clear image will be hard to get. But, for being entirely consisting of carbon, there will be no unnecessary peak during the EDX analysis.

Authors run the EDX analysis by using the SEM sampling method, as it also enables realizing high- magnification observation. In this case, an Au peak appears during the EDX analysis; but, it can be distinguished from the proximate P or S peaks.

(2) Special Notes on Analysis

* Change setting mode between SEM and EDX. As detailed explanation is found in the SEM instruction manual, refer to them.
  The following table shows the outstanding difference between the SEM: Hitachi S-570 and the EDX:
  Horiba EMAX-1770:

Equipment:	SEM	EDX
Accelerating voltage:	10 kV	20 kV
Working distance:	1 - 2 mm (note) (distance from object lens to sample)	20 mm
Feature:	Information on top-most surface of membrane may be obtained. Little damage to sample.	Subject to EDX detector and energy. Large damage to sample

  Note: Depending on the type of SEM, it may not be possible to come closer to this value; thus, it will be necessary to set so as to obtain the most optimum image by referring to the instruction manual.
* For observation, first grasp the overall situation at low magnification (x200 to x800). Observe the parts presenting remarkable fouling, and those where fouling is moderate at magnification x400. Then, make the EDX analysis of those parts.
  It is desirable to realize the observation and analysis at the same magnification as far as possible.
  The following magnification and their characteristics:

  x200 - x800: Allows grasping the overall situation of fouling. Allows fouling by trichophyton (mildew) or micro-organisms.
  x4000: Allows grasping situation of microbes and scale. (Incidentally, the magnifica-

tion over x4000 will not be suitable for the EDX analysis.)

NITTO
TECHNICAL
DATA SHEET

Analysis of the NTR-759HR-S8 Element

No. R-1949

DATE: OCT 23, 1991
Reported by Nitto Denko Corporation
Product Development, Membrane Business Unit

1. Preface

This report covers the analysis of the returned spiral wound RO element, NTR-759HR-S8, used in so-and-so Plant in Japan.

2. Sample Element

* NTR-759HR-S8 : Total 4 elements

Serial No.	Position
8070004	Inlet place of the vessel at the first bank
8070007	Inlet place of the vessel at the first bank
8070009	Outlet place of the vessel at the third bank
8070040	Outlet place of the vessel at the third bank

* Start operation : July 1988

* Returned : August 1991
(Operated about 3 years)

3. Items Analyzed / Tested

(1) General appearance

(2) Rejection and flux measurement of elements (under the test condition specified in the inspection procedure)

(3) SEM and EDX(or XMA) (as to observation of membrane surface and inorganic analysis of the foulant deposited on the membrane)

(4) FT-IR (organic analysis of the foulant)

Note: SEM is the abbreviation of Scanning Electron Microscopy
EDX (or, XMA) is the abbreviation of Energy Dispersive X-ray Microanalyzer.

4. Results

(1) General appearance

There was no deformation, breakage or leakage of the element.

(2) Rejection and flux measurement of elements

In Figure 1., the test results were shown. Although the all elements showed the permeate flux decline by about 15 to 30% compared with the out-going test results, there was no change in the rejection performance. The pressure drops of feed inlet and outlet within the elements were increased by about 10 to 30 %.

The above mentioned changes were more remarkably observed in the third bank elements which were located at the down stream, accordingly the phenomena of the membrane fouling are presumed.

For your reference, the data of RO pure water flux versus pressure were also shown in Fig. 1. All elements showed that the permeate fluxes proportionally were increased by the operation pressures.

(3) & (4) SEM , EDX(or, XMA) and FT-IR

The two elements of No.8070004(at inlet place of vessel in the first bank) and No.8070009(at outlet place of vessel in third bank) were disassembled and the sample membranes of which were analyzed.

In the table 2, results are shown. In particular, the down stream elements have large amounts of deposits which are grey and brownish foulants on the membrane surface. The foulants were identified as slime, bacteria and particles by the analysis of using SEM, EDX and FT-IR059. The particles consist of either silicates (coexisting with Al and Fe) or organic compound as the main component.

Among absorptions in FT-IR, amide compounds, ether bonding (-O-), methylene($-CH_2-$), hydroxyl(-OH) functional groups are presumed to be associated with bacteria and slime (also decomposed dead bacteria, metabolized, etc.,)

These analysis results are very similar to the former results (which was reported on December 28, 1990 by the technical paper R-0623).

5. Summary

(1) all elements showed the permeate flux decline by about 15 to 30 % compared with the out-going test results, there was no change in the rejection of NaCl test performance.

The pressure drops of feed inlet and outlet within the elements were increased by about 10 to 30 %.

As a conclusion, the changes more remarkably observed on the third bank elements were affected by the membrane fouling.

(2) On the membrane surface in particular, of the down stream elements, grey and brownish foulants were much accumulated.

The foulants were identified as slime, bacteria and particles. There are two types of particles which consist of either silicates (coexisting with Al and Fe) or organic compound as the main component.

(3) Since the actual operational flux data seemed to have had no pressure dependance in the RO plant, we examined the

pressure dependance on element flux with RO pure water as feed.

All elements have linear relationship between pressure and water flux.

We would like to suggest that the actual net driving pressure in the current RO plant should be checked if there are abnormal pressure gauges or the permeate-side pressures are significant.

(4) These analysis results are very similar to the former results (cf. the technical paper R-0623, reported on December 28, 1990).

Table 1. Element Performance of Rejection and Flux

Element Location	1st Bank, inlet	1st Bank, inlet
Lot No.	8070004	8070007
Out-going Test		
Rejection (%)	*99.6	*99.5
Flux(m^3/d), at 25°C	*31.2	*30.1
Pressure drop(kgf/cm^2)	0.2 to 0.3	0.2 to 0.3
Pure water Flux(m^3/d), at 25°C	34.6	34.5
Returned Element Test		
Rejection (%)	*99.4	*99.4
Flux(m^3/d), at 25°C	*26.8	*24.9
Pressure drop(kgf/cm^2)	0.33	0.30
Pure water Flux(m^3/d), at 25°C	29.6	28.2

Element Location	1st Bank, inlet	1st Bank, inlet
Lot No.	8070009	8070040
Out-going Test		
Rejection (%)	*99.6	*99.6
Flux(m^3/d), at 25°C	*32.1	*29.8
Pressure drop(kgf/cm^2)	0.2 to 0.3	0.2 to 0.3
Pure water Flux(m^3/d), at 25°C	32.4	31.5
Returned Element Test		
Rejection (%)	*99.5	*99.3
Flux(m^3/d), at 25°C	*21.2	*24.0
Pressure drop(kgf/cm^2)	0.38	0.35
Pure water Flux(m^3/d), at 25°C	23.6	27.3

Measuring conditions:
0.15% NaCl solution (pH 6.5),
Pressure = 15 kgf/cm^2, Concentrate flow rate = 90 liter/min
* Note: The out-going tests with NaCl solution were done by sampling several from the product for inspection, no data was taken, so typical RO performance which is close to the above lot number is listed.

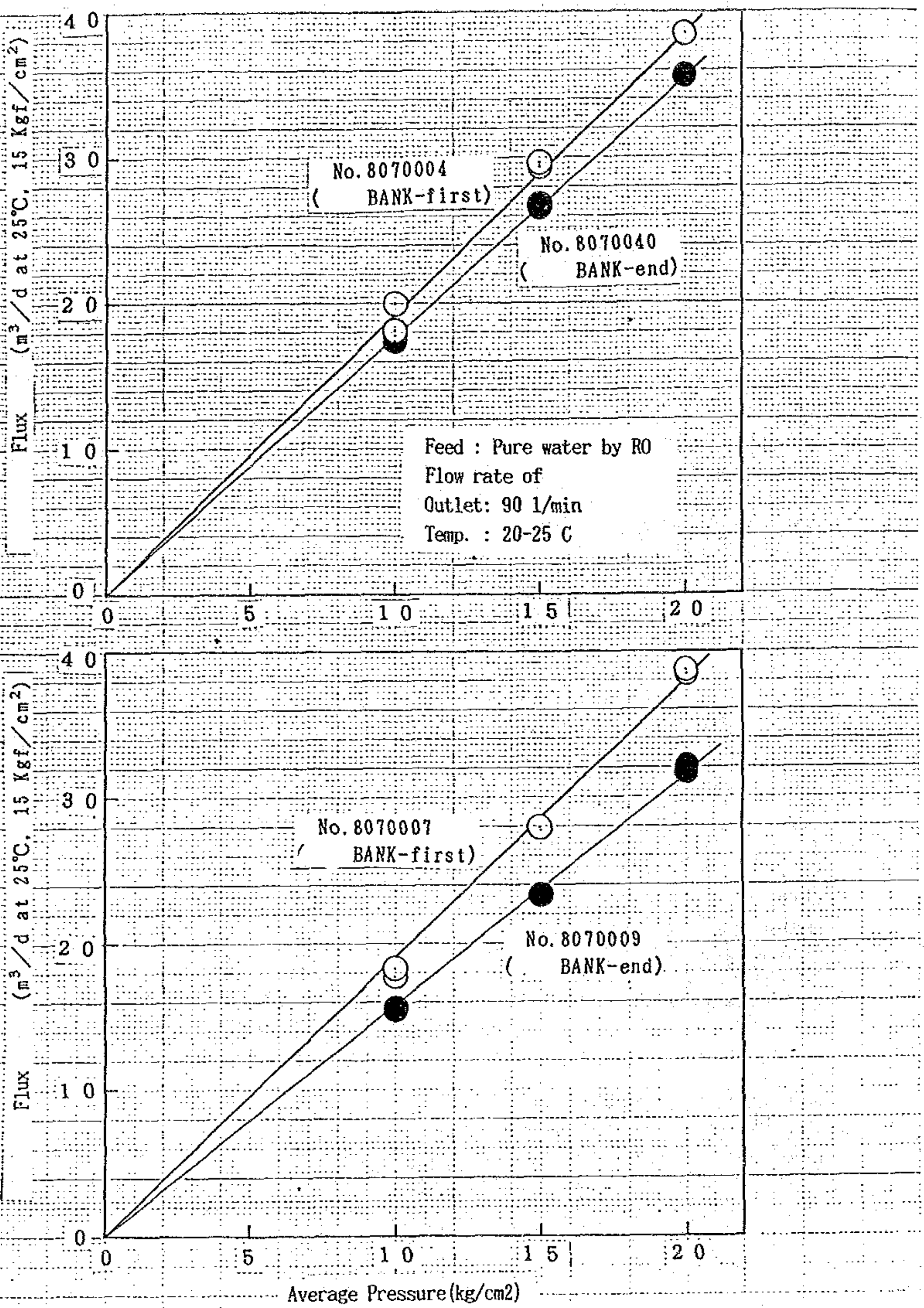


Fig. 1 Results of Flux Mesurement
(NTR759HR-S8)

Table 2-1 (Element Serial No.8070004, No.8070009)

	RESULT OF ANALYSIS	REFERENCE
Observation of disassembled element	(Sample No.8070004 at 1st Bank, inlet) Small amount of deposit of brownish foulant exists on membrane surface. (Photo 2 is a magnification of photo 1) (Sample No.8070009 at 3rd Bank, outlet) Large amounts of deposit of brownish and grey color foulant exists on the entire membrane surface. (Photo 4 is a magnification of photo 3)	Photo 1 through Photo 4
SEM	(Sample No.8070004) SEM 1, SEM 2 - Magnification of photo 2 show deposit of particles on the membrane surface. SEM 3, 4 & 5 - Magnification of SEM 1 & 2 show that foulant consists of particle and slime. (Sample No.8070009) SEM 6, SEM 7 - Magnification of photo 4 show the entire membrane surface was covered with deposit of particles, bacteria and slime. SEM 8, 9 & 10 - Magnification of SEM 6 & 7 show that the entire membrane surface was covered with deposit of large amounts of particle and slime. (Brownish portion of sample No.8070009) SEM 13,14 & 15 - Magnification of SEM 11 & 12 show that the entire membrane surface was covered with deposit of large amounts of particle and slime.	SEM1 through SEM15
EDX (XMA)	(Sample No.8070004 at 1st Bank, inlet) XMA 1 - Surface analysis of SEM 1 shows that inorganics are less than the detectable limits. (The particles are organics) XMA 2 - Analysis of spot 1 on the SEM 3 shows that: Particle 1 & 4: inorganics as Fe Spot 2, Particle 3 & 4: inorganics is less than the detectable limits. (The particles are organics.) XMA 3 - Analysis of particle 6 on the SEM 4 shows that: Particle 6: inorganics as Si Particle 7 & 8: inorganics are less than the detectable limits.	XMA 1 through XMA 12

(The particles are organics)
Particle 9: inorganics as Fe
Particle 10: inorganics as Fe and Si

XMA 4 – Analysis of particle 11 on the SEM 5 shows that:
Particle 11: inorganics as Si,Al,Fe and Ca
Particle 12: inorganics as Si and Al
Particle 13: inorganics as Si
Particle 14: inorganics are less than the detectable limits.
(The particles are organics)
Particle 15: Inorganics as Si and Fe.

(Sample No.8070009 at 3rd Bank, outlet)
XMA 5 – Surface analysis of SEM 6 shows that inorganics are less than the detectable limits.
(The particles are organics)

XMA 6 – Analysis of particle 16 on the SEM 8 shows that:
Particle 16 &18: inorganics as Fe, Si and Al
Particle 17 & 21, Spot 20: inorganics are less than the detectable limits.
(The particles are organics)
Particle 19: inorganics as Fe and Si.

XMA 7 – Analysis of particle 22 on the SEM 9 shows that:
Particle 22: inorganics as Si,Al,K
Particle 23 & 25: inorganics are less than the detectable limits.
(The particles are organics)
Particle 24: inorganics as Si, AL, and Fe
Particle 26: inorganics as Si, Al, K and Fe.

