing of nearly any application. On-site technical help is also offered for conducting the site evaluations or to simply provide training for operators and site personnel. And upon completion of testing, Eriez will provide a written summary of the test work which will include a full-scale metallurgical prediction for an industrial-scale installation. Experience has shown that when properly completed, the pilot-scale findings will be consistent with the full scale installation.



500mm Column Flotation Cell



250x400mm CrossFlow



400mm HydroFloat



Flotation



Hydraulic Separation



Lab & Pilot Equipment, Testing, and Technical Services

WORLD AUTHORITY IN ADVANCED SEPARATION TECHNOLOGIES

Customer-Focused Service Spanning the World of Minerals

Eriez Flotation Division (EFD) is focused on addressing specialty flotation applications through innovative technology and expert support.

EFD is committed to providing state-of-the-art equipment and process solutions for new and existing projects worldwide. We understand and quickly respond to the needs of our clients. Our versatility is demonstrated by the diversity of our engineering services and the varying sizes of projects we have successfully completed around the world.

Our test lab and pilot facilities in Erie, PA are available to demonstrate and pilot solutions based on your unique needs.

Contact the nearest Eriez Flotation Division office for technical support or design engineering to suit your specific application.



Eriez Flotation Division | Canada
7168 Venture St
Delta, BC, V4G 1H6
Canada
Office: +1 604-952-2300
efdca@eriez.com

Eriez Flotation Division | Brazil
Av. Getúlio Vargas, nº 456 - 120 andar
Funcionários - Belo Horizonte - MG
Brazil
Office: +55 31 3281 9108
efdbr@eriez.com

Eriez Flotation Division | Chile
Badajoz, 130 Of. 1505
Las Condes, Santiago
Chile
Office: +56 2 29523400
efdcl@eriez.com

Website: www.eriezflotation.com



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