

付属資料 7.1.1-3

ROプラントの性能シュミレーション結果 (1)



資料 No 1

Standard RO : 8040-HSY-SWC1 PERFORMANCE

Rej = 99.5% Flux 5000gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)

12-16-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 25.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2,ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 67.4 kg/cm2

Concentrate pressure : 66.6 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	6.4	625.5	3.9	1.04	66.6	8040-HSY-SWC1	972 162x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.3	0.1	790.8	39.4
Mg	1555.0	128.0	1555.0	128.0	4.4	0.4	2588.7	213.1
Na	13284.0	577.6	13284.0	577.6	180.1	7.8	22019.9	957.4
K	493.0	12.6	493.0	12.6	8.3	0.2	816.1	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	2.7	0.0	202.4	3.3
SO4	3675.0	76.6	3694.5	77.0	11.4	0.2	6149.9	128.1
Cl	23500.0	662.9	23500.0	662.9	290.4	8.2	38973.1	1099.4
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		498.7		71541.9	
pH	8.0		7.0		5.4		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	27.4	27.5	51.0
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.7
Langelier ind.	1.11	0.03	0.68
Stiff & Davis ind.	0.12	-0.96	-0.35
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	477.7	477.7	816.5

資料 No 2

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 25.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.3 kg/cm2

Concentrate pressure : 61.7 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.04	61.7	8040-HSY-SWC1 1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.7	0.1	790.5	39.4
Hg	1555.0	128.0	1555.0	128.0	5.5	0.5	2588.0	213.0
Na	13284.0	577.6	13284.0	577.6	225.3	9.8	21989.8	956.1
K	493.0	12.6	493.0	12.6	10.4	0.3	814.7	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.4	0.1	202.0	3.3
SO4	3675.0	76.6	3694.5	77.0	14.3	0.3	6148.0	128.1
Cl	23500.0	662.9	23500.0	662.9	363.3	10.2	38924.5	1098.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		624.0		71458.4	
pH	8.0		7.0		5.4		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	27.4	27.5	51.0
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.7
Langelier ind.	1.11	0.03	0.68
Stiff & Davis ind.	0.12	-0.96	-0.35
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	477.7	477.7	815.4

資料 No 3

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow :      10000 H3-D

Feedwater temperature :      25.0 C      Recovery :      40.0%  
 Raw water pH :      8.00      Element age :      0.0 years  
 Acid dosage, ppm(100%):      19.9 H2SO4      Flux decline coefficient :      -0.035  
 Acidified feed CO2, ppm :      19.9      3-yr salt passage increase factor : 1.3

Feed pressure : 60.0 kg/cm2

Concentrate pressure : 59.6 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	4.1	625.5	2.5	1.03	59.6	8040-HSY-SWC1	1524 254x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.2	0.1	790.2	39.4
Mg	1555.0	128.0	1555.0	128.0	7.1	0.6	2587.0	212.9
Na	13284.0	577.6	13284.0	577.6	288.1	12.5	21948.0	954.3
K	493.0	12.6	493.0	12.6	13.3	0.3	812.8	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	4.3	0.1	201.3	3.3
SO4	3675.0	76.6	3694.5	77.0	18.3	0.4	6145.3	128.0
Cl	23500.0	662.9	23500.0	662.9	464.5	13.1	38857.0	1096.1
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		797.8		71342.6	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	27.4	27.5	51.0
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.7
Langelier ind.	1.11	0.03	0.67
Stiff & Davis ind.	0.12	-0.96	-0.35
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	477.7	477.7	813.9

# 資料 No 4

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 30.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 76.2 kg/cm2

Concentrate pressure : 74.7 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	10.0	625.5	6.0	1.05	74.7	8040-HSY-SWC1	624 104x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.0	0.0	791.0	39.5
Mg	1555.0	128.0	1555.0	128.0	3.3	0.3	2589.5	213.1
Na	13284.0	577.6	13284.0	577.6	133.3	5.8	22051.1	958.7
K	493.0	12.6	493.0	12.6	6.2	0.2	817.5	21.0
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	2.0	0.0	202.9	3.3
SO4	3675.0	76.6	3694.5	77.0	8.5	0.2	6151.9	128.2
Cl	23500.0	662.9	23500.0	662.9	215.0	6.1	39023.4	1100.8
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		369.2		71628.2	
pH	8.0		7.0		5.2		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.6	26.8	49.6
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.6
Langelier ind.	1.22	0.14	0.79
Stiff & Davis ind.	0.20	-0.88	-0.26
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	485.8	485.7	831.3

資料 No 5

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 30.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 69.8 kg/cm2

Concentrate pressure : 68.6 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	8.0	625.5	4.8	1.04	68.6	8040-HSY-SWC1 780 130x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.2	0.1	790.8	39.4
Mg	1555.0	128.0	1555.0	128.0	4.1	0.3	2588.9	213.1
Na	13284.0	577.6	13284.0	577.6	166.9	7.3	22028.7	957.8
K	493.0	12.6	493.0	12.6	7.7	0.2	816.5	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	2.5	0.0	202.6	3.3
SO4	3675.0	76.6	3694.5	77.0	10.6	0.2	6150.4	128.1
Cl	23500.0	662.9	23500.0	662.9	269.1	7.6	38987.3	1099.8
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		462.1		71566.3	
pH	8.0		7.0		5.3		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.6	26.8	49.6
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.6
Langelier ind.	1.22	0.14	0.79
Stiff & Davis ind.	0.20	-0.88	-0.26
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	485.8	485.7	830.5

# 資料 No 6

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow :      10000 M3-D

Feedwater temperature :      30.0 C      Recovery :      40.0%  
 Raw water pH :      8.00      Element age :      0.0 years  
 Acid dosage, ppm(100%):      19.9 H2SO4      Flux decline coefficient :      -0.035  
 Acidified feed CO2, ppm :      19.9      3-yr salt passage increase factor : 1.3

Feed pressure : 65.5 kg/cm2

Concentrate pressure : 64.7 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	6.4	625.5	3.9	1.04	64.7	8040-HSY-SWC1	972 162x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.6	0.1	790.6	39.4
Mg	1555.0	128.0	1555.0	128.0	5.1	0.4	2588.2	213.0
Na	13284.0	577.6	13284.0	577.6	210.0	9.1	22000.0	956.5
K	493.0	12.6	493.0	12.6	9.7	0.2	815.2	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.2	0.1	202.1	3.3
SO4	3675.0	76.6	3694.5	77.0	13.3	0.3	6148.6	128.1
Cl	23500.0	662.9	23500.0	662.9	338.5	9.5	38941.0	1098.5
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		581.4		71486.8	
pH	8.0		7.0		5.4		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.6	26.8	49.6
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.6
Langelier ind.	1.22	0.14	0.79
Stiff & Davis ind.	0.20	-0.88	-0.27
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	485.8	485.7	829.5



# 資料 No 7

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow : 10000 M3-D  
 Feedwater temperature : 30.0 C      Recovery : 40.0%  
 Raw water pH : 8.00      Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4      Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9      3-yr salt passage increase factor : 1.3

