Modern Water Management-basic Track

RO Calculation

Content:

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- Concentration Factor
- Flux
- Mass Balance
- Net Differential Pressure
- Net Driving Pressure (NDP)
- Silt Density Index (SDI)
- Langelier Saturation Index (LSI)

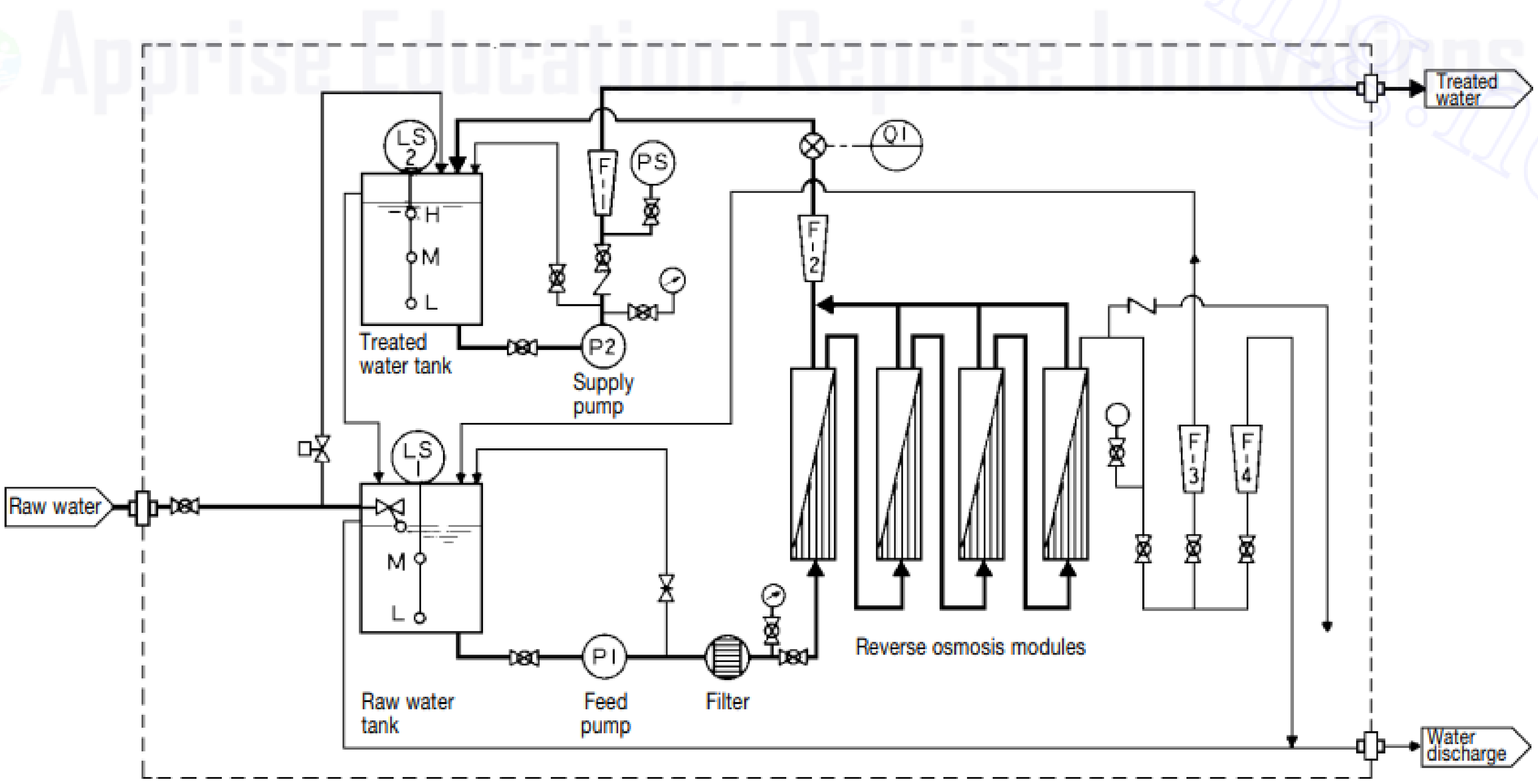


Fig. 5.37 Flow diagram of a small size reverse osmosis unit

Recovery

Recovery is the amount of water that is being 'recovered' as good permeate water.

% Recovery$= \frac{Permeate\ Flow\ Rate\ (gpm)}{Feed\ Flow\ Rate\ (gpm)}$**x100**

if the recovery rate is 75% then this means that for every 100 gallons of feed water that

enter the RO system, you are recovering 75 gallons as usable permeate water and 25 gallons are going to drain as concentrate. Industrial RO systems typically run anywhere from 50% to 85% recovery depending on the feed water characteristics and other design considerations.

