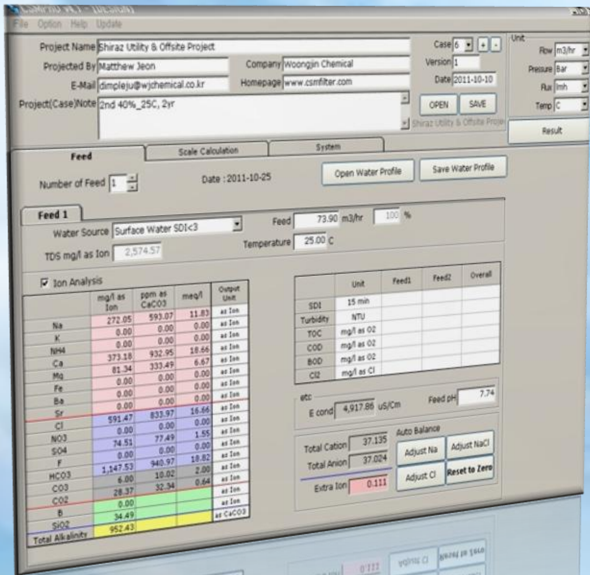


CSM®

RO System Design & CSMPRO 4.1 ver.

Presenter : Matthew Jeon

CONTENTS

I. System Design

Consideration of Feed Source, Application

The membrane system design depends on
Feed Source, Feed Quality, Feed/Product Flow, and Required Product Quality.

- Water Source
  - Well Water / Softened Water / Surface Water / Sea Water / Effluent Water
- Feed Quality
  - Pretreatment System / Feed Water Quality
- Feed / Product flow
  - Required Product Flow Rate / Recovery
- Required product quality
  - Application / Specify Water Quality Needed after RO Treatment

Selection of configuration and No. Passes

- **Plug flow**
  - The standard flow configuration, where the feed water is passed once through the system.

- **Concentrate Recirculation**
  - Common system used in commercial application, as well as in larger systems when the number of elements is too small to achieve a sufficiently high system recovery with plug flow.

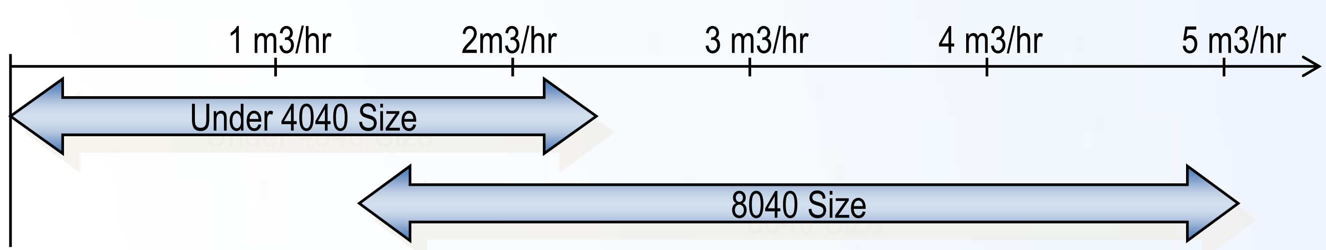
- **Double Pass system**
  - Combination system of two conventional RO system where permeate of the first system becomes the feed for the second system. It is used to produce ultra pure water for semi-conductor and pharmaceutical and sea water desalination.

- **Permeate Blending**
  - The system, where some ratio of feed water or permeate of 1^{st} pass is mixed to final product. The smaller system can be achieved.

Membrane Type Selection

Membranes are selected by
Feed Concentration, Fouling Tendency, Required Rejection and Energy Requirements.

- **Feed Concentration**
  - Under 1,000 mg/L ; BL series
  - Under 10,000 mg/L ; BN, BE
  - Under 50,000 mg/L ; SHN, SHA, SHF
- **Application**
  - Softening, Concentration, 1st Pass of Seawater ; NF
  - Wastewater reuse, Zero discharge ; FEn, FL, FLR
  - Ultra pure water, HERO System ; HUE, UL
- **Energy Requirements**
  - Low pressure requirement ; BL, FL, UL
  - Normal pressure requirement ; BE, FEn, HUE
  - High pressure requirement ; BR, SHN, SHA, SHF
- **Membrane Dimension**



Determining of Average Flux

The average permeate flux should be determined by the Feed Water Quality (SDI) as well as Feed Water Sources

Kinds of feed water source	RO Permeate	Well Water	Surface Water		Filtered Municipal Effluent (Wastewater)		Seawater	
					MF or UF Pretreatment	Conven-tional	Well or MF	Open intake
SDI	< 1	< 3	< 3	< 5	< 3	< 5	< 3	< 5
Average Flux (gfd)	21-25	16-20	13-17	12-16	10-14	8-12	8-12	7-10

Calculation of the No. of membranes & PV

The Number of Elements and Pressure Vessels needed

$$N_E = \frac{Q_P}{f * S_E} \qquad N_V = \frac{N_E}{N_{E/PV}}$$

N_E : The number of elements
Q_P : The design permeate flowrate
f : The design flux
N_v : The number of pressure vessel
$N_{E/PV}$: The number of elements per pressure vessel

For the Surface Feed Water (SDI < 5), to get 100 m3/hr of the product water

- Determine the average flux
  - from the data for design guide lines : 12- 16 gfd
  - In this calculation, we select the target flux to be 12 gfd
- Determine the module size and grade
  - In this case, we select RE8040-BE module (Effective area is 400ft$^{2)}$
- Calculation
  - 400 ft^2/element x 12 gfd = 4,800gpd / element = 757ℓ/hr,elements
- To get 100㎥/hr, how many RE 8040-BE elements are required ?
  - 100,000 ℓ/hr ÷ 757ℓ/hr/element = 132.1 elements
  - 133 elements are required
- How many vessels (6 elements/vessel) are required ?
  - 133 elements ÷ 6elements/vessel = 22.2 ▸ 23 vessels

Determining of System Array

The number of stages is a function of the planned system recovery, the number of elements per vessel and the feed water quality.

- **Designed system recovery depends on feed water source and quality in general**
  - For the Sea water feed : 30 - 60%
  - For the Brackish water feed : 75 - 85%
  - For the RO permeate feed : 85 - 95%

- **Array on system recovery**
  - Less than the 50% Recovery : one array
  - Less than the 80% Recovery : two array
  - over 80% Recovery : three array