XMA 8 – Analysis of particle 27 on the SEM 10 shows that:
Particle 27: inorganics as Si,Al,Ca
Particle 28: inorganics as Si, Al, K
Particle 29: Inorganics as Si, Al, and Fe.
Particle 30: inorganics are less than the detectable limits.
(The particles are organics)
Particle 31: inorganics as Si

(Brownish portion of sample No.8070009)
XMA 9 – Surface analysis of SEM 11 shows that inorganics are less than the detectable limits. (The particles are organics)

XMA 10 – Analysis of particle 32 on the SEM 13 shows that:

Particle 32: inorganics as Si,Al, K
Particle 33: inorganics as Si,Al,Fe and K
Particle 34 & 35: inorganics are less than the detectable limits.
(The particles are organics)

XMA 11 – Analysis of particle 36 on the SEM 14 shows that:

Particle 36: inorganics as Si, Fe
Particle 37: inorganics as Si, Al
Particle 38: Inorganics are less than the detectable limits.
(The particles are organics)
Particle 39: inorganics as Si,Al,K

XMA 12 – Analysis of Particle 40 on the SEM 15 shows that:

Particle 40: inorganics as Si, Fe, P
Particle 41: inorganics as Fe
Particle 42,44: inorganics as Si
Particle 43: inorganics as Si,Al,K,Fe
Particle 45: inorganics as Si,Al

FT-IR

(Sample No.8070004 at 1st Bank, inlet)
Fig 2 – The differential spectrum between the surface of photo 2 new membrane, which represents IR spectrum of the foulants on the membrane surface. Fig 2

(Sample No.8070009 at 3rd Bank, outlet)
Fig 3 – The differential spectrum between the surface of photo 4 new membrane, which represents IR spectrum of the foulants on the membrane surface. Fig 3

In the both Figures, the similar peaks are observed.
The peaks at 400 to 600 cm^{-1} are presumed to be the absorption of inorganics like Si and Fe compounds.
The following peaks are presumed to be:
at 1050 cm^{-1} for –O– group,
at 1550,1650 cm^{-1} for amide compounds, and
at 3300 to 3400 cm^{-1} for –OH group respectively.

Note: On the EDX(or,XMA) the peak of S came from the support layer material of the polysulfon membrane and that of Au came from its vaporization on the samples.
They are not foulants.

(1-Inlet, No. 8070004)

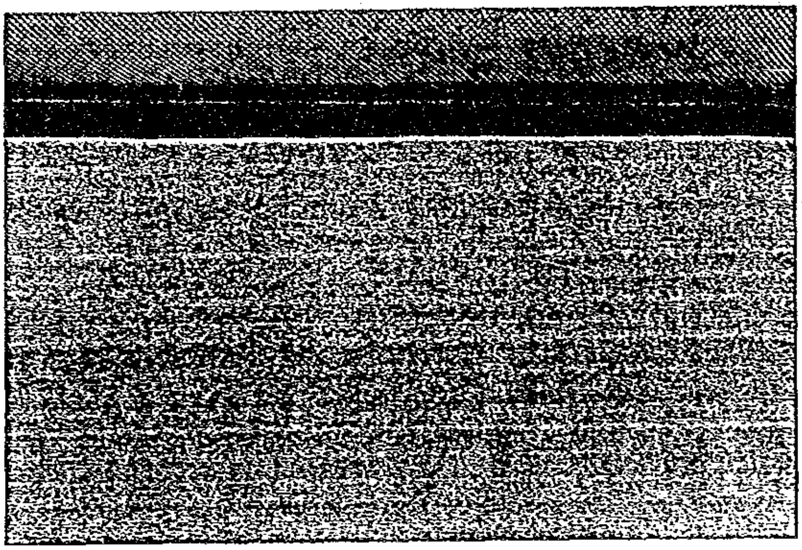


Photo. 1

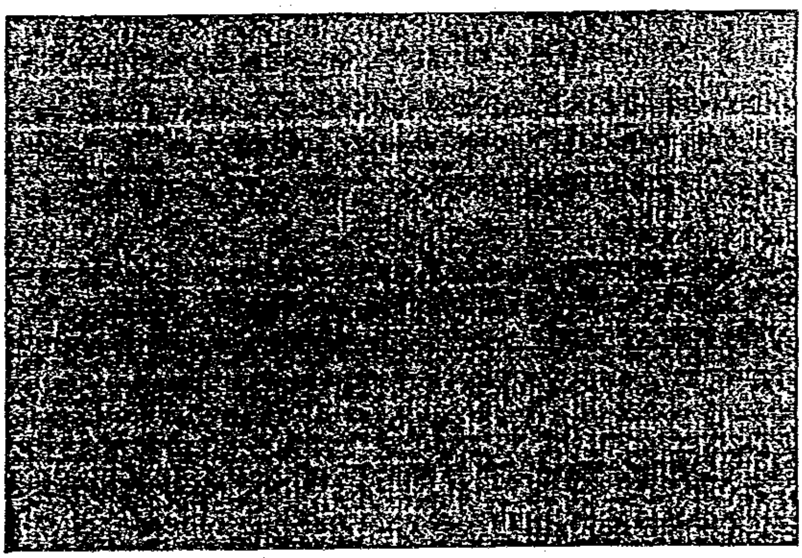


Photo. 2

(3-outlet, No. 8070009))

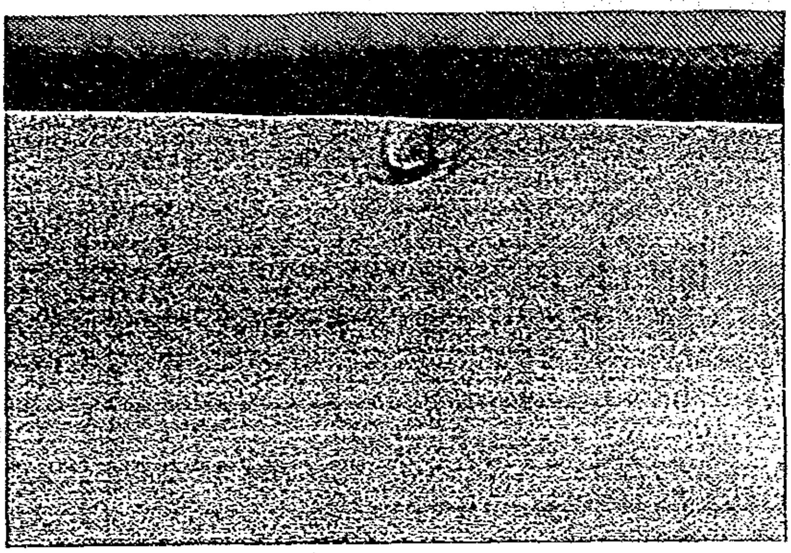


Photo. 3

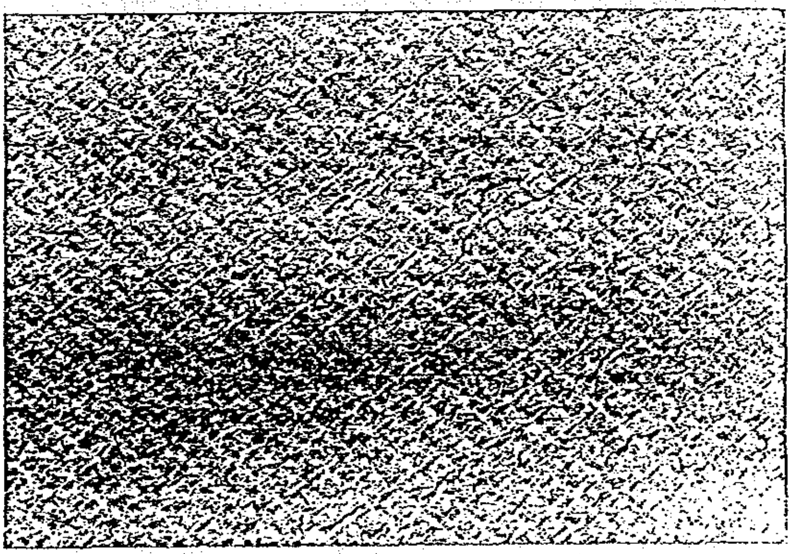
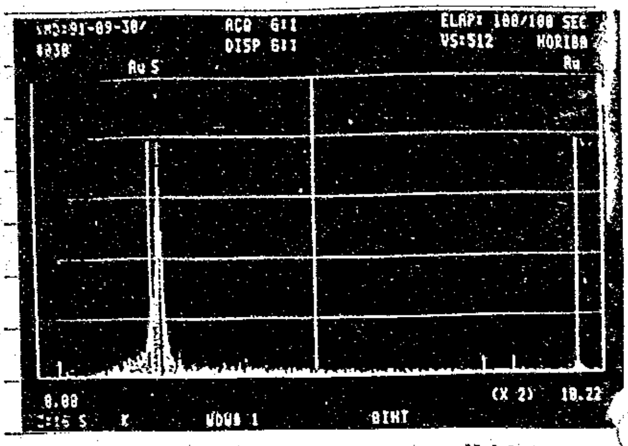


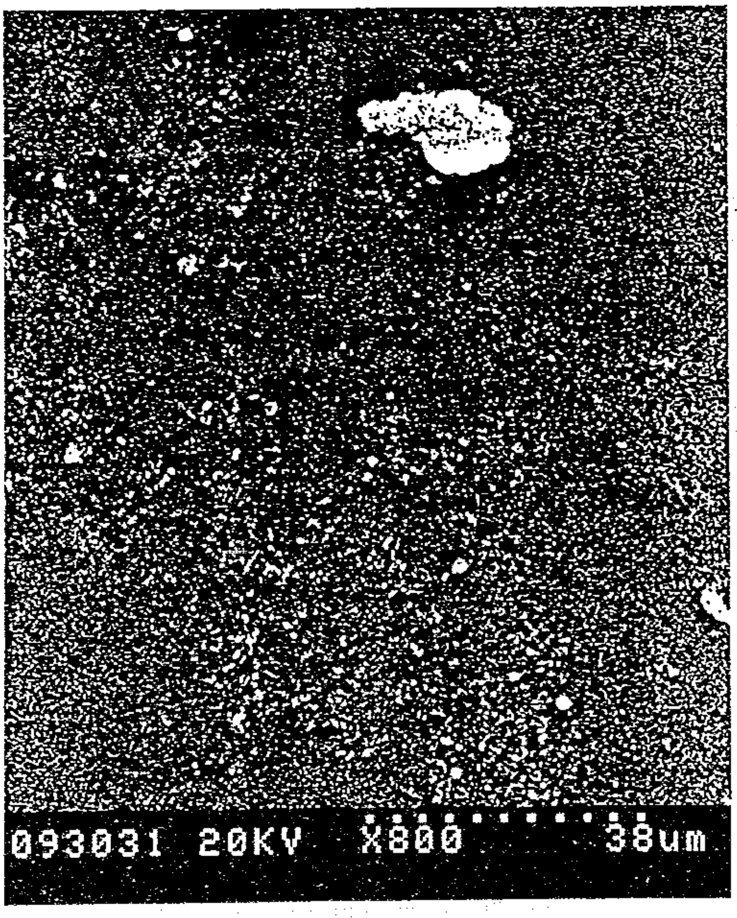
Photo. 4

(1-Inlet, No. 8070004)



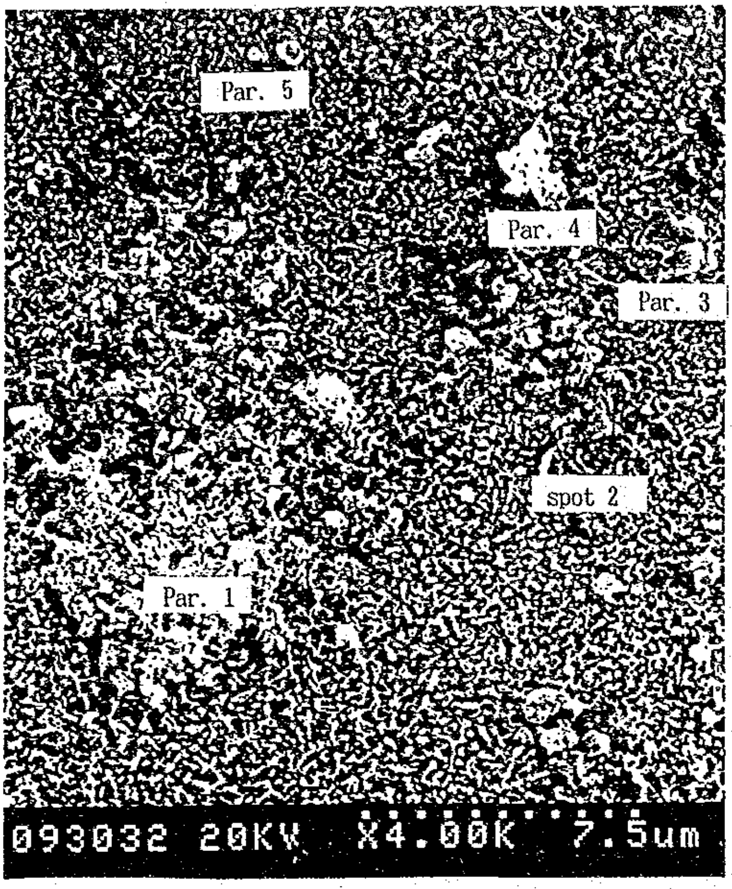
XMA 1

SEM 1

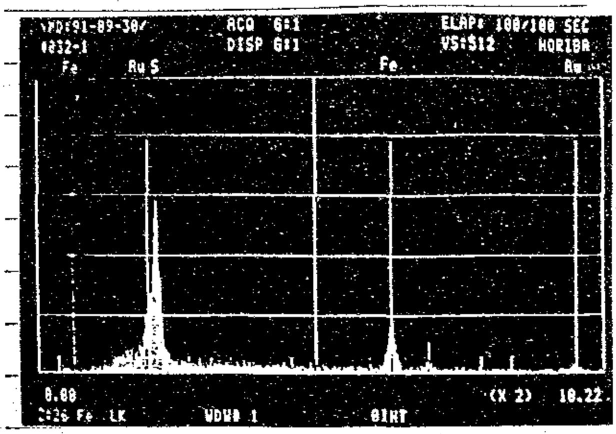


SEM 2

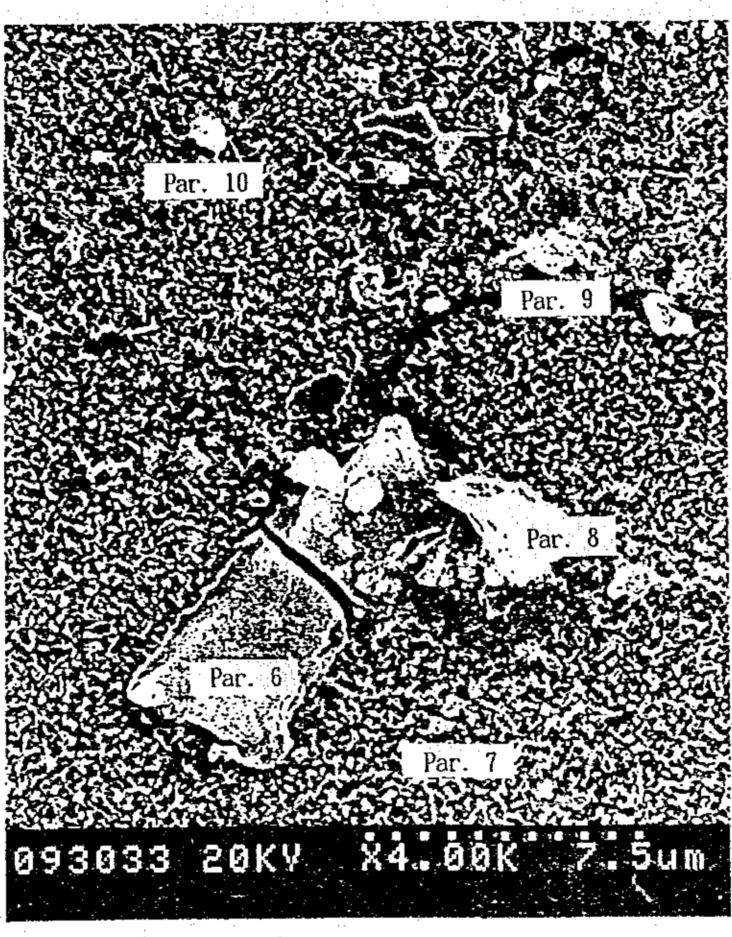
(1-Inlet, No.8070004)



