

## Membrane Filtration of Colloidal Silica

A cost-effective and efficient solution

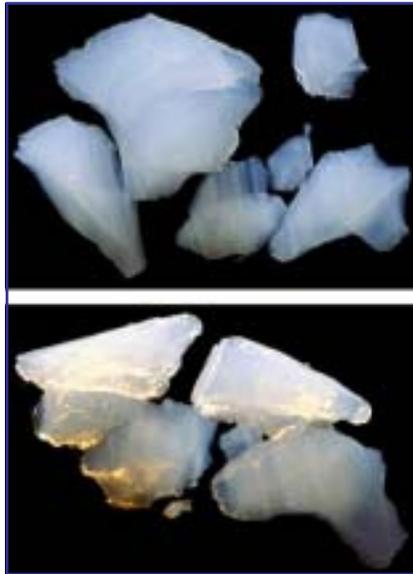
### Background

New Logic Research's patented V◇SEP membrane filtration system has been installed at Silica Gel processing plants. Vibrational membrane filtration is an innovative new way to dewater or diafilter Silica product. V◇SEP can be used as a pre-treatment for a spray dryer or evaporator. It can replace other less reliable pre-treatment systems such as Centrifuges. Today's Industrial Silica market is very competitive and efficiency in operating costs can make the difference. The V◇SEP system consumes about 12 kW of electricity and can reduce the gas consumption of a spray dryer by an average of 700,000 Therms/year. Also, the power consumption of a V◇SEP system is 10-20 times lower than Centrifuges.

New Logic's vibrating Membrane System is currently being used for dewatering of PVC Latex, Paper Coatings, Titanium Dioxide, Latex Paint Wastewater, and many other thick slurries where volume reduction is desired. There are Silica customers who are using V◇SEP to diafilter the slurry to wash it and remove impurities and salts and for product recovery from wastewater during wash down.

### Characteristics

Colloidal Silica comes in many forms and has many unique properties. It has a strange and widespread number of uses. It is used as a viscosity additive for the latex in tennis shoe soles and is also used for de-inking during paper recycling. Colloidal Silica has many unique characteristics that make it useful. The man-made amorphous type has no defined shape and the surface of the particles has great molecular charge. Just as the coastline of Norway is saturated with fjords giving a very



small country one of the largest coastlines in the world, the surface area of amorphous Silica is incredibly large in relation to its size. Silica Gel has a surface area equal to 700m<sup>2</sup>/g. Only activated carbon has a higher surface area. Another way to illustrate this is that the surface area of one teaspoon of colloidal Silica gel is equal to more than one football field in size.

Fumed Silica is more densely gathered due to its chemical synthesis process. Silica Gel is a suspension solution of random colloidal silica without definite form or size. The particles in the solution form a loose network due to the "Brownian Motion Theory" which describes the random collision of fluid molecules against the suspended matter. Because the particles repel each other, they are evenly dispersed and will not settle out. In addition, colloidal silica will have a very high viscosity and a low gel point. Colloidal Silicas and other Silicates can have Gel points as low as 15-35%. The gel point is the concentration at which the fluid will not flow and cannot be pumped.

### Raw Materials

The main ingredient for amorphous silica is regular quartz sand which can be found in abundance anywhere. This sand is processed with Sodium Carbonate, Na<sub>2</sub>CO<sub>3</sub> which is made using the Solvay process combining salt, ammonia, carbon dioxide, and limestone all naturally occurring substances.

#### Silica Gel:

Step One, sand is fused with Sodium Carbonate in a high temperature furnace. The result is Sodium Silicate and Carbon Dioxide gas.



Step 2, the Silica Gel is made using Sulfuric Acid:



The result is an aqueous salty solution containing Silica colloids. The Sodium Sulfate salts must be washed using diafiltration and then the Silica must be partially dewatered. The exact methods used will vary, however, most all silica ends up in a salty solution that must be rinsed and then dewatered.

### Silica Gel Production Process

During the refining process, the colloidal Silica is suspended in a salty aqueous slurry. This slurry must be desalted and dewatered. V◇SEP is uniquely able to be used as a diafiltration process and then to dewater in a single pass. During diafiltration, a UF membrane is used which will reject the particles and allow the salty water to pass through the membrane. By successive rinses, the silica can be completely separated from the salt solution. The resulting gel is nearly pure colloidal silica with some water.