❖ For the RO permeate : System is designed to get 90% recovery with 2 array

❖ For the Waste water : System is designed to get 75% recovery with 3 array

Consideration in Design

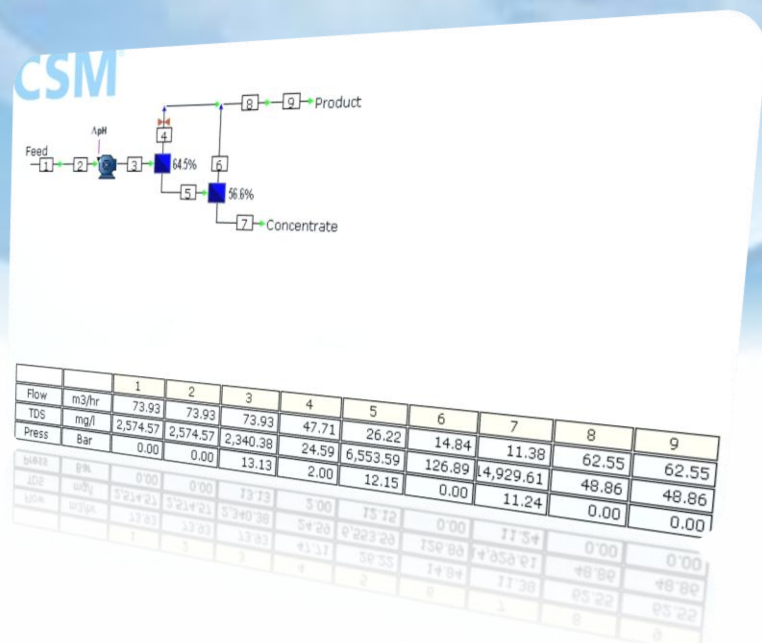
- **Improve product quality**
  - Use part or all seawater elements for brackish feed water
  - Use seawater elements in one or both stages of double pass system
  - Recycle permeate of last stage into feed
  - Use Split partial blending in double pass system

- **Increase system recovery**
  - Feed the concentrate to a second system, after specific pretreatment
  - Recycle the concentrate to feed stream

- **Obtain high system recovery and uniform permeate flow**
  - Use booster pumps between stages to compensate for osmotic pressure increase
  - Use permeate back pressure from first to last stage
  - Use Hybrid system design with tighter membranes in the first stage than in the second stage

- **Reduce the plant capacity to obtain just the required permeate quality**
  - Blend the permeate with feed water

II. CSMPRO Introduction



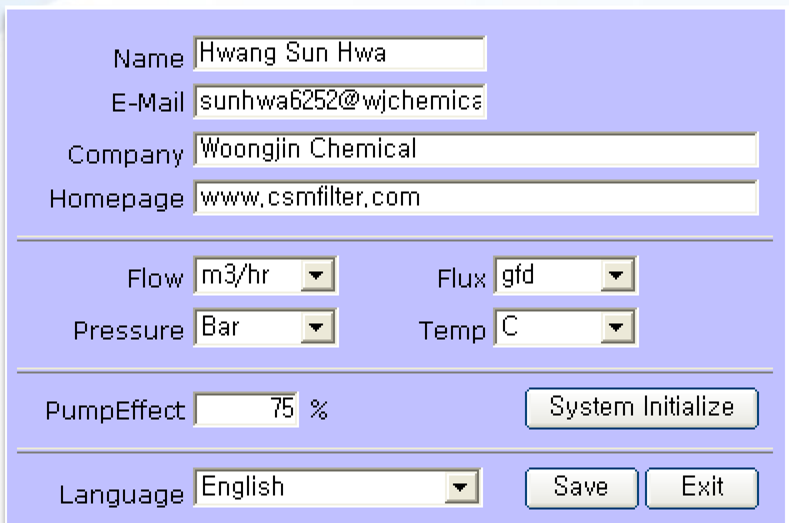
		1	2	3	4	5	6	7	8	9
Flow	m3/hr	73.93	73.93	73.93	47.71	26.22	14.84	11.38	62.55	62.55
TDS	mg/l	2,574.57	2,574.57	2,340.38	24.59	6,553.59	126.89	14,929.61	48.86	48.86
Press	Bar	0.00	0.00	13.13	2.00	12.15	0.00	11.24	0.00	0.00

Major Features

1. Live up to date	◆ Automatically download new files via internet before execution of the program ◆ All data files and program files are included
2. Support to multiple language	◆ English, Korean, Chinese, Japanese are supported ◆ Able to add new languages
3. Easy Design	◆ Automatic array design ◆ Must be reviewed by an expert engineer
4. Various Output Print	◆ Save in PDF, RTF (Editable by MS Word) format ◆ Copy into a clipboard and paste on any program which support OLE
5. Improved User interface	◆ Support a multicase design in a single file ◆ Divinatory designs a layout to find what user wants

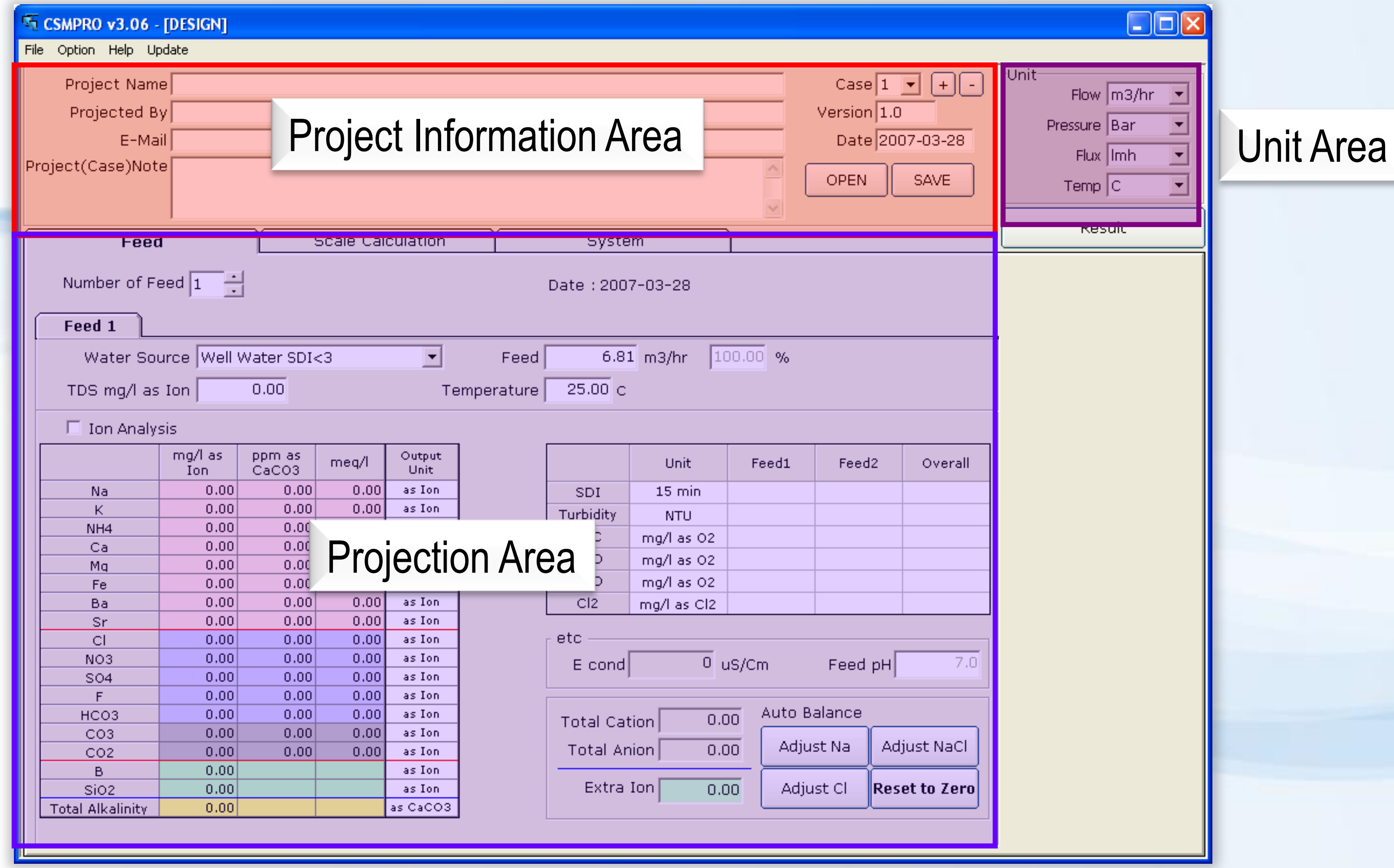
1. Language select box will appear at Initial execution.
   English / Korean / Chinese(Simpl.) / Japanese are now available

