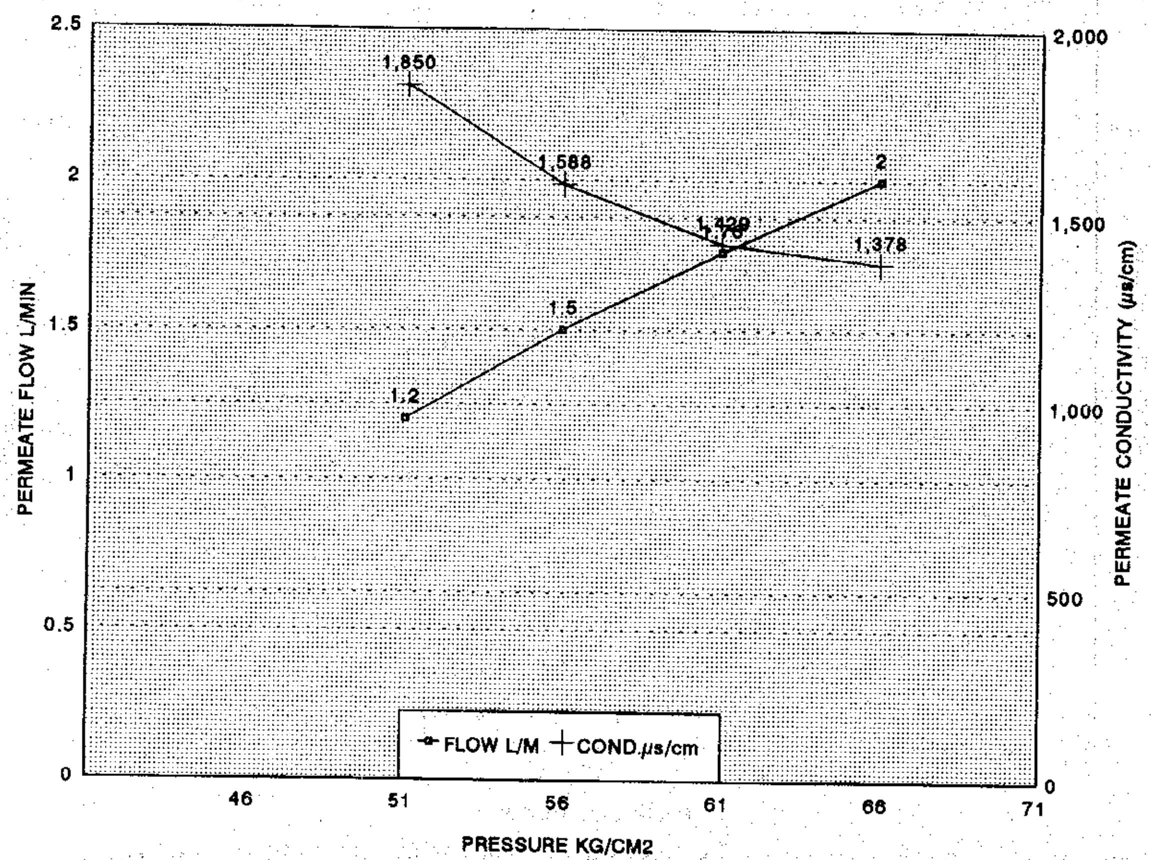

Fig. 6-A Performance of Fluid System TFCL S7721 SWRO Membrane

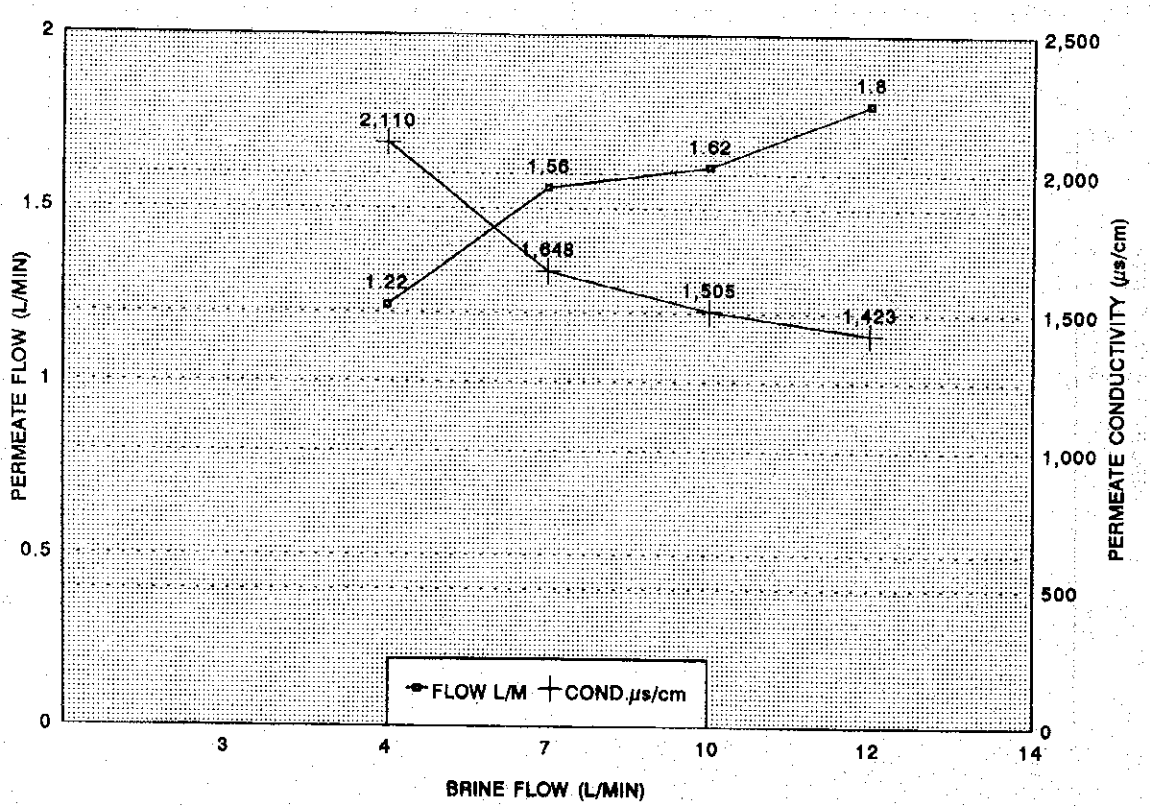

Fig. 6-B Performance of Fluid System TFCL S7721 SWRO Membrane

(OPERATION CONDITIONS:FEED SDI=2.5±0.2,pH=6.8±0.2, TWO ELEMENTS IN SERIES)