Colloidal Silica sells for about \$25 per Pound. While in production, 2.3 tons of product is recovered each hour per 84" V◇SEP.

**Silica:** Silicon Dioxide, SiO<sub>2</sub>. Occurring naturally as a crystal, as in sand, or manmade using chemical processing to become a colloidal group of particles which have non-defined amorphous shapes.

**Silica Gel:** The word "Gel" in the name is misleading. Silica Gel is one form of colloidal silica which is produced by reacting Sodium Carbonate with pure Silica Sand with pressure, temperature, and Sulfuric Acid as one step. Silica Gel is a colloidal Silica which is a man-made suspension of solid particles in a liquid which forms a loose network.

**Fumed Silica:** This is another man-made type of colloidal Silica. It is produced by reacting Silicon Tetrachloride, SiCl<sub>4</sub>, with water and steam. It is more pure and lacks the surface charges of Silica Gel. As a result, its properties and uses are different.

**Precipitated Silica:** This is another form of colloidal Silica. It is produced by yet another chemical synthesis process giving unique properties.

**Silicate:** Generic name for any metallic compound also containing Silica, ie Na<sub>2</sub>O.SiO<sub>2</sub>

**Silica Zeolite:** Alumino-Silicate, (Al<sub>2</sub>O<sub>3</sub>.SiO<sub>2</sub> main component of Clay), which is naturally hydrated. The material is dewatered and the interlocked water molecules are also removed by calcination resulting in a molecularly charged receptor for other molecules.

**Diatomaceous Earth:** Naturally occurring decayed remains of "Diatoms" which are a form of unicellular algae having silica casings for bodies. The decomposed material closely resembles man-made amorphous silica as it is not cubic crystalline shaped like Silicon Dioxide normally is in nature.

**Siliceous:** Any substance containing Silicon Dioxide, (Silica)

**Fine Ground Silica:** Created by grinding pure Silicon Dioxide sand to form a powder. Not the same as colloidal silica because the particle still have uniform crystalline shape although very small in size. Because the particles are dense crystals, they lack surface area and don't have the adsorptive qualities of amorphous colloidal silica.

**Activated:** Similar to Clacined which is driving off liquid ingredients using extreme heat just below the melting point of the material. Activation is driving off gases in the same manner using extreme heat. The remaining product has very good adsorption properties, ie activated carbon.



**New Logic's patented V◇SEP equipped with 1300 SF (120m<sup>2</sup>) membrane for the treatment of Chemical Processing dewatering**

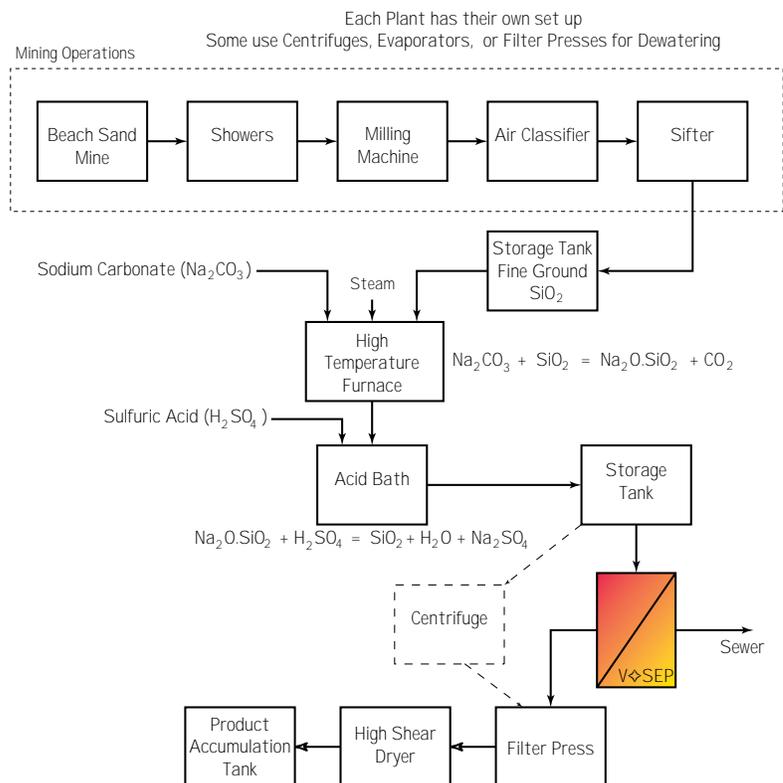
### New Logic's Solution

Technological advances in membrane filtration systems and membranes have created an opportunity for the efficient and economical treatment of Silica Diafiltration and Concentration. The "Vibratory Shear Enhanced Process" or V◇SEP™ developed by New Logic makes it possible to filter chemical processing streams without the fouling problems exhibited by conventional membrane systems.

