

Total Dissolved Solid Removal

Both Conventional UF membranes and **RSL Membranes™** are defined as membranes that will remove colloidal solids but not dissolved solids. However, based on the definition of total suspended solids (TSS), total solids (TS) and total dissolved solids (TDS), both membranes types will remove some dissolved solids. TS is calculated by taking a sample of the water, placing it in a crucible, and evaporating the water. The crucible is weighed before and after. TSS is measure by passing a sample of water through a filter. The filter is dried and weighed before and after. $TS \text{ minus } TSS = TDS$. In North America there are three different standards to measure TSS.

- a. EPA Method 160.2,
- b. Standard Method 2540-D, and
- c. ASTM Method D5907.

The three standards use different pore size filters to separate the TSS from a sample. The filter pore size can range from 0.7 micron to 1.5 micron. In Europe and Asia, 0.45-micron pore size is used for the filter which is the standard we have adopted for RSL membranes™.

However, **RSL Membranes™**, like UF membranes separate colloids as small as 0.01 micron. Therefore, both membranes can remove dissolved solids. Our research has shown that **RSL Membranes™** remove as much 50% of dissolved solids (TDS) based on the testing of raw water versus permeate using a 0.45-micron filter.

One significant benefit of the **RSL Membranes™** is their ability to absorb certain metals during the filtration process. Testing and ICP analysis has provided a data base which confirms that **RSL™ Powder**, used as the membrane skin layer, has consistently adsorbed

1. Aluminum >85%
2. Barium > 70%
3. Boron >40%
4. Fe >85%
5. Si >65%

Other metals, to a lesser extent are also being adsorbed. Table 4 summarizes a study that evaluated the adsorption capability of **RSL™ Powders** compared to conventional media (Activated Alumina and Diatomaceous Earth- DE) used for filter cake/dynamic membrane filtration processes. With this level of adsorption capability, specifically for Barium and Silica, **RSL Membranes™** are an excellent choice for pretreatment of water prior to RO membranes in pure water applications. Barium and silica create scaling issues for RO Membranes.

Table 4 Adsorption of Metals -RSL Powders 1 and 2 vs Activated Alumina and Diamataceous Earth

metals	RSL Powder 1		RSL Powder 2		Activated Alumina		Diamataceous Earth	
	Reduction (%)	Data Set	Reduction (%)	Data Set	Reduction (%)	Data Set	Reduction (%)	Data Set
Al	85.06%	6	88.60%	4	50%	1	25%	1
B	41.67%	6					-11%	1
Ba	75.25%	4	31.28%	4	39%	2	-100%	1
Ca	16.71%	7			61%	2	-16%	1
Co								
Cr								
Cu					-1%	1		
Fe	91.37%	5	76.92%	1	-2%	1	100%	1
K	22.80%	5	42.00%	2			-13%	1
Li	19.80%	5			2%	1	-13%	1
Mg	18.14%	7			3%	1	-9%	1
Mn			5.56%	3	-3%	2	100%	1
Na	12.83%	6			27%	1	-11%	1
Ni					3%	1		
P					6%	1		
S	6.14%	7					-12%	1
Si	68.71%	7	72.25%	4	2%	1	26%	1
Sr	29.20%	5			16%	1	-6%	1
Ti			79.12%	3	100%	1		
V			28.13%	1				
Zn	13.00%	4			11%	1		

With the ability to remove solids less than 0.45 micron and to adsorb numerous dissolved metals, **RSL Membranes™** not only provide almost total elimination of TSS in the permeate, they also provide useful reductions in TDS levels.

Research and Development Objectives

1. Develop new powders that provide simultaneously strong EDL repulsion forces at the surface of the powder layer on the RSL membrane and specific adsorptive capabilities of elements