NEW LOGIC RESEARCH

Application Note

V✧SEP Filtration for Precious Metals Recovery

A cost-effective and efficient processing solution

Overview

A unique membrane filtration system, known as V✧SEP (Vibratory Shear Enhanced Process), was developed by New Logic of Emeryville, California. The technology employs vibrational oscillation of an advanced polymeric membrane to improve the throughput and to prevent colloidal fouling of the membrane surface.

This new technology provides a innovative and cost effective method of recovering colloidal precious metals of all kinds from wastestreams resulting from mining or excavation. Existing technologies are limited in the yield possible for metals recovery. By using precise membrane filtration, nearly complete capture of valuable metals can now be accomplished. New Logic's V✧SEP has the ability to perform membrane separations not possible using conventional membrane systems. Membrane wastewater treatment systems that are compact, economical, and reliable are now possible for the mining industry.

Mining Regulation

One of the challenges of today's mining and excavating operations is that heavy metals which pose a potential environmental hazard are naturally occurring elements in the ground. For a typical mine, one ton of waste rock can contain five ounces of zinc, three ounces of lead, and two ounces of arsenic. On average, the earth's crust has background levels of about 2 ppm of arsenic. Since the average soil contains 2 ppm of arsenic, almost any water used in mining or excavation operations has the potential for being out of compliance with EPA directives.

The problem can be even more difficult if the mining involves rare earth metals where Uranium, Radium, or other radioactive elements can be found. As long as the radioactive elements are not disturbed, there is not classification as a hazardous material that needs superfund attention. But if the rock is moved from one place to another, a release of radioactive materials has occurred and must be reported.

In addition to the fact that these wastewaters may be possible environmental hazards, valuable product metals can also be lost. Processing of these waters can be profitable in recovering precious metals and also in avoiding fines and regulatory scrutiny.

Precious Metals

Silver

Silver was found as a free metal and easily worked into useful shapes and was widely used by early man. The beauty, weight and lack of corrosion made silver a store of value. The early discovery that water, wine, milk and vinegar stayed pure longer in silver vessels led to its desirability as a container for long voyages. Today, the demands of modern technology have revealed the remarkable range of electrical, optical, and medicinal properties that have placed silver as the key metal in many applications. Sterling flatware, jewelry, brazing alloys & solders, batteries, coins,, catalysts, and medical supplies, all consume significant amounts of silver.

Gold

While monetary uses for gold exceed all other uses, a number of important industrial applications exist. Lustrous, easily fashioned, and tarnish-resistant, gold is a favorite material in the jewelry industry. More gold is used for jewelry than for any other industrial application. Other applications include: dental supplies, where gold is used in fillings and orthodontic devices; aerospace, where gold-containing brazing alloys are important to jet engine assembly; and in glass manufacturing, where gold and gold oxide are used in heat-insulating windows and to decorate glass and porcelain dinnerware.

Platinum

Platinum was discovered by early Spanish explorers in Columbia in 1735. When Platinum was discovered, people didn't know what to do with it and called it "Platina" meaning Silver of little value. The native people of Columbia were aware of Platinum often finding the white heavy nuggets when panning for gold. The native people would throw the Platinum nuggets back thinking it was gold that wasn't ripe yet. Pure Platinum is malleable, ductile and harder than silver; it does not tarnish in air or dissolve in acid. Most Platinum used today comes from South Africa or Russia.

Gold - Physical Properties	
Atomic Number	79
Atomic Weight	196.97
Boiling Point	2970ºC
Melting Point	1063ºC
Crystal Structure	Face-centered Cubic
Density (Solid)	19.32 g/cc
Tensile Strength	19,000 psi
Hardness	28 DPH

Gold - Typical Analysis	
Element	Composition
Gold	99.95%
Silver plus Copper	0.04%
Silver	0.035%
Copper	0.02%
Palladium	0.02%
Iron	0.005%
Cadmium	0.0001%
Lead	0.005%

Silver - Physical Properties	
Atomic Number	47
Atomic Weight	107.88
Boiling Point	2212ºC
Melting Point	960.8ºC
Crystal Structure	Face-centered Cubic
Density (Solid)	10.49 g/cc
Tensile Strength	18,200 psi
Hardness	25 DPH

