Presentation

On

RO – 03 – Performance & Design Calculation

Prepared By

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RO – 03 – Performance & Design Calculation

RO Performance & Design Calculation

Numerous Calculation are linked with **RO System**
RO Instrumentation are linked with **Quality, Flow, Pressure**
Other **Considerations** are **Temperature, Operating Hour**

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RO Performance & Design Calculation

RO Performance & Design Calculation Consideration

Operational Parameter are taken into Consideration

Feed Water	Permeate Water	Reject Water
Flow Rate	Flow Rate	Flow Rate
Pressure	Pressure	Pressure
pH	pH	TDS
Temperature	TDS	Hardness
TDS	Hardness	Conductivity
Hardness	Conductivity	
Conductivity		
Turbidity		

RO – Salt Rejection%

Salt Rejection is one of the **Indicator of RO Effectiveness**

How Effectively RO Membranes are **Removing Contaminants**

Shows Overall System Performance rather than **Individual**

Good RO = 95% - 99% Rejection of Feed Contaminants

$$\text{Salt Rejection \%} = \frac{[\text{Cond.}_{\text{Feed}} - \text{Cond.}_{\text{Permeat}}]}{\text{Cond.}_{\text{Feed}}} \times 100$$

Salt Rejection% High = RO Membrane **Performance Good**

Salt Rejection% Low = RO Membrane **Need Clean or Replace**

RO

RO – Salt Passage%

Salt Passage is a simple **Inverse of Salt Rejection**

Salt Amount expressed as a **Percentage**

Salt Passing through the **RO System**

$$\text{Salt Passage\%} = [1 - \text{Salt Rejection\%}]$$

$$\text{Salt Rejection \%} = 1 - \frac{[\text{Cond.}_{\text{Feed}} - \text{Cond.}_{\text{Permeat}}]}{\text{Cond.}_{\text{Feed}}} \times 100$$

Salt Passage% High = RO Membrane **Need Clean or Replace**

Salt Passage% Low = RO Membrane **Performance Good**

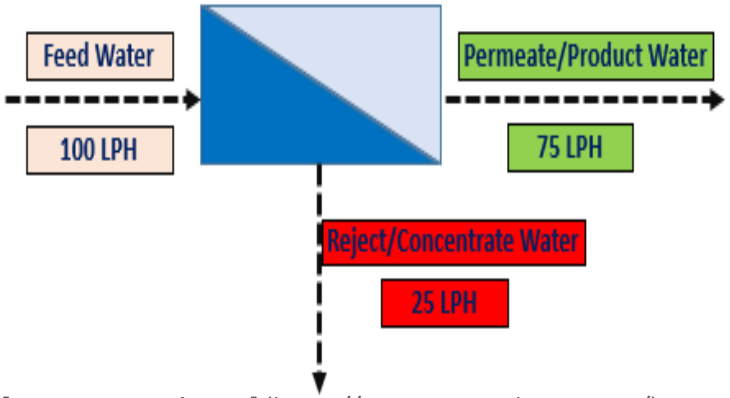
RO

RO – Rejection Definition

RO - Rejection

Amount of **Feed Water** that **"Rejected"** by Membrane

$$\text{Rejection \%} = \frac{[\text{TDS}_{\text{Feed}} - \text{TDS}_{\text{Product}}}{\text{TDS}_{\text{Feed}}} \times 100$$



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RO

RO – Recovery%

Recovery% Termed as Water Recovered as Permeate Water

Recovery% Termed as Water Not Sent as Reject/Concentrate

Depends on Feed Water Chemistry & RO Pretreatment

$$\text{Recovery\%} = \frac{\text{Permeate Flow Rate [gpm]}}{\text{Feed Flow Rate [gpm]}} \times 100$$