2. CSMPRO live update agent will appear on the screen to download recent version



3. User can set a preference as left dialog box to use this program easily.
   User information, preferred units, and languages are able to set and/or change with this windows.
   [Option] – [Preference] on the head menus

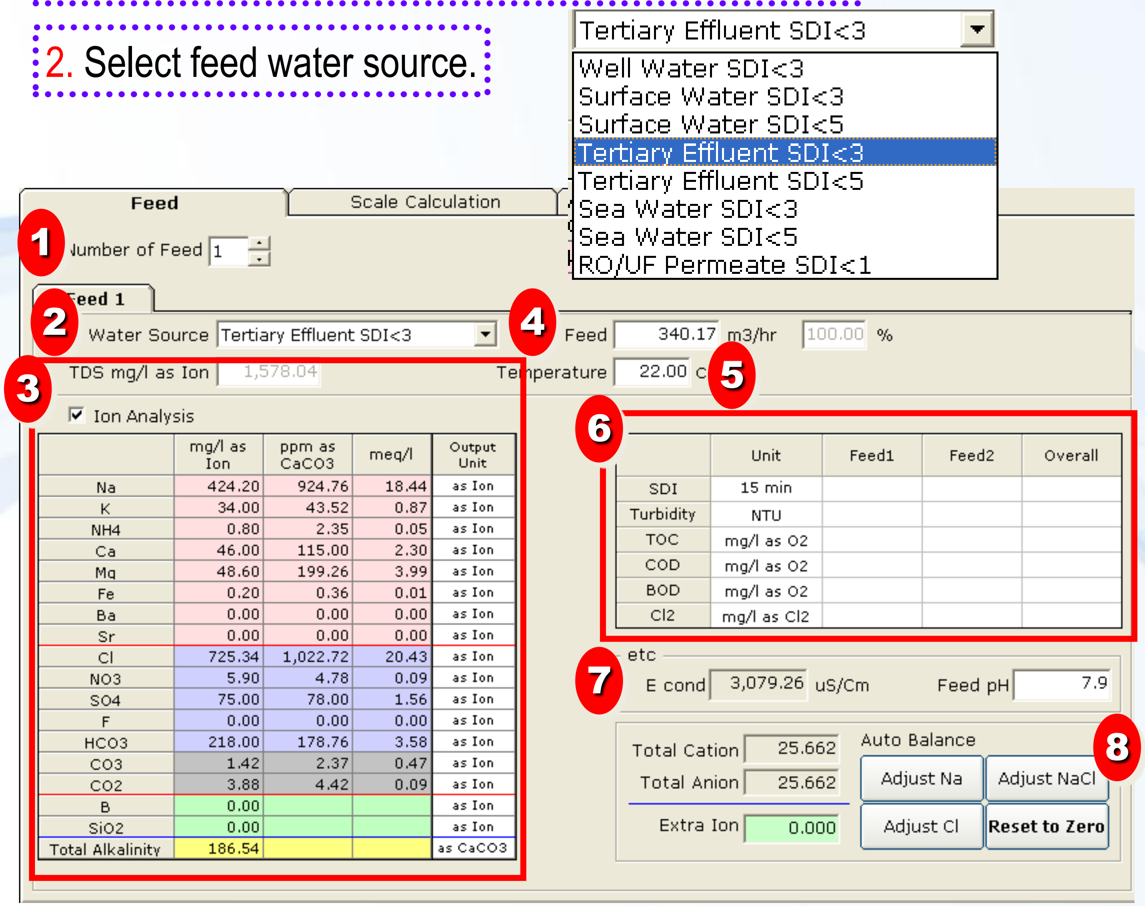
II. CSMPRO Introduction Registration



System Design - Feed

1. Using this if there are multiple feed water sources

2. Select feed water source.



3. Feed water concentration.
   Using TDS term or Ionic concentration

4. Feed flow for each feed source.
   This is used for multiple feed waters

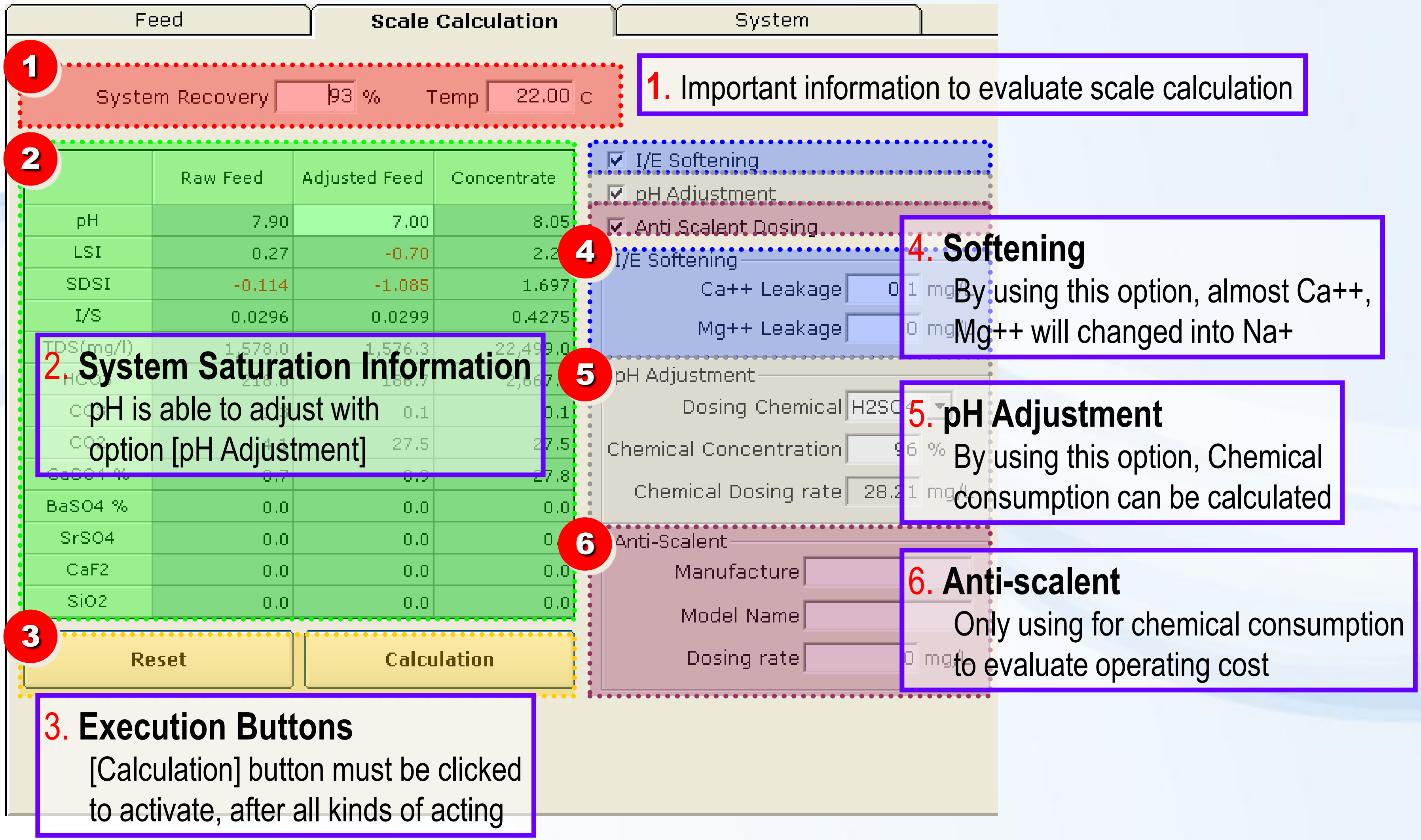
5. Temperature of feed water

6. Additional feed water quality.
   No use for calculation but for understand the feed water condition

7. Conductivity will be calculated automatically, but it's not exact.
   There is no exact conversion factor between TDS and Conductivity.
   And input feed water pH.