In this case study, the V◇SEP membrane system utilizes an Ultrafiltration membrane which will reject the suspended solids and colloids. New Logic uses over 200 membranes and tighter RO and NF membranes are available.

V◇SEP is capable of handling thick slurries and concentrating the feed stream to a sludge which can be dried. The filtrate from this can be reused for washdown operations, used as plant water, or sewerred. The V◇SEP can be used by itself or in conjunction with other equipment for a comprehensive treatment system.

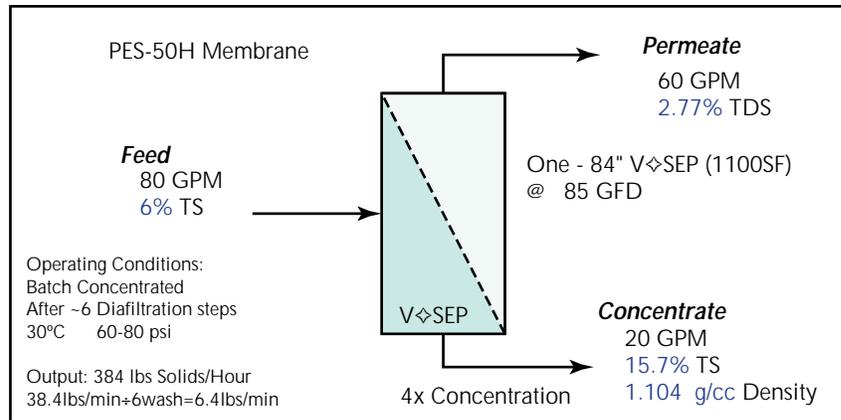
*V◇SEP ... A New Standard in Rapid Separation*



**Silica Gel Process Block Diagram**

## Process Description

V $\diamond$ SEP is capable of handling influent streams in a single pass with very little pre-treatment. Usually just a 100 mesh prescreen is all that is required. In this case study, the V $\diamond$ SEP was used to replace a centrifuge. The Block diagram below shows the treatment system. The raw process feed enters the feed tank at the left of the drawing. From here it goes to a bag filter and then to the V $\diamond$ SEP machine itself. The concentrate is returned to the feed tank for successive washes until the conductivity reached the design target at which time it is diverted to the concentrate holding tank for further treatment, The Filtrate is partially reused in washdown operations and partially sewerred.



contaminants. The operating conditions are 30°C at about 80 psi using an Ultra-filtration membrane. The footprint of the V $\diamond$ SEP is about 16 SF (1.5 M<sup>2</sup>).

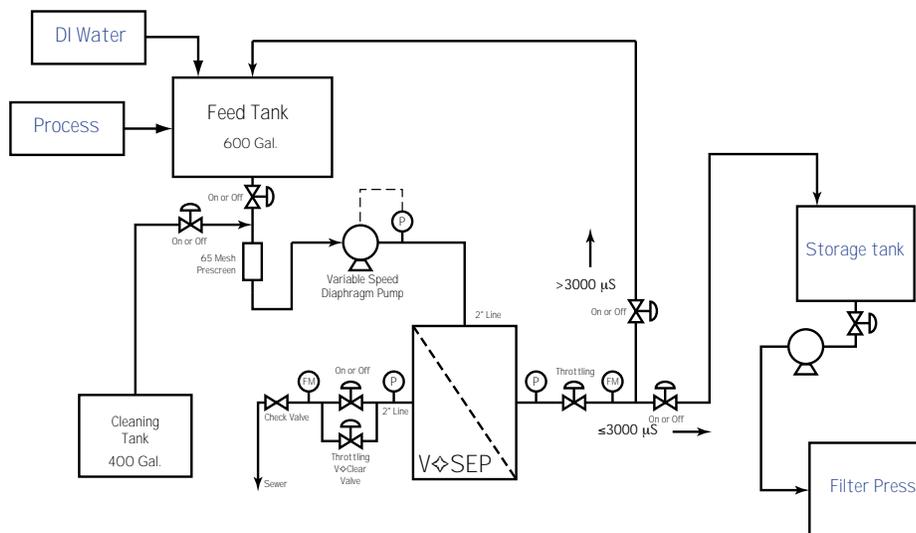
## Process Conditions

The membrane treatment system can process at a rate of about 80 GPM (18 m<sup>3</sup>/hr). The process feed containing salts is first concentrated to remove the bulk of the water. Then, with a process of wash volumes, water is added and the removed thus diluting and removing the unwanted salts and other dissolved