High Recovery% = Sending Less Amount Water to Reject

High Recovery% = Lead Larger **Problem** due to **Scale & Fouling**

Low Recovery% = Sending High Amount Water to Reject

RO

RO – Recovery%

Recovery% Termed as Water Recovered as Permeate Water
Recovery% Termed as Water Not Sent as Reject/Concentrate
Depends on Feed Water Chemistry & RO Pretreatment

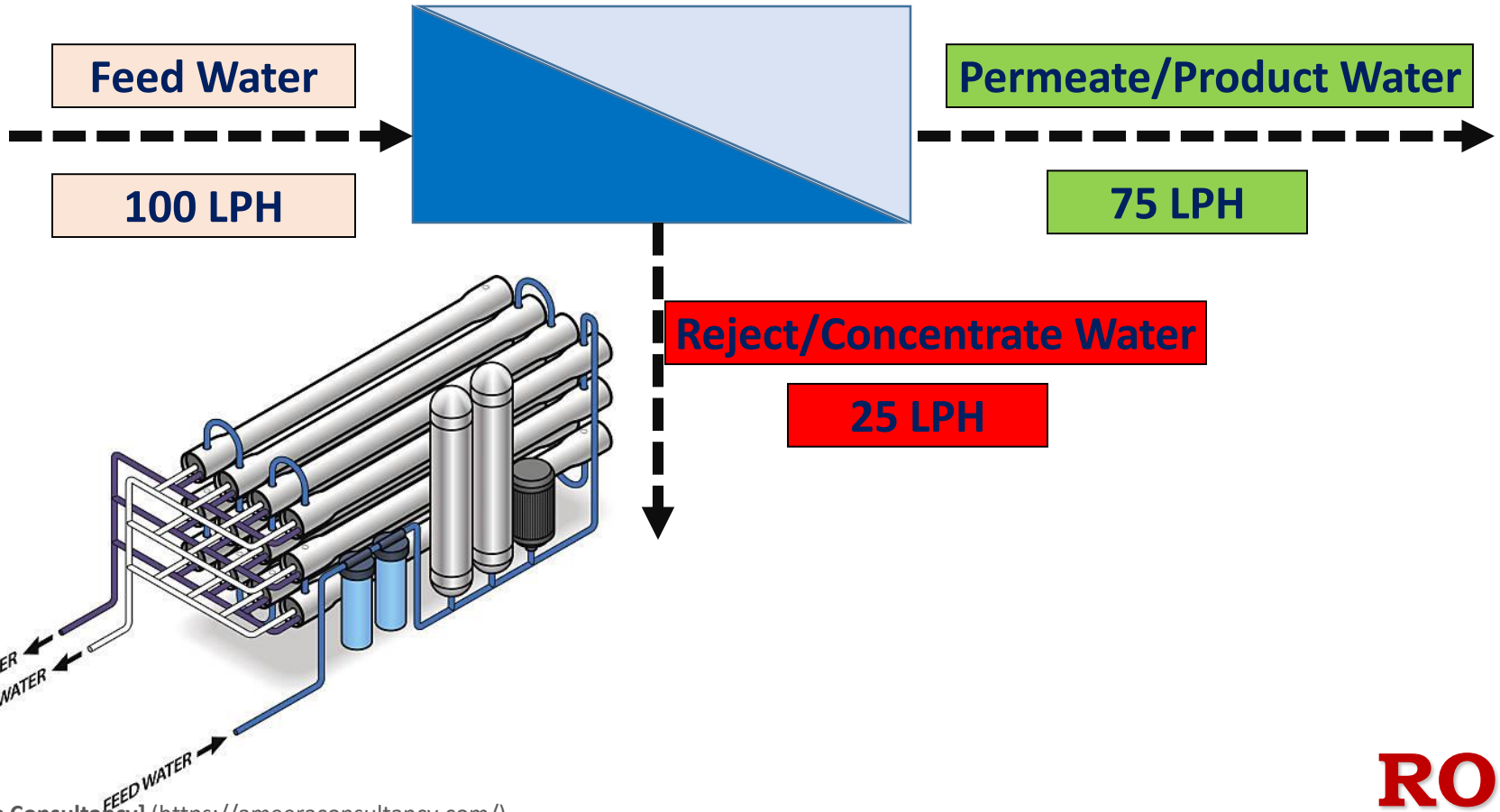
$$\text{Recovery\%} = \frac{\text{Permeate Flow Rate [gpm]}}{\text{Feed Flow Rate [gpm]}} \times 100$$