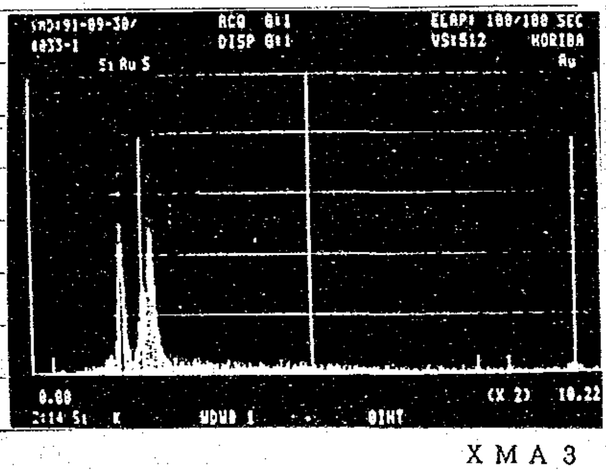
SEM 3



XMA 2



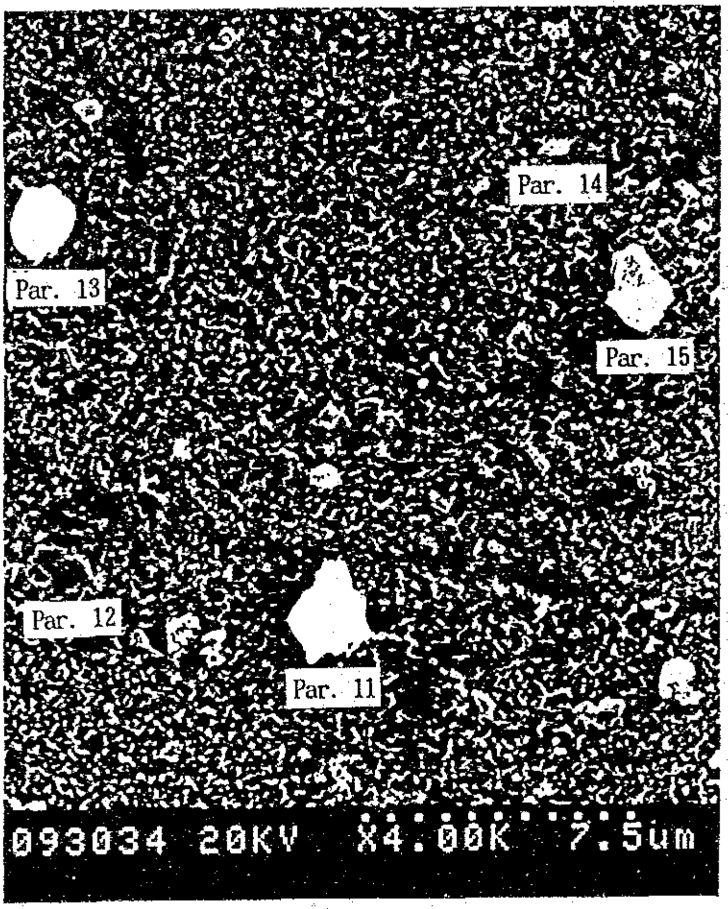
SEM 4



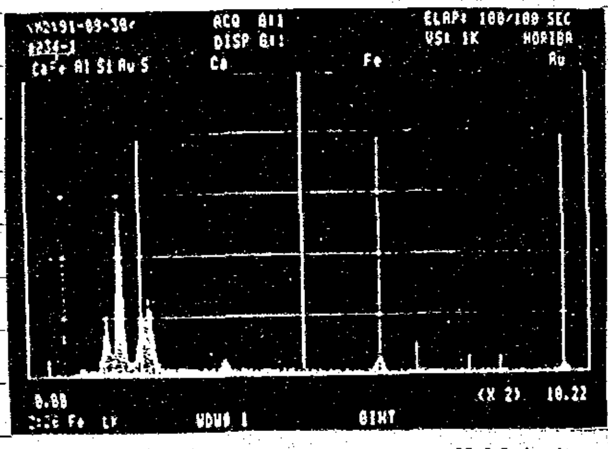
XMA 3

日東電工
日東電工株式会社

(1-Inlet, No. 8070004)

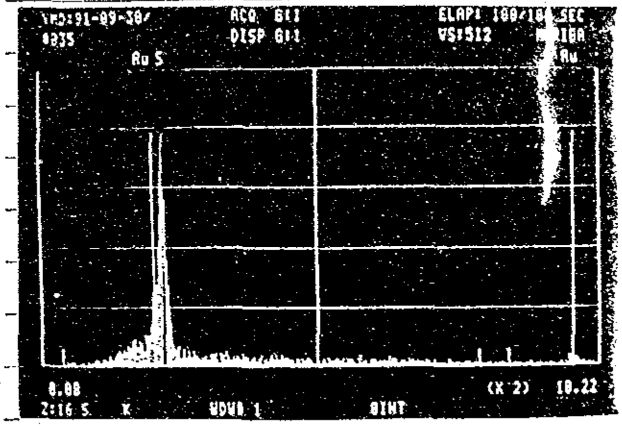


SEM 5

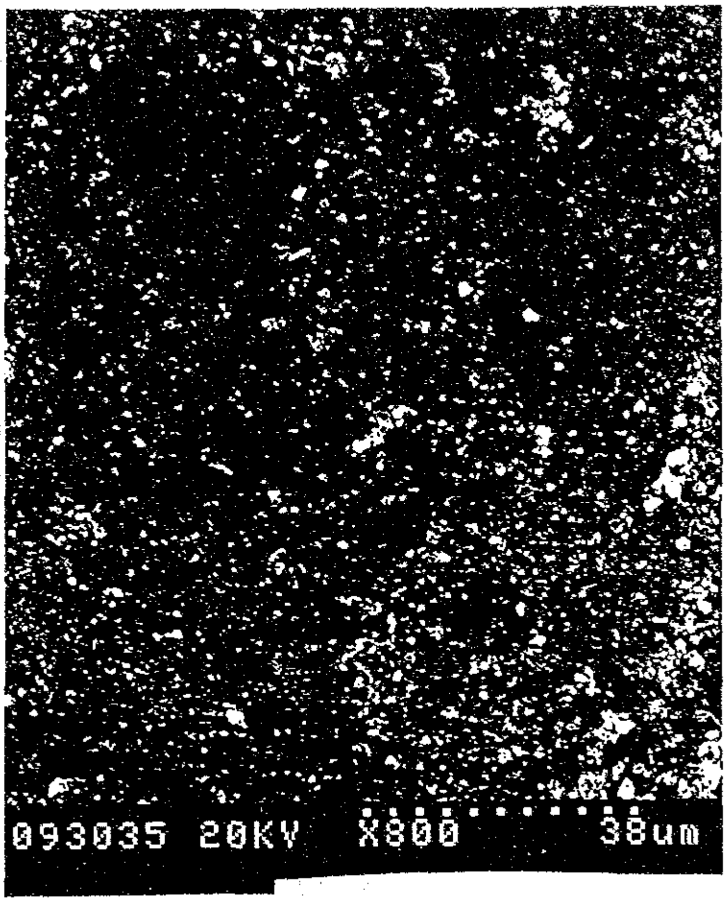


XMA 4

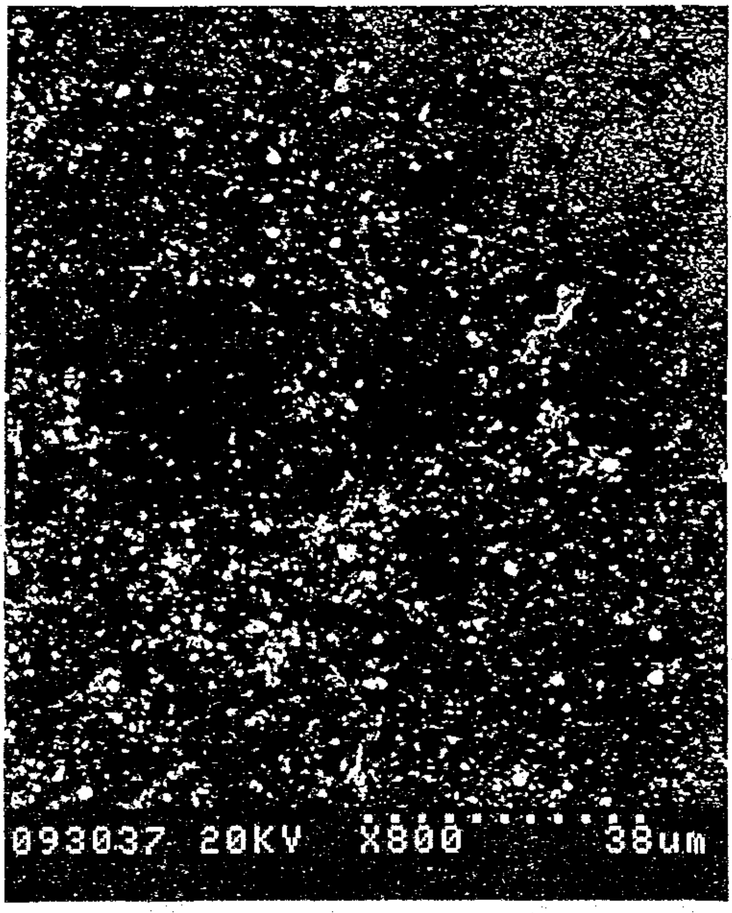
(3-Outlet, No. 8070009)



XMA 5

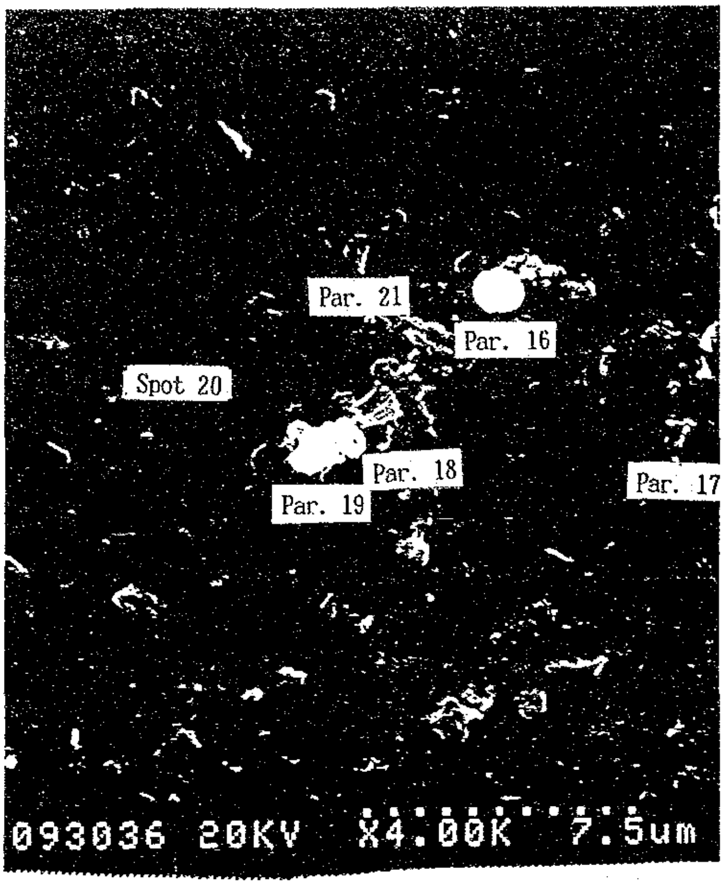


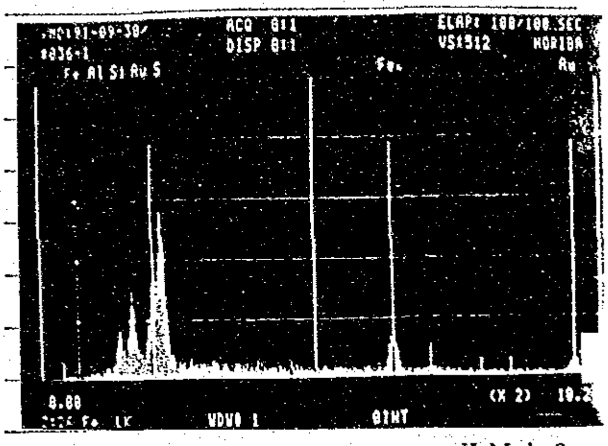
SEM 6



SEM 7

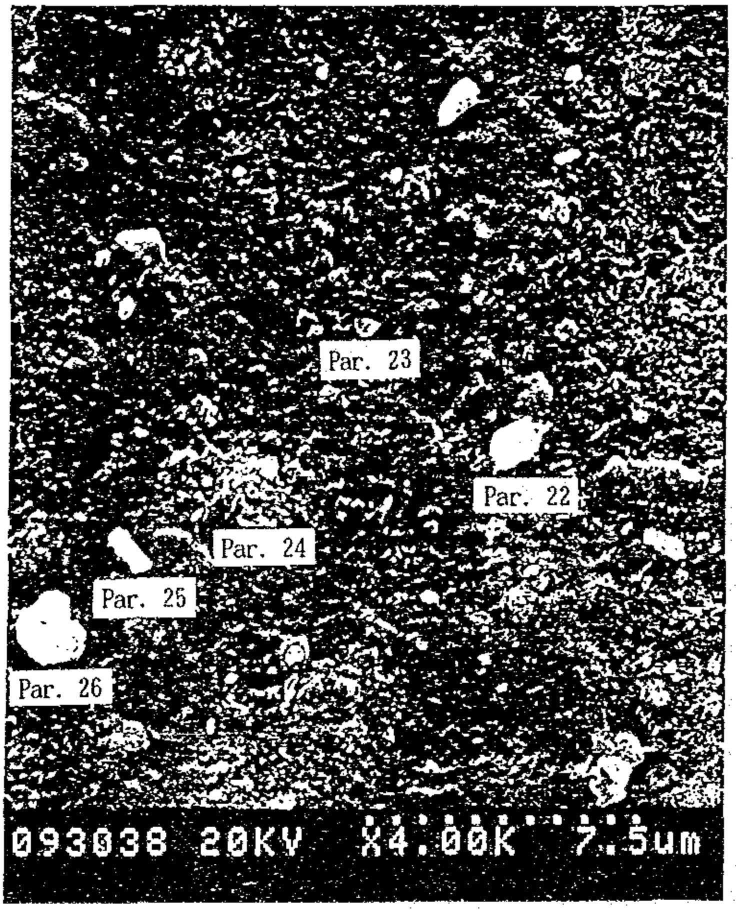
(3-Outlet, No. 8070009)