8. Using this button to balance ion concentration between anion and cation

II. CSMPRO Introduction System Design – Scale Calculation

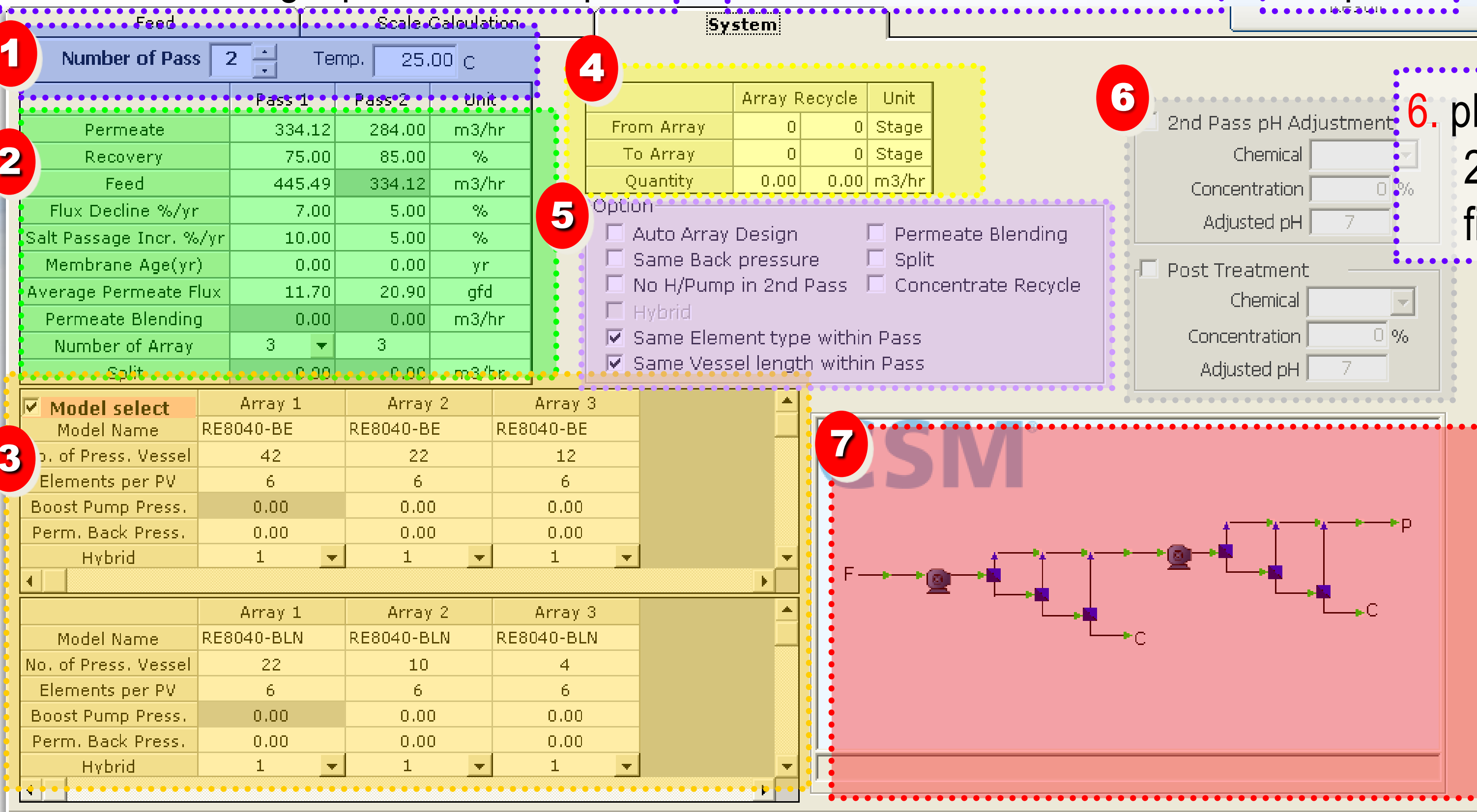


System Design – System

1. Choose a single pass / double pass

4. Concentrate recirculation

5. Options



6. pH Adjustment for 2nd pass feed and/or final product

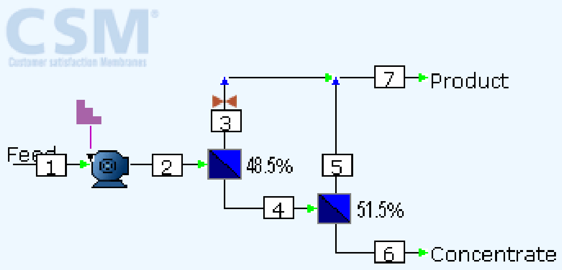
2. Design parameters

3. Array Configurations

7. Brief block diagram

Diagram

Result Scan | Diagram



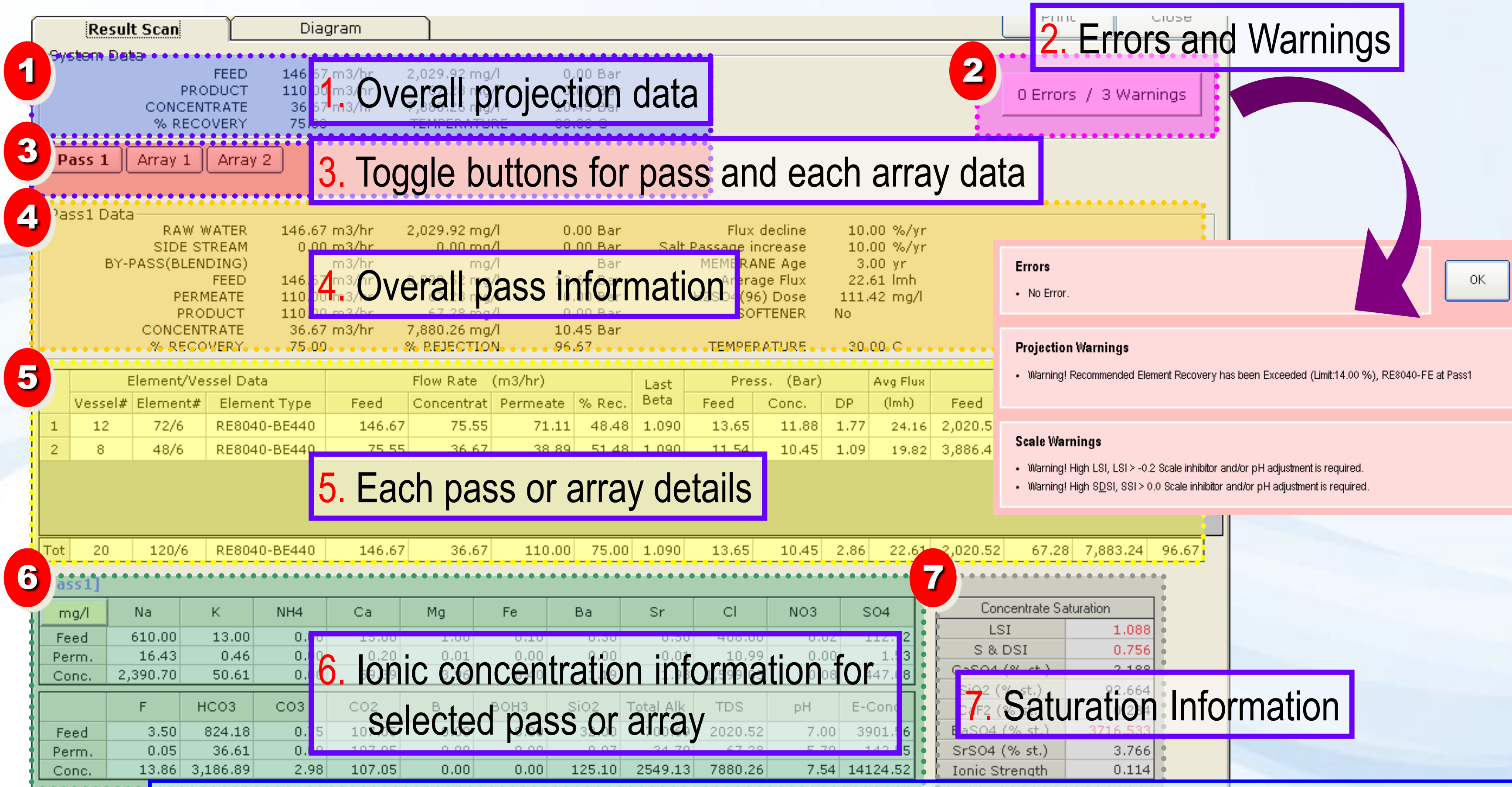
		1	2	3	4	5	6	7
Flow	m3/hr	146.67	146.67	71.11	75.55	38.89	36.67	110.00