65% Recovery =	Feed 100	Permeate 65	Reject 35
75% Recovery =	Feed 100	Permeate 75	Reject 25
85% Recovery =	Feed 100	Permeate 85	Reject 15

RO

RO – 75% Recovery Meaning

RO – The Meaning of 75% Recovery, based on Design



RO

RO – Concentration Factor

More Water in Permeate = More Conc. Salt in Reject
Higher Conc. Factor = High Potential Scale
Salt Passing through the RO System

$$\text{Concentration Factor} = \frac{1}{1 - \text{Recovery\%}}$$

High Conc. Factor = High Potentiality of RO Membrane Scaling
Salt Passage% Low = RO Membrane Performance Good

RO

RO – Concentration Factor

Feed Water Flow ..... 100 gpm
Permeate Water Flow ..... 75 gpm
Recovery% ..... [75/100]x100 = 75%

Concentration Factor = [1/[1-75%]] = 4

A Concentration Factor 4 means; Feed x 4 = Concentrate

Feed 300 ppm, Conc. Will be = 300 x 4 = 1200 ppm

$$\text{Concentration Factor} = \frac{1}{1 - \text{Recovery\%}}$$

RO

RO – Mass Balance

To Determine the **Flow & Quality** of Instrumentation

Mass Balance Provides Signal that **RO Performance is Good**

Mass Balance Provides Signal that **RO System Need Calibration**

Mass Balance:
[Feed Flow X Feed Cond.] =
[Permeate Flow X Permeate Cond.] + [Conc. Flow X Conc. Cond.]

RO

RO – Mass Balance

To Determine the **Flow & Quality** of Instrumentation

Mass Balance Provides Signal that **RO Performance is Good**

Mass Balance Provides Signal that **RO System Need Calibration**

Feed Water Flow ..... ??? gpm
Feed Water Conductivity ..... 500 µS
Permeate Flow ..... 5 gpm
Permeate Conductivity ..... 10 µS
Concentrate Flow ..... 2 gpm
Concentrate Conductivity ..... 1200 µS

RO

RO – Mass Balance

Feed Flow = [Permeate Flow + Reject Flow] = 5 + 2 = 7

[Feed Flow X Feed Conductivity] = 7 X 500 = 3500

[Permeate Flow X Permeate Cond.] + [Conc. Flow X Conc. Cond.]
= [5 X 10] + [2 X 1200]
= 50 + 2400 = 2450

Difference:
= [3500 – 2450]X100/[3500 + 2450]
= 18%

Good Result = < 5% +-

Adequate Result = 5% - 10%+-

Unacceptable Result = > 10%+- [Calibration Need]

RO

RO – Mass Balance

RO – Mass Balance

Feed Water	=	Product	+	Reject
Feed Water 100	=	Product 75	+	Reject 25
Feed Water 100	=	Product 85	+	Reject 15
Feed Water 100	=	Product 98	+	Reject 02