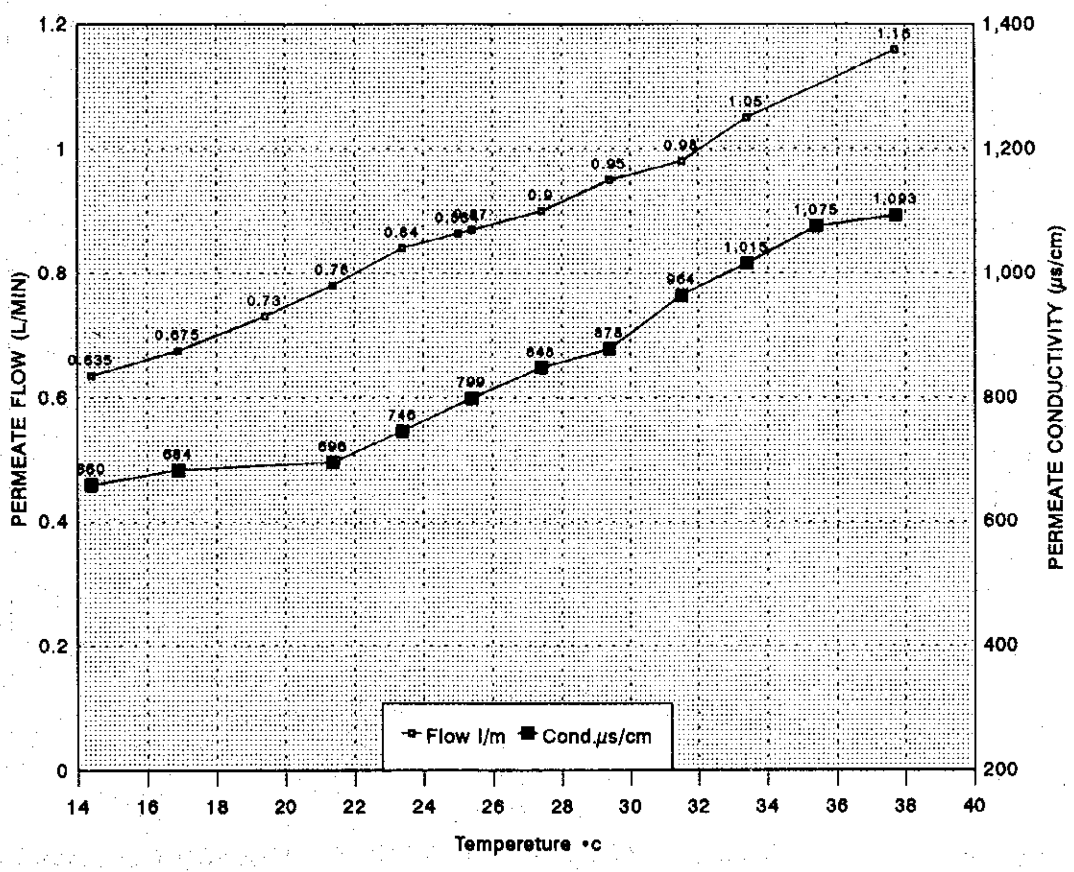

Fig. 7-A Performance of Fluid System TFCL S7721 Membrane vs Temperature

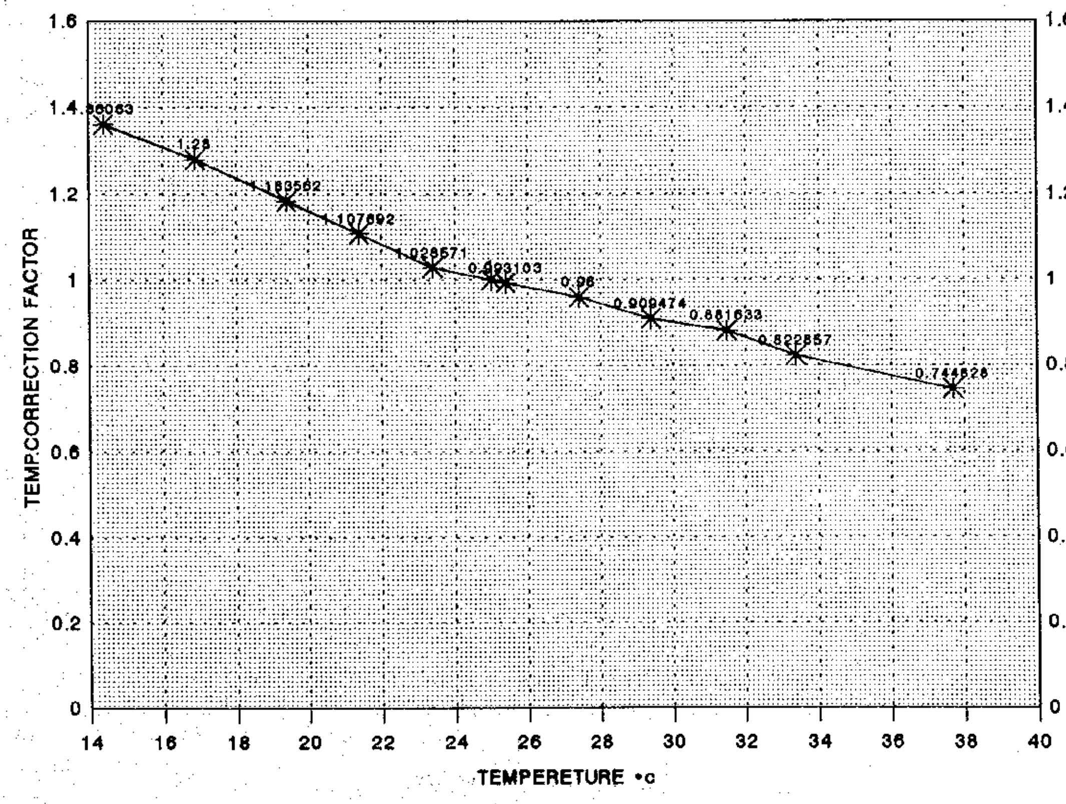

Fig. 7-B Performance of Fluid System TFCL S7721 Membrane vs Temperature

(OPERATION CONDITIONS: PRESSURE= 56 KG/CM2,FEED SDI=2.6, PRESSURE VESSEL 2.5 X 40 INCH)