Silver - Typical Analysis	
Element	Composition
Silver	99.99%
Tellurium	0.0005%
Bismuth	0.0005%
Copper	0.01%
Palladium	0.001%
Iron	0.001%
Selenium	0.0005%
Lead	0.001%

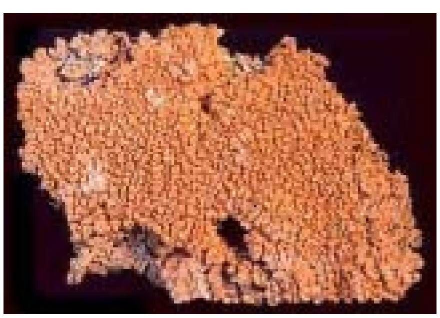
Application Note

An abandoned Gold Mine located in Nevada. The picture shows the remnants of the headframe used for the crushing operation. Also shown are the tanks used for processing of the slurried gold ore. The tailings pond is located down below the headframe

Precious Metals Mining Process

The mineralogy of the precious metal will determine the best recovery process. Metallurgical testing is almost always required to optimize a recovery flow sheet. Major categories of commercially viable recovery processes include the following:

1.Gravity separation
2.Flotation
3.Cyanidation
4.Refractory ore processing
5.Amalgamation



Copper Ore from Arizona

Water Treatment in Mining

Water is a necessary part of almost all mining and excavation operations. Wastewater can occur as surface run-off from the mine, overflow from concentrator facilities, old open pits, dumps, roads & other surface disturbances, which are a part of excavation. Water is decanted from the tailings impoundment area. Run off mine drainage must be prevented from entering the groundwater. Concentrator thickener overflows must also be treaated.

Conventional systems consist of diversion ditches, super ponds, polishing ponds, a central collection tank, lime treatment facility, pH control, computer controlled reagent addition and extensive upstream and downstream monitoring. The superpond discharges into one of the polishing (finishing) ponds for settlement and aeration. The ponds overflow to a common discharge where water is reclaimed and recycled to the concentrator. Excess water is discharged into Creeks. Discharge pH and volume is continuously monitored at a weir. During all of these operations, some amount of valuable metals are being lost. Normal methods rely on flocculation or precipitation of the metals. Very often only about 90% of the precious metals can be recovered using the standard methods. One of the reasons for this is the existance of Colloidal gold, silve, platinum, rhodium,and other extremely valuable metals. Collidal particles are very small suspended solids that will not readily settle out. Generally they are 5 - 5000 Angstroms in size and are difficult to filter out using corase filtration methods.

The subject of this application summary is that now the recovery of these colloids is possible using polymeric ultrafiltraion membranes. The membrane system known as V✧SEP has many unique and compelling advantages over conventional membrane filtration.

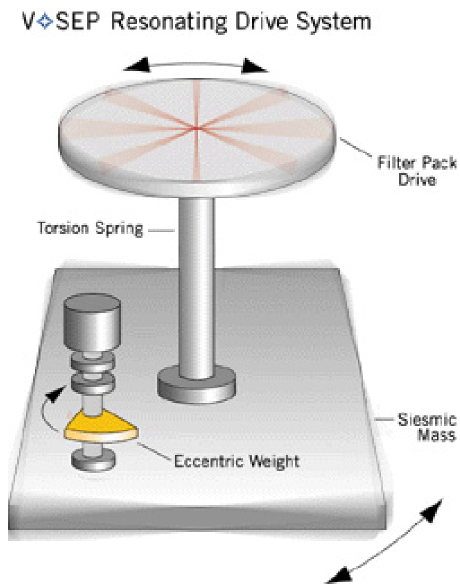
Processed Gold Ingot

Vibratory Shear Process

V✧SEP's unique separation technology is based upon an oscillating movement of the membrane surface with respect to the liquid to be filtered. The result is that blinding of the membrane surface due to the build up of solids is eliminated and free access to the membrane pores is provided to the liquid fraction to be filtered. The shear created from the lateral displacement caused suspended solids and colloidal materials to be repelled and held in suspension above the membrane surface. This combined with laminar flow of the fluid across the membrane surface keeps the liquid homogeneous and allows very high levels of recovery of filtrate. In the case of Precious Metals Recovery, up to 97% of the water can be filtered in a single pass filtration using V✧SEP.

Flux is inversely related to % recovery, so the optimum % recovery may vary for each application. Other methods like filter presses are done in batch mode with operators opening and cleaning the filter cake on a regular basis. V✧SEP is a continuous automated process requiring very little operator attendance.

