Nitto
Innovation for Customers

HYDRANAUTICS

REMOVING SULFATE FROM COAL MINE WASTEWATER USING NANOFILTRATION

Case study

Using ESNA4-LD membranes to reduce sulfate concentrations in industrial wastewater from coal mining in China.

A Coal Company's expansion project produces a large quantities of mine wastewater. This wastewater cannot be discharged to natural water bodies because it contains several contaminants at higher concentrations than those permitted by local regulations.

Regulations governing sulfate concentrations have become more stringent as mine planners and operators are required to include sulfate management in their water management plans. The maximum discharge limit for sulfates is 250 mg/l while the wastewater from the coal mine contained about 1,200 mg/l.

The Company could had used a reverse osmosis (RO) system to treat this wastewater, but this would remove almost all ions (when not required) and would also require a high operating pressure. Also, the company cannot consume all mine wastewater because their demand is low. The Company was looking for a consistent, reliable and low-cost solution.


Location	Ordos, Inner Mongolia, China
Feed water	Coal mine well water
Application	Sulfate removal to meet discharge standards
Capacity	884 m³/h (221 x 4 trains)
Start-up date	June 2019
NF Design	30:15 array of 7M vessels

Hydranautics offered their Energy-Saving Nanofiltration (ESNA) membrane, ESNA4-LD, that selectively removes sulfates from water. Being a NF membrane, ESNA4-LD rejects divalent and trivalent ions such as SO_4, Ca, Mg, Fe, Mn, etc. ESNA4-LD uses the Low Differential LD Technology® patented by Hydranautics to minimize colloidal fouling. ESNA4-LD membranes have a 34 mil thick feed spacer to prevent colloidal fouling and increase the effectiveness of membrane cleaning. As a result, the membrane does not require frequent cleaning
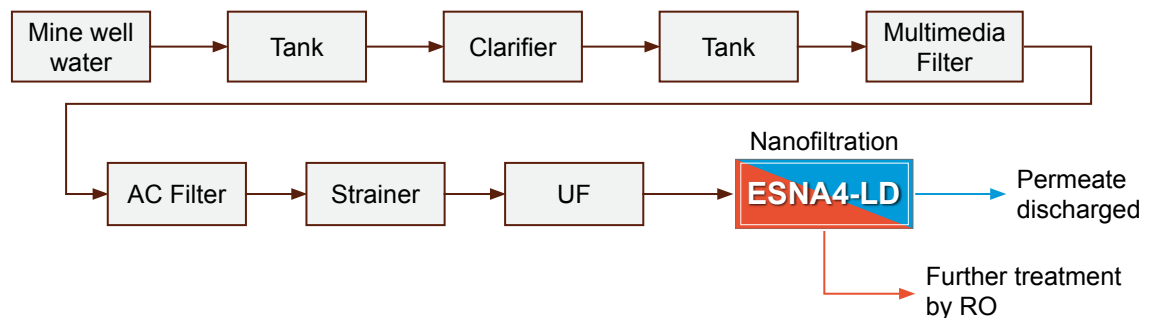
	Capacity

Capacity
884 m³/h
(221 x 4 trains)

Membrane model
ESNA4-LD

Flux
18.8 lmh

NF Design
(30:15) x 7 Array

| Parameter | Units | Feed | Permeate | |
			Actual data	Discharge Requirement
pH	-	8	7.4	6 – 9
COD_{cr}	mg/l	18	9	≤ 20
BOD_5	mg/l	3	2	≤ 4
F^-	mg/l	0.6	< 0.1	≤ 1.0
SO_4^{2-}	mg/l	1,220	7.6	≤ 250
Cl^-	mg/l	79.6	6.4	≤ 250
NO_3^- (as N)	mg/l	1.24	0.4	≤ 10
Fe^{2+}	mg/l	0.034	0.02	≤ 0.3
Mn^{2+}	mg/l	0.07	0.004	≤ 0.1

Table 1: Permeate quality

(thus, reducing treatment cost) while offering consistent performance for a longer duration.

