VSEP Vibes Newsletter

Welcome to the New Logic Research Newsletter.

Vanguard Renewables Selects VSEP

Vanguard Renewables is a national leader in developing food and dairy waste-to-renewable energy projects. The Company is committed to advancing decarbonization by reducing greenhouse gas emissions from farms and food waste and supporting regenerative agriculture on partner farms. The Company currently owns and operates farm-based anaerobic digesters in the Northeast and plans to commission more than 100 food waste and manure co-digestion and manure-only digestion sites nationwide by 2026. Vanguard has established relationships and renewable natural gas offtake agreements with national utilities including Dominion Energy, Enbridge, Eversource, National Grid, ONE Gas, and VGS, which along with a strategic alliance with Dairy Farmers of America, positions the Company to significantly increase U.S. production and delivery of renewable natural gas to commercial and residential customers across the country.

Principle cost drivers for these projects include the transportation of the manure to the anaerobic digester and also treatment of the spent digestate after the biogas has been harvested. After completing a full-scale pilot test using New Logic's VSEP RO filtration system in conjunction with Colorado State University, Vanguard Renewables has purchased a 6-module VSEP system that will be used to dewater dairy cow manure prior to transportation to the digester. Six other similar projects are currently in development where the VSEP technology will be considered.

Vanguard RENEWABLES

The full-scale pilot test was conducted at a Dairy north of Denver Colorado. The objective was to dewater the manure to save on transportation costs. Vanguard wanted to capture all of the volatile solids from the cow manure and to make clean water that the dairy could keep and use for washdown or for irrigation. The VSEP system was operated for several months at the dairy by a dairy services company called Dairy Specialists as well as staff from Colorado State University. The benefit of this process is that Vanguard would get all the volatile solids needed for gas production but with a 70-80% volume reduction to reduce hauling costs. More concentrated solids also means a smaller digester can produce more gas. The benefit for the dairy is free disposal of its manure and return of clean water for reuse.

To accomplish this, a VSEP RO system was used as primary treatment. Then a conventional Spiral RO system was used to polish the VSEP RO permeate to make drinking water quality filtrate. The final concentrate from the VSEP captured

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100% of the volatile solids with a total solids level of 8.1%. The treated water from the two-stage system had near zero levels of Chemical Oxygen Demand (COD) and conductivity of only193 µS.

Analyte	VSEP Feed	VSEP Reject	VSEP Permeate	Spiral RO Permeate
TS (%)	3.64	8.13	0.14	0.02
TSS (ppm)	28,879	82800	0	0
VSS (ppm)	10604	28275	0	0
Conductivity	12890	21920	2160	193
COD (ppm)	35480	62050	360	<0.01
TN (ppm)	1950	4490	170	13.60

The full-scale system purchased will be installed at the same dairy and will process about 58 gpm (13.2 m3/hr) of screened manure and will produce 70-80% of the volume as clean treated water and 20-30% as concentrated solids for gas production. The system is expected to be shipped in early 2023 and commissioned later in the Summer.

The next VSEP Vanguard project will likely be a co-digestion project in Wisconsin where food waste and manure will be used for gas production and the VSEP will treat the digestate after the biogas has been extracted. Five other projects for Vanguard are in development for locations throughout the West.

New Logic's Family Grows

Desi Ortega works in our membrane assembly section. She is one of our most productive workers and has produced dozens of perfect VSEP filter packs. Recently Desi produced something even more perfect and amazing. Desi has given birth to a beautiful and healthy new baby. She will be taking a little time off to enjoy this very special time. This is her first child and it is a life changing event.

So while our filter production rate may be off for a while, New Logic wishes Desi the best as she recuperates and forms the bonds of a lifetime with her new child. There have been many sons and daughters of New Logic employees who have come to work here. So, who knows, maybe someday, Desi's new child will be brought onboard as well.