RO

Industrial RO System

Industrial RO System

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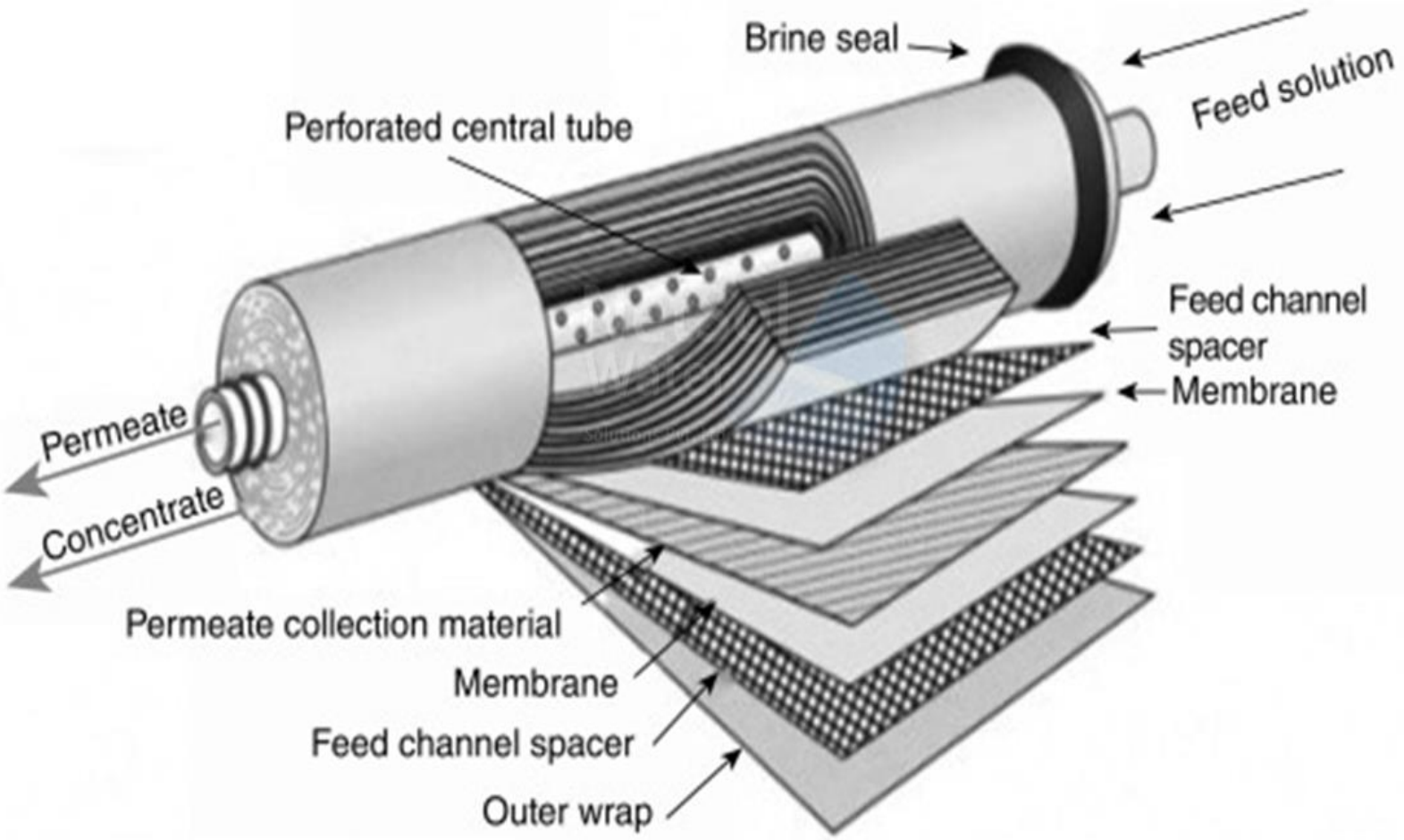
RO Membrane