Concentration Factor

the concentration factor is related to the RO system recovery and is an important equation for RO system design. The more water you recover as permeate (the higher the % recovery), the more concentrated salts and contaminants you collect in the concentrate stream. This can lead to higher system design. The more water you recover as permeate (the higher the % recovery), the more concentrated salts and contaminants you collect in the concentrate stream. This can lead to higher potential for scaling on the surface of the RO membrane when the concentration factor is too high for the system design and feed water composition.

$$\textbf{Concentration Factor} = \frac{\mathbf{1}}{(\mathbf{1} - \boldsymbol{Recovery}\ \%)}$$

Recovery vs. Concentration Factor

Recovery	Concentration Factor
50%	2
75%	4
80%	5
90%	10
95%	20
97.5%	40
98%`	50

Flux

Flux is used to express the amount of water that passes (permeates) through a reverse osmosis membrane during a given time - **gallons per square foot per day (GFD)** or liters per square meter per hour (l/m2/hr).a higher flux means more water is permeating through the RO membrane. RO systems are designed to operate within a certain flux range to ensure the water flowing through the RO membrane is not too fast or slow.

GFD= $\frac{gpm\ of\ permeate\ x\ 1{,}440\ min/day}{\#\ of\ RO\ elements\ in\ system\ x\ square\ footage\ of\ each\ RO element}$

Mass Balance

A Mass Balance equation is used to help determine if your flow and quality instrumentation is reading properly or requires calibration. If your instrumentation is not reading correctly, then the performance data trending that you are collecting is useless.

You will need to collect the following data from an RO system to perform a Mass Balance calculation:

1. Feed Flow (gpm)
2. Permeate Flow (gpm)
3. Concentrate Flow (gpm)
4. Feed Conductivity (µS)
5. Permeate Conductivity (µS)
6. Concentrate Conductivity (µS)

The mass balance =(Feed flow1 x Feed Conductivity) = (Permeate Flow x Permeate Conductivity) + (Concentrate Flow x Concentrate Conductivity)

Feed Flow = Permeate Flow + Concentrate Flow

For example, if you collected the following data from an RO system:

- Permeate Flow 5 gpm
- Feed Conductivity 500 µS
- Permeate Conductivity 10 µS
- Concentrate Flow 2 gpm
- Concentrate Conductivity 1200 µS
- Then the Mass Balance Equation would be: (7x500) = (5 x 10) + (2x1200)
- 3,500 ≠ 2,450

Then find the difference: (Difference / Sum) x 100 = 18%

A difference of +/- 5% is ok. A difference of +/-- 5% to 10% is generally adequate. A difference of > +/- 10% is unacceptable and calibration of the RO instrumentation is required to ensure that you are collecting useful data. In the example above, the RO mass balance equation falls out of range and requires attention