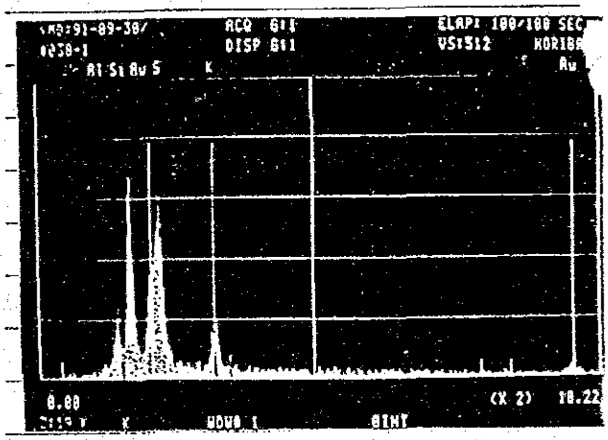




XMA 6

SEM 8





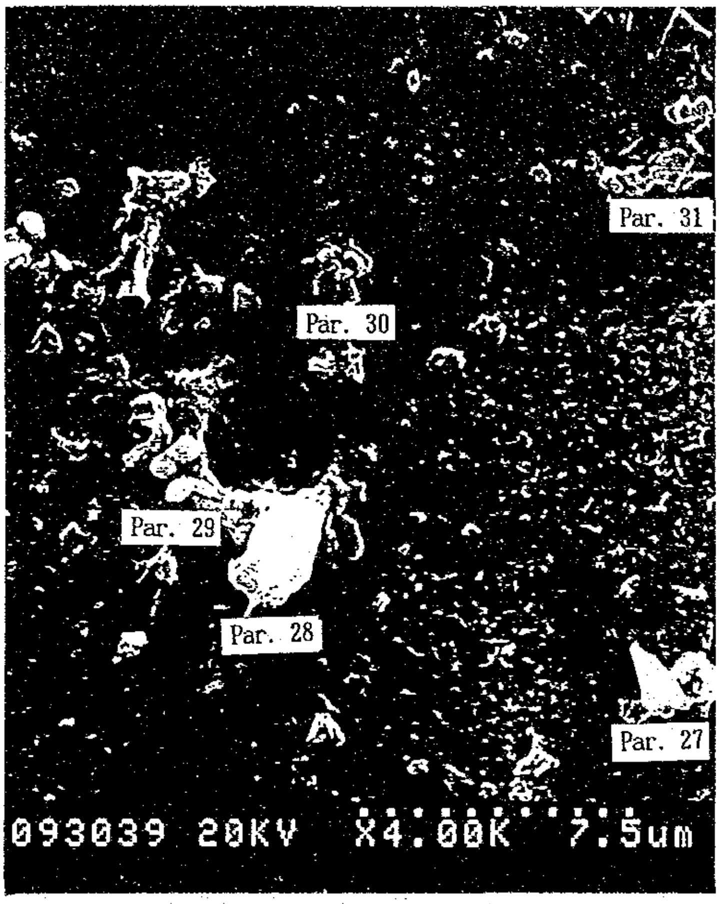
XMA 7

SEM 9

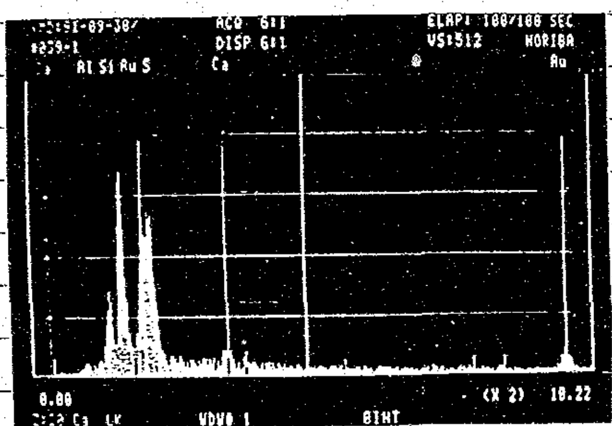
日東電工

日東電工株式会社

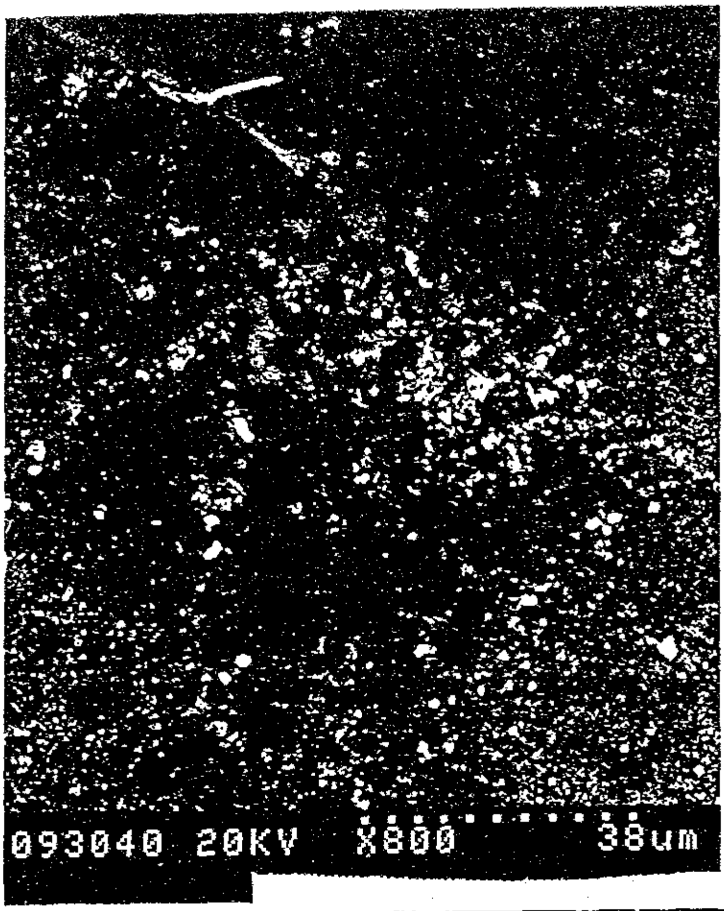
(3-Outlet, No. 8070009)



S E M10



X M A 8



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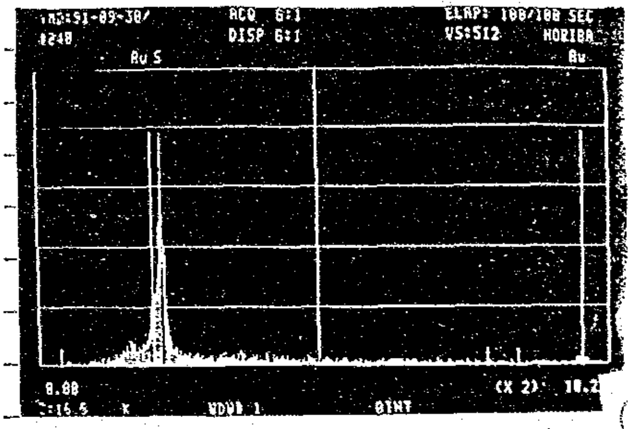
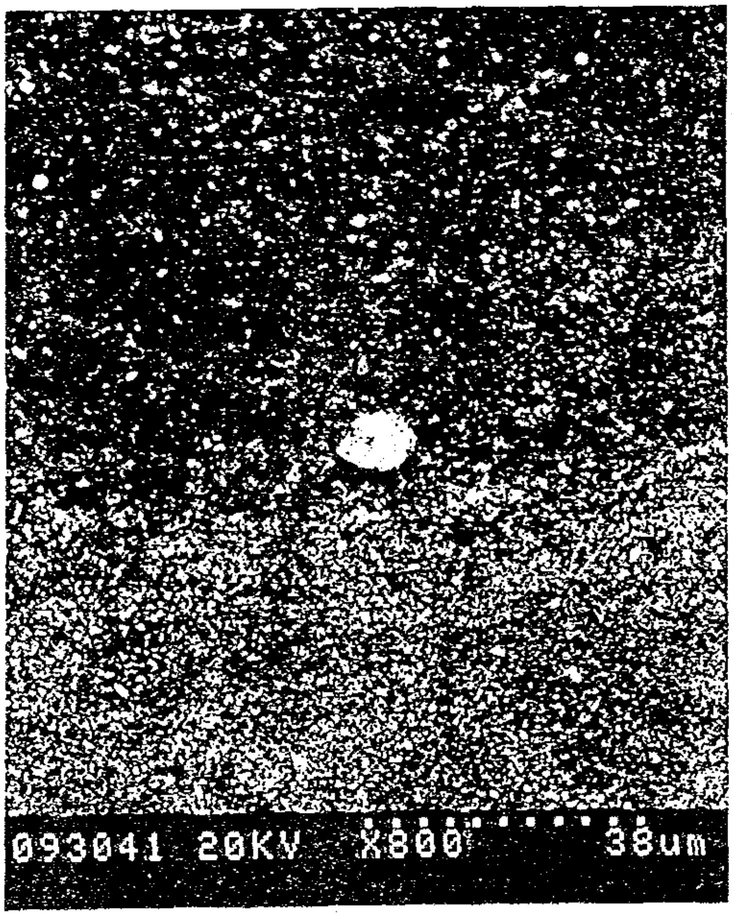


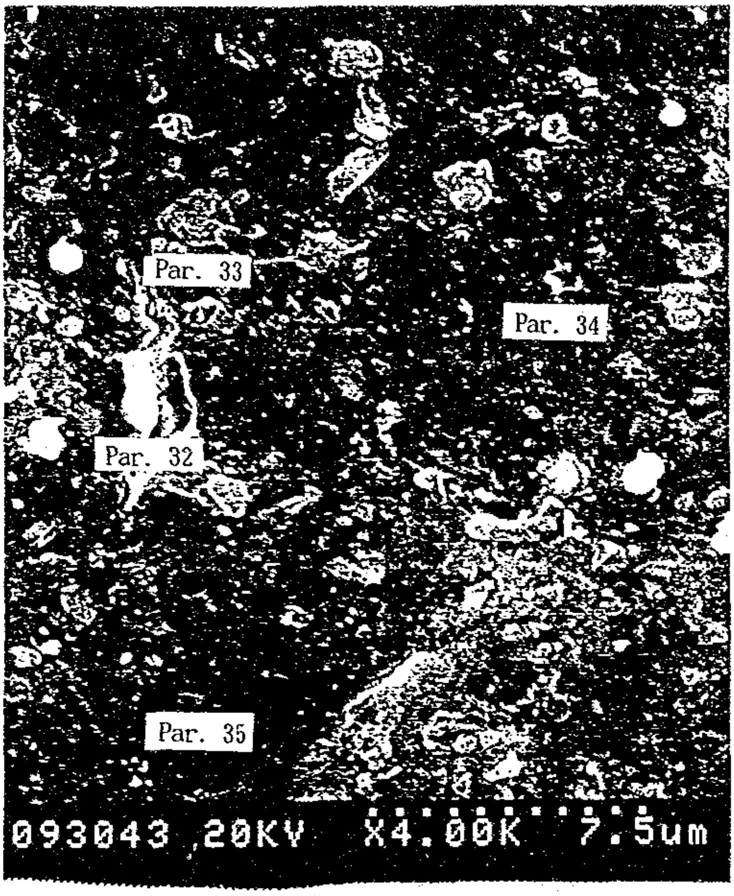
XMA 9

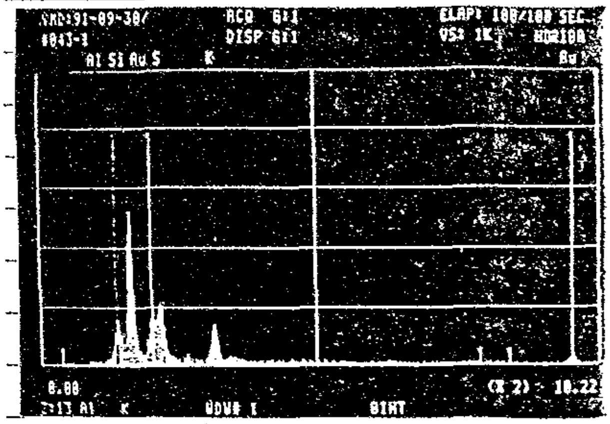
SEM11



SEM12

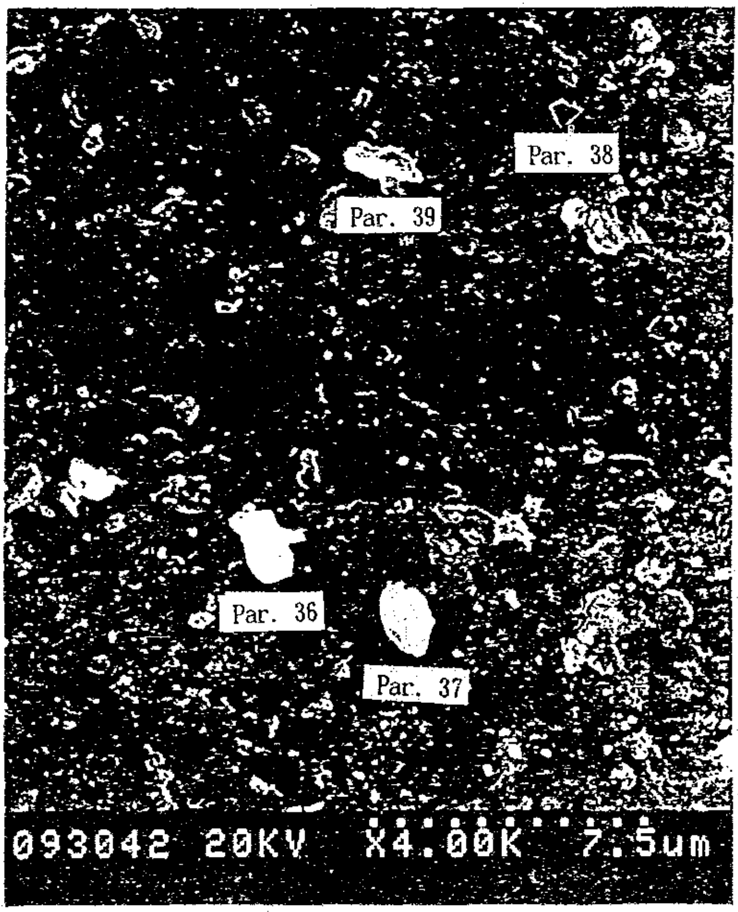
(3-Outlet, No. 8070009)