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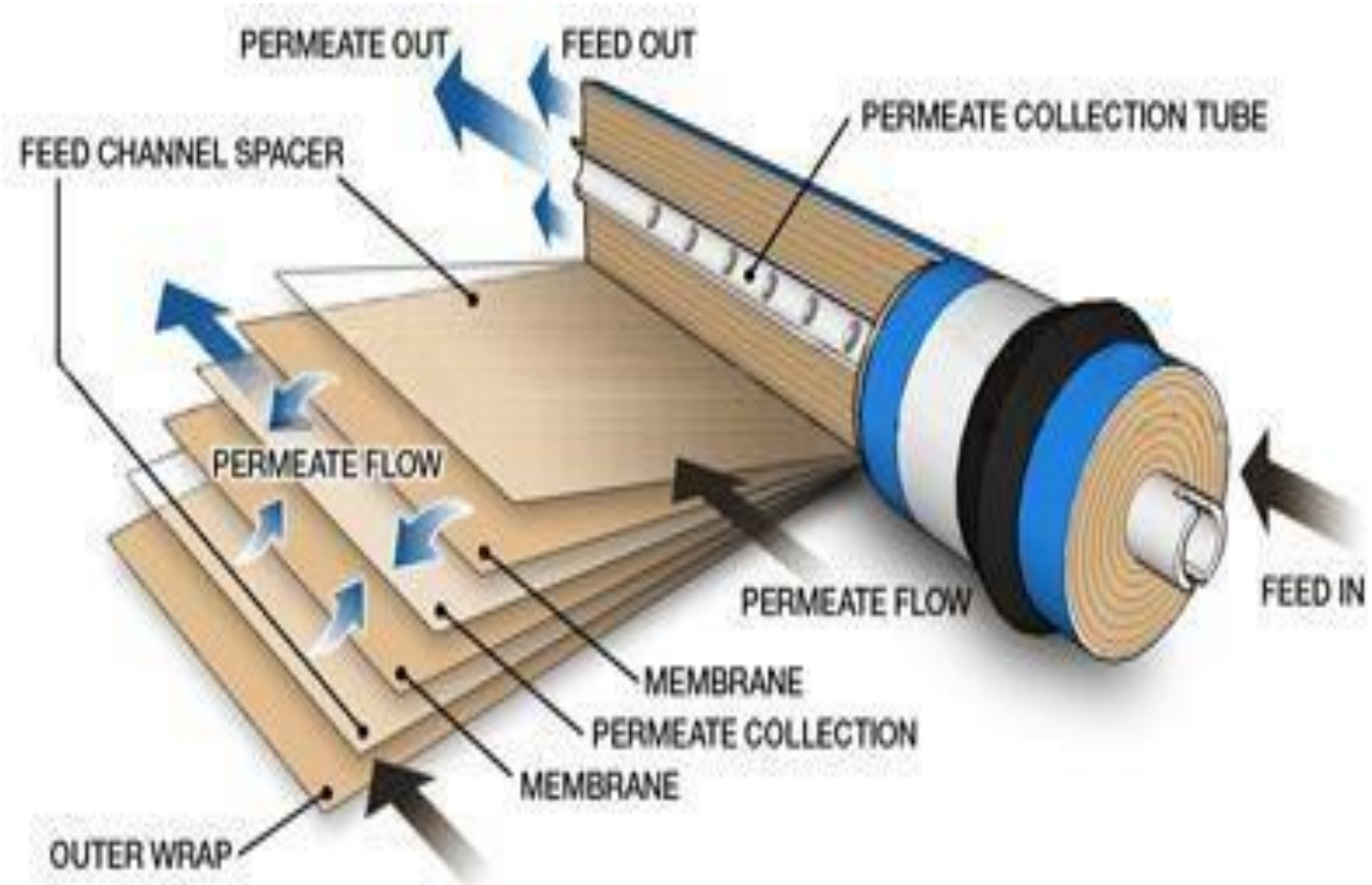
RO Membrane