The industrial V✧SEP machines contain many sheets of membrane, which are arrayed as parallel disks separated by gaskets. The disk stack is contained within a Fiberglass Reinforced Plastic (FRP) cylinder. This entire assembly is vibrated in torsional oscillation similar to the agitation of a washing machine. The resulting shear is 150,000 inverse seconds, which is ten times greater than the shear in crossflow systems. High shear has been shown to significantly reduce the fouling of many materials. The resistance to fouling can be enhanced with membrane selection where virtually



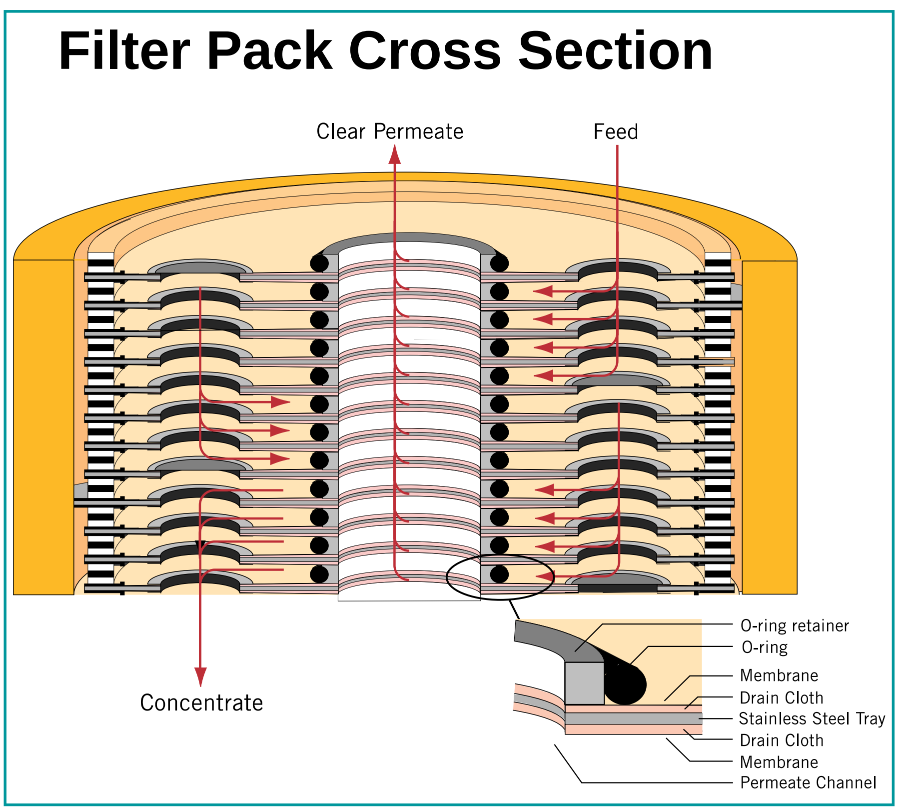
An eccentric weight induces a wobble that resonates at about 50 Hz giving vibration to the Filter Pack above

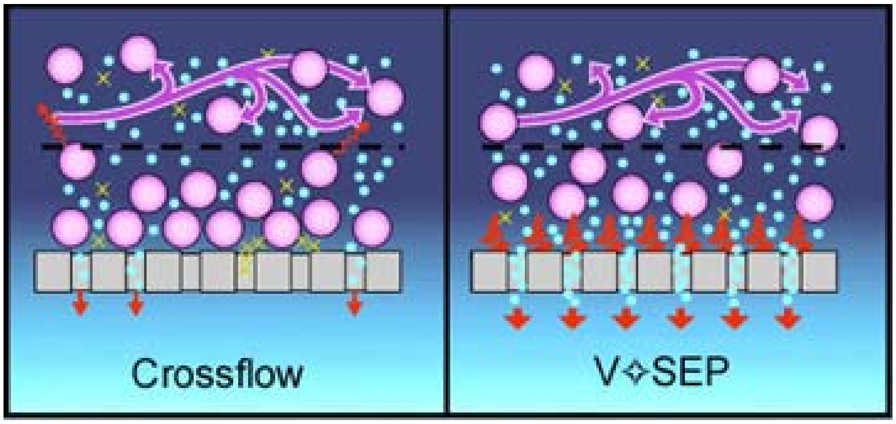
any commercially available membrane materials such as polypropylene, Teflon, polyester, and polysulfone can be used.