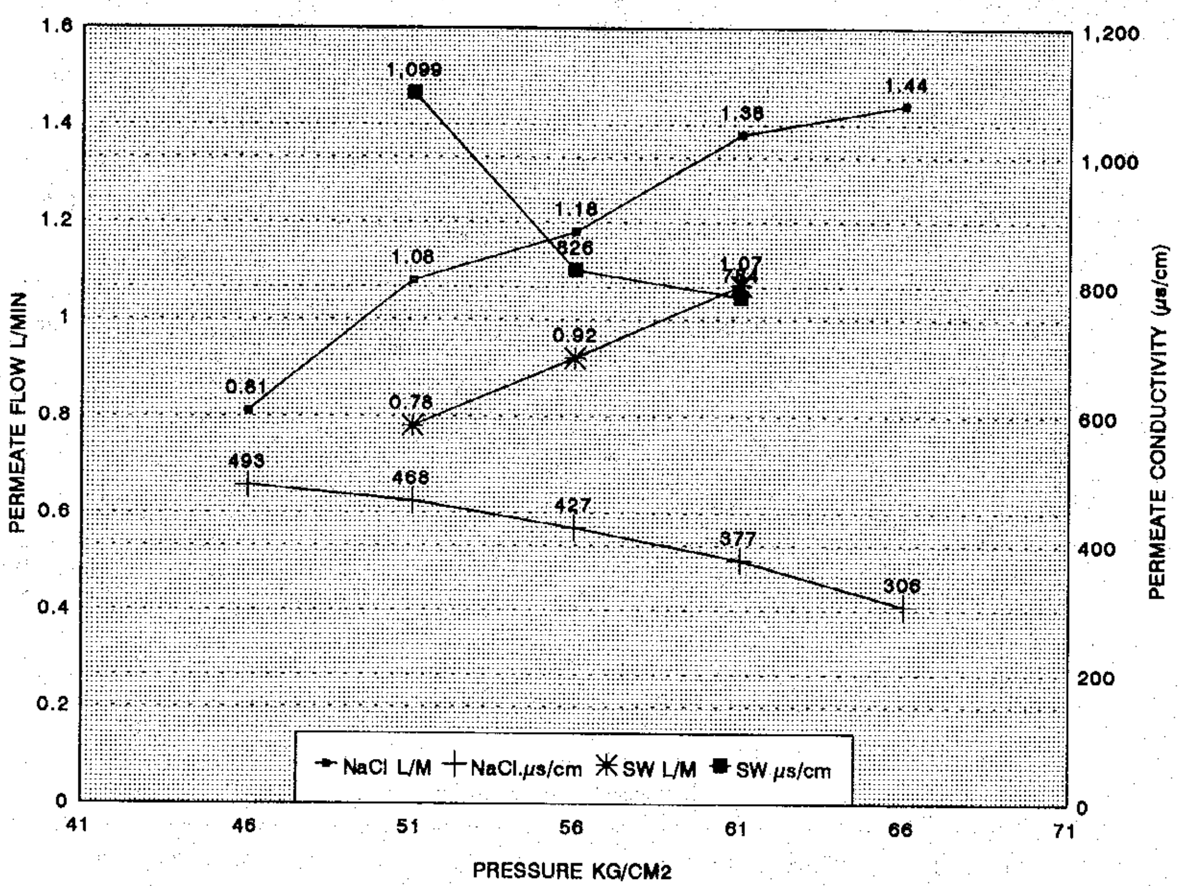

Fig. 8-A Performance of Fluid System TFCL S7721 SWRO Membrane

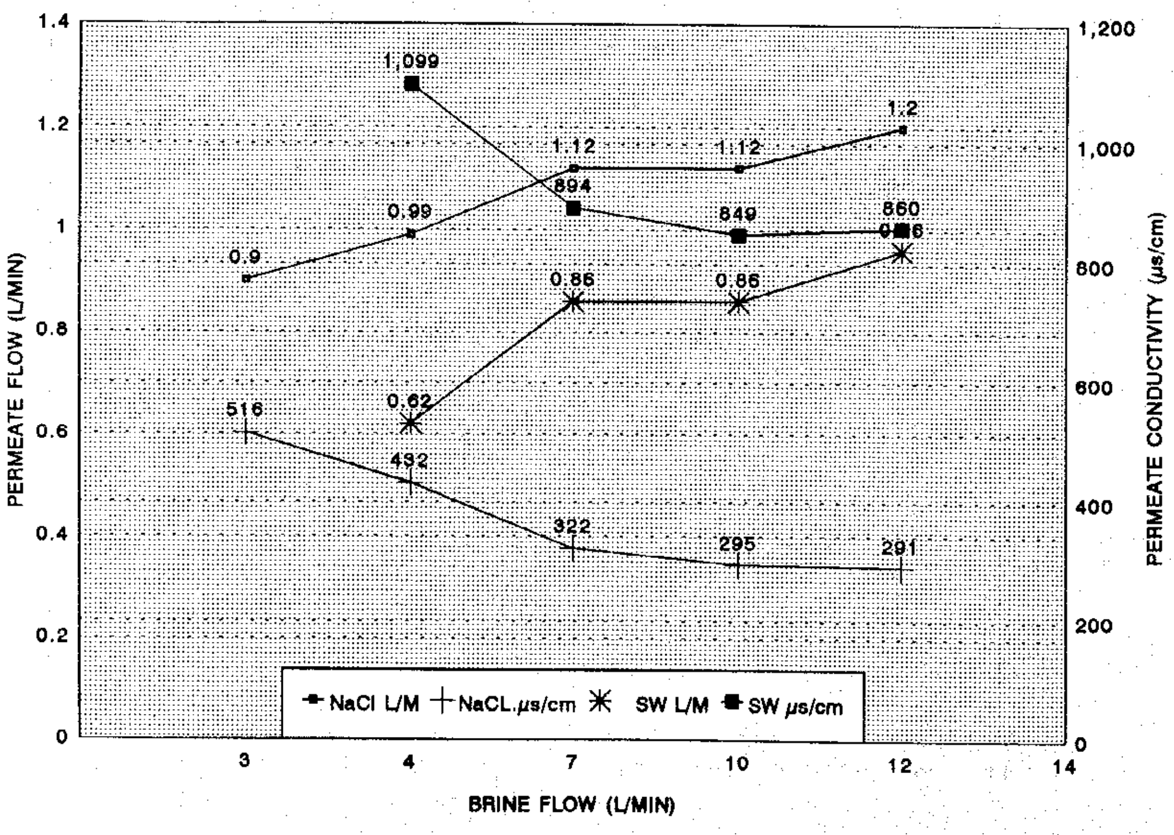

Fig. 8-B Performance of Fluid System TFCL S7721 SWRO Membrane

(OPERATION CONDITIONS:FEED= SEA WATER & 3.5% NaCl SOLUTION, pH=6.8,TEMP=25±2 °C, SINGLE ELEMENT)