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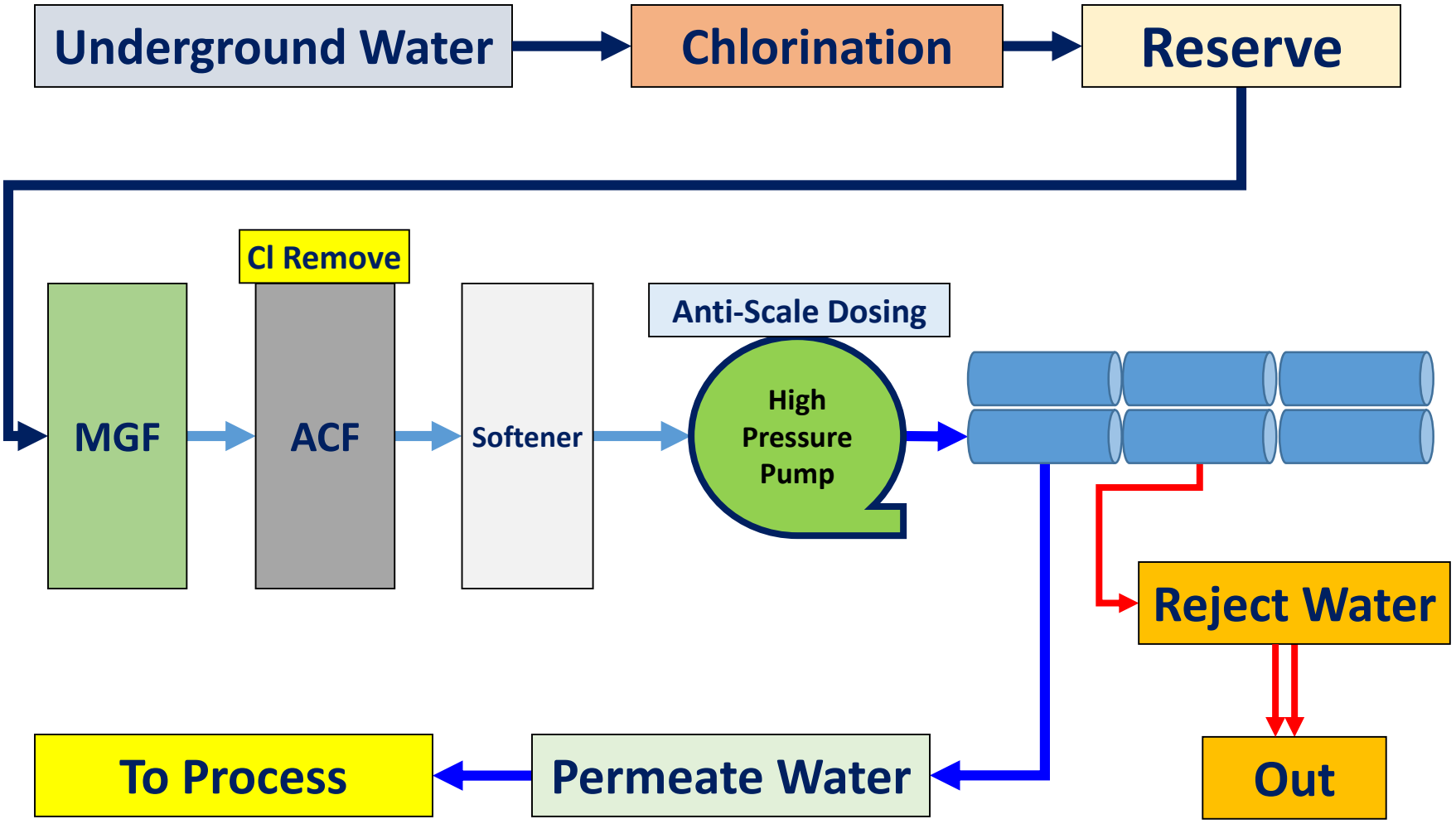
Basic Components of RO Plant