Net Differential Pressure

$$\Delta P = P_f - P_c$$

ΔP differential pressure, "delta P" or pressure drop

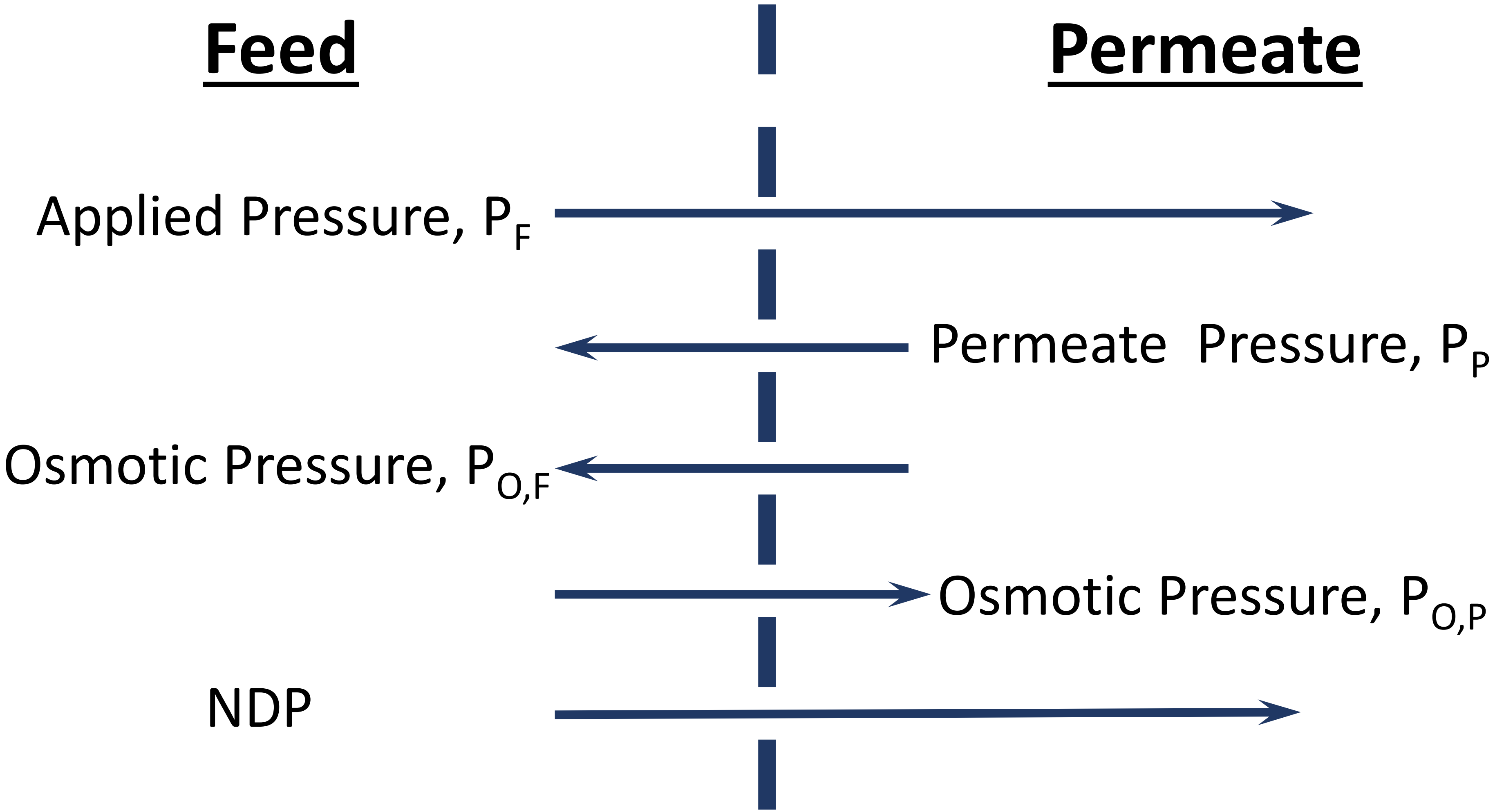
P_f = feed pressure

P_c = concentrate pressure

Net Driving Pressure (NDP)

- Net Driving Pressure (NDP) - The net driving pressure refers to the difference between the feed pressure and the osmotic pressure. The net driving pressure is the measure of the actual driving pressure available to force the water through the membrane. As net driving pressure increases, the flux increases proportionally (given all other factors are held constant).

Net Driving Pressure (NDP)



Silt Density Index (SDI)