Each Series i system contains up to 2000 square feet of membrane filtration area. A single V✧SEP unit is capable of processing from 5 to 200 U.S. gallons per minute while producing crystal clear filtrate and a concentrated sludge in a single pass. This large throughput capability can be accomplished with a system, which occupies only 20 square feet of floor space and consumes 15 hp.

Conventional vs. V✧SEP

The main difference between V✧SEP and traditional crossflow membrane filtration is the mechanism by which the foulants are prevented from accumulating on the membrane surface. A





An illustration showing the shear energy at the membrane surface for conventional crossflow systems and for V✧SEP

traditional crossflow system relies on the fluid velocity of the feed material alone to create shear forces needed to reduce fouling. This mechanism assists in slowing the fouling process but because a thin, stagnant boundary layer remains on the membrane surface, the foulants from the stream will accumulate over time and deteriorate the throughput rate. On the other hand, a V✧SEP system utilizes a patented vibratory drive mechanism that vibrates the membrane surface creating a shear force that disrupts the boundary layer. The resulting motion of the vibration drive is a 3/4 inch peak to peak displacement, which constantly repels solids and other foulants away from the membrane surface. This mechanism enables the filter module to maintain higher, sustained throughput rates and process larger volumes of material economically. Rather than simply preventing fouling with high-velocity feed, V✧SEP reduces fouling by adding shear to the membrane surface with vibration. This vibration produces shear waves that propagate sinusoidally from the membrane's surface. As a result, the stagnant boundary layer is eliminated which increases the filtration rates.

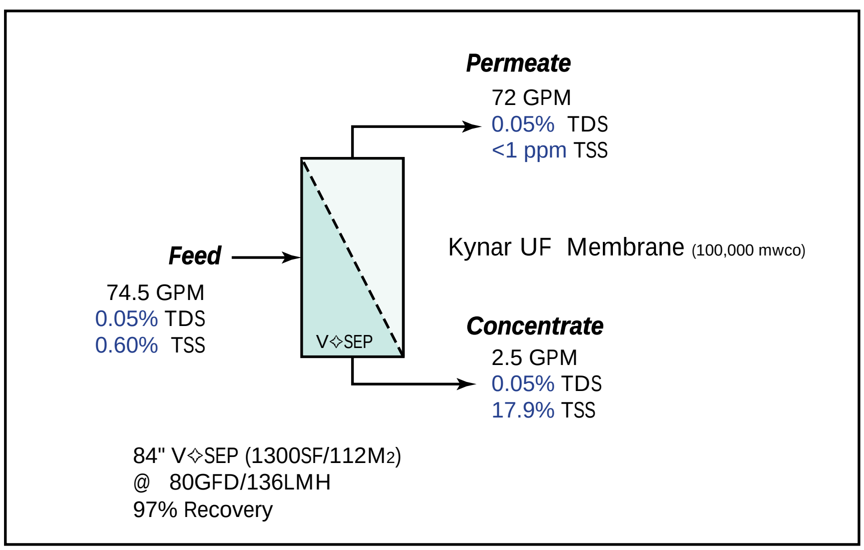
Results using V✧SEP

V✧SEP's Reverse Osmosis membrane module is capable of treating Mining and Excavation Drainage and providing a filtrate, which is free from suspended solids. The V✧SEP process does not involve any chemical addition. V✧SEP modules containing about 1300 SF (120m2) of filtration media are modular and can be run in parallel as needed to meet any process flow requirements.

Each 84" V✧SEP module can produce up to 72 gpm of clean water from the leachate pond using ultrafiltration membranes. Since the units are modular and can be used in parallel or in series, the number of V✧SEPs needed can be calculated based on the amount of material to be processed, (GPD or GPM). At 30°C the membrane flux is about 80 GFD (Gallons per Square Foot per Day). System throughput is also a function of the extent to which the feed is concentrated.

Process Description

The mining leachate or run-off is collected and stored in holding ponds. After proper residence time, the Feed Liquor is pumped into the V✧SEP system for filtration. The viscosity of the material plays a big part in the rate of filtration. Heat will help to decrease the viscosity of the slurry and therefore improves the throughput of the V✧SEP system. Counter-current heat exchangers and recovery boilers are used to warm the feed material.