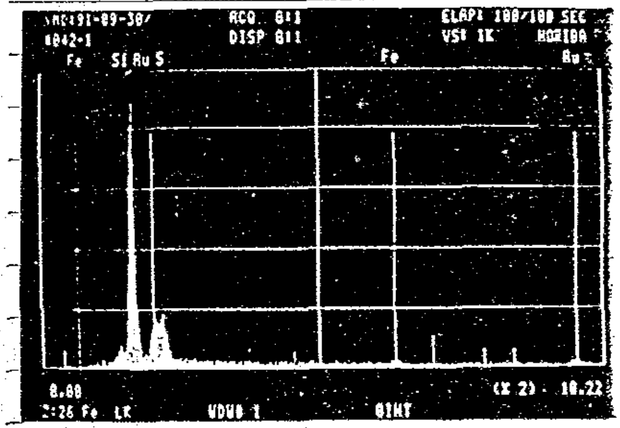




XMA 10

SEM13

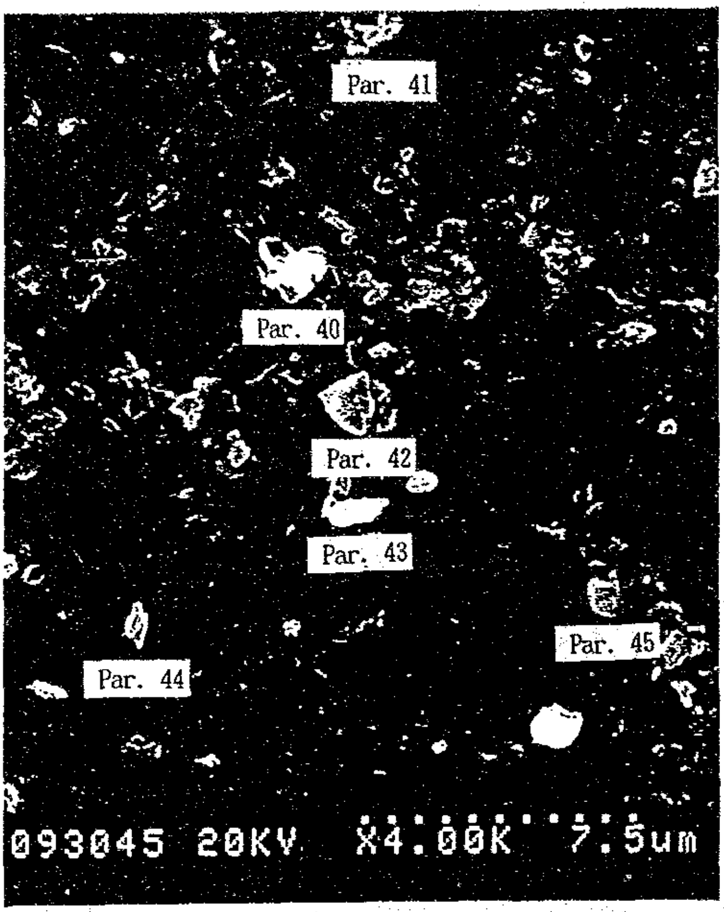




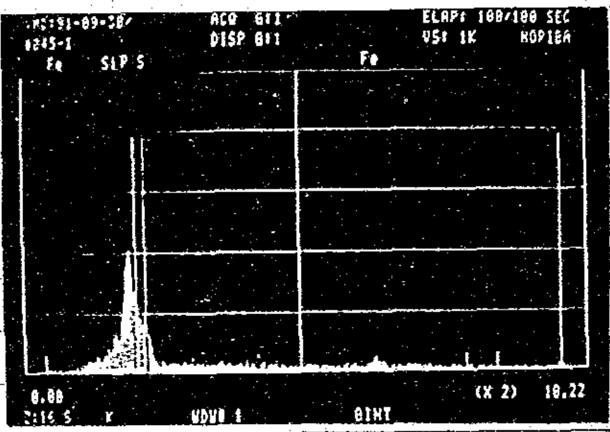
XMA 11

SEM14

(3-Outlet, No. 8070009)



SEM15



XMA12

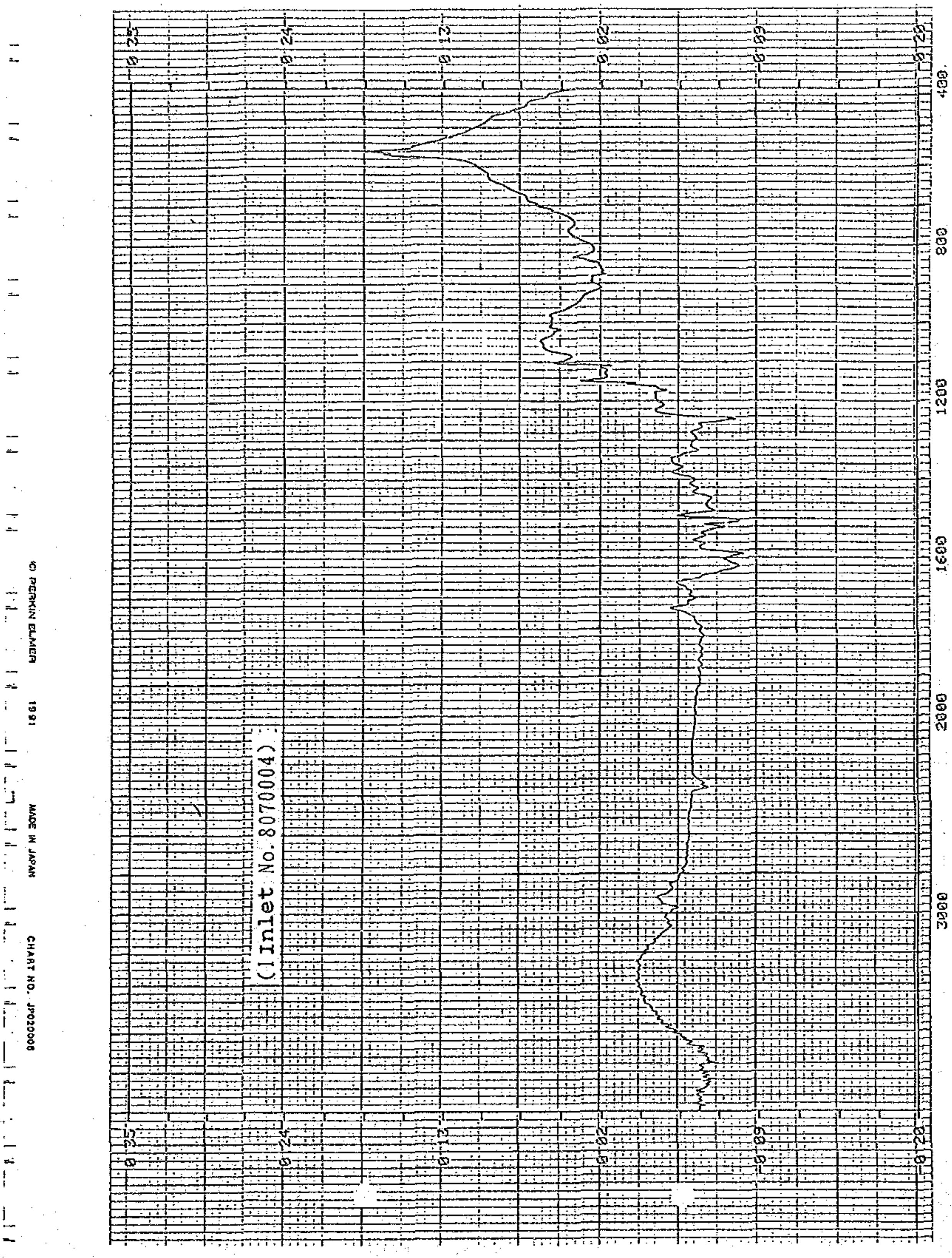

(1 Inlet No. 8070004)
0.35
0.24
0.13
0.02
-0.09
-0.20
400
800
1200
1600
2000
3000
© PERKIN ELMER 1991 MADE IN JAPAN CHART NO. JP020006

Fig 2

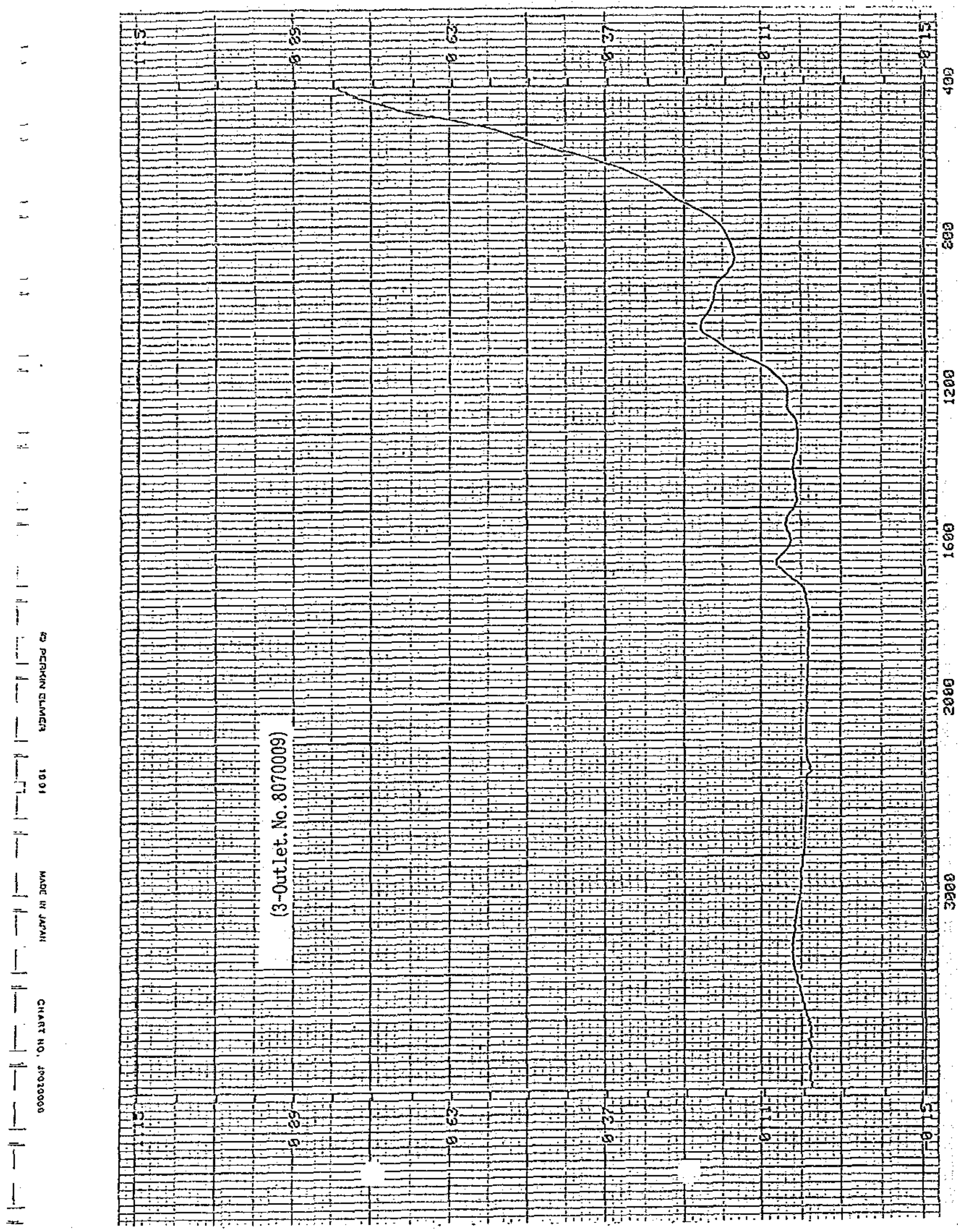


Fig 3

APPENDIX R6-2

APPENDIX R6-2 Result of Literature Survey.