TDS	mg/l	2,029.92	2,020.52	39.68	3,886.47	117.78	7,883.24	67.28
Press	Bar	0.00	13.65	2.00	11.88	0.00	10.45	0.00

Block Diagram with brief information

After click a [RESULT], the program will show a this diagram. Some information including flow, TDS, pressure, flow diagram and recovery is demonstrated on the results.

For more details, choose a [Result Scan] Tab.

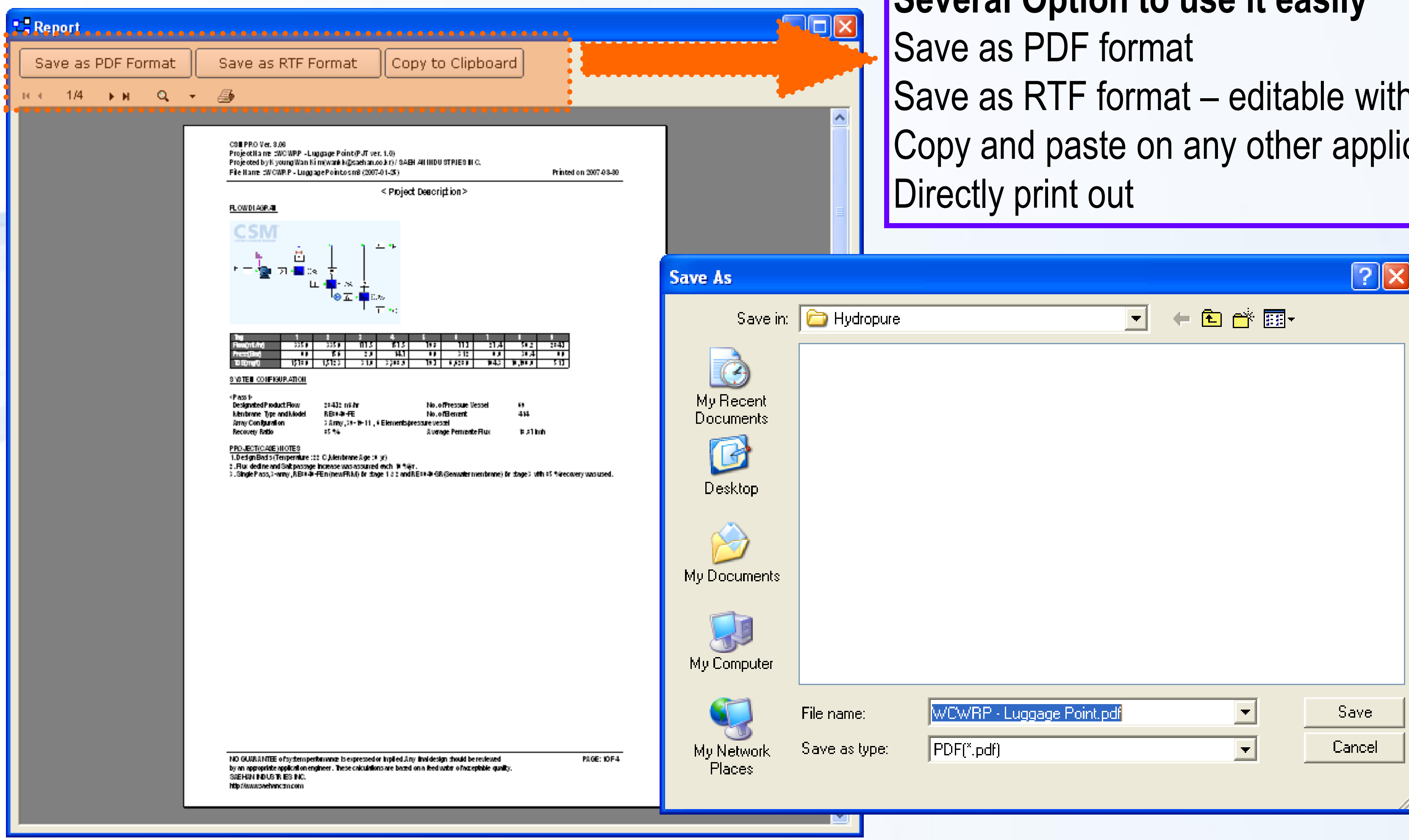
Result Scan



Limitation Warning

Limitation tool tip will be appeared when mouse pointer locate on a **red values** which exceeded than limitation in Each pass or array details (5) and saturation information (7)