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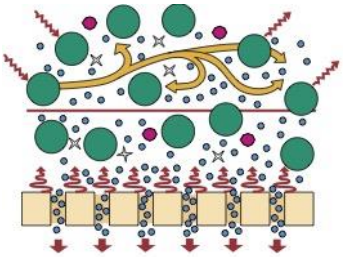
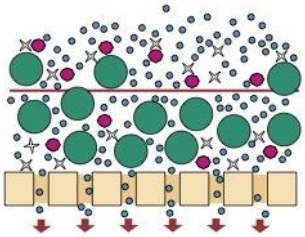
VSEP is a Membrane Crystallizer

In inorganic chemistry, all mineral compounds have a limit as to how much can be dissolved in water. In the water and wastewater business, it is important to understand this equilibrium. Some compounds like Barium Sulfate or Silica can have very low solubilities. Other things like Sodium Chloride will have very high solubility levels.

Conventional spiral wound membrane systems have tight spaces between the membrane and rely on laminar crossflow to create shear at the membrane surface. But these membrane elements cannot allow precipitation to occur or the minerals will attach to and scale the membrane blinding off the water's access to the pores of the membranes. During filtration, water leaves and goes through the membrane. The dissolved minerals are held back and begin to increase in concentration levels near the membrane where they are held back.



VSEP with Crossflow



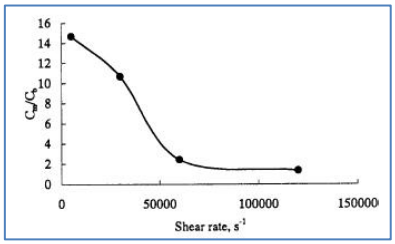
Conventional RO Membrane

This is known as "concentration polarization". Laminar crossflow will have some ability to wash away these minerals, but because of the drag of the membrane surface, this will have only a limited effect. If the solubility of any of these minerals is exceeded, then precipitation and scaling will occur. For this reason, software programs are used to determine the maximum water removal rate or recovery rate that can be possible before this happens. This could result in a spiral system only being able to remove 70-85% of the volume as

Copper Sulfate Crystals produced from VSEP

clean water leaving a significant volume or reject brine that can be problematic to dispose of.

If you are able to keep the concentration of minerals low at the membrane surface, then you can achieve greater volume reductions and reduce the volume of brine left. VSEP employs an oscillating resonance to create very high levels of shear at the membrane surface. This very high level of shear disrupts the concentration polarization and keeps the liquid solution uniform in concentration. As a result of this, VSEP can exceed the solubility limit of the minerals and allow them to precipitate in the bulk flow and form solids where there are plenty of good nucleation sites available from seed crystals and other suspended solids that make much better perch points than the hydrophilic membrane.



For a Newtonian fluid flowing between two parallel membranes the shear rate can be measured as it relates to a gradient of concentration. The shear rate is equal to the velocity of the moving plate in meters per second divided by the distance between the two plates squared

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measured in meters. With VSEP, this equates to about 74,500 s^{-1} (inverse seconds). This amount of shear drastically reduces the concentration gradient and results in a nearly 1 to 1 concentration factor. Basically, the fluid is uniform in concentration without respect to location or distance from the membrane.

The most common application for VSEP is to take the reject from another membrane system that has stopped at that recovery level due to solubility limits. Almost all VSEP projects involve filtering an effluent or water that is saturated and at its solubility limit. Normally, this reject would go to a thermal crystallizer or evaporator. But by using the energy efficient VSEP, more clean water volume can be removed leaving a much smaller volume of brine that must be disposed of. The limit for VSEP is not solubility, but osmotic pressure, or the pressure that must be used to get the water to flow through the membrane, which is the reverse direction the water wants to go.

Sometimes an aqueous fluid is already saturated and a spiral membrane cannot be used at all. This can occur with brackish groundwater, mine tailings, and other industrial processes. In these cases, membranes were not normally considered. Membranes are a very effective tool because a membrane size can be chosen to reject ions selectively or completely as needed. This ability to choose the separation characteristics is not as easy to deploy with other technologies such as ion exchange or chemical-physical treatment. Also membranes would be far less expensive that brute force evaporation. For this reason, VSEP is a very elegant option for brine concentration.