1．使用ﾃﾞｰﾀﾍﾞｰｽ　STN FILE CA
2．検索期間
3．検索結果

```
=> S MSF OR MULTISTAGE FLASH
           165 MSF
          5123 MULTISTAGE
          8912 FLASH
           521 MULTISTAGE FLASH
                 (MULTISTAGE(W)FLASH)
L8         596 MSF OR MULTISTAGE FLASH

=> S RO OR REVERSE OSMOSIS OR SWRO
          2195 RO
         16249 REVERSE
          8460 OSMOSIS
          6780 REVERSE OSMOSIS
                 (REVERSE(W)OSMOSIS)
             2 SWRO
L9        8819 RO OR REVERSE OSMOSIS OR SWRO

=> S HYBRID
L10      14217 HYBRID

=> S (L8 OR L9) AND L10
L11         21 (L8 OR L9) AND L10

=> S HYBRID(L)(DESALT? OR DESALINAT?)
         14217 HYBRID
          1441 DESALT?
          7589 DESALINAT?
L12         18 HYBRID(L)(DESALT? OR DESALINAT?)

=> S L11 OR L12
L13         28 L11 OR L12

=> S L13 AND (ENGLISH OR JAPAN)/LA
       5896525 ENGLISH/LA
       1032382 JAPAN/LA
L14         24 L13 AND (ENGLISH OR JAPAN)/LA

=> S L14 NOT P/DT
       1602145 P/DT
L15         23 L14 NOT P/DT
```