Print Out



Several Option to use it easily

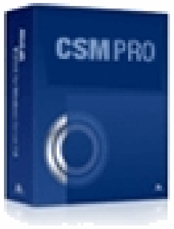
Save as PDF format

Save as RTF format – editable with MS Word

Copy and paste on any other applications

Directly print out

III. CSMPRO 4.1 Features

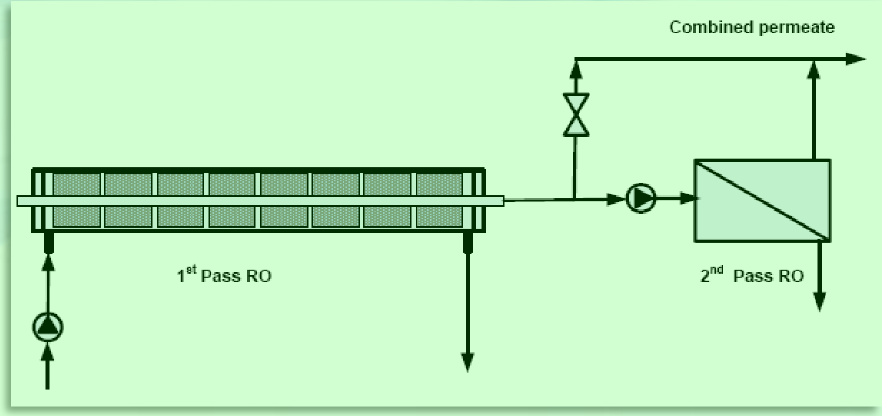


Split Partial Blending

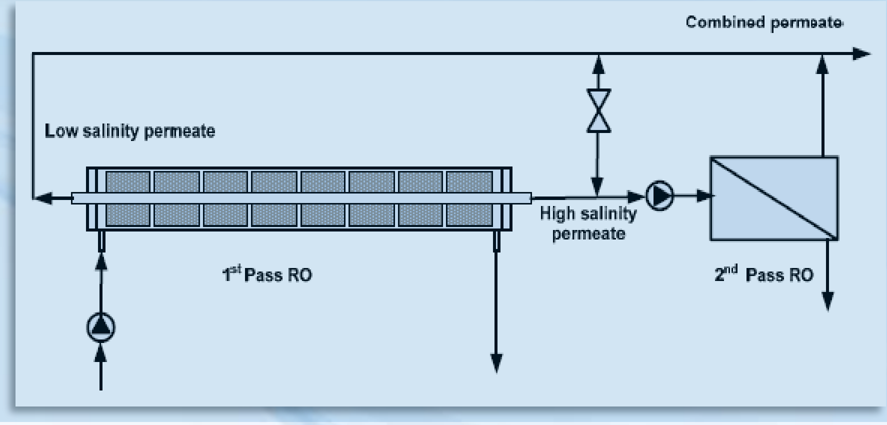
Split Partial Blending?

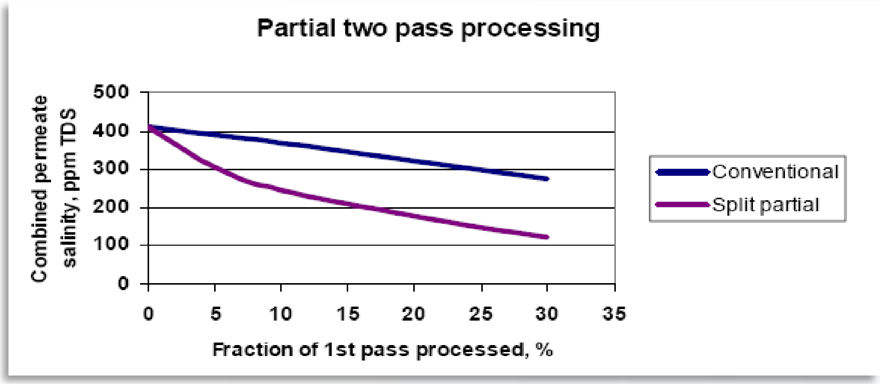
Permeate is collected from both sides of the pressure vessel. Low TDS front permeate is than sent directly to final product line, while higher TDS back permeate is treated by partial second pass RO plant.

1. "Partial" Double Pass RO System



2. "Split-Partial" Double pass RO System





Advantages of Split Partial

1. Smaller first & second pass RO trains
2. Better permeate quality
3. Reduced capital & operating cost
4. Flexibility in system operation according to actual conditions

Split Partial Blending

Feed | Scale Calculation | **System**

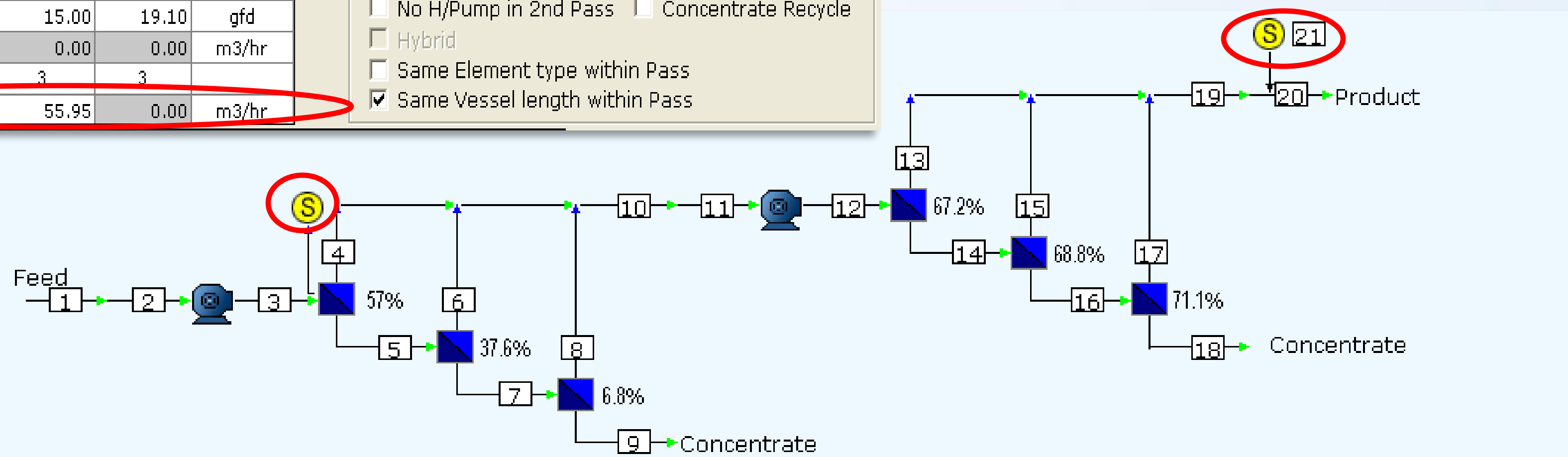
Number of Pass 2 Temp. 25.00 C

	Pass 1	Pass 2	Unit
Permeate	444.05	433.39	m3/hr
Recovery	75.00	85.00	%
Feed	666.67	444.05	m3/hr
Flux Decline %/yr	7.00	5.00	%
Salt Passage Incr. %/yr	10.00	5.00	%
Membrane Age(yr)	0.00	0.00	yr
Average Permeate Flux	15.00	19.10	gfd
Permeate Blending	0.00	0.00	m3/hr
Number of Array	3	3	
Split	55.95	0.00	m3/hr