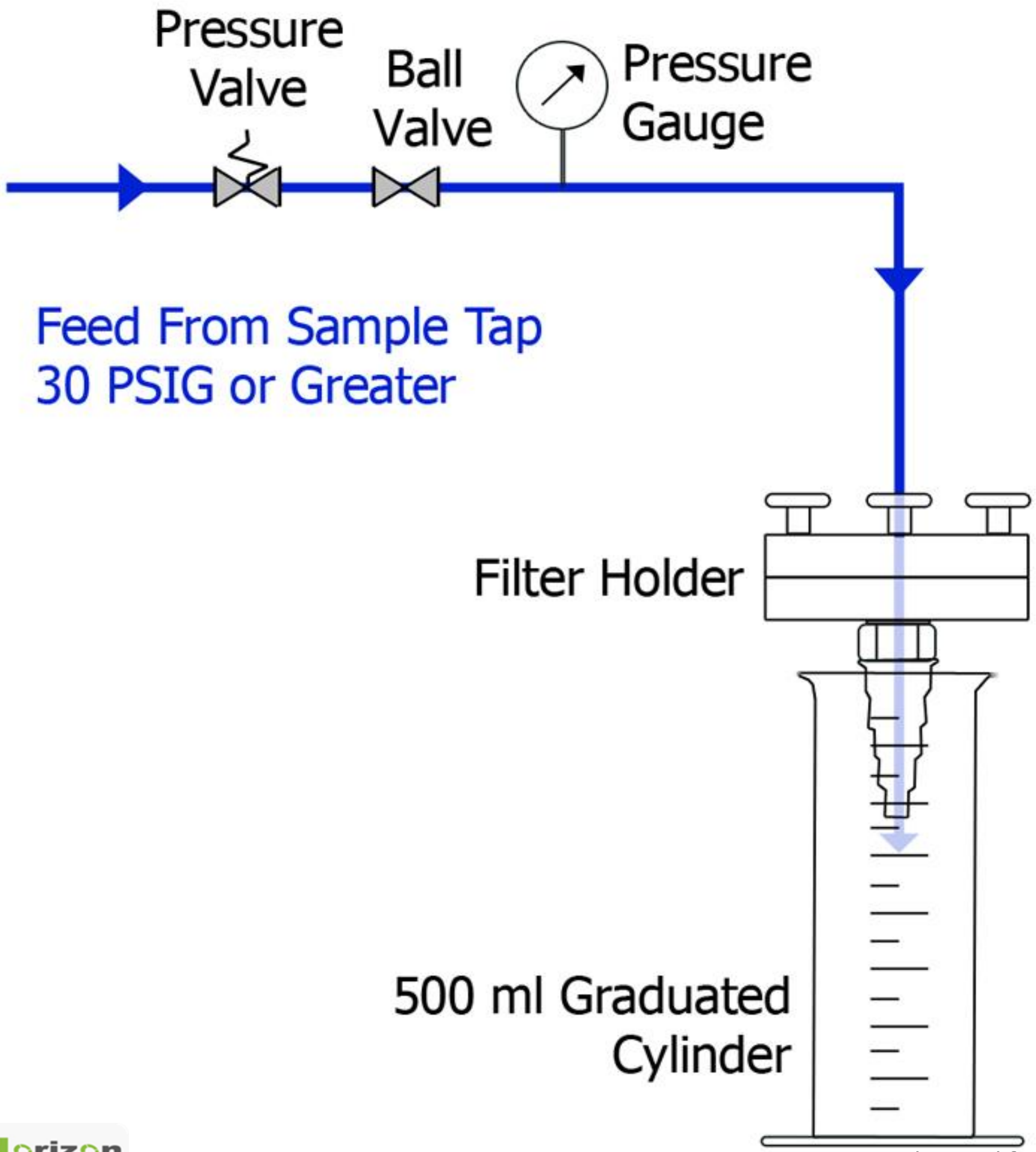
- It is a method of determining the feed water quality of reverse osmosis membrane systems. SDI is a measurement of the fouling potential of suspended solids, not the amount of solids.
- reverse osmosis systems require the SDI to be below 5.0 in seawater systems, and below 2.0 in brackish systems.
- SDI values are reported as SDIX, where X is the total time, reported in minutes, required to obtain the final sample (typically at fifteen minutes, or less).
- it is a simple, pressure regulated test to measure the flow decline, or decline in filtration rate, of the feed water through a 0.45μ filter.

General Rules of SDI

- Ensure that the o-ring is clean and in good condition.
- Prior to installing filter, flush the equipment to remove any contaminants.
- Carefully load membrane filter, avoiding exposure to fingers (most test equipment is supplied with specialty tweezers).
- Ensure all air is purged from inlet side of filter housing.
- Take the temperature of the feed water prior to the test; this should not vary more than +/- 1°C during the test.

Procedure:

- 1. Purge any air in the filter holder. This can be achieved by opening a bleed valve or loosening the filter holder while cracking the ball valve. After purging, close the valve or holder.
- 2. Place a 500 mL graduated cylinder under the filter apparatus to measure the time it takes to fill.
- 3. Open the ball valve fully, verifying the regulator is set at 30psi, and measure the time it takes to fill 100mL and 500mL from the time the valve is opened. Record these values, leaving the valve open and letting the flow continue.
- 4. Subsequent measurements should be conducted at five minutes, ten minutes and fifteen minutes from the time that the valve was initially opened. Again, record the amount of time it took to fill 100mL and 500mL, leaving the valve open and let ting the flow continue until completion of the test.
- 5. Verify temperature fluctuation has not exceeded +/- 1°C from the initial temperature


Pressure
Valve
Ball
Valve
Pressure
Gauge
Feed From Sample Tap
30 PSIG or Greater
Filter Holder
500 ml Graduated
Cylinder

- SDI = P30/TT = 100 * (1-Ti/Tf) / TT
- Where SDI15 = Silt Density Index at 15 minutes, passing water through a 0.45-µm membrane filter at a constant applied gauge pressure of 207 kPa (30 psi)Tt = total test time in minutes Ti = initial time, in seconds, to obtain 500mL sample Tf = time required, in seconds, to obtain 500mL at 15 minutes (or less)

SDI < 1	Several years without colloidal fouling
SDI < 3	Several months between cleaning
SDI 3 – 5	Particular fouling likely a problem, frequent cleaning
SDI > 5	Unacceptable, additional pre-treatment is needed

Any questions?

Thank you