抄録付きで出力

```
L16  ANSWER 1 OF 23  COPYRIGHT 1991 ACS
AN   CA114(16):145961w
TI   Pervaporation-based hybrid systems
AU   Ray, Rod; Friesen, Dwayne; Wytcherley, Randi; Schofield, Richard
LO   USA
SO   Proc. Int. Conf. Pervaporation Processes Chem. Ind., 4th, 200-14.
     Edited by: Bakish, Robert A.  Bakish Mater. Corp.: Englewood, N. J.
SC   48-1 (Unit Operations and Processes)
DT   C
CO   56XCAO
PY   1989
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LA   Eng
AN   CA114(16):145961w
AB   The concept of a pervaporation-based hybrid system is described for use in sepg. a process stream into 2 streams, one enriched in the solute and the other enriched in the solvent. In this hybrid system, a solute-removal unit operation (pervaporation) is balanced with a solvent-removal unit operation (reverse osmosis) to enable each unit to operate under conditions as close to optimum as possible; thus, the unit operations work synergistically as an efficient system. In the example presented, a pervaporation/reverse-osmosis hybrid system performs a sepn. that neither membrane process can perform alone. Such a hybrid system can offer the flexibility needed to sustain optimum performance, accommodating changes in membrane performance or fluctuations in the compn. of the feed stream that inevitably occur over time.

L16 ANSWER 2 OF 23 COPYRIGHT 1991 ACS
AN   CA112(12):104488n
TI   Hybrid desalting systems
AU   Awerbuch, Leon; May, Sherman; Soo-Hoo, Randall; Van der Mast, Victor
CS   Bechtel Group Inc.
LO   San Francisco, CA, USA
SO   Desalination, 76(1-3), 189-97
SC   61-4 (Water)
SX   48, 52
DT   J
CO   DSLNAH
IS   0011-9164
PY   1989
LA   Eng
AN   CA112(12):104488n
AB   Currently, most large scale seawater desalination plants are dual-purpose multistage flash plants producing both power and desalinated water. These plants produce high purity distd. water and provide excess elec. power for sale at a typical ratio of 10 MW/Mgal-day.

L16 ANSWER 3 OF 23 COPYRIGHT 1991 ACS
AN   CA112(12):104487m
TI   Optimum design for a hybrid desalting plant
AU   Al-Mutaz, I. S.; Soliman, M. A.; Daghthem, A. M.
CS   Coll. Eng., King Saud Univ.
LO   Riyadh 11421, Saudi Arabia
SO   Desalination, 76(1-3), 177-87
SC   61-4 (Water)
DT   J
CO   DSLNAH
IS   0011-9164
PY   1989
LA   Eng
AN   CA112(12):104487m
AB   Two stage reverse osmosis desalination plants require only 1/2 of the multistage flash installation cost while producing water with comparable price. By combining seawater reverse osmosis plants with the dual purpose multistage flash plants, the capital and operating costs can be reduced and the excess power can be efficiently utilized. The design parameters for such a hybrid plant are the applied pressure, the recovery, the no. of stages, and heat transfer areas for the multistage flash plant. Different cost scenarios are suggested and their effect on the optimum parameters are

investigated. Significant savings can be obtained from upgrading of multistage flash and reverse osmosis plants instead of hybridization.

L16 ANSWER 4 OF 23 COPYRIGHT 1991 ACS
AN CA112(12):104358v
TI Prospects of hybrid RO [reverse osmosis]-MSF [multistage flash] desalting plants in Kuwait
AU Al-Marafie, A. M. R.
CS Coll. Eng. Pet., Kuwait Univ.
LO Kuwait 13060, Kuwait
SO Desalination, 72(3), 395-404
SC 61-0 (Water)
DT J
CO DSLNAH
IS 0011-9164
PY 1989
LA Eng
AN CA112(12):104358v
AB A review with 9 refs. discusses the economic feasibility of a hybrid single-stage reverse osmosis-multistage flash desalination plant and the benefits that Kuwait could accrue if such a system is implemented. Topics covered include water consumption pattern in Kuwait, features of a hybrid system, and the economics of a hybrid reverse osmosis-multistage flash desalination plant.

L16 ANSWER 5 OF 23 COPYRIGHT 1991 ACS
AN CA112(12):104353q
TI Integrated production of power and water
AU Al-Sofi, Mohamed Abdul Kareem
CS Saline Water Convers. Corp.
LO Alkhobar 31952, Saudi Arabia
SO Desalination, 76(1-3), 89-105
SC 61-0 (Water)
SX 48
DT J
CO DSLNAH
IS 0011-9164
PY 1989
LA Eng
AN CA112(12):104353q
AB The review and discussion, with 16 refs., covers integrated prodn. of power and water, including seawater desalination, reverse osmosis, multistage flash evapn., hybrid water desalination plants, and system flexibility and reliability.

L16 ANSWER 6 OF 23 COPYRIGHT 1991 ACS
AN CA112(10):83736z
TI Process arrangements for hybrid seawater desalination plants
AU Kamal, I.; Schneider, W.; Tusel, G. F.
LO Homburg/Saar, Fed. Rep. Ger.
SO Desalination, 76(1-3), 323-35
SC 61-4 (Water)
SX 52
DT J
CO DSLNAH
IS 0011-9164
PY 1989
LA Eng
AN CA112(10):83736z

AB The combination of 2 once-through multistage flash (MSF) desalination plants, or once-through MSF and reverse osmosis with power recovery, can lead to more economical plant designs than the brine recycle process currently used. Various combinations are compared wih a ref. case to illustrate the considerable power savings and improvement in the overall cost.

L16 ANSWER 7 OF 23 COPYRIGHT 1991 ACS
AN CA112(6):38583m
TI Dehydration of multicomponent organic systems by a reverse osmosis/pervaporation hybrid process. Module, process design and economics
AU Rautenbach, R.; Herion, C.; Franke, M.
CS Inst. Verfahrenstech., RWTH Aachen
LO Aachen D-5100, Fed. Rep. Ger.
SO Proc. Int. Conf. Pervaporation Processes Chem. Ind., 3rd, 274-86. Edited by: Bakish, Robert A. Bakish Mater. Corp.: Englewood, N. J.
SC 45-4 (Industrial Organic Chemicals, Leather, Fats, and Waxes)
DT C
CO 56POAK
PY 1988
LA Eng
AN CA112(6):38583m
AB For the recovery of a solvent mixt. from an aq. mixt., a process was developed consisting of reverse osmosis (RO) and phase sepn. in a first stage. The aq. phase of the separator was recirculated to the RO unit, thus permitting a high water recovery rate without exceeding the limiting orgs. concn. in the RO modules. The org. phase of the separator, contg. .apprx.30% water, was dehydrated to 2% water by pervaporation; results of iso-PrOH pervaporation expts. and calcns. on lab. and pilot scales were presented. Reasons for significantly lower performance of the pilot plant than predicted were discussed.

L16 ANSWER 8 OF 23 COPYRIGHT 1991 ACS
AN CA110(18):156441v
TI Dehydration of multicomponent organic systems by a reverse osmosis pervaporation-hybrid process - module-, process design and economics
AU Rautenbach, R.; Herion, C.; Franke, M.
CS Tech. Akad. Wuppertal
LO Wuppertal, Fed. Rep. Ger.
SO Desalination, 70(1-3), 445-53
SC 45-4 (Industrial Organic Chemicals, Leather, Fats, and Waxes)
SX 42, 60
DT J
CO DSLNAH
IS 0011-9164
PY 1988
LA Eng
AN CA110(18):156441v
AB The recovery of water and solvents from the aq. phase of materials obtained after steam stripping of active carbon adsorbents (used in paint-drying ovens) was discussed. The advantages of using a hybrid process consisting of a reverse-osmosis stage, a second phase sepn., and a pervaporation stage were illustrated.

L16 ANSWER 9 OF 23 COPYRIGHT 1991 ACS
AN CA110(12):101419p
TI Two examples of hybrid processes: electrodialysis - contact sludge reactor and reverse osmosis - phase separator

AU Rautenbach, R.; Kopp, W.; Herion, C.
CS Inst. Verfahrenstech., RWTH Aachen
LO Aachen 5100, Fed. Rep. Ger.
SO Chim. Oggi, (10), 51-5
SC 61-4 (Water)
SX 48, 60
DT J
CO CHOGDS
IS 0392-839X
PY 1988
LA Eng
AN CA110(12):101419p
AB Two examples are presented for substantially increasing the water recovery rate of membrane processes by the addn. of a mech. unit operation. In the 1st case, a crystallizer/clarifier was integrated into the retentate loop of an electrodialysis. In presence of sufficient amts. of seeding crystals, the crystallizer/clarifier prevented scaling and/or blocking of the electrodialysis membranes and spacers even at very high water recovery rates. Based on exptl. results, $MgSO_4$ and $CaCO_3$ were pptd. and sepd. besides $CaSO_4$. In the 2nd case, a gravity settler was integrated into the retentate loop of a reverse osmosis sepg. water from an aq. soln. of several org. solvents of industrial effluents. By recycling the water-rich phase from the settler, the water recovery rate of the process was extended to figures far above the limits of the reverse osmosis process set by osmotic pressure and chem. stability of the membranes.

L16 ANSWER 10 OF 23 COPYRIGHT 1991 ACS
AN CA108(24):206840f
TI Membrane-based hybrid processes
AU Gienger, J. K.; Ray, R. J.
CS Bend Res., Inc.
LO Bend, OR 97701-8599, USA
SO AIChE Symp. Ser., 84(261, New Membr. Mater. Processes Sep.), 168-77
SC 48-1 (Unit Operations and Processes)
DT J
CO ACSSCQ
IS 0065-8812
PY 1988
LA Eng
AN CA108(24):206840f
AB The evaluation of membrane-based hybrid processes is illustrated by generic optimization curves that are based on optimization variables appropriate for the particular sepn. examd. The optimization is described of a reverse-osmosis (RO)/evaporator hybrid process to conc. corn steep water, and a membrane/vapor-recompression hybrid process to recover energy from the exhaust air from coal drying.

L16 ANSWER 11 OF 23 COPYRIGHT 1991 ACS
AN CA108(2):10910j
TI Hybrid desalting systems - a new alternative
AU Awerbuch, Leon; Van der Mast, Victor; Soo-Hoo, Randall
CS Bechtel Natl. Inc.
LO San Francisco, CA, USA
SO Desalination, 64, 51-63
SC 61-4 (Water)
DT J
CO DSLNAH
IS 0011-9164

PY 1987
LA Eng
AN CA108(2):10910j
AB Design and economics of hybrid seawater desalination plants using multiple stage flash evapn. and reverse osmosis are described and discussed.

L16 ANSWER 12 OF 23 COPYRIGHT 1991 ACS
AN CA107(8):61946n
TI Simultaneous production of desalinated water and power using a hybrid-cycle OTEC plant
AU Panchal, C. B.; Bell, K. J.
CS Argonne Natl. Lab.
LO Argonne, IL 60439, USA
SO J. Sol. Energy Eng., 109(2), 156-60
SC 52-2 (Electrochemical, Radiational, and Thermal Energy Technology)
SX 61
DT J
CO JSEEDO
IS 0199-6231
PY 1987
LA Eng
AN CA107(8):61946n
AB A systems study was done for simultaneous prodn. of desalinated water and elec. power using a hybrid-cycle 10-MW OTEC system (combination of open and closed-cycle). Design and plant operating criteria for adjusting the ratio of water prodn. to power generation is described, and their effects on the total system were evaluated.

L16 ANSWER 13 OF 23 COPYRIGHT 1991 ACS
AN CA105(14):120136g
TI Membrane-based hybrid processes for energy-efficient waste-water treatment
AU Ray, Roderick J.; Kucera-Gienger, Jane; Retzlaff, Sandra
CS Bend Res., Inc.
LO Bend, OR 97701, USA
SO J. Membr. Sci., 28(1), 87-106
SC 60-3 (Waste Treatment and Disposal)
DT J
CO JMESDO
IS 0376-7388
PY 1986
LA Eng
AN CA105(14):120136g
AB Two different membrane-based hybrid wastewater treatment processes for corn steep water, and the recycle of space-station wash waters are discussed. Lab. data used to design the membrane section of each of the hybrid processes is presented. These processes make use of a novel, fouling-resistant reverse-osmosis membrane module. Also included is a discussion of the criteria used for the design of the membrane-based hybrid processes for each application. The corn-steep-water treatment process was optimized using operating costs as the optimization variable. The space-station wash water recycle system, however, was optimized for min. launch and resupply penalties and for min. power requirements. The expected performance of each membrane-based hybrid process is compared with the performance of the conventional unit operation.

L16 ANSWER 14 OF 23 COPYRIGHT 1991 ACS
AN CA105(14):118149v

TI Solar pond/fuel assisted water desalination plant
AU Aly, S. E.
CS King Abdulaziz Univ. Jeddah
LO Jeddah, Saudi Arabia
SO Waerme- Stoffuebertrag., 20(3), 263-8
SC 52-3 (Electrochemical, Radiational, and Thermal Energy Technology)
SX 48, 61, 69
DT J
CO WASBBW
IS 0042-9929
PY 1986
LA Eng
AN CA105(14):118149v
AB A thermodn. anal. of a hybrid solar pond/fuel-assisted generator-water desalination system shows that the plant can produce 70 kW shaft power with a basic efficiency of 15% and 200 ton/day fresh water. The plant concept has a power generation loop and a desalination loop that can operate sep. for power generation or can be combined to produce fresh water. The system design and component parameters are described.

L16 ANSWER 15 OF 23 COPYRIGHT 1991 ACS
AN CA104(6):39405b
TI Hybrid desalting technology maximizes recovery
AU Kohli, H.; Emmermann, D.; Kadaj, R.; Said, H.
CS Envirogenics Syst. Co.
LO El Monte, CA 91731, USA
SO Desalination, 56, 61-8
SC 61-4 (Water)
DT J
CO DSLNAH
IS 0011-9164
PY 1985
LA Eng
AN CA104(6):39405b
AB A combination of reverse osmosis and distn. technologies is employed in a 51,000 m3/day treatment plant to obtain 99% recovery. The desalination plant is designed to minimize reject-brine flow rate due to constraints on brine discharge. The treatment scheme specified includes softening by pellet reactors, gravity sand filtration followed by desalination and evapn. pond. Possibilities of eliminating lined evapn. ponds for reject brine by concg. brine to dry solids and pretreatment options for future plants are discussed.

L16 ANSWER 16 OF 23 COPYRIGHT 1991 ACS
AN CA104(4):23999n
TI Field trials of hybrid acid-additive treatment for control of scale in MSF plants
AU Butt, F.; Rahman, F.; Al-Abdallah, A.; Al-Zahrani, H.; Maadhah, A.; Amin, M.
CS Res. Inst., Univ. Pet. Miner.
LO Dhahran 31261, Saudi Arabia
SO Desalination, 54, 307-20
SC 61-8 (Water)
SX 56
DT J
CO DSLNAH
IS 0011-9164
PY 1985

LA Eng
AN CA104(4):23999n
AB Field trials of the additive-only (Albrivap-G [99627-90-4]) treatment and the hybrid (acid Albrivap DSB [99627-89-1]) treatment were carried out on an multistage flash (MSF) unit at 112.8.degree. top brine temp. The main objectives were to reduce the abnormally high frequency of acid cleaning with the existing additive treatment, and to test the techno-economic viability of the hybrid treatment. The economics and the corrosion and thermal performance of the hybrid treatment were outstanding: the period of operation between consecutive acid cleanings was increased from 19 days to .ltoreq.164 days (51/2 months) and the frequency of acid cleaning was thereby reduced from 7 to at most 1/yr of 51/2 operating months. The cost of scale control treatment was reduced by 50% and energy cost of the extn. steam was reduced by 11% resulting in considerable savings in the operating cost of the 3-unit MSF plant.

L16 ANSWER 17 OF 23 COPYRIGHT 1991 ACS
AN CA99(4):27723u
TI Reduction of nitrate concentration in drinking water by a hybrid process with zero discharge based on reverse osmosis
AU Van Opbergen, G.; Peters, T.; Rautenbach, R.; Tils, H.
CS Josef Van Opbergen
LO Neuss D-4040/22, Fed. Rep. Ger.
SO Desalination, 47, 267-74
SC 61-5 (Water)
SX 60
DT J
CO DSLNAH
IS 0011-9164
PY 1983
LA Eng
AN CA99(4):27723u
AB A hybrid process for removal of NO3- from well waters is based on reverse osmosis and solves the problem of the conc.-disposal by treating this conc. in a zero discharge system utilizing selective ion-exchange, electrodialysis and thin-film-evapn. A pilot-plant with a capacity of 50 m3/d permeate is under construction on the premises of a municipal waterworks. Special factors of interest are the reliability as well as the actual costs of such a process, the possibility of utilizing brine for the regeneration of the ion-exchanger, and the optimal concn. factors for every step of the process.

L16 ANSWER 18 OF 23 COPYRIGHT 1991 ACS
AN CA96(16):129475v
TI Desalination of sea water by an electrodialysis-reverse osmosis hybrid system
AU Schmoldt, H.; Strathmann, H.; Kaschemekat, J.
CS Forschungsinst., Berghof G.m.b.H.
LO Tuebingen, Fed. Rep. Ger.
SO Water, Essence Life, Proc. Int. Congr. Desalin. Water Re-use, Volume 1, 567-82. Edited by: Bakish, Robert. Int. Desalin. Environ. Assoc.: Teaneck, N. J.
SC 61-4 (Water)
DT C
CO 47IAA7
PY 1981
LA Eng
AN CA96(16):129475v

AB Seawater desalination by a 2-stage reverse osmosis-electrodialysis system has a small economic advantage over 2-stage reverse osmosis seawater desalination. Significant cost savings would result from using reverse osmosis membranes with a high flux and lower salt rejection but with low compaction values, with possible earlier switchover to the less costly electrodialysis process.

L16 ANSWER 19 OF 23 COPYRIGHT 1991 ACS
AN CA96(8):57497d
TI Combined MSF/VTE-modules for hybrid thermal seawater desalination plants
AU Hapke, J.; Uckermann, B.
CS Univ. Dortmund
LO Dortmund 4600, Fed. Rep. Ger.
SO Desalination, 39(1-2-3), 373-84
SC 61-4 (Water)
DT J
CO DSLNAH
IS 0011-9164
PY 1981
LA Eng
AN CA96(8):57497d
AB The design of combined MSF/VTE-modules for seawater desalination plants is described. A computer-aided model for the detn. of the mass and energy balance as well as for the rating of heat exchanger surfaces was established. The heating-surface-rating is the basis of design studies for standardized modules.

L16 ANSWER 20 OF 23 COPYRIGHT 1991 ACS
AN CA96(6):40642z
TI Desalination of sea water by an electrodialysis-reverse osmosis hybrid system
AU Schmoldt, H.; Strathmann, H.; Kaschemekat, J.
CS Forschungsinst. Berghof GmbH
LO Tuebingen, Fed. Rep. Ger.
SO Desalination, 38(1-2-3), 567-82
SC 61-4 (Water)
DT J
CO DSLNAH
IS 0011-9164
PY 1981
LA Eng
AN CA96(6):40642z
AB In a reverse osmosis unit with 4 plate and frame membrane modules with membranes of different order fluxes and salt rejections with feedwater (4.5% NaCl soln.) salt concns. <45,000 ppm and hydrostatic pressures <80 bar, membranes with a high salt rejection had relatively low flux but also relatively small compaction values while those with low salt rejection had high flux and large compaction. A hybrid system of reverse osmosis-electrodialysis with a electrodialysis unit consisting of one stack with a total membrane area of 300 m2 was more efficient than a 2-stage reverse osmosis system for desalination of seawater with a salt concn. of 45,000 ppm.

L16 ANSWER 21 OF 23 COPYRIGHT 1991 ACS
AN CA90(10):74319r
TI Hybrid cycle - ocean thermal energy conversion power desalting plant
AU Awerbuch, L.
CS Am. Embassy

LO Tel-Aviv, Israel
SO Proc. Int. Symp. Fresh Water Sea, 6(1), 347-56
SC 52-1 (Electrochemical, Radiational, and Thermal Energy Technology)
SX 48, 61
DT J
CO PSFSDZ
IS 0378-2298
PY 1978
LA Eng
AN CA90(10):74319r
AB In the title hybrid cycle, warm seawater is flashed in a barometric flash evaporator, the steam flows to the shell side of a double-fluted tube evaporator or the tube side of a horizontal spray film evaporator with the boiling of NH3 and the prodn. of distd. water. The NH3 vapor drives a turbogenerator and the exhausted NH3 vapor is condensed in an indirect condenser by cold seawater and recycled. Flash and indirect evaporator designs, noncondensible gas removal, heat-transfer enhancement, temp. losses, and fouling are discussed.

L16 ANSWER 22 OF 23 COPYRIGHT 1991 ACS
AN CA86(22):160558s
TI Hybrid reverse osmosis - ultrafiltration membranes
AU Sachs, S. B.; Zisner, E.; Herscovici, G.; Shelef, G.