	Array Recycle		Unit
From Array	0	0	Stage
To Array	0	0	Stage
Quantity	0.00	0.00	m3/hr

Option

- ☐ Auto Array Design
- ☐ Permeate Blending
- ☐ Same Back pressure
- ☑ Split
- ☐ No H/Pump in 2nd Pass
- ☐ Concentrate Recycle
- ☐ Hybrid
- ☐ Same Element type within Pass
- ☑ Same Vessel length within Pass



		1	2	3	4	5	6	7	8	9	10
Flow	m3/hr	666.67	666.67	666.67	324.07	286.65	107.79	178.86	12.19	166.67	444.05
TDS	mg/l	2,424.05	2,424.05	2,424.05	11.25	5,623.79	35.87	8,991.39	127.41	9,639.76	20.42
Press	Bar	0.00	0.00	13.53	0.00	10.92	0.00	8.29	0.00	4.11	0.00

		11	12	13	14	15	16	17	18	19	20	21
Flow	m3/hr	444.05	444.05	298.26	145.79	100.33	45.47	32.33	13.14	430.91	486.86	55.95
TDS	mg/l	20.42	20.42	0.25	61.67	1.14	195.24	5.36	662.35	0.84	1.42	5.90
Press	Bar	0.00	8.32	0.00	5.68	0.00	4.03	0.00	3.01	0.00	0.00	0.00

Hybrid

Hybrid?

To optimize feed pressure and system salt rejection, several kinds of membranes are installed to one pressure vessel.

	Flux (GPD)	Rejection (%)
RE 8040 SHN	6,000	99.75
RE 8040 SHA	7,500	99.75
RE 8040 SHF	9,000	99.70

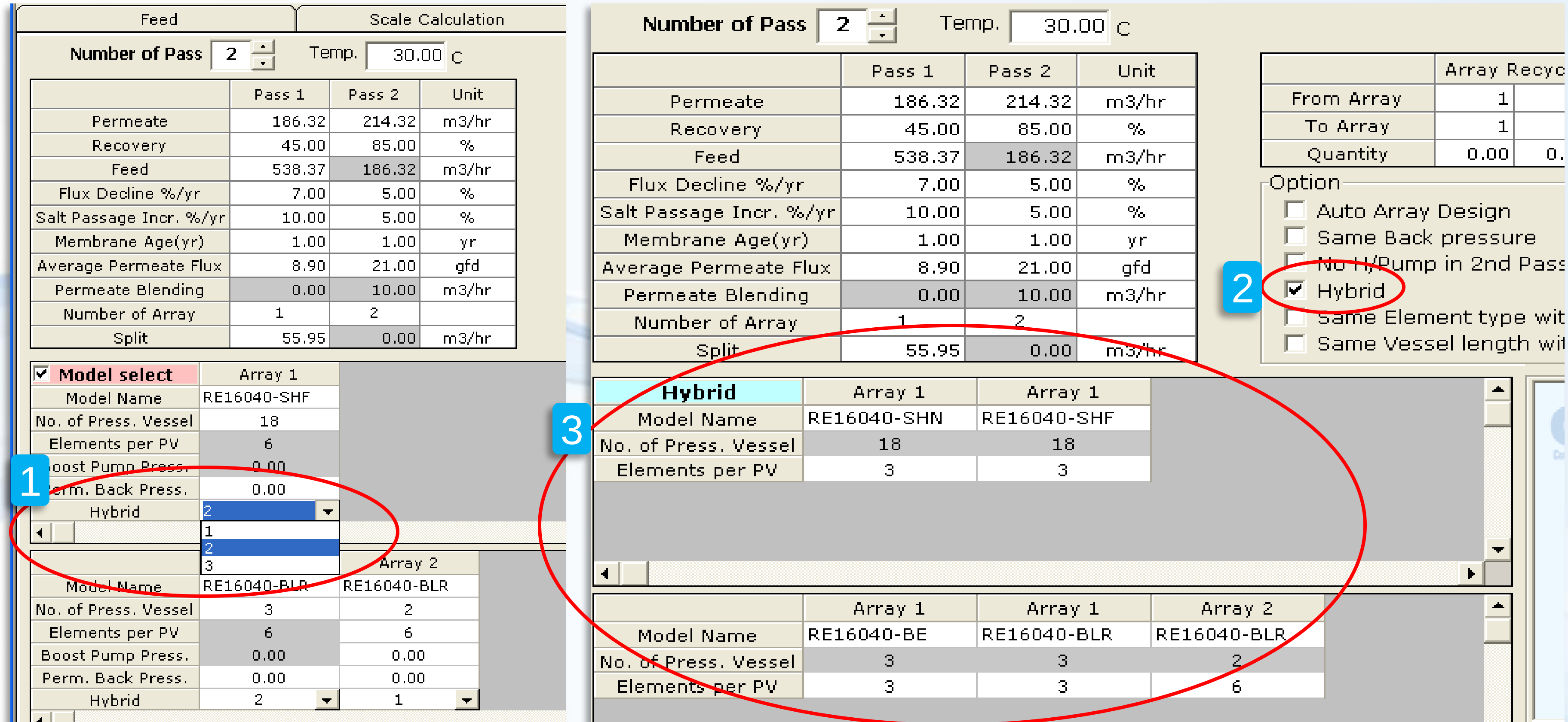
Front → Rear

Vessel (Single stage)		1	2	3	4	5	6	7
Single	SHN	SHN	SHN	SHN	SHN	SHN	SHN	SHN
	SHA	SHA	SHA	SHA	SHA	SHA	SHA	SHA
	SHF	SHF	SHF	SHF	SHF	SHF	SHF	SHF
Hybri	A	SHN	SHN	SHA	SHA	SHA	SHF	SHF
	B	SHN	SHN	SHN	SHN	SHF	SHF	SHF
	C	SHF	SHF	SHA	SHA	SHA	SHN	SHN
	D	SJF	SHF	SHF	SHF	SHN	SHN	SHN

Hybrid

Installed Membrane			Permeate Quality TDS (mg/l)	Power Consumption (kw hr/day)
Single	SHN 6EA		140.7	18,158
	SHA 6EA		182.3	16,951
	SHF 6EA		265.9	16,204
Hybrid	A	SHN 2EA + SHA 3EA + SHF 2EA	177.1	16,834
	B	SHN 4EA + SHF 3EA	182.4	17,237
	C	SHF 2EA + SHA 3EA + SHN 2EA	191.2	16,222
	D	SHF 4EA + SHN 3EA	229.2	16,379