RO - Monitoring

RO Monitoring is very much Important Thing

Entire RO is a Costly Item

RO Fouling tends to be the Change of Membrane

Pretreatment: 90% of Operational Problems are found here

System: 90% of Operational Problems are found here

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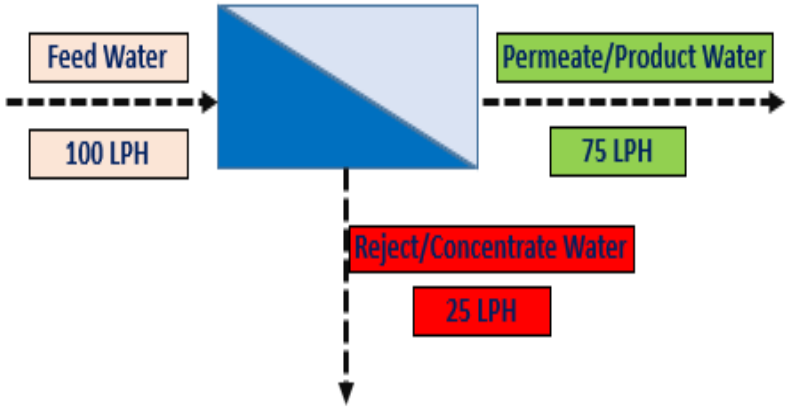
RO – Monitoring [Pretreatment]

RO Pretreatment Monitoring

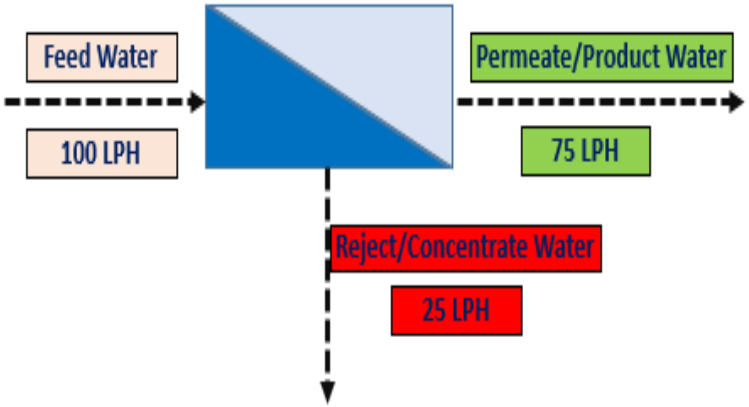
- Silt Density Index [SDI]
- pH
- Chlorination
- Turbidity
- Temperature
- Pressure
- Conductivity
- Microbiological Foulants [Bacteria, Silica, Hardness

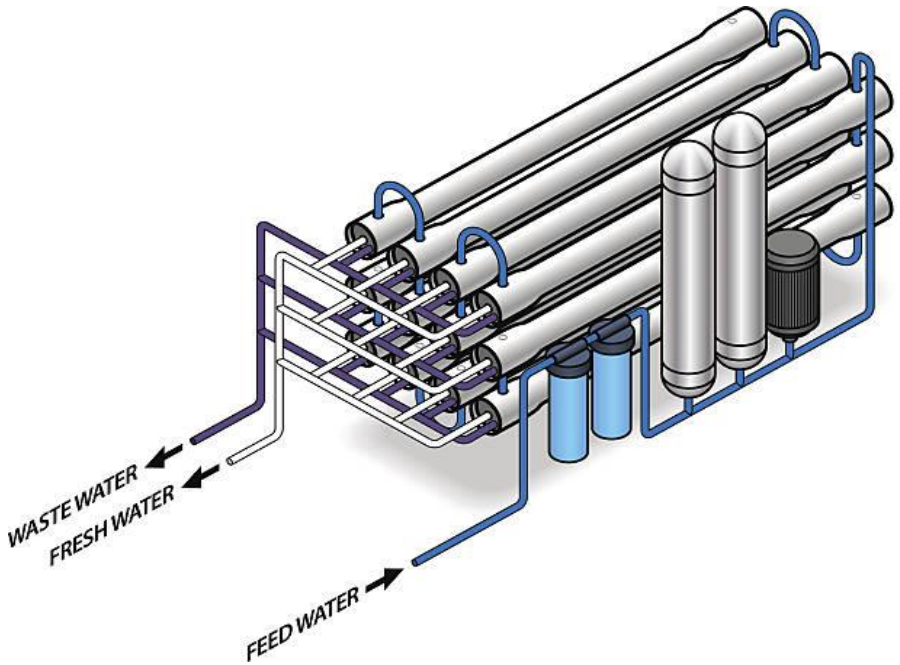


RO – Monitoring [System]