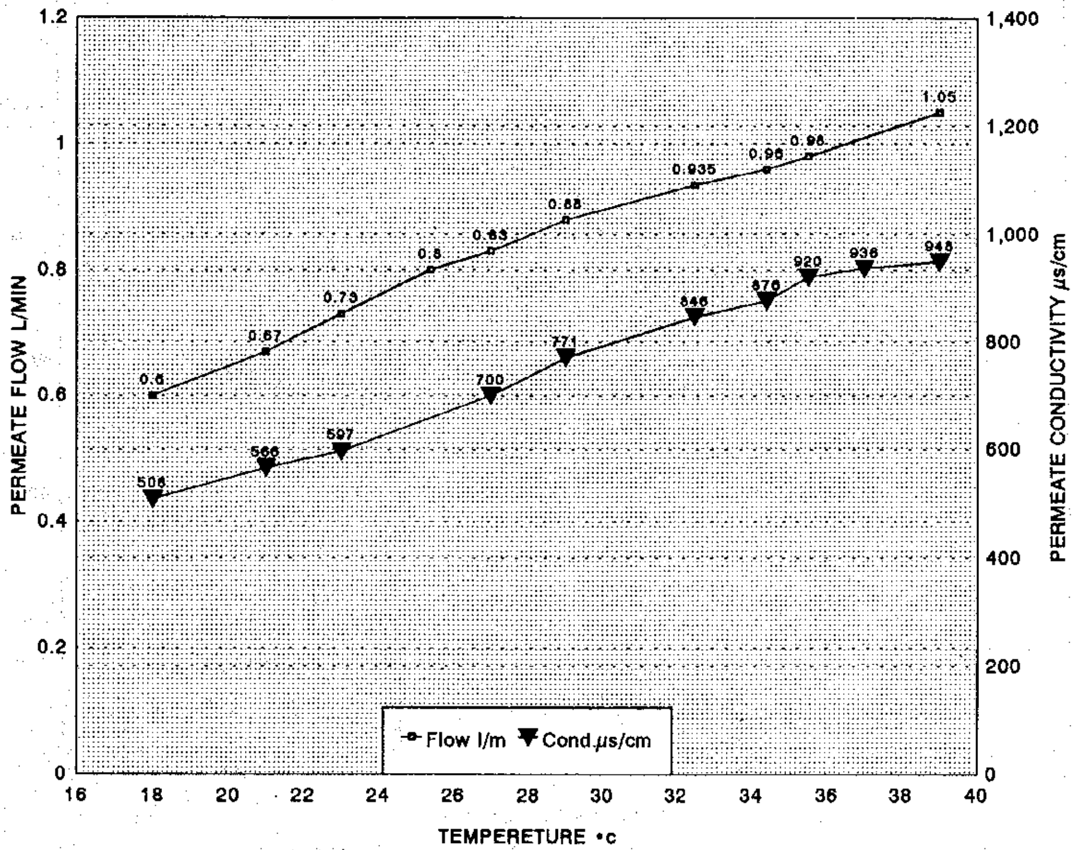

Fig. 9-A **Performance of Filmtec SW 2540 SWRO Membrane vs Temperature**

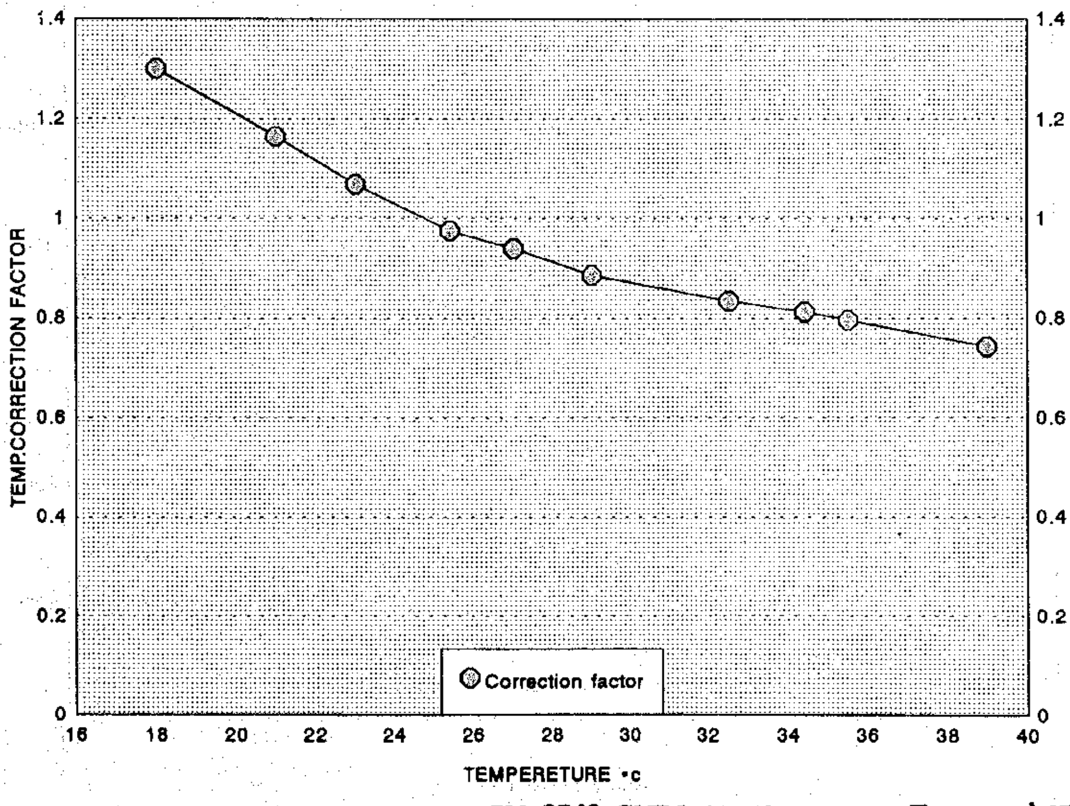

Fig. 9-B **Performance of Filmtec SW 2540 SWRO Membrane vs Temperature**

(OPERATION CONDITIONS:PRESSURE=56 KG/CM2, FEED SDI=2.4, PRESSURE VESSEL 2.5 X 40 INCH)