As an example, we recently completed a bench test on simulated copper mine tailings water. The solution contained 12 g/L of Copper Sulfate along with Iron, Calcium, and Sodium salts. The idea here was to concentrate the Copper from the tailings pond so that it can be recovered by other means.

The testing operated at high pressure and removed a large percentage of the volume as filtrate using a low pH tolerant Nanofiltration membrane. At the end of the concentration conducted at about 40°C some precipitates were visible and the concentrate was turbid, likely with Calcium Sulfate. So the VSEP was crystallizing solids as the concentration was completed. All of the remaining concentrate was place in a bucket for analysis. When the bucket cooled, about 600 grams of Copper Sulfate Crystals were collected.

This is an example of what can be done to harvest minerals from dilute effluent streams. VSEP has been used for this purpose in other industries to harvest Lithium, Potassium, Precious Metals, and other valuable metals. Very often, when people first investigate the VSEP for an application, they draw comparisons to spiral RO membranes and ask questions about how the VSEP compares economically and otherwise to a spiral. Because VSEP uses membranes, they assume it is an alternative to a spiral. However, New Logic manufactures both spiral membrane systems and VSEP systems. We use each type where it is appropriate. VSEP is more accurately compared to evaporation or crystallization.

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Get to know New Logic – Matt Ayers

Matt spent his early life in Vancouver Canada, so it was there that he learned to speak Canadian. After that he relocated in the San Francisco Bay Area. Matt graduated from the University of California at Berkeley with a Bachelor of Science degree in Chemical Engineering. Matt is one of the smartest guys at New Logic, if not the smartest. Working for New Logic now for more than 20 years, Matt is our Engineering Manager and is responsible for the system design for each VSEP system that is produced. If you have a VSEP system, Matt was the brain behind the product.

Matt manages a team of chemical, mechanical, and electrical engineers who take a clean sheet of paper and create a very complex piece of machinery. When a VSEP system is sold, a concept system is created based on pilot testing or historical data. But then, Matt will take that rough shell and fill in all the little details. A very thorough engineering package is developed for the client to review and approve prior to fabrication.

Matt manages the customer project all the way from the kick-off meeting through the factory acceptance test. Then the project is passed off to the field engineering group where an engineer will be assigned as the project manager who will look after the equipment starting from the commissioning and training. Matt's contributions to New Logic have been invaluable and he is one of the reasons for our success.

The Workhorse – VSEP LP Pilot Machine

The VSEP LP machine is a sturdy, compact design and has many excellent features. It is highly portable and can be easily installed in a couple hours. The design of this unit is sensible and has remained unchanged for many years, mostly due to the extremely high reliability.

These machines are used at our facility to run bench tests on samples provided by our customers. They are also rented by customers who wish to do their own testing or prefer to have the test work done using New Logic Staff at the customer's site during field pilot testing. The shipment will include the machine with controls, a pump, feed tank, and all hoses necessary for plumbing connections. The machine is designed for 480 VAC 60hz operation. Special electrical arrangements can be made for voltage or frequency need which are not standard. This is

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often necessary for customers located outside the United States. The main idea is that we provide everything needed so that the pilot trial can be completed efficiently with accurate results. These machines are also purchased by customers who have small scale filtering needs, especially for lab testing of chemical samples. Other customers use the LP VSEP machine at the site in conjunction with larger machines in order to test the effect of new feed streams or new procedures prior to introducing changes in the operation of the large model.

There are two basic configurations for the V✧SEP LP Pilot machine. The first is L Mode, which stands for "Lab". In L mode, a single sheet of membrane is used for quick comparisons of different membranes on a relative basis. Once the best membrane is chosen, the VSEP can be converted to having a much larger membrane filter pack installed.