Feed pressure : 61.9 kg/cm2      Concentrate pressure : 61.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.03	61.3	6040-HSY-SWC1	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.0	0.1	790.3	39.4
Mg	1555.0	128.0	1555.0	128.0	6.5	0.5	2587.3	212.9
Na	13284.0	577.6	13284.0	577.6	265.8	11.6	21962.8	934.9
K	493.0	12.6	493.0	12.6	12.3	0.3	813.5	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	4.0	0.1	201.6	3.3
SO4	3675.0	76.6	3694.5	77.0	16.9	0.4	6146.2	128.0
Cl	23500.0	662.9	23500.0	662.9	428.5	12.1	38881.0	1096.8
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		736.0		71383.7	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.5	26.6	49.6
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.6
Langelier ind.	1.22	0.14	0.78
Stiff & Davis ind.	0.20	-0.88	-0.27
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	485.8	485.7	828.1

# 資料 No 8

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow :      10000 M3-D

Feedwater temperature :      30.0 C      Recovery :      40.0%

Raw water pH :      8.00      Element age :      0.0 years

Acid dosage, ppm(100%):      19.9 H2SO4      Flux decline coefficient :      -0.035

Acidified feed CO2, ppm :      19.9      3-yr salt passage increase factor : 1.3

Feed pressure :      59.9 kg/cm2

Concentrate pressure :      59.5 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	4.1	625.5	2.5	1.03	59.5	8040-HSY-SWC1	1524    254x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.5	0.1	790.0	39.4
Mg	1555.0	128.0	1555.0	128.0	8.3	0.7	2586.1	212.8
Na	13284.0	577.6	13284.0	577.6	340.1	14.8	21913.3	952.8
K	493.0	12.6	493.0	12.6	15.8	0.4	811.2	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.1	0.1	200.8	3.3
SO4	3675.0	76.6	3694.5	77.0	21.6	0.5	6143.1	128.0
Cl	23500.0	662.9	23500.0	662.9	548.4	15.5	38801.1	1094.5
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		941.9		71246.5	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.6	26.8	49.6
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.4	0.4	0.6
Langelier ind.	1.22	0.14	0.78
Stiff & Davis ind.	0.20	-0.88	-0.27
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	485.8	485.7	826.3

# 資料 No 9

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 68.9 kg/cm2 Concentrate pressure : 67.8 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	8.0	625.5	4.8	1.04	67.8	8040-HSY-SWC1 780 130x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.5	0.1	790.7	39.4
Mg	1555.0	128.0	1555.0	128.0	4.8	0.4	2588.5	213.0
Na	13284.0	577.6	13284.0	577.6	195.8	8.5	22009.5	956.9
K	493.0	12.6	493.0	12.6	9.1	0.2	815.6	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.0	0.0	202.3	3.3
SO4	3675.0	76.6	3694.5	77.0	12.4	0.3	6149.2	128.1
Cl	23500.0	662.9	23500.0	662.9	315.7	8.9	38956.2	1098.9
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		542.2		71512.9	
pH	8.0		7.0		5.4		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.14
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	493.8	493.7	843.5

# 資料 No 10

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 63.8 kg/cm2

Concentrate pressure : 63.0 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	6.4	625.5	3.9	1.03	63.0	8040-HSY-SWC1 972 162x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.8	0.1	790.5	39.4
Mg	1555.0	128.0	1555.0	128.0	6.0	0.5	2587.7	213.0
Na	13284.0	577.6	13284.0	577.6	243.5	10.6	21977.7	955.6
K	493.0	12.6	493.0	12.6	11.3	0.3	814.1	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.7	0.1	201.8	3.3
SO4	3675.0	76.6	3694.5	77.0	15.5	0.3	6147.2	128.1
Cl	23500.0	662.9	23500.0	662.9	392.6	11.1	38905.0	1097.5
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		674.2		71424.9	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.14
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	493.8	493.7	842.3

# 資料 No 11

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow :      10000 M3-D  
 Feedwater temperature :      35.0 C      Recovery :      40.0%  
 Raw water pH :      8.00      Element age :      0.0 years  
 Acid dosage, ppm(100%):      19.9 H2SO4      Flux decline coefficient :      -0.035  
 Acidified feed CO2, ppm :      19.9      3-yr salt passage increase factor : 1.3

Feed pressure : 61.7 kg/cm2      Concentrate pressure : 61.1 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.03	61.1	8040-HSY-SWC1	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.3	0.1	790.1	39.4
Mg	1555.0	128.0	1555.0	128.0	7.6	0.6	2586.6	212.9
Na	13284.0	577.6	13284.0	577.6	312.1	13.6	21931.9	953.6
K	493.0	12.6	493.0	12.6	14.5	0.4	812.0	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	4.7	0.1	201.1	3.3
SO4	3675.0	76.6	3694.5	77.0	19.8	0.4	6144.3	128.0
Cl	23500.0	662.9	23500.0	662.9	503.2	14.2	38831.2	1095.4
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		864.3		71298.2	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	493.8	493.7	840.7

# 資料 No 12

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 58.9 kg/cm2

Concentrate pressure : 58.5 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	4.1	625.5	2.5	1.03	58.5	8040-HSY-SWC1	1524 254x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.9	0.1	789.7	39.4
Mg	1555.0	128.0	1555.0	128.0	9.7	0.8	2585.2	212.8
Na	13284.0	577.6	13284.0	577.6	393.9	17.1	21877.4	951.2
K	493.0	12.6	493.0	12.6	18.2	0.5	809.5	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.9	0.1	200.3	3.3
SO4	3675.0	76.6	3694.5	77.0	25.1	0.5	6140.8	127.9
Cl	23500.0	662.9	23500.0	662.9	635.1	17.9	38743.3	1092.9
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1090.8		71147.2	
pH	8.0		7.0		5.7		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	838.7

# 資料 No 13

HYDRANAUTICS DESIGN PROGRAM - VERSTON 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow :      10000 M3-D  
 Feedwater temperature :      40.0 C      Recovery :      40.0%  
 Raw water pH :      8.00      Element age :      0.0 years  
 Acid dosage, ppm(100%):      19.9 H2SO4      Flux decline coefficient :      -0.035  
 Acidified feed CO2, ppm :      19.9      3-yr salt passage increase factor : 1.3

Feed pressure : 65.9 kg/cm2      Concentrate pressure : 64.8 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	8.0	625.5	4.8	1.04	64.8	8040-HSY-SWC1	780 130x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.7	0.1	790.6	39.4
Mg	1555.0	128.0	1555.0	128.0	5.5	0.4	2588.0	213.0
Na	13284.0	577.6	13284.0	577.6	223.3	9.7	21991.2	956.1
K	493.0	12.6	493.0	12.6	10.3	0.3	814.8	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.4	0.1	202.0	3.3
SO4	3675.0	76.6	3694.5	77.0	14.2	0.3	6148.0	128.1
Cl	23500.0	662.9	23500.0	662.9	360.0	10.2	38926.7	1098.1
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		618.3		71462.2	
pH	8.0		7.0		5.4		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	25.5	25.6	47.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.44	0.36	1.00
Stiff & Davis ind.	0.43	-0.65	-0.02
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	501.8	501.7	856.5