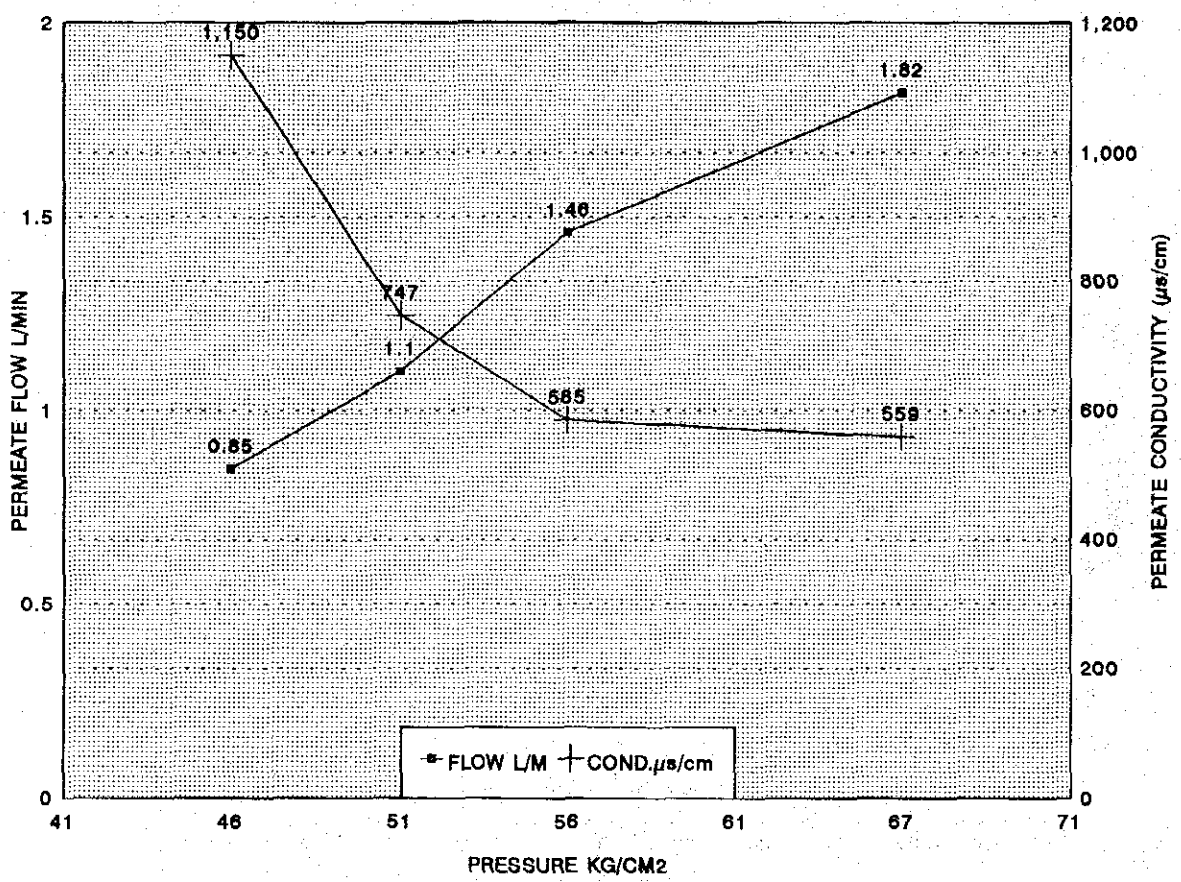

Fig. 10-A Performance of Filmtec SW 30-2540 SWRO Membrane

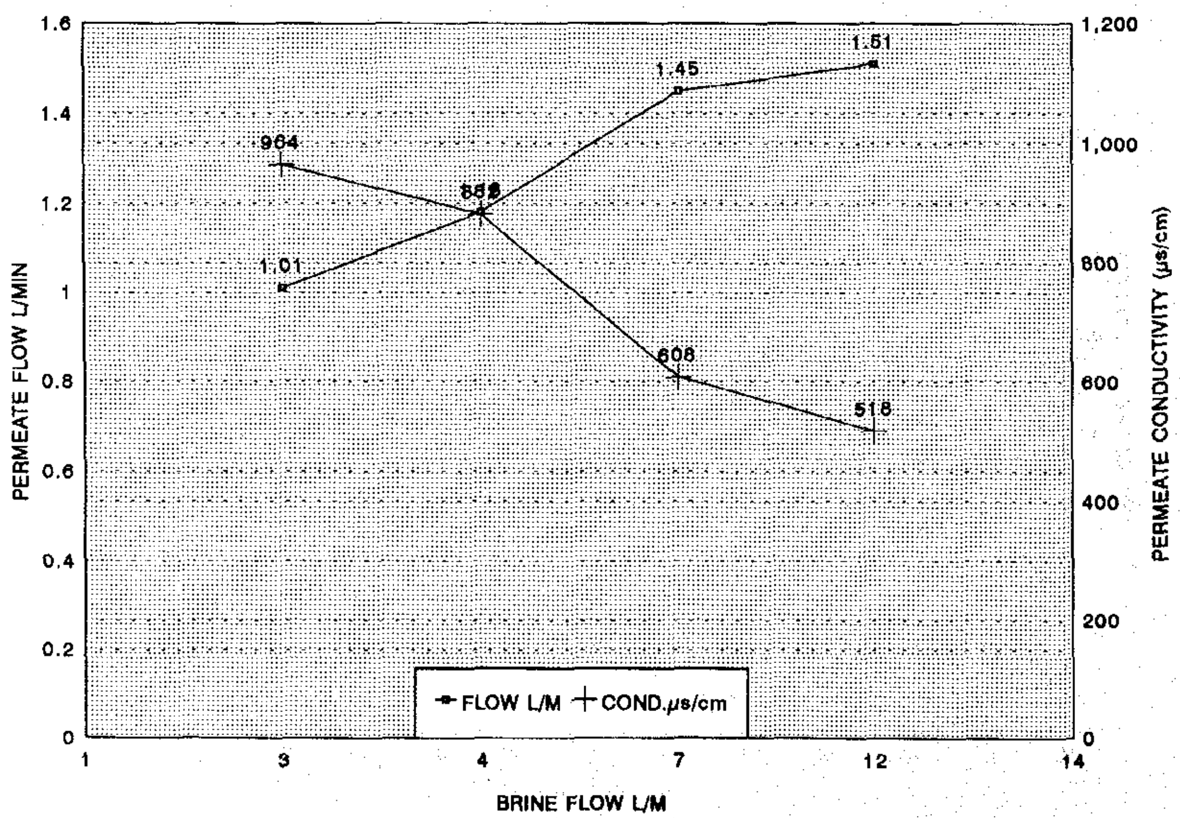

Fig. 10-B Performance of Filmtec SW 30-2540 SWRO Membrane

(OPERATION CONDITIONS:FEED SDI=2.5±0.5, pH=6.8±0.2, TEMP=25±2°C, TWO ELEMENTS IN SERIES)