## Process Results

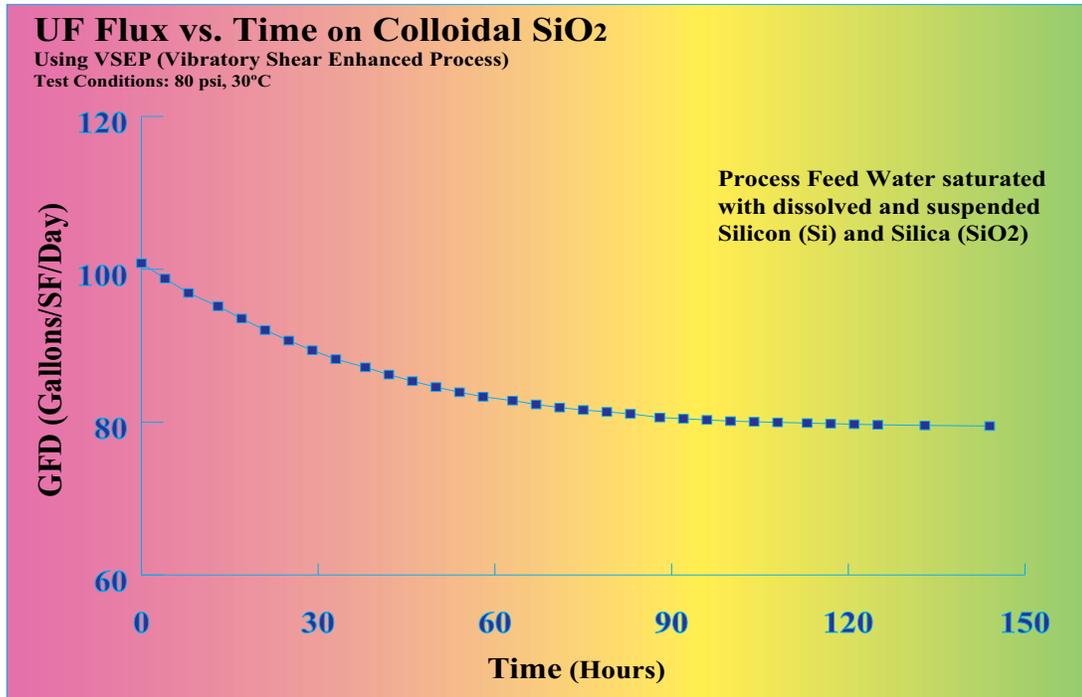
This rate of production would be equal to about 105,000 gallons per day. The concentrate produced is about 15% total solids which is very near the Gel Point with extremely high viscosity. This stream is sent for further processing using other equipment.

Colloidal:  
A group of small particles suspended in a solution from about 10 nm to 1.0 $\mu$ m. These particles have non-defined random shape and size and differ from other particles which have uniform shape or size.



### System Operation:

This process is run in manual mode and the raw product is diafiltered in the feed tank until enough of the salts and impurities are removed to meet the design criteria of the final Silica product. Diafiltration includes 6 washing steps where an equal volume of De-ionized water is first added to the feed tank. Then the tank is batch concentrated by removing permeate from the system until the volume returns to the original before adding water. This process repeats 6 times or until the conductivity of the concentrate is less than 3000  $\mu$ S. Once the concentrate is within specification, the concentrate from the VSEP unit is diverted to another feed tank where it is stored for use by a filter press or other means of final concentration.



The V◇SEP is periodically cleaned using a caustic cleaner to reset the flux and produce consistent long term results.

### System Throughput

The V◇SEP system performance is a function of temperature, % recovery, & % Total Solids in the feed slurry. The more concentrated and colder the feed, the lower the throughput of the V◇SEP system. Temperature affects the viscosity of the liquid and viscosity affects the liquid fraction's ability to move through the membrane surface. In general, one 84" V◇SEP is capable of producing 60-80 gpm of clean water filtrate from Colloidal Silica at a recovery of 75% of the total volume as permeate.