Typical V✧SEP performance on Mining and Excavation Drainage

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The heated slurry is pumped into the V✧SEP Filter Pack at about 100-psi. The contents of the feed tank are taken out of the side of a cone bottom tank so that settled solids are excluded. The resulting permeate is sent to a process water storage tank for reuse in the operations. The reject material, about 3% of the volume, is sent for further processing of the colloidal precious metals it contains.This post treatment is very effective and economical since the wastewater has been volume reduced by 97%.

When the permeate rate drops off, the Filter Pack is cleaned using New Logic's formulated membrane cleaners out of a Clean in Place tank of about 260 gallons. Cleaning solution is recirculated with pressure and vibration to dissolve foulants that have found their way to the membrane. Actual site conditions at various mine locations have shown that the membrane can be cleaned easily and the results from week to week are predictable and stable.

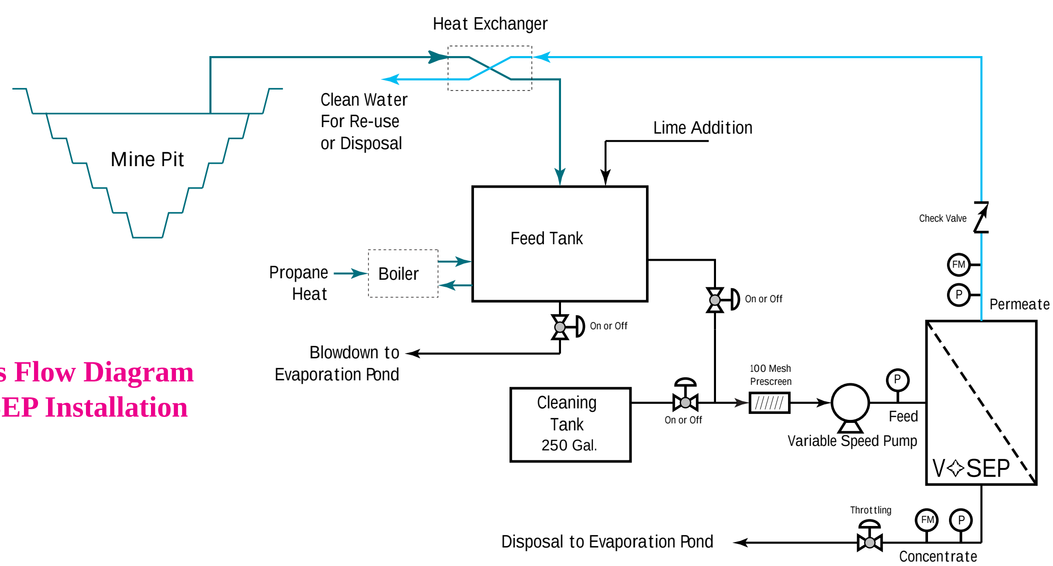
System Components

The V✧SEP system is configurable for manual mode where the operator would initiate operating sequences, or for full automation including seamless cleaning operations with round robin cleaning or multiple units. The V✧SEP has a PLC (Programmable Logic Controller) which monitors pressure, flow rate, and frequency. It also provides the safety in operation by monitoring conditions and initiating an alarm shut down should some configurable parameters be reached. The control stand contains the PLC, Operator display and terminal strips for wiring connections to instrumentation.

The Filter Pack is mounted on the V✧SEP base unit and contains about 1300 SF, (120m2), of membrane area and is constructed out of high temperature materials. The V✧ SEP drive system, which vibrates the Filter Pack, is engineered using space age alloys and materials to withstand the applied stress from a resonating frequency of about 50 Hz. Each base unit is fully stress tested and the factory prior to shipment. The V✧SEP drive system is made up of the Seismic Mass, Torsion Spring, Ecentric Bearing, and Lower Pressure Plate.

Project Economics

The table on the next page shows the operating costs for the installation of one V✧SEP module as currently configured. The V✧SEP is uniquely energy efficient. It comes with a 20 HP dive motor and a 10 HP Pump Motor. Operators interface and maintenance is limited to starting and stopping the unit and a periodical cleaning of the membrane after an extended run. The membrane replacement is the largest operating cost and it is estimated that the life of each module is approximately 2 years. Operator care can improve the life of the Filter Pack and yield additional savings.