Hybrid



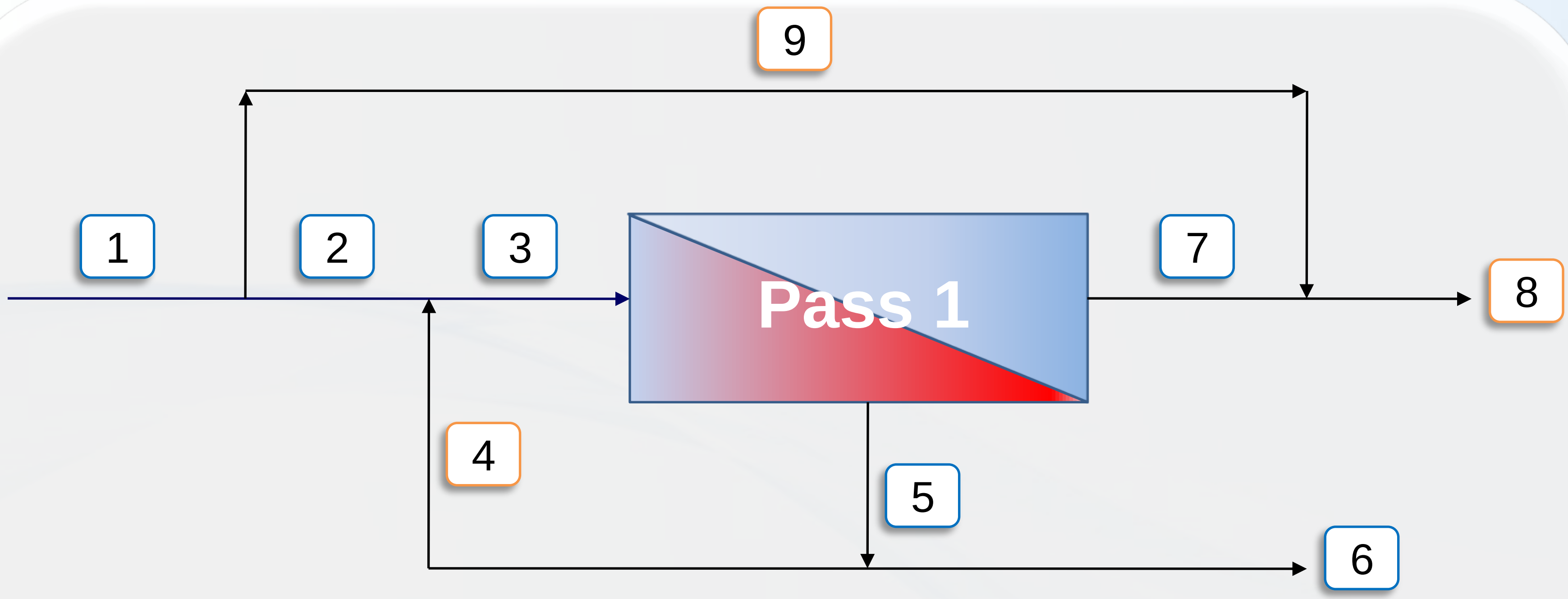
◆ **System Information**

Double Pass (1st pass : 1 array, 2nd pass : 3-2 array, 6 elements/PV)

1st pass : 1st stage : 16040-SHN 3pcs & 16040-SHF 3pcs

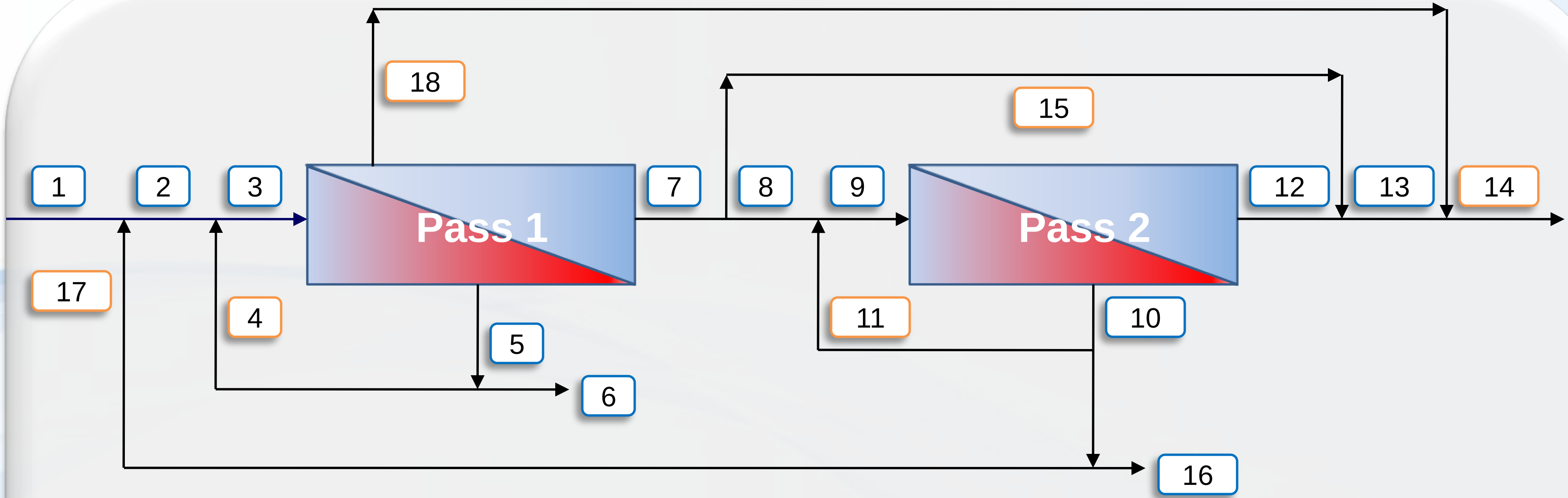
2nd pass 1st stage: 16040-BE 3pcs & 3 16040-BLR 3pcs

Recovery – Single Pass



Case		Pass Recovery	System Recovery
1	No blending, No array recycle (no 4, no 9)	=7/2 = 8/1	=8/1
2	Blending (9, no 4)	=7/2 = (8-9)/(1-9)	=8/1
3	Array recycle (4, no 9)	=7/2 =8/1	=8/1
4	Blending, array recycle (4, 9)	=7/2 =(8-9)/(1-9)	=8/1

Recovery – Double Pass



Case		pass 1 recovery	pass 2 recovery	system recovery
5	No recycle, No blending, No split (no 4, 11, 15, 17, 18)	=7/2 =7/1	=12/8 =14/8	=14/1
6	blending (15, no 4, 11, 17, 18)	=7/2 =7/1	=12/8=(14-15)/(7-15)	=14/1
7	concentrate recycle (17, no 4, 11, 15, 18)	=7/2=7/(1+17)	=12/8	=14/1
8	blending, concentrate recycle (15, 17, no 4, 11, 18)	=7/2=7/(1+17)	=12/8=(14-15)/(7-15)	=14/1
9	blending, concentrate & array recycle (4, 11, 15, 17, 18)	=7/2=7/(1+17)	=12/8=(14-15)/(7-15)	=14/1
10	Blending, concentrate & array recycle, Split (4, 11, 15, 17, 18)	=(7+18)/2=(7+18)/(1+17)	=12/8=(14-15-18)/(7-15)	=14/1

CSMPRO, NOW…

2011, CSMPRO4.1

- ◆ Correct Aver. Perm. Flux calculation
- ◆ pH adjustment bug was fixed
- ◆ Correct definition of recovery

2012, CSMPRO5.0 is coming soon!

- ◆ Apply correction equation depending on feed water concentration
- ◆ Increase prediction accuracy of perm. TDS & Feed pressure
- ◆ Remove some bugs

Thank You!

WOONGJIN CHEMICAL CO.,LTD

www.csmfilter.com