RO System Monitoring

- Present Salt Rejection
- Differential Pressure
- Percent Recovery





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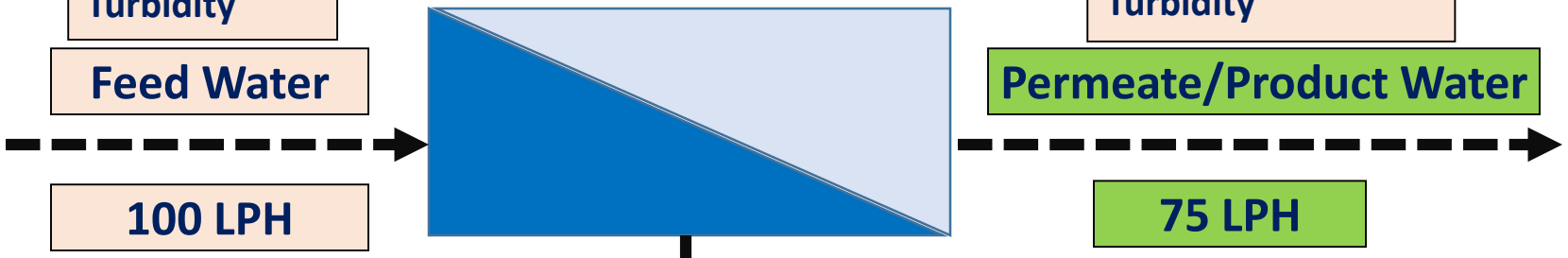
RO – Important Parameter Location

Feed Flow,
Feed Pressure
pH,
SDI
Temperature,
Conductivity,
Turbidity

Feed Water

100 LPH



Permeate Flow,
Permeate Pressure,
pH,
Temperature,
Conductivity,
Turbidity

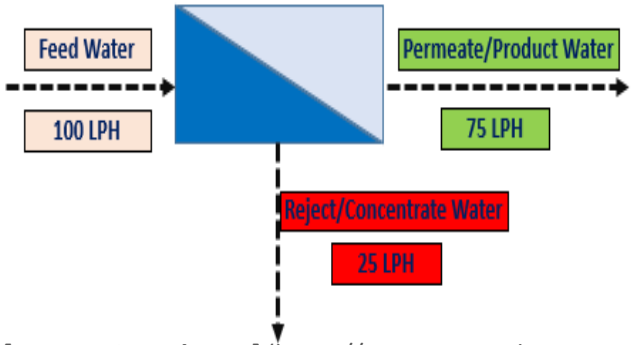
Permeate/Product Water

75 LPH

Reject/Concentrate Water

25 LPH

Reject Flow,
Reject Pressure,
Conductivity,
Turbidity



RO

RO – Daily Operation & Performance Data

RO – Daily Operation & Performance Data

Feed Water pH	Permeate Water pH, Temp.
Feed Water Temperature	Permeate Water Conductivity, Turbidity
Feed Water Conductivity	Permeate Water Flow, Pressure
Feed Water Turbidity	Reject Water Flow, Pressure
Feed Water SDI	Reject Water Conductivity, Turbidity
Feed Water Flow	**Percent Salt Rejection [Calculated]**
Feed Water Pressure	**Differential Pressure [Calculated]**
Daily Graphical Trend	**Percent Recovery [Calculated]**

RO

Any Question…!?

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