Simplified Process Flow Diagram for a typical V✧SEP Installation

System Operation:
This process is run almost completely automatically. Miscellaneous recirc lines and instrumentation are not shown for clarity.
Control Valves opening initiates the feed pump at minimum frequency and gradually spins up to set point.
The concentrate valve then throttles to maintain flow. Once pressure reaches 30 psi, vibration initiates.
Once all other functions are operating, the throttling concentrate valve initializes to open and close at preset time intervals.
Shut down reverses all these steps.

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V✧SEP Operating Costs

Description	Description
V✧SEP System Power Consumption*	$ 7,180
System Maintenance & Cleaning	$ 8,640
Annual Production (at 80 gfd)	39,100,000 gal/yr

*based on 0.05 $/kW electricity cost

Mining Leachate Options

Mining and excavation operations are at risk for compliance with discharge regulations. The EPA may not even consider data from treatment systems that exceed 50 mg/L of total suspended solids (TSS). If results are well under 50 mg/L with the current discharge, a metals spectrum analysis should be done to determine complete metals compliance.

Wetlands & Natural Bioremediation

Suitable as treatment, but requires large areas of land and huge amounts of water that may not be readily available in arid western states. In addition, there are environmental risks that still linger as leaching into groundwater and local wellwater systems are a considerable liability. In addition, wildlife and habitat can be at risk of exposure to heavy metal poisoning. And of course, metals recovery would not be practical using this method.

Ion Exchange Resins

An effective treatment system, but cannot handle more that 500 ppm TDS and therefore must be used in tandem with other pretreatment systems such as membranes. Replacement or recharging of the resins used can be expensive and time consuming. Resin Exchange "blow down" can be toxic and present a problem to deal with.

Chemical Flocculation/Clarification

The drawbacks with this option will me the uncertainty of the final discharge amounts of the various metals over the long term. Variations in the effectiveness of the chemical precipitation and throughput to the clarifier leave open the possibility of process upsets and fines. Colloidal gold may not completely react and loss of valuable product can result. Some precious metals are resistant to precipitation nad recovery using this method is not possible. In addition the use of chemicals is expensive and also is a liability

Lime Storage Tanks used for Flocculation and Sedimentation

Conventional Membrane Systems

Also suffer from limits on TDS, TSS, and organic constituents. Depending on the process conventional membrane systems would be a part of a multi stage treatment process. Also, crossflow systems will require high fluid velocity to avoid diffusion polarization of the membrane and consequently reduced flux. The result of this is poor % recovery of filtrate, which can be sewered. The reject from conventional membrane systems could be further treated by yet another treatment process or hauled as waste. Since operating costs such as hauling are part of any equipment purchasing decisions, the % recovery with crossflow filters is not very attractive.

Gold Mining Run-off Pond

V✧SEP Membrane Systems

V✧SEP provides an automated continuous process for volume reducing excavation run-off. There is no chemical addition and there are no spent resins to change. V✧SEP is capable of very high recoveries of filtrate compared to conventional membrane systems and can provide 100% capture of precious metal colloids for recovery. By volume reducing as much as 97%, conventional chemical leaching treatments for the final metal recovery involves less chemical and working area for hold up volume. The V✧SEP footprint is small and the system is self contained without pre-treatment. A small shed is all that is required and can be located close to the source of the wastewater to be treated

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Installed V✧SEP Mining Applications

- Acid Mine Drainage
- Phosphate Fertilizer
- Radioactive Nuclei Removal
- Metals Removal from wastewater
- Arsenic Removal
- Titanium Dioxide Concentration
- Calcium Carbonate Dewatering
- Kaolin Clay Concentration
- Bentonite Clay
- Railcar Washwater
- Product Recovery from Wastewater

Company Profile

New Logic is a privately held corporation located in Emeryville, CA approximately 10 miles from San Francisco. New Logic markets, engineers, and manufactures a membrane dewatering and filtration systems used for chemical processing, waste streams, pulp & paper processing, mining operations, and drinking water applications. The V✧SEP technology was invented by Dr. Brad Culkin in 1985. Dr. Culkin holds a Ph. D. in Chemical Engineering and was formerly a senior scientist with Dorr-Oliver Corporation. V✧SEP was originally developed as an economic system that would efficiently separate plasma from whole blood. The company received a contract to produce a membrane filtration prototype, which would later be incorporated into a blood analyzer system.

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