The second configuration with more membrane area installed for the LP VSEP is P Mode which stands for Pilot. So, the LP VSEP machine can be used as a laboratory unit with a single sheet of membrane in L mode or a larger pilot unit with 38 pieces of membrane in P mode. In pilot mode, the LP VSEP has a filtering area of approximately 16 square feet (1.5 m2) compared to the 0.5 square feet when using a single sheet of membrane in L mode. Scale up is predictable and nearly linear in both the Series L and the LP. Linear scale up is an important strength of membrane technologies, including VSEP.

The LP VSEP comes with rolling casters so it can be moved around easily and quickly installed. But some of our distributors have built very elaborate and fancy pilot test mobile units so that everything is connected and ready to run when they drive up to the customer's facility. The pictures here in this article are only some of the many creative mobile treatment plants our distributors have built.

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Acid Purification with Nanofiltration

One of the benefits of membranes and especially Nanofiltration (NF) is the ability to perform molecular separations on a Nano scale. By choosing the correct porosity of the membrane, you can selectively separate dissolved ions. This can be a very useful way to remove impurities. New Logic has extensive experience in purifying acid using several acid resistant NF membranes.

While NF membranes are also available in conventional spiral wound construction, unlike these systems, VSEP does not require pre-treatment with UF or other technologies and can take the pregnant acid solution and filter it in a single step. Additionally, because of the resonance of the membrane, VSEP can deliver higher flux rates and higher recovery rates than conventional spiral membrane systems. The VSEP system can also be fabricated with materials of construction that are compatible with low pH solutions.

Acid is used in many mining processes to dissolve metals from a crushed ore, especially for metal oxides. Heap Leaching is the process of using acid solutions to leach out metals. This method is commonly used for low-grade ore which would otherwise not be economical to process. The leaching reagent (often dilute sulfuric acid) is sprayed on top of a heap pile and allowed to trickle down through the crushed ore. The resulting "pregnant" leach solution of sulfuric acid and metal sulfate is collected. After that, the metals are removed from the pregnant acidic solution using various methods including solvent extraction. After the metal is removed from the acidic solution, the acid is recycled. The acid solution may become increasingly contaminated with other metals and other unwanted materials. Purification of the acid solution can extend the life and allow for near unlimited recycling.

In addition to the acid used for leaching during the mining process, some acids are produced as a product precursor. This includes Phosphoric acid. Phosphorous is harvested from Phosphate ore using Sulfuric acid. This converts the Phosphate into Phosphoric Acid and a Gypsum byproduct. This acid must also be purified before it can be sold to make a fertilizer product.

When filtering with NF, the Acid and water will pass through the membrane. Metals and other contaminants are mostly rejected by the membrane and removed from the solution. Here are some typical NF rejection rates when it comes to purifying various acid streams:

30% Phosphoric Acid		
Analyte		Rejection Rate
Aluminum	Al	85%
Cadmium	Cd	54%
Calcium	Ca	54%
Chromium	Cr	60%
Fluoride	F	89%
Iron	Fe	86%
Magnesium	Mg	84%
Nickel	Ni	63%
Uranium	U	60%

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25% Sulfuric Acid		
Analyte		Rejection Rate
Aluminum	Al	90%
Cobalt	Co	85%
Calcium	Ca	95%
Chromium	Cr	90%
Fluoride	F	80%
Iron	Fe	92%
Magnesium	Mg	95%
Nickel	Ni	94%
Zinc	Zn	95%

Hydrochloric Acid Solution		
Analyte		Rejection Rate
Aluminum	Al	92%
Iron	Fe	84%
Lead	Pb	51%
Nickel	Ni	82%
Palladium	Pd	98%
Platinum	Pt	75%
Rhodium	Ru	82%
Ruthenium	Ru	89%
Zinc	Zn	51%

In addition to having Nanofiltration membranes that are compatible with strong acids, New Logic can also select elastomers and metals that are compatible as well. New Logic has installed several Acid Purification projects.

About the newsletter author:

Greg Johnson is CEO of New Logic Research and is responsible for the development of VSEP technology since 1992. gjohnson@vsep.com

New Logic Research, Inc.
2527 Aviation Way
Minden, NV 89423 USA

775-783-7600

www.vsep.com
info@vsep.com

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