### System Components

The process feed is pulled out of an existing 5000 gal feed tank. The tank is located near to the V◇SEP and the feed

pump of the V◇SEP system is able to prime with only head pressure from the tank. The liquid transfers through a pre-screening unit to remove large particles, (100 mesh). There are many types of mechanical screens that could be used. The picture below shows the type used.



The feed water then flows into a vertical multistage centrifugal feed pump

which provides the pressure to the Filtration unit. The bag filters and pumps are provided with the V◇SEP system and are skid mounted for easy installation.

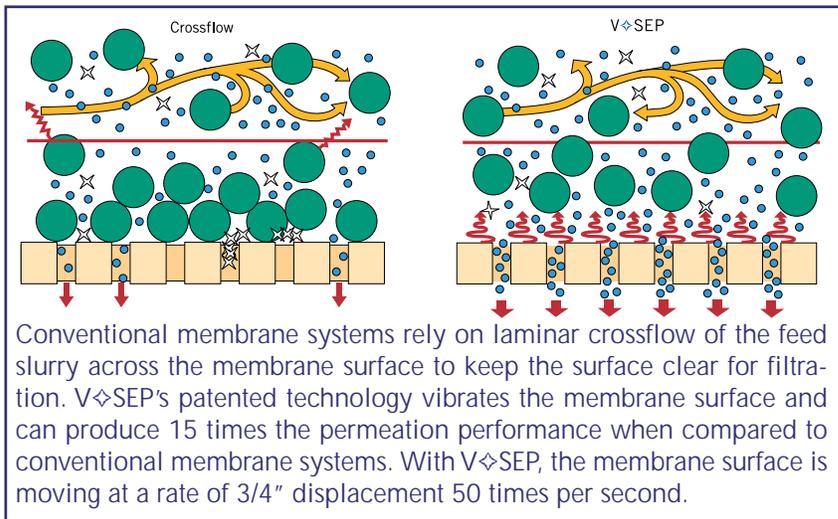
The V◇SEP system comes with a cleaning tank and many of the valves and other interface equipment. The system is "Plug and Play". The feed tank, transfer pumps, heat exchangers, and boiler are not normally included, but, can be provided as part of a complete process package. The V◇SEP system is automated and controlled by a PLC (Programmable Logic Controller). Operator interface is limited to monitoring the system and making periodic adjustment to parameter settings. The system comes standard with "Foxboro" brand instrumentation including pressure sensors, tank level sensors, flow transmitters, pH analyzers, temperature meters, and conductivity sensors to monitor the process conditions and will send a 4-20 mA digital signal to the PLC for seamless operation.

## Company

New Logic is a privately held company located in Emeryville, California. Incorporated in 1986, New Logic manufactures a proprietary membrane filtration system called V $\diamond$ SEP $\text{\textsuperscript{\textcircled{R}}}$  (for Vibratory Shear Enhanced Processing). Originally developed for blood plasma separation, the technology has been scaled up to meet the growing separation needs for many industries. V $\diamond$ SEP can be employed in water treatment, product separation, solids dewatering or wastewater treatment. The industries and applications for V $\diamond$ SEP are quite diversified and include: **Pulp & Paper** (black liquor, whitewater, box plant effluent, end of pipe), **Industrial Water Pretreatment** (ultrapure, boiler feed, surface water), **Pigments & Paint** (latex emulsions, product recovery), **Mining** (mine tailings), **Solids Dewatering** (calcium carbonate, kaolin clay, TiO<sub>2</sub>), and **Metal Working** (oily wastewater, metal hydroxides).

## Technical Services

New Logic has years of experience and expertise in membrane filtration. Their 40,000 sq. ft. facility provides comprehensive manufacturing and facilities. Highly trained engineers and technical staff are available to support your application questions. Feasibility testing can be accomplished in-house, or a fleet



of pilot units are available to support on-site testing. Operational surveys are available to help assess your needs and the potential cost savings. An experienced team of technicians are available to support both on-site pilot work and V $\diamond$ SEP system installations.

## People

From scientists to customer service associates, New Logic recruits some of the best people available. Academic credentials include doctorates and advanced degrees from such notable universities as Northwestern, Cal Berkeley, UCLA, Johns Hopkins and others.

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