CS Israel Desalination Eng.
LO Tel-Aviv, Israel
SO Proc. Int. Symp. Fresh Water Sea, 4, 167-77
SC 60-1 (Sewage and Wastes)
SX 37
DT J
CO PSFSDZ
PY 1976
LA Eng
AN CA86(22):160558s
AB Assym. non-cellulosic membranes having a intermediate performance between the reverse osmosis membrane and an ultrafilter have been developed. The main characteristics are high fluxes [4-10 m3/m2 day at low pressure (6-10 atm)] and moderate rejections for various salts. From 200 mg/L solns. of NaNO3, Na2SO4, and KH2PO4, rejections up to 40%, 70% and 90%, resp., were obtained. The new membranes can withstand large variations in pH (1-13) and have excellent chem. and biol. stability. The membranes have been tested in a mobile sewage ultrafiltration pilot plant operating on oxidn. pond effluent. High rejections for BOD, COD, bacteria and suspended solids as well as a 20% redn. in salinity have been obtained.

L16 ANSWER 23 OF 23 COPYRIGHT 1991 ACS
AN CA86(20):145218n
TI Hybrid reverse osmosis - ultrafiltration membranes
AU Sachs, S. B.; Zisner, E.; Herscovici, G.
CS Israel Desalination Eng.
LO Tel Aviv, Israel
SO Desalination, 18(2), 99-111
SC 60-2 (Sewage and Wastes)
DT J
CO DSLNAH
PY 1976
LA Eng
AN CA86(20):145218n
AB A new group of asymmetric noncellulosic membranes having

performances intermediate between those of conventional reverse-osmosis membranes and ultrafilter is discussed. The chief characteristics of the membranes are high fluxes (4-10 m3/m2-day) at low pressures (6-10 atm) and moderate rejection for various salts. With 200 mg/L solns of $NaNO_3$, Na_2SO_4, and KH_2PO_4, rejections .ltoreq.40%, 70%, and 90%, resp., were obtained. The new membranes can withstand large variations in pH (1-13) and have excellent chem. and biol. stability. In tests in a mobile sewage treatment pilot plant, operating on oxidn. pond effluent, high rejections for BOD, COD, bacteria, and suspended solids as well as a 20% redn. in salinity were obtained.

海水淡水化ﾊｲﾌﾞﾘｯﾄﾞ法に関する文献

1．使用ﾃﾞｰﾀﾍﾞｰｽ　　DIALOG
2．検索期間
3．検索結果

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6: NTIS_64-92/9201B1	27
8: COMPENDEX PLUS_1970-1991/NOV	51
40: ENVIROLINE_70-91/NOV	10
41: POLLUTION ABSTRACTS _ 70-91/NOV	10
44: AQUATIC SCIENCE ABSTRACTS _ 78-91/SEP	13
103: ENERGY SCIENCE & TECHNOLOGY_74-91/DEC(ISS23)	64
TOTAL: FILES 6,8,40 and ...	175

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APPENDIX R6—3

APPENDIX R6-3 Result of the Simulated Hybrid RO Plant

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990) 01-10-92
Calculation was made by: NITTO DENKO

Project name : NACL RO SYSTEM SIMURATION Permeate flow : 29065 GPD

Feedwater temperature : 20.0 C
Raw water pH : 6.50
Acid dosage, ppm(100%): 0.0 H2SO4
Acidified feed CO2,ppm : 0.0

Recovery : 35.0%
Element age : 0.0 years
Flux decline coefficient : -0.035
3-yr salt passage increase factor :1.5

Feed Pressure : 810.3 psi Concentrate Pressure : 776.3 psi

Pass	Feed Flow Total gpm	Feed Flow Vessel gpm	Conc. Flow Total gpm	Conc. Flow Vessel gpm	Beta	Conc. Press. psi	Element Type	Element No.	Array
1	57.7	57.7	37.5	37.5	1.04	776.3	UTC-80HF-SW8"S	6	1x6

Ion	Raw water mg/l	Raw water ppm*	Feed water mg/l	Feed water ppm*	Permeate mg/l	Permeate ppm*	Concentrate mg/l	Concentrate ppm*
Ca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	13760.0	29913.0	13760.0	29913.0	276.0	599.9	21020.6	45697.0
K	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HCO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cl	21240.0	29957.7	21240.0	29957.7	425.4	599.9	32447.9	45765.7
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	0.0		0.0		0.0		0.0	
TDS	35000.0		35000.0		701.3		53468.5	
pH	6.5		6.5					

Notes: *ppm as CaCO3. Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	0.0	0.0	0.0
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.0	0.0	0.0
Langelier ind.	0.00	0.00	0.00
Stiff & Davis ind.	0.00	0.00	0.00
Ionic strength	0.62	0.62	0.97
Osmotic press.,psi	407.2	407.2	634.2

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990) 01-10-92
Calculation was made by: NITTO DENKO

Project name : NACL RO SYSTEM SIMURATION Permeate flow : 29065 GPD

Feedwater temperature : 20.0 C
Raw water pH : 6.50
Acid dosage, ppm(100%): 0.0 H2SO4
Acidified feed CO2,ppm : 0.0

Recovery : 35.0%
Element age : 0.0 years
Flux decline coefficient : -0.035
3-yr salt passage increase factor :1.5

Feed Pressure : 887.6 psi Concentrate Pressure : 853.1 psi

Pass	Feed Flow Total gpm	Feed Flow Vessel gpm	Conc. Flow Total gpm	Conc. Flow Vessel gpm	Beta	Conc. Press. psi	Element Type	Element No.	Array
1	57.7	57.7	37.5	37.5	1.05	853.1	UTC-80HR-SW8"S	6	1x6

Ion	Raw water mg/l	Raw water ppm*	Feed water mg/l	Feed water ppm*	Permeate mg/l	Permeate ppm*	Concentrate mg/l	Concentrate ppm*
Ca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	13760.0	29913.0	13760.0	29913.0	126.7	275.4	21101.0	45871.8
K	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HCO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cl	21240.0	29957.7	21240.0	29957.7	195.3	275.4	32571.8	45940.5
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	0.0		0.0		0.0		0.0	
TDS	35000.0		35000.0		322.0		53672.8	
pH	6.5		6.5					

Notes: *ppm as CaCO3. Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	0.0	0.0	0.0
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.0	0.0	0.0
Langelier ind.	0.00	0.00	0.00
Stiff & Davis ind.	0.00	0.00	0.00
Ionic strength	0.62	0.62	0.97
Osmotic press.,psi	407.2	407.2	636.8

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990) 01-10-92
Calculation was made by: NITTO DENKO

Project name : NACL RO SYSTEM SIMURATION Permeate flow : 29065 GPD

Feedwater temperature :	20.0 C	Recovery :	35.0%
Raw water pH :	6.50	Element age :	0.0 years
Acid dosage, ppm(100%):	0.0 H2SO4	Flux decline coefficient :	-0.035
Acidified feed CO2,ppm :	0.0	3-yr salt passage increase factor :	1.5

Feed Pressure : 1021.7 psi Concentrate Pressure : 986.6 psi

Pass	Feed Flow Total gpm	Feed Flow Vessel gpm	Conc. Flow Total gpm	Conc. Flow Vessel gpm	Beta	Conc. Press. psi	Element Type	Element No.	Array
1	57.7	57.7	37.5	37.5	1.06	986.6	SC-8000-SW8"S	6	1x6

Ion	Raw water mg/l	Raw water ppm*	Feed water mg/l	Feed water ppm*	Permeate mg/l	Permeate ppm*	Concentrate mg/l	Concentrate ppm*
Ca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	13760.0	29913.0	13760.0	29913.0	442.7	962.4	20930.9	45501.9
K	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HCO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cl	21240.0	29957.7	21240.0	29957.7	682.3	962.4	32309.5	45570.5
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	0.0		0.0		0.0		0.0	
TDS	35000.0		35000.0		1125.0		53240.4	
pH	6.5		6.5					

Notes: *ppm as CaCO3. Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	0.0	0.0	0.0
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.0	0.0	0.0
Langelier ind.	0.00	0.00	0.00
Stiff & Davis ind.	0.00	0.00	0.00
Ionic strength	0.62	0.62	0.96
Osmotic press.,psi	407.2	407.2	631.3

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990) 01-10-92
Calculation was made by: NITTO DENKO

Project name : NACL RO SYSTEM SIMURATION   Permeate flow : 29065 GPD

Feedwater temperature :	20.0 C	Recovery :	35.0%
Raw water pH :	6.50	Element age :	0.0 years
Acid dosage, ppm(100%):	0.0 H2SO4	Flux decline coefficient :	-0.035
Acidified feed CO2,ppm :	0.0	3-yr salt passage increase factor :	1.5

Feed Pressure : 748.2 psi   Concentrate Pressure : 714.6 psi

Pass	Feed Flow Total gpm	Feed Flow Vessel gpm	Conc. Flow Total gpm	Conc. Flow Vessel gpm	Beta	Conc. Press. psi	Element Type	Element No.	Array
1	57.7	57.7	37.5	37.5	1.03	714.6	UTC-70-SW8"S	6	1x6

	Raw water		Feed water		Permeate		Concentrate	
Ion	mg/l	ppm*	mg/l	ppm*	mg/l	ppm*	mg/l	ppm*
Ca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	13760.0	29913.0	13760.0	29913.0	678.5	1475.0	20803.9	45225.8
K	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HCO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cl	21240.0	29957.7	21240.0	29957.7	1045.8	1475.0	32113.8	45294.5
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	0.0		0.0		0.0		0.0	
TDS	35000.0		35000.0		1724.3		52917.7	
pH	6.5		6.5					

Notes: *ppm as CaCO3.   Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	0.0	0.0	0.0
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.0	0.0	0.0
Langelier ind.	0.00	0.00	0.00
Stiff & Davis ind.	0.00	0.00	0.00
Ionic strength	0.62	0.62	0.96
Osmotic press.,psi	407.2	407.2	627.3

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990) 01-10-92
Calculation was made by: NITTO DENKO

Project name : NACL RO SYSTEM SIMURATION Permeate flow : 29065 GPD

Feedwater temperature : 20.0 C
Raw water pH : 6.50
Acid dosage, ppm(100%): 0.0 H2SO4
Acidified feed CO2,ppm : 0.0

Recovery : 35.0%
Element age : 0.0 years
Flux decline coefficient : -0.035
3-yr salt passage increase factor :1.5

Feed Pressure : 882.6 psi Concentrate Pressure : 848.1 psi

Pass	Feed Flow Total gpm	Feed Flow Vessel gpm	Conc. Total gpm	Flow Vessel gpm	Beta	Conc. Press. psi	Element Type	Element No.	Array
1	57.7	57.7	37.5	37.5	1.05	848.1	NTR-759SW-SW8S	6	1x6

Ion	Raw water mg/l	Raw water ppm*	Feed water mg/l	Feed water ppm*	Permeate mg/l	Permeate ppm*	Concentrate mg/l	Concentrate ppm*
Ca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	13760.0	29913.0	13760.0	29913.0	269.0	584.7	21024.4	45705.2
K	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HCO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cl	21240.0	29957.7	21240.0	29957.7	414.6	584.7	32453.7	45773.9
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	0.0		0.0		0.0		0.0	
TDS	35000.0		35000.0		683.6		53478.1	
pH	6.5		6.5					

Notes: *ppm as CaCO3. Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	0.0	0.0	0.0
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.0	0.0	0.0
Langelier ind.	0.00	0.00	0.00
Stiff & Davis ind.	0.00	0.00	0.00
Ionic strength	0.62	0.62	0.97
Osmotic press.,psi	407.2	407.2	634.3

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990) 01-10-92
Calculation was made by: NITTO DENKO

Project name : NACL RO SYSTEM SIMURATION Permeate flow : 29065 GPD

Feedwater temperature : 20.0 C
Raw water pH : 6.50
Acid dosage, ppm(100%): 0.0 H2SO4
Acidified feed CO2,ppm : 0.0

Recovery : 35.0%
Element age : 0.0 years
Flux decline coefficient : -0.035
3-yr salt passage increase factor :1.5

Feed Pressure : 807.4 psi Concentrate Pressure : 773.5 psi

Pass	Feed Flow Total gpm	Feed Flow Vessel gpm	Conc. Flow Total gpm	Conc. Flow Vessel gpm	Beta	Conc. Press. psi	Element Type	Element No.	Array
1	57.7	57.7	37.5	37.5	1.04	773.5	NTR-759HR-SW8S	6	1x6

Ion	Raw water mg/l	Raw water ppm*	Feed water mg/l	Feed water ppm*	Permeate mg/l	Permeate ppm*	Concentrate mg/l	Concentrate ppm*
Ca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	13760.0	29913.0	13760.0	29913.0	319.1	693.6	20997.4	45646.6
K	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HCO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cl	21240.0	29957.7	21240.0	29957.7	491.8	693.6	32412.1	45715.3
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	0.0		0.0		0.0		0.0	
TDS	35000.0		35000.0		810.8		53409.6	
pH	6.5		6.5					

Notes: *ppm as CaCO3. Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	0.0	0.0	0.0
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.0	0.0	0.0
Langelier ind.	0.00	0.00	0.00
Stiff & Davis ind.	0.00	0.00	0.00
Ionic strength	0.62	0.62	0.97
Osmotic press.,psi	407.2	407.2	633.5

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990) 01-10-92
Calculation was made by: NITTO DENKO

Project name : NACL RO SYSTEM SIMURATION Permeate flow : 29065 GPD

Feedwater temperature : 33.0 C
Raw water pH : 6.50
Acid dosage, ppm(100%): 0.0 H2SO4
Acidified feed CO2,ppm : 0.0

Recovery : 35.0%
Element age : 0.0 years
Flux decline coefficient : -0.035
3-yr salt passage increase factor :1.5

Feed Pressure : 835.6 psi Concentrate Pressure : 801.7 psi

Pass	Feed Flow Total gpm	Feed Flow Vessel gpm	Conc. Flow Total gpm	Conc. Flow Vessel gpm	Beta	Conc. Press. psi	Element Type	Element No.	Array
1	57.7	57.7	37.5	37.5	1.04	801.7	UTC-80HRSW8"S	6	1x6

Ion	Raw water mg/l	Raw water ppm*	Feed water mg/l	Feed water ppm*	Permeate mg/l	Permeate ppm*	Concentrate mg/l	Concentrate ppm*
Ca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	13760.0	29913.0	13760.0	29913.0	190.5	414.1	21066.7	45797.1
K	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HCO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cl	21240.0	29957.7	21240.0	29957.7	293.6	414.1	32518.8	45865.8
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	0.0		0.0		0.0		0.0	
TDS	35000.0		35000.0		484.0		53585.5	
pH	6.5		6.5					

Notes: *ppm as CaCO3. Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	0.0	0.0	0.0
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.0	0.0	0.0
Langelier ind.	0.00	0.00	0.00
Stiff & Davis ind.	0.00	0.00	- 0.00
Ionic strength	0.62	0.62	0.97
Osmotic press.,psi	425.3	425.3	663.9

HYDRANAUTICS DESIGN PROGRAM -- VERSION 4.05 (1990) 01-10-92
Calculation was made by: NITTO DENKO

Project name : NACL RO SYSTEM SIMURATION Permeate flow : 29065 GPD

Feedwater temperature : 33.0 C
Raw water pH : 6.50
Acid dosage, ppm(100%): 0.0 H2SO4
Acidified feed CO2,ppm : 0.0

Recovery : 35.0%
Element age : 0.0 years
Flux decline coefficient : -0.035
3-yr salt passage increase factor :1.5

Feed Pressure : 763.7 psi Concentrate Pressure : 730.6 psi

Pass	Feed Flow Total gpm	Feed Flow Vessel gpm	Conc. Flow Total gpm	Conc. Flow Vessel gpm	Beta	Conc. Press. psi	Element Type	Element No.	Array
1	57.7	57.7	37.5	37.5	1.03	730.6	UTC-80HFSW8"S	6	1x6

Ion	Raw water mg/l	Raw water ppm*	Feed water mg/l	Feed water ppm*	Permeate mg/l	Permeate ppm*	Concentrate mg/l	Concentrate ppm*
Ca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	13760.0	29913.0	13760.0	29913.0	415.1	902.4	20945.7	45534.1
K	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HCO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cl	21240.0	29957.7	21240.0	29957.7	639.8	902.4	32332.4	45602.8
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	0.0		0.0		0.0		0.0	
TDS	35000.0		35000.0		1054.9		53278.1	
pH	6.5		6.5					

Notes: *ppm as CaCO3. Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	0.0	0.0	0.0
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.0	0.0	0.0
Langelier ind.	0.00	0.00	0.00
Stiff & Davis ind.	0.00	0.00	0.00
Ionic strength	0.62	0.62	0.96
Osmotic press.,psi	425.3	425.3	659.8

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990) 01-10-92
Calculation was made by: NITTO DENKO

Project name : NACL RO SYSTEM SIMURATION   Permeate flow : 29065 GPD

Feedwater temperature :	33.0 C	Recovery :	35.0%
Raw water pH :	6.50	Element age :	0.0 years
Acid dosage, ppm(100%):	0.0 H2SO4	Flux decline coefficient :	-0.035
Acidified feed CO2,ppm :	0.0	3-yr salt passage increase factor :	1.5

Feed Pressure : 906.6 psi   Concentrate Pressure : 872.2 psi

Pass	Feed Flow Total gpm	Feed Flow Vessel gpm	Conc. Flow Total gpm	Conc. Flow Vessel gpm	Beta	Conc. Press. psi	Element Type	Element No.	Array
1	57.7	57.7	37.5	37.5	1.05	872.2	SC8000-SW8"S	6	1x6

Ion	Raw water mg/l	Raw water ppm*	Feed water mg/l	Feed water ppm*	Permeate mg/l	Permeate ppm*	Concentrate mg/l	Concentrate ppm*
Ca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	13760.0	29913.0	13760.0	29913.0	661.5	1438.0	20813.0	45245.8
K	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HCO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cl	21240.0	29957.7	21240.0	29957.7	1019.5	1438.0	32127.9	45314.4
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	0.0		0.0		0.0		0.0	
TDS	35000.0		35000.0		1681.0		52941.0	
pH	6.5		6.5					

Notes: *ppm as CaCO3.   Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	0.0	0.0	0.0
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.0	0.0	0.0
Langelier ind.	0.00	0.00	0.00
Stiff & Davis ind.	0.00	0.00	0.00
Ionic strength	0.62	0.62	0.96
Osmotic press.,psi	425.3	425.3	655.4

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990) 01-10-92
Calculation was made by: NITTO DENKO

Project name : NACL RO SYSTEM SIMURATION   Permeate flow : 29065 GPD

Feedwater temperature :	33.0 C	Recovery :	35.0%
Raw water pH :	6.50	Element age :	0.0 years
Acid dosage, ppm(100%):	0.0 H2SO4	Flux decline coefficient :	-0.035
Acidified feed CO2,ppm :	0.0	3-yr salt passage increase factor :	1.5

Feed Pressure : 729.9 psi   Concentrate Pressure : 697.5 psi

Pass	Feed Flow Total gpm	Feed Flow Vessel gpm	Conc. Flow Total gpm	Conc. Flow Vessel gpm	Beta	Conc. Press. psi	Element Type	Element No.	Array
1	57.7	57.7	37.5	37.5	1.02	697.5	UTC-70-SW8"S	6	1x6

Ion	Raw water mg/l	Raw water ppm*	Feed water mg/l	Feed water ppm*	Permeate mg/l	Permeate ppm*	Concentrate mg/l	Concentrate ppm*
Ca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	13760.0	29913.0	13760.0	29913.0	1025.2	2228.7	20617.2	44820.0
K	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HCO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cl	21240.0	29957.7	21240.0	29957.7	1580.1	2228.7	31826.1	44888.7
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	0.0		0.0		0.0		0.0	
TDS	35000.0		35000.0		2605.3		52443.3	
pH	6.5		6.5					

Notes: *ppm as CaCO3.   Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	0.0	0.0	0.0
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.0	0.0	0.0
Langelier ind.	0.00	0.00	0.00
Stiff & Davis ind.	0.00	0.00	0.00
Ionic strength	0.62	0.62	0.95
Osmotic press.,psi	425.3	425.3	648.9

HYDRANAUTICS DESIGN PROGRAM - VERSION 4.05 (1990) 01-10-92
Calculation was made by: NITTO DENKO

Project name : NACL RO SYSTEM SIMURATION   Permeate flow : 29065 GPD

Feedwater temperature : 33.0 C   Recovery : 35.0%
Raw water pH : 6.50   Element age : 0.0 years
Acid dosage, ppm(100%): 0.0 H2SO4   Flux decline coefficient : -0.035
Acidified feed CO2,ppm : 0.0   3-yr salt passage increase factor :1.5

Feed Pressure : 812.6 psi   Concentrate Pressure : 778.9 psi

Pass	Feed Flow Total gpm	Feed Flow Vessel gpm	Conc. Flow Total gpm	Conc. Flow Vessel gpm	Beta	Conc. Press. psi	Element Type	Element No.	Array
1	57.7	57.7	37.5	37.5	1.04	778.9	NTR-759SW-SW8S	6	1x6

Ion	Raw water mg/l	Raw water ppm*	Feed water mg/l	Feed water ppm*	Permeate mg/l	Permeate ppm*	Concentrate mg/l	Concentrate ppm*
Ca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Na	13760.0	29913.0	13760.0	29913.0	403.8	877.9	20951.8	45547.3
K	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
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	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HCO3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SO4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cl	21240.0	29957.7	21240.0	29957.7	622.4	877.9	32341.8	45616.0
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	0.0		0.0		0.0		0.0	
TDS	35000.0		35000.0		1026.3		53293.5	
pH	6.5		6.5					

Notes: *ppm as CaCO3.   Calculated concentrations are accurate to +/- 10%

	Raw water	Feed water	Concentrate
CaSO4/Ksp*100,%	0.0	0.0	0.0
SrSO4/Ksp*100,%	0.0	0.0	0.0
BaSO4/Ksp*100,%	0.0	0.0	0.0
SiO2 sat.,%	0.0	0.0	0.0
Langelier ind.	0.00	0.00	0.00
Stiff & Davis ind.	0.00	0.00	0.00
Ionic strength	0.62	0.62	0.96
Osmotic press.,psi	425.3	425.3	660.0