# 資料 No 14

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow :      10000 M3-D

Feedwater temperature :      40.0 C      Recovery :      40.0%

Raw water pH :      8.00      Element age :      0.0 years

Acid dosage, ppm(100%):      19.9 H2SO4      Flux decline coefficient :      -0.035

Acidified feed CO2, ppm :      19.9      3-yr salt passage increase factor : 1.3

Feed pressure : 63.6 kg/cm2

Concentrate pressure : 62.8 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	625.5	1.03	62.8	8040-HSY-SWC1	972	162x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.1	0.1	790.2	39.4
Mg	1555.0	128.0	1555.0	128.0	7.0	0.6	2587.0	212.9
Na	13284.0	577.6	13284.0	577.6	284.4	12.4	21950.4	934.4
K	493.0	12.6	493.0	12.6	13.2	0.3	812.9	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	4.3	0.1	201.4	3.3
SO4	3675.0	76.6	3694.5	77.0	18.1	0.4	6145.4	128.0
Cl	23500.0	662.9	23500.0	662.9	458.5	12.9	38861.0	1096.2
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		787.6		71349.3	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	25.5	25.6	47.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.44	0.36	1.00
Stiff & Davis ind.	0.43	-0.65	-0.02
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	501.8	501.7	855.0



# 資料 No 15

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow :      10000 M3-D  
 Feedwater temperature :      40.0 C      Recovery :      40.0%  
 Raw water pH :      8.00      Element age :      0.0 years  
 Acid dosage, ppm(100%):      19.9 H2SO4      Flux decline coefficient :      -0.035  
 Acidified feed CO2,ppm :      19.9      3-yr salt passage increase factor : 1.3

Feed pressure : 60.5 kg/cm2      Concentrate pressure : 60.0 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.03	60.0	8040-HSY-SWC1	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.7	0.1	789.9	39.4
Mg	1555.0	128.0	1555.0	128.0	8.8	0.7	2585.8	212.8
Na	13284.0	577.6	13284.0	577.6	359.6	15.6	21900.3	952.2
K	493.0	12.6	493.0	12.6	16.7	0.4	810.6	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.4	0.1	200.6	3.3
SO4	3675.0	76.6	3694.5	77.0	22.9	0.5	6142.2	128.0
Cl	23500.0	662.9	23500.0	662.9	579.8	16.4	38780.1	1093.9
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		995.9		71210.5	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	25.5	25.6	47.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.44	0.36	1.00
Stiff & Davis ind.	0.43	-0.65	-0.02
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	501.8	501.7	853.1

# 資料 No 16

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow :      10000 M3-D

Feedwater temperature :      40.0 C      Recovery :      40.0%  
 Raw water pH :      8.00      Element age :      0.0 years  
 Acid dosage, ppm(100%):      19.9 H2SO4      Flux decline coefficient :      -0.035  
 Acidified feed CO2, ppm :      19.9      3-yr salt passage increase factor : 1.3

Feed pressure : 59.1 kg/cm2

Concentrate pressure : 58.7 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	4.1	625.5	2.5	1.02	58.7	8040-HSY-SWC1	1524 254x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	3.5	0.2	789.4	39.4
Mg	1555.0	128.0	1555.0	128.0	11.3	0.9	2584.1	212.7
Na	13284.0	577.6	13284.0	577.6	460.6	20.0	21833.0	949.3
K	493.0	12.6	493.0	12.6	21.3	0.5	807.4	20.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	6.9	0.1	199.6	3.3
SO4	3675.0	76.6	3694.5	77.0	29.3	0.6	6137.9	127.9
Cl	23500.0	662.9	23500.0	662.9	742.6	20.9	38671.6	1090.9
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1275.5		71024.0	
pH	8.0		7.0		5.8		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	25.5	25.6	47.6
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.44	0.36	0.99
Stiff & Davis ind.	0.43	-0.65	-0.03
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	501.8	501.7	850.6

# 資料 No 17

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow :      10000 M3-D  
 Feedwater temperature :      45.0 C      Recovery :      40.0%  
 Raw water pH :      8.00      Element age :      0.0 years  
 Acid dosage, ppm(100%):      19.9 H2SO4      Flux decline coefficient :      -0.035  
 Acidified feed CO2,ppm :      19.9      3-yr salt passage increase factor :1.3

Feed pressure : 65.6 kg/cm2      Concentrate pressure : 64.5 kg/cm2

Pass	Feed Flow Total Vessel m3/h    m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5    8.0	625.5	4.8	1.03	64.5	8040-HSY-SWC1	780	130x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.9	0.1	790.4	39.4
Mg	1555.0	128.0	1555.0	128.0	6.4	0.5	2587.4	213.0
Na	13284.0	577.6	13284.0	577.6	259.5	11.3	21967.0	955.1
K	493.0	12.6	493.0	12.6	12.0	0.3	813.7	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.9	0.1	201.6	3.3
SO4	3675.0	76.6	3694.5	77.0	16.5	0.3	6146.5	128.1
Cl	23500.0	662.9	23500.0	662.9	418.4	11.8	38887.8	1097.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		718.6		71395.4	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	25.0	25.2	46.7
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.55	0.47	1.11
Stiff & Davis ind.	0.55	-0.53	0.11
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	509.8	509.7	869.3

# 資料 No 18

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow :      10000 M3-D

Feedwater temperature :      45.0 C      Recovery :      40.0%  
 Raw water pH :      8.00      Element age :      0.0 years  
 Acid dosage, ppm(100%):      19.9 H2SO4      Flux decline coefficient :      -0.035  
 Acidified feed CO2, ppm :      19.9      3-yr salt passage increase factor : 1.3

Feed pressure :      63.6 kg/cm2      Concentrate pressure :      62.8 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	6.4	625.5	3.9	1.03	62.8	8040-HSY-SWC1	972 162x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.5	0.1	790.0	39.4
Mg	1555.0	128.0	1555.0	128.0	8.1	0.7	2586.3	212.9
Na	13284.0	577.6	13284.0	577.6	330.8	14.4	21919.5	953.0
K	493.0	12.6	493.0	12.6	15.3	0.4	811.5	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.0	0.1	200.9	3.3
SO4	3675.0	76.6	3694.5	77.0	21.0	0.4	6143.5	128.0
Cl	23500.0	662.9	23500.0	662.9	533.4	15.0	38811.1	1094.8
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		916.1		71263.6	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	25.0	25.2	46.7
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.55	0.47	1.10
Stiff & Davis ind.	0.55	-0.53	0.10
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	509.8	509.7	867.5

資料 No 19

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-16-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow : 10000 M3-D  
 Feedwater temperature : 45.0 C      Recovery : 40.0%  
 Raw water pH : 8.00      Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4      Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9      3-yr salt passage increase factor : 1.3

Feed pressure : 60.7 kg/cm2      Concentrate pressure : 60.2 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.03	60.2	8040-HSY-SWC1	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	3.1	0.2	789.6	39.4
Mg	1555.0	128.0	1555.0	128.0	10.3	0.8	2584.8	212.7
Na	13284.0	577.6	13284.0	577.6	418.3	18.2	21861.1	950.5
K	493.0	12.6	493.0	12.6	19.4	0.5	808.8	20.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	6.3	0.1	200.0	3.3
SO4	3675.0	76.6	3694.5	77.0	26.6	0.6	6139.7	127.9
Cl	23500.0	662.9	23500.0	662.9	674.5	19.0	38717.0	1092.2
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1158.6		71102.0	
pH	8.0		7.0		5.7		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	25.0	25.2	46.7
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.55	0.47	1.10
Stiff & Davis ind.	0.55	-0.53	0.10
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	509.8	509.7	865.3

# 資料 No 20

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL =1      Permeate flow :      10000 M3-D

Feedwater temperature :      35.0 C      Recovery :      30.0%  
 Raw water pH :      8.00      Element age :      0.0 years  
 Acid dosage, ppm(100%):      19.9 H2SO4      Flux decline coefficient :      -0.035  
 Acidified feed CO2,ppm :      19.9      3-yr salt passage increase factor :1.3

Feed pressure : 55.4 kg/cm2

Concentrate pressure : 54.4 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array		
1	1389.9	6.8	973.0	4.8	1.03	54.4	8040-HSY-SWC1	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.1	0.1	677.7	33.8
Mg	1555.0	128.0	1555.0	128.0	6.8	0.6	2218.5	182.6
Na	13284.0	577.6	13284.0	577.6	276.1	12.0	18858.8	819.9
K	493.0	12.6	493.0	12.6	12.8	0.3	698.8	17.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.1	0.0
HCO3	146.4	2.4	122.5	2.0	4.2	0.1	173.3	2.8
SO4	3675.0	76.6	3694.5	77.0	17.5	0.4	5270.3	109.8
Cl	23500.0	662.9	23500.0	662.9	445.1	12.6	33380.7	941.6
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.7	
TDS	43129.4		43124.6		764.4		61279.0	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	40.3
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.5
Langelier ind.	1.33	0.25	0.70
Stiff & Davis ind.	0.31	-0.77	-0.34
Ionic strength	0.89	0.89	1.30
Osmotic press.,psi	493.8	493.7	714.9

資料 No. 21

HYDRAUNAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1      Permeate flow :      10000 M3-D  
 Feedwater temperature :      35.0 C      Recovery :      35.0%  
 Raw water pH :      8.00      Element age :      0.0 years  
 Acid dosage, ppm(100%):      19.9 H2SO4      Flux decline coefficient :      -0.035  
 Acidified feed CO2, ppm :      19.9      3-yr salt passage increase factor : 1.3

Feed pressure : 58.3 kg/cm2      Concentrate pressure : 57.6 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1191.4	5.9	774.4	3.8	1.03	57.6	8040-HSY-SWC1	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.2	0.1	729.6	36.4
Mg	1555.0	128.0	1555.0	128.0	7.1	0.6	2388.5	196.6
Na	13284.0	577.6	13284.0	577.6	290.8	12.6	20280.3	881.8
K	493.0	12.6	493.0	12.6	13.5	0.3	751.2	19.3
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.1	0.0
HCO3	146.4	2.4	122.5	2.0	4.4	0.1	186.2	3.1
SO4	3675.0	76.6	3694.5	77.0	18.5	0.4	5673.9	118.2
Cl	23500.0	662.9	23500.0	662.9	468.8	13.2	35901.4	1012.7
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		805.3		65912.0	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100, %	26.0	26.2	44.1
SrSO4/Ksp*100, %	0.0	0.0	0.0
BaSO4/Ksp*100, %	0.0	0.0	0.0
SiO2 sat., %	0.3	0.3	0.5
Langelier ind.	1.33	0.25	0.79
Stiff & Davis ind.	0.31	-0.77	-0.25
Ionic strength	0.89	0.89	1.40
Osmotic press., psi	493.8	493.7	772.7

# 資料 No 22

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.50 (1993)  
 Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 45.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 65.6 kg/cm2

Concentrate pressure : 65.1 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	926.6	4.6	509.6	2.5	1.03	65.1	8040-HSY-SWC1	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.5	0.1	861.6	43.0
Mg	1555.0	128.0	1555.0	128.0	8.2	0.7	2820.6	232.1
Na	13284.0	577.6	13284.0	577.6	335.0	14.6	23878.7	1038.2
K	493.0	12.6	493.0	12.6	15.5	0.4	883.7	22.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.0	0.1	218.7	3.6
SO4	3675.0	76.6	3694.5	77.0	21.3	0.4	6699.8	139.6
Cl	23500.0	662.9	23500.0	662.9	540.1	15.2	42285.4	1192.8
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.9	
TDS	43129.4		43124.6		927.7		77649.4	
pH	8.0		7.0		5.6		7.3	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100, %	26.0	26.2	53.8
SrSO4/Ksp=100, %	0.0	0.0	0.0
BaSO4/Ksp=100, %	0.0	0.0	0.0
SiO2 sat., %	0.3	0.3	0.6
Langelier ind.	1.33	0.25	1.00
Stiff & Davis ind.	0.31	-0.77	-0.04
Ionic strength	0.89	0.89	1.67
Osmotic press., psi	493.8	493.7	921.8



資料 No. 23

IDEAL RO PERFORMANCE specification

Rejection = 99.75% Flux 5000 gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
Raw water pH : 8.00 Element age : 0.0 years  
Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2 Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5 5.1	625.5	3.1	1.02	62.3	SEAWATER RO#8S	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.2	0.1	790.9	39.4
Mg	1555.0	128.0	1555.0	128.0	3.9	0.3	2589.1	213.1
Na	13284.0	577.6	13284.0	577.6	159.5	6.9	22033.7	958.0
K	493.0	12.6	493.0	12.6	7.4	0.2	816.7	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	2.4	0.0	202.6	3.3
SO4	3675.0	76.6	3694.5	77.0	10.1	0.2	6150.7	128.1
Cl	23500.0	662.9	23500.0	662.9	257.1	7.3	38995.3	100.0
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		441.6		71580.0	
pH	8.0		7.0		5.3		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.90
Stiff & Davis ind.	0.31	-0.77	-0.14
Tonic strength	0.89	0.89	1.53
Osmotic press.,psi	493.8	493.7	844.4

資料 No. 24

IDEAL RO PERFORMANCE SPECIFICATION

Rejection = 99.60% Flux 5000 gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
Raw water pH : 8.00 Element age : 0.0 years  
Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2

Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3	SEAWATER RO#9S 1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.9	0.1	790.4	39.4
Mg	1555.0	128.0	1555.0	128.0	6.2	0.5	2587.5	213.0
Na	13284.0	577.6	13284.0	577.6	254.9	11.1	21970.0	955.2
K	493.0	12.6	493.0	12.6	11.8	0.3	813.8	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.8	0.1	201.7	3.3
SO4	3675.0	76.6	3694.5	77.0	16.2	0.3	6146.7	128.1
Cl	23500.0	662.9	23500.0	662.9	411.0	11.6	38892.6	1097.1
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		706.0		71403.7	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.14
Ionic strength	0.89	0.89	1.53
Osmotic press.,psi	493.8	493.7	842.1

資料 No. 25

IDEAL RO PERFORMANCE SPECIFICATION

Rejection = 99.50% Flux 5000 gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
Raw water pH : 8.00 Element age : 0.0 years  
Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2

Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3	SEAWATER RO#05	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.4	0.1	790.1	39.4
Mg	1555.0	128.0	1555.0	128.0	7.8	0.6	2586.5	212.9
Na	13284.0	577.6	13284.0	577.6	318.5	13.8	21927.7	933.4
K	493.0	12.6	493.0	12.6	14.8	0.4	811.8	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	4.8	0.1	201.0	3.3
SO4	3675.0	76.6	3694.5	77.0	20.3	0.4	6144.0	128.0
Cl	23500.0	662.9	23500.0	662.9	513.5	14.5	38824.3	1095.2
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		882.0		71286.4	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat., %	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.53
Osmotic press., psi	493.8	493.7	840.5

資料 No. 26

IDEAL RO PERFORMANCE SPECIFICATION  
 Rejection = 99.45% Flux 5000 gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
 Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2

Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3	SEAWATER RO#1S 1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.6	0.1	789.9	39.4
Mg	1555.0	128.0	1555.0	128.0	8.6	0.7	2585.9	212.8
Na	13284.0	577.6	13284.0	577.6	350.2	15.2	21906.5	952.5
K	493.0	12.6	493.0	12.6	16.2	0.4	810.9	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.3	0.1	200.7	3.3
SO4	3675.0	76.6	3694.5	77.0	22.3	0.5	6142.6	128.0
Cl	23500.0	662.9	23500.0	662.9	564.7	15.9	38790.2	1094.2
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		969.9		71227.8	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100.%	26.0	26.2	48.5
SrSO4/Ksp=100.%	0.0	0.0	0.0
BaSO4/Ksp=100.%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press., psi	493.8	493.7	839.7

資料 No 27

IDEAL RO PERFORMANCE SPECIFICATION  
 Rejection = 99.40% Flux 5000 gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
 Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2

Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3 SEAWATER RO#2S	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.9	0.1	789.8	39.4
Mg	1555.0	128.0	1555.0	128.0	9.4	0.8	2585.4	212.8
Na	13284.0	577.6	13284.0	577.6	382.0	16.6	21885.4	951.5
K	493.0	12.6	493.0	12.6	17.7	0.5	809.9	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.8	0.1	200.4	3.3
SO4	3675.0	76.6	3694.5	77.0	24.3	0.5	6141.3	127.9
Cl	23500.0	662.9	23500.0	662.9	615.9	17.4	38756.1	1093.3
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1057.8		71169.2	
pH	8.0		7.0		5.7		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	838.9

資料 No 28

IDEAL RO PERFORMANCE SPECIFICATION  
Rejection = 99.35% Flux 5000 gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
Raw water pH : 8.00 Element age : 0.0 years  
Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2

Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3 SEAWATER RO#4S	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	3.1	0.2	789.6	39.4
Mg	1555.0	128.0	1555.0	128.0	10.1	0.8	2584.9	212.7
Na	13284.0	577.6	13284.0	577.6	413.7	18.0	21864.2	950.6
K	493.0	12.6	493.0	12.6	19.2	0.5	808.9	20.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	6.2	0.1	200.1	3.3
SO4	3675.0	76.6	3694.5	77.0	26.3	0.5	6139.9	127.9
Cl	23500.0	662.9	23500.0	662.9	667.0	18.8	38722.0	1092.3
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1145.7		71110.6	
pH	8.0		7.0		5.7		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.88
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	838.2

資料 No. 29

IDEAL RO PERFORMANCE SPECIFICATION  
 Rejection = 99.30% Flux 5000 gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
 Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2

Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3 SEAWATER RO#3S	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	3.3	0.2	789.4	39.4
Mg	1555.0	128.0	1555.0	128.0	10.9	0.9	2584.4	212.7
Na	13284.0	577.6	13284.0	577.6	445.4	19.4	21843.1	949.7
K	493.0	12.6	493.0	12.6	20.6	0.5	807.9	20.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	6.7	0.1	199.8	3.3
SO4	3675.0	76.6	3694.5	77.0	28.4	0.6	6138.6	127.9
Cl	23500.0	662.9	23500.0	662.9	718.2	20.3	38687.9	1091.3
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1233.5		71052.0	
pH	8.0		7.0		5.7		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100.%	26.0	26.2	48.5
SrSO4/Ksp=100.%	0.0	0.0	0.0
RaSO4/Ksp=100.%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.88
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press., psi	493.8	493.7	837.4

資料 No 30

IDEAL RO PERFORMANCE SPECIFICATION  
 Rejection = 99.25% Flux 5000 gpc

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
 Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2

Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h m3/h	Conc. Flow Total Vessel m3/h m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5 5.1	625.5 3.1	1.02	62.3	SEAWATER RO#5S	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	3.6	0.2	789.3	39.4
Mg	1555.0	128.0	1555.0	128.0	11.7	1.0	2583.9	212.7
Na	13284.0	577.6	13284.0	577.6	477.1	20.7	21822.0	948.8
K	493.0	12.6	493.0	12.6	22.1	0.6	806.9	20.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	7.2	0.1	199.5	3.3
SO4	3675.0	76.6	3694.5	77.0	30.4	0.6	6137.2	127.9
Cl	23500.0	662.9	23500.0	662.9	769.3	21.7	38653.8	1090.4
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1321.3		70993.5	
pH	8.0		7.0		5.8		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.88
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press., psi	493.8	493.7	836.6



資料 No 31

IDEAL RO PERFORMANCE SPECIFICATION  
Rejection = 99.20% Flux 5000 gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)

12-17-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2

Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3 SEAWATER RO#6S	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	3.8	0.2	789.1	39.4
Mg	1555.0	128.0	1555.0	128.0	12.5	1.0	2583.3	212.6
Na	13284.0	577.6	13284.0	577.6	508.7	22.1	21800.8	947.9
K	493.0	12.6	493.0	12.6	23.5	0.6	806.0	20.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	7.7	0.1	199.1	3.3
SO4	3675.0	76.6	3694.5	77.0	32.4	0.7	6135.9	127.8
Cl	23500.0	662.9	23500.0	662.9	820.3	23.1	38619.8	1089.4
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1409.0		70935.0	
pH	8.0		7.0		5.8		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.88
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	835.8

資料 No 32

IDEAL RO PERFORMANCE SPECIFICATION  
Rejection = 99.00% Flux 5000gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
Calculation was made by: J I C A

12-17-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
Raw water pH : 8.00 Element age : 0.0 years  
Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.8 kg/cm2 Concentrate pressure : 62.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	62.3	SEAWATER RO#7S	1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	4.8	0.2	788.5	39.3
Mg	1555.0	128.0	1555.0	128.0	15.6	1.3	2581.2	212.4
Na	13284.0	577.6	13284.0	577.6	635.2	27.6	21716.5	944.2
K	493.0	12.6	493.0	12.6	29.4	0.8	802.1	20.6
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.1	0.0
HCO3	146.4	2.4	122.5	2.0	9.5	0.2	197.9	3.2
SO4	3675.0	76.6	3694.5	77.0	40.5	0.8	6130.5	127.7
Cl	23500.0	662.9	23500.0	662.9	1024.3	28.9	38483.8	1085.6
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1759.4		70701.4	
pH	8.0		7.0		5.9		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.6
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.87
Stiff & Davis ind.	0.31	-0.77	-0.16
Ionic strength	0.89	0.89	1.51
Osmotic press.,psi	493.8	493.7	832.7

付属資料 7.1.1-4

ROプラントの性能シュミレーション結果 (2)



資料 No. 33

IDEAL RO PERFORMANCE SPECIFICATION  
Rejection = 99.50% Flux 4000 gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)

01-07-93

Calculation was made by: J I C A

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
Raw water pH : 8.00 Element age : 0.0 years  
Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 65.1 kg/cm2

Concentrate pressure : 64.5 kg/cm2

Pass	Feed Flow Total Vessel m3/h m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5 5.1	625.5	3.1	1.03	64.5	SEAWATER RO12S	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	1.9	0.1	790.4	39.4
Mg	1555.0	128.0	1555.0	128.0	6.1	0.5	2587.6	213.0
Na	13284.0	577.6	13284.0	577.6	251.0	10.9	21972.7	955.3
K	493.0	12.6	493.0	12.6	11.6	0.3	813.9	20.9
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	3.8	0.1	201.7	3.3
SO4	3675.0	76.6	3694.5	77.0	15.9	0.3	6146.9	128.1
Cl	23500.0	662.9	23500.0	662.9	404.6	11.4	38896.9	1097.2
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		695.0		71411.1	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100, %	26.0	26.2	48.5
SrSO4/Ksp*100, %	0.0	0.0	0.0
BaSO4/Ksp*100, %	0.0	0.0	0.0
SiO2 sat., %	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.14
ionic strength	0.89	0.89	1.53
osmotic press., psi	493.8	493.7	842.2

資料 No. 34

IDEAL RO PERFORMANCE SPECIFICATION  
Rejection = 99.50% Flux 4500gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
Calculation was made by: J I C A

01-07-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D  
Feedwater temperature : 35.0 C Recovery : 40.0%  
Raw water pH : 8.00 Element age : 0.0 years  
Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 63.6 kg/cm2 Concentrate pressure : 63.3 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.03	63.3	SEAWATER RO10S 1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.1	0.1	790.2	39.4
Mg	1555.0	128.0	1555.0	128.0	7.0	0.6	2587.0	212.9
Na	13284.0	577.6	13284.0	577.6	284.6	12.4	21950.2	954.4
K	493.0	12.6	493.0	12.6	13.2	0.3	812.9	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	4.3	0.1	201.4	3.3
SO4	3675.0	76.6	3694.5	77.0	18.1	0.4	6145.4	128.0
Cl	23500.0	662.9	23500.0	662.9	458.9	12.9	38860.7	1096.2
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		788.3		71348.9	
pH	8.0		7.0		5.5		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.14
Ionic strength	0.89	0.89	1.53
Osmotic press., psi	493.8	493.7	841.3

資料 No 35

IDEAL RO PERFORMANCE SPECIFICATION  
 Rejection = 99.50% Flux 5500gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
 Calculation was made by: J I C A

01-07-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D

Feedwater temperature : 35.0 C Recovery : 40.0%  
 Raw water pH : 8.00 Element age : 0.0 years  
 Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
 Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 62.0 kg/cm2 Concentrate pressure : 61.4 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	61.4	SEAWATERRO #9S 1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.6	0.1	789.9	39.4
Mg	1555.0	128.0	1555.0	128.0	8.6	0.7	2585.9	212.8
Na	13284.0	577.6	13284.0	577.6	352.4	15.3	21905.0	952.4
K	493.0	12.6	493.0	12.6	16.3	0.4	810.8	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.3	0.1	200.7	3.3
SO4	3675.0	76.6	3694.5	77.0	22.4	0.5	6142.6	128.0
Cl	23500.0	662.9	23500.0	662.9	568.3	16.0	38787.8	1094.2
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		976.0		71223.7	
pH	8.0		7.0		5.6		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	26.0	26.2	48.5
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	839.7

資料 No. 36

Rejection = 99.50% Flux 6000 gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
Calculation was made by: J I C A

01-07-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D  
Feedwater temperature : 35.0 C Recovery : 40.0%  
Raw water pH : 8.00 Element age : 0.0 years  
Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 61.3 kg/cm2

Concentrate pressure : 60.7 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Conc. Flow Total Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.02	60.7	SEAWATERRO #8S 1218 203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	2.9	0.1	789.7	39.4
Mg	1555.0	128.0	1555.0	128.0	9.5	0.8	2585.4	212.8
Na	13284.0	577.6	13284.0	577.6	386.5	16.8	21882.4	951.4
K	493.0	12.6	493.0	12.6	17.9	0.5	809.7	20.8
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	5.8	0.1	200.4	3.3
SO4	3675.0	76.6	3694.5	77.0	24.6	0.5	6141.1	127.9
Cl	23500.0	662.9	23500.0	662.9	623.1	17.6	38751.2	1093.1
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1070.3		71160.9	
pH	8.0		7.0		5.7		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.89
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	838.8



資料 No. 37

Rejection = 99.50% Flux 6500gpd

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990)  
Calculation was made by: J I C A

01-07-93

Project name : SAUDI ARABIAN SEAWATER MODEL #1 Permeate flow : 10000 M3-D  
Feedwater temperature : 35.0 C Recovery : 40.0%  
Raw water pH : 8.00 Element age : 0.0 years  
Acid dosage, ppm(100%): 19.9 H2SO4 Flux decline coefficient : -0.035  
Acidified feed CO2, ppm : 19.9 3-yr salt passage increase factor : 1.3

Feed pressure : 60.7 kg/cm2 Concentrate pressure : 60.1 kg/cm2

Pass	Feed Flow Total Vessel m3/h	Flow Vessel m3/h	Conc. Total m3/h	Flow Vessel m3/h	Beta	Conc. Press. kg/cm2	Element Type	Element No.	Array
1	1042.5	5.1	625.5	3.1	1.01	60.1	SEAWATER R011S	1218	203x6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	475.0	23.7	475.0	23.7	3.2	0.2	789.6	39.4
Mg	1555.0	128.0	1555.0	128.0	10.3	0.8	2584.8	212.7
Na	13284.0	577.6	13284.0	577.6	420.6	18.3	21859.6	950.4
K	493.0	12.6	493.0	12.6	19.5	0.5	808.7	20.7
NH4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ba	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CO3	0.5	0.0	0.1	0.0	0.0	0.0	0.2	0.0
HCO3	146.4	2.4	122.5	2.0	6.3	0.1	200.0	3.3
SO4	3675.0	76.6	3694.5	77.0	26.8	0.6	6139.6	127.9
Cl	23500.0	662.9	23500.0	662.9	678.1	19.1	38714.6	1092.1
F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
NO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SiO2	0.5		0.5		0.0		0.8	
TDS	43129.4		43124.6		1164.7		71097.9	
pH	8.0		7.0		5.7		7.2	

Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp=100,%	26.0	26.2	48.5
SrSO4/Ksp=100,%	0.0	0.0	0.0
BaSO4/Ksp=100,%	0.0	0.0	0.0
SiO2 sat.,%	0.3	0.3	0.6
Langelier ind.	1.33	0.25	0.88
Stiff & Davis ind.	0.31	-0.77	-0.15
Ionic strength	0.89	0.89	1.52
Osmotic press.,psi	493.8	493.7	838.0



付属資料 7.1.2-1

## 汚染膜の分析方法の指導



KINGDOM OF SAUDI ARABIA  
SALINE WATER CONVERSION CORPORATION  
AL-JUBAIL PLANT

المملكة العربية السعودية  
المؤسسة العامة لتحلية المياه المالحة  
مركز تطوير الأبحاث والتدريب



الرقم  
التاريخ  
المشروعات

January 17, 1994

To : Mr. Kitagawa/JICA Team, Al Jubail  
From : Abdulrahman Abanmy/Manager RDC (A)

**Sub : Lecture on Analysis of Fouled Membranes by Prof. Taniguchi**

SWCC R&D welcomes the idea and will be happy to arrange for the lecture at RDC, Al-Jubail. Emphasis is to be on sample preparation and analytical procedure. Also, SWCC would like Prof. Taniguchi to participate in autopsy and analysis of fouled membrane to be performed at the RDC, Al-Jubail. Samples of fouled membranes will be provided by SWCC.

Advanced instruments necessary for fouled membrane autopsy and necessary tests to be performed are outlined in Appendix-1. All instruments are now available at the RDC.

For your information, SWCC R&D has been working on this subject for the last three years. Topic has been discussed in detail at the Center as well as with various SWCC staff engaged in SWRO work. Consultation & assistance has been provided by RDC to other Saudi Organization engaged in RO work. Moreover, several SWCC staff have participated in the autopsy and analysis of fouled membranes in U.S.A. and Japan.

Looking forward to Prof. Taniguchi presentation.

Regards,

(Abdulrahman Abanmy)  
Manager RDC (A)

## **APPENDIX 1**

### **TESTING AND AUTOPSY OF FOULED MEMBRANES**

To establish the reasons for the decline in the performance of fouled membranes, spiral wound or hollow fine fiber the following analytical and autopsy tests are to be performed by our laboratory on fouled membranes obtained from RO plants:

#### **A. Samples and Sample Selection**

Membrane elements are to be selected from the:

- Worst performing membranes, and
- Best performing membranes.

In addition, new membranes elements will be included, in this test.

For the case of the worst performing membranes two elements are to be selected from the first inlet and the last outlet elements in the vessel. Selection of the best performing membranes are to be taken again, from the first and last outlet elements in the vessel.

#### **B. Performance Evaluation of Fouled Membranes**

Performance evaluation measuring product water

- Flow rate and
- Salt rejection (or product conductivity)

for the above samples are to be determined under standard conditions.

(The performance of the used (fouled) elements is to be compared to that of the new elements and also to their expected performance versus their time in operation).

### C. General Appearance of Disassembled RO Elements (Autopsy Test)

In this case color of the membranes and deposit collected on them are to be examined, photographed and recorded. Also, the element is to be examined for biological fouling, slime, smell, rupture, etc.

### D. Determination of Structure and Composition of Deposits

Deposits on the membrane are to be collected and analysed using Inductively Coupled Plasma (ICP), or Atomic Absorption (AA) for the following elements: Fe, Ni, Cr, Mo, Cu, Mn, Ca, Mg, Al, Zn, Co, etc.

(This test is designed to identify the composition of foulant materials collected from the membrane surface. Note both ICP and AA are available at SWCC R&D laboratory).

### E. Membrane Surface Analysis

For this type of analysis several analytical techniques can be used

#### 1. Scanning Electron Microscope (SEM)

This technique shows magnified view of deposits on membrane or deposits removed from the membrane. Based on the morphology of the material the SEM<sup>\*</sup> technique can differentiate between inorganic, organic and biological matter. Inorganic matter can be identified by X-ray microanalyzer (XMA)<sup>\*</sup>, an accessory attachment to SEM, while the organic matter can be identified by Fourier

\* AVAILABLE AT OUR LAB

<sup>\*</sup>  
Transform Infrared spectroscopy (FT-IR). (FT-IR) Membrane surface properties and the composition of inorganic matter can be examined also by the use of Electron Spectroscopy for Chemical Analysis (ESCA).

## 2. Alternative Method for Identification of Inorganic Elements

### Energy Dispersive X-Ray Spectroscopy (EDS)

Method allows for the identification of elements present on membrane and in deposits removed from membrane or other parts of it. It gives semi-quantitative results of the major, minor and traces of these elements.

<sup>\*</sup>  
The X-Ray Diffraction is used to identify crystalline patterns of inorganic compounds found in the deposit, e.g., scale and corrosion products, while X-Ray Fluorescence Analysis can be used to identify their (inorganic material) structure.

## 3. Structure Identification of Organic Matter By Fourier Transform Infra Red (FT-IR)

The FT-IR spectroscopy is applied in the analysis of organic substances adhered to the RO membranes. The same technique can be applied in the determination of the acetyl group ratio in the polymer chain. (FT-IR is available at SWCC R&D center).

## F. Determination of Physical & Chemical Properties of the Membranes

In this case several test conditions can be applied:

### 1. Strength and Elongation of the membrane using Instron<sup>\*</sup>

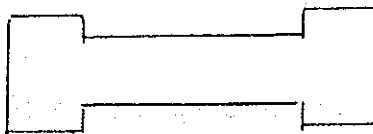
For a spiral wound membranes the stress/strain (S/S) curve can be established

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*\* AVAILABLE AT OUR LABORATORY*



for a thinfilm membrane using a dumb-bell shaped sample



cut by a die from the membrane, while for a hollow fine fiber membrane the S/S curve can be determined by using a fiber sample. Polymer strength and elongation are established from the S/S curve.

## 2. Molecular Weight Determination

The standard process used here is gel permeation chromatography (GPC) which gives polymer molecular distribution. This measurement can be determined using High Performance Liquid Chromatography (HPLC)\* equipped with a GPC column (HPLC is available at SWCC R&D center but not the GPC permeation column).

## 3. Viscosity Measurement

Viscosity measurement is used in many cases to determine polymer molecular weight, it also gives an indication of its physical properties.

(These three measurements: F1, F2 & F3 provide an indication of changes in the polymer molecular weight and chain structure).

## 4. Degree of Polymer Acetylation

Either one of two methods may be utilised:

The wet chemical analysis method in which the polymer is hydrolysed in a proper solvent and free acid is measured by neutralisation titration. Alternatively, the FT-IR method is used to measure the acetyl group absorption at 1725  $\text{cm}^{-1}$  &


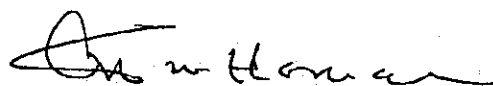
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\* AVAILABLE AT OUR LAB.

1230 cm<sup>-1</sup>.

(The results of this test show whether acetate group hydrolysis occurred or did not take place).

(For experimental procedures for the above tests F1, F2, F3 and F4 the standard methods of analysis are to be employed for the determination of plastic stress/strain, molecular weight by gel permeation chromatography, viscosity measurements and acetyl group determination).

A handwritten signature in black ink, appearing to be 'S. R.', written in a cursive style.A handwritten signature in black ink, appearing to be 'S. R. Thomas', written in a cursive style.

付属資料 7.1.2-2

ファウリング物質分析 (1)

SEM・EDX分析操作マニュアル



ファウリング物質分析(1)  
SEM・EDX分析操作マニュアル

この分析法は汚染された膜面や汚染物を捕捉したメンブレンフィルター表面の汚染物形態観察・無機分析に適用する。以下に手順を示す。

1. サンプルを十分乾燥させる(自然乾燥がもっとも良い。加温する場合は40℃まで)
2. 7mm角にサンプルを切り、SEM用のアルミホルダーに両面テープを用いて貼り付ける。両面テープはなるべく薄手のものを用い(例えば弊社のNO. 500)、サンプルより大きくしない。
3. アルミホルダーに貼り付けたサンプルの4隅に導電性銀塗料を少量塗布する。  
注)ホルダー、導電性塗料をカーボン製のものを用いても差し支えない。EDXのみの分析にはカーボン製の方がホルダーのアルミニウムや塗料の銀がピークとして出ないので好ましい。
4. 塗料が乾燥したらイオンコーターで蒸着する。EDX分析の場合はカーボン蒸着。SEM観察の場合はAu、Au-Pd蒸着を行う。蒸着層は100Å前後にする。カーボン蒸着はEDX分析の時、Auのピークが出ないので分析し易い。しかし、カーボン系で調製したサンプルでは4000倍を越えると分解能が悪くなり、汚染物の詳細な構造や膜面の微細な観察には適さない。
5. SEMにセットする。  
分析可になれば通常、次の条件でサンプルの観察・分析を行う。ただし、SEMによって機能や操作が異なる場合があるので詳しくは取扱説明書を参照のこと。  
加速電圧が低いほど表面の情報が得られやすく膜や汚染物のダメージも生じにくいのでSEM観察に適する。

	加速電圧 (KV)	ワーキングディスタンス (mm)
SEM観察	< 10	2 - 5
EDX分析	20	20

## 6. SEM・EDX観察

まず低倍率で全体の状態を把握する。それからサンプルを代表する部分について中倍（×800）、高倍（×4000）で詳しく観察、分析する。EDXも中倍で全面、高倍でスポット分析を行うと表面の状態がよく分かる。

高倍を×4000としたのは菌体が明瞭に確認出来る倍率であり、菌汚染の判断がしやすい点と、EDXでも十分な解像度が得られるためである。

### （備考）

- ・EDXでは汚染状態によって線分析や面分析を行うと汚染状態がより分かりやすいがピークのカウン数が約1000以下では十分な信号が得られない。
- ・堆積状態によっては断面方向の観察も有意義である。断面は液体窒素中でサンプルを破断させ、ホルダーに立てて蒸着する。
- ・写真はネガで撮るのが好ましいが、現像・焼き付けに時間がかかり、露出状態も後で確認することになるので迅速な対応を行うためにはポラロイドやビデオプリンター、等を活用する。

## 7. SEMサンプルの保管

分析後のサンプルはシャーレー等に入れ、分析結果がまとまるまで保管するのが望ましい。分析がまとまればサンプルをホルダーから取り、エタノールで導電性塗料を拭い、次のサンプルホルダーとして再利用する。

以 上

付属资料 7.1.2-3

ファウリング物質分析 (2)

FT-IR分析操作マニュアル





ファウリング物質分析(2)  
FT-IR分析操作マニュアル

1. ATR(多重反射)法による膜面分析

この分析法は汚染された膜面や汚染物を捕捉したメンブレンフィルター表面の有機、無機の汚染物質分析に適用する。

- 1-1. サンプルを十分自然乾燥させる。加温する場合は40℃程度で行う。
- 1-2. サンプルをFT-IRのATRホルダーに入る大きさに切る。切り取る時、分析面に手などが触れないようにピンセットでサンプルを保持する。サンプルは毎回ほぼ同じ大きさに切る。
- 1-3. ATRの反射板にKRS-5を用いる。これは広い波数範囲(400-4000 $\text{cm}^{-1}$ )にわたって吸収が得られる。反射板の角度は45度。
- 1-4. 反射板に均等にしっかりサンプルを圧着させる。
- 1-5. 十分ノイズの影響が無視できるレベルまで積算する。分解能は8 $\text{cm}^{-1}$ で十分。  
注) FT-IRの性能や機構で積算回数が異なるので、各機器の取り扱い説明書を参照のこと。
- 1-6. 新膜との差スペクトルをとる。差をとる時、新膜の強い吸収がベースラインまで差し引かれるように調整する。
- 1-7. 標準スペクトル集やオリジナルの標準スペクトルファイルと照合させ汚染物を同定する。

## 2. KBr法による汚染物分析

この分析法は汚染物そのもの、および水中溶解成分の有機、無機分析に適用する。膜面から取り出せる量の汚染物や水サンプルの場合、十分乾固しKBrと共にすりつぶしペレットとして吸収をとる。

- 2-1. サンプルは十分乾燥させる。完全に乾燥させるために110℃×2hの乾燥を行うのが望ましい。
- 2-2. 乾燥後、適量を少量のKBrと共にメノウの乳鉢に入れ、十分混合する。この時、湿気が入らないように空調がなされている部屋で手早く混合する。
- 2-3. ペレット作成治具でペレットを作成する。最近はややハンディな治具があるのでこれを活用する。
- 2-4. ATRと同様、吸収をとる。量によって吸収が大きくなったり小さくなったりすることがある。この場合、KBrとサンプルとの混合比率を変え、最適なスペクトルが得られるように調整する。

以上