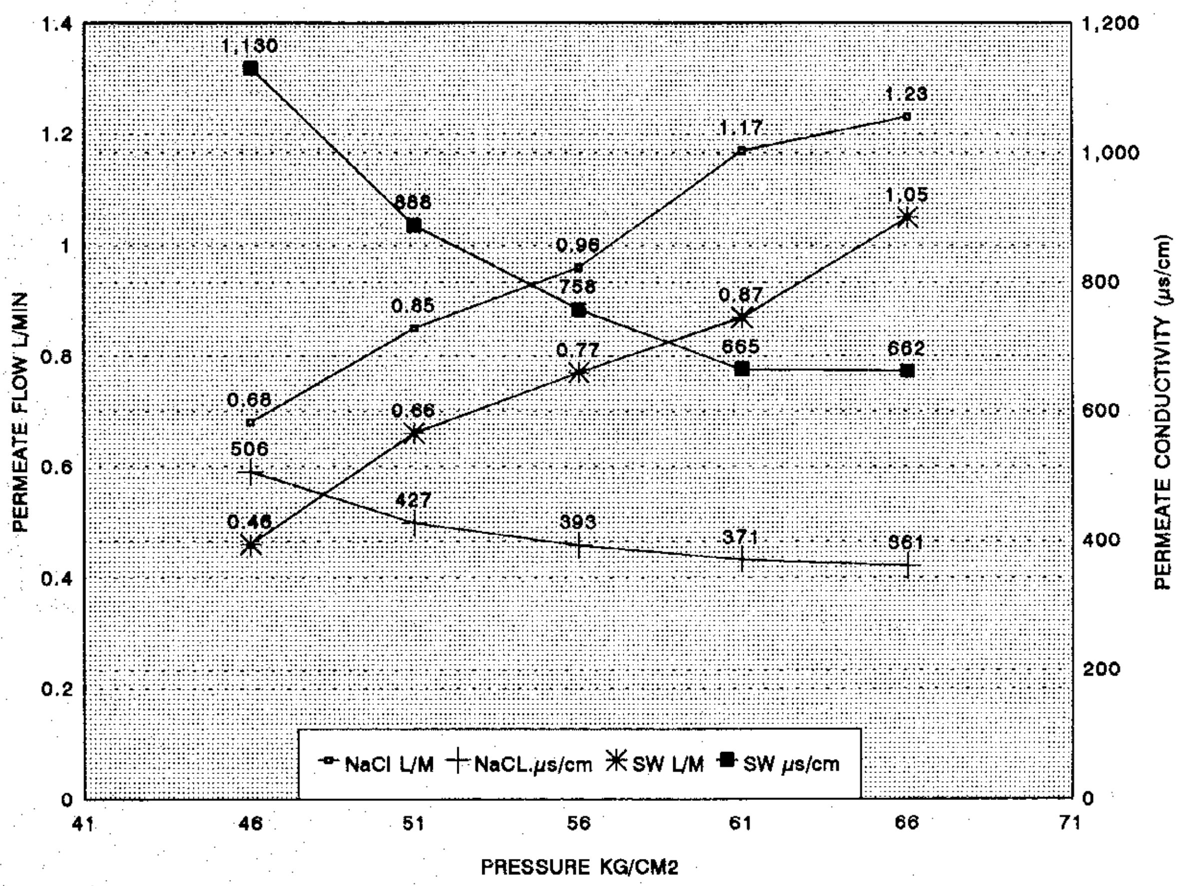

Fig. 11-A Performance of Filmtec SW 30-2540 SWRO Membrane

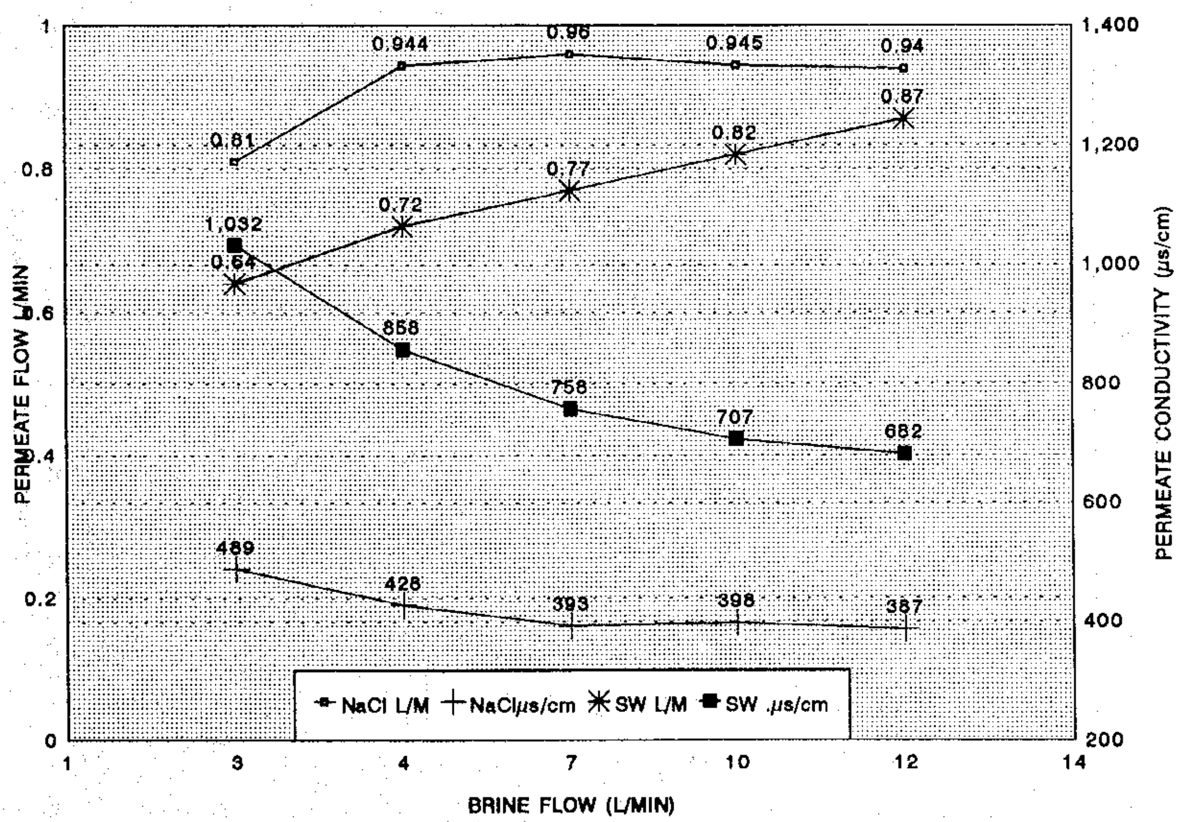

Fig. 11-B Performance of Filmtec SW 30-2540 SWRO Membrane

(OPERATION CONDITIONS: FEED= SEA WATER & 3.5% NaCl SOLUTION, pH=6.8±0.2, TEMP=25±2°C, SINGLE ELEMEN)