Pretreatment to the NF system was designed to remove turbidity, heavy metals, TOC and it comprised of a clarifier with chemical dosing, multi-media filter, activated carbon filter followed by an ultrafiltration (UF) system. Refer to the block diagram on the previous page.

Four NF trains were installed to treat a total flow of 884 m³/h with 85% recovery. The balance 15% NF reject water is treated by RO and the final reject from RO is re-used by the Coal Company for slag cooling and flushing.

All four trains were commissioned in June 2019 and the plant's performance has been stable since then. NF feed water turbidity was less than 0.2 NTU and ORP less than +200 mV. While the

ESNA4-LD membranes reduced sulfates from 1,200 mg/l to less than 10 mg/l, some reduction in other ions and TOC was also observed. Refer to Table 1 for typical permeate quality data. Typical performance data of Train #1 is provided in Table 2.

After 3 months of operation, the first CIP was conducted for the 2nd stage with citric acid solution, to remove potential scaling. It was observed that the 2nd stage pressure drop had increased from 0.1 MPa to 0.2 MPa while the feed flow reduced by about 20%.

The 1st stage had no significant fouling after 3 months of operation since ESNA4-LD's 34 mil feed spacer reduced particle and colloidal fouling.

Feed water source	Coal mine water	ORP	+170 mV
Feed EC	2,835 µS/cm	Operating temperature	26.4°C
Design recovery	85%	pH	7.75
Design flow rate	260 m³/h	Feed turbidity	0.12 NTU

Train #1 performance data*

Feed pressure	0.5 MPa	Feed flow	230 m³/h
1st Stage conc. pressure	0.42 MPa	Permeate flow	160 m³/h
2nd Stage feed pressure	0.58 MPa	Final concentrate flow	70 m³/h
2nd Stage conc. pressure	0.5 MPa	Recirculation flow	20 m³/h
Permeate pressure	0.06 MPa	Recovery	69.5%
Permeate EC	56.7 µS/cm	Average salt rejection	98%

as on 31st July 2019

Table 2: Typical performance data of Train #1

The
IMPACT

Since sulfate was the only ion to be removed, using the ESNA4-LD NF membrane was an excellent choice.

The ESNA4-LD permeate was extremely low in sulfates, thus qualifying the treated mine wastewater for discharge to natural water bodies.

ESNA4-LD was a better choice than conventional low-pressure RO, because it required a lower operating pressure of only 0.5 MPa, thus saving electrical energy and reducing CO_2 emissions. The Company is very satisfied with the plant's performance and the cost savings.

About the author

MR. PENGHUI WANG

Penghui Wang *is working as a technical support for Hydranautics – A Nitto Group Company. He is an environmental engineer serving in the China region. As technical support, he is responsible for helping customers solve varies practical problems at site.*

For more information about Hydranautics case studies, contact us at **hy-info@nitto.com** or visit our website at **membranes.com**

About Hydranautics

Since our founding in 1963, Hydranautics has been committed to the highest standards of technology research, product excellence and customer fulfillment. Hydranautics entered the Reverse Osmosis (RO) water treatment field in 1970 and is one of the most respected and experienced firms in the membrane separations industry. We joined the Osaka, Japan based Nitto Denko corporation in 1987 which was founded in 1918 and now has 117 companies in more than 20 countries, with over 30,000 employees worldwide. Our alliance with this global film industry giant boosts Hydranautics to a superior level of technological sophistication, product performance and customer response.

We are not simply product manufacturers; we are your membrane technology partners. As leaders of high quality membrane solutions, we believe our obligations extend beyond manufacturing and selling our products. Our skilled staff of technicians, engineers and service professionals assist in designing, operating and maintaining a robust, reliable and efficient membrane system to meet your requirements and exceed your expectations. Our support is offered from early stage conceptual design and engineering to start-up and maintenance, no matter the location globally whether it is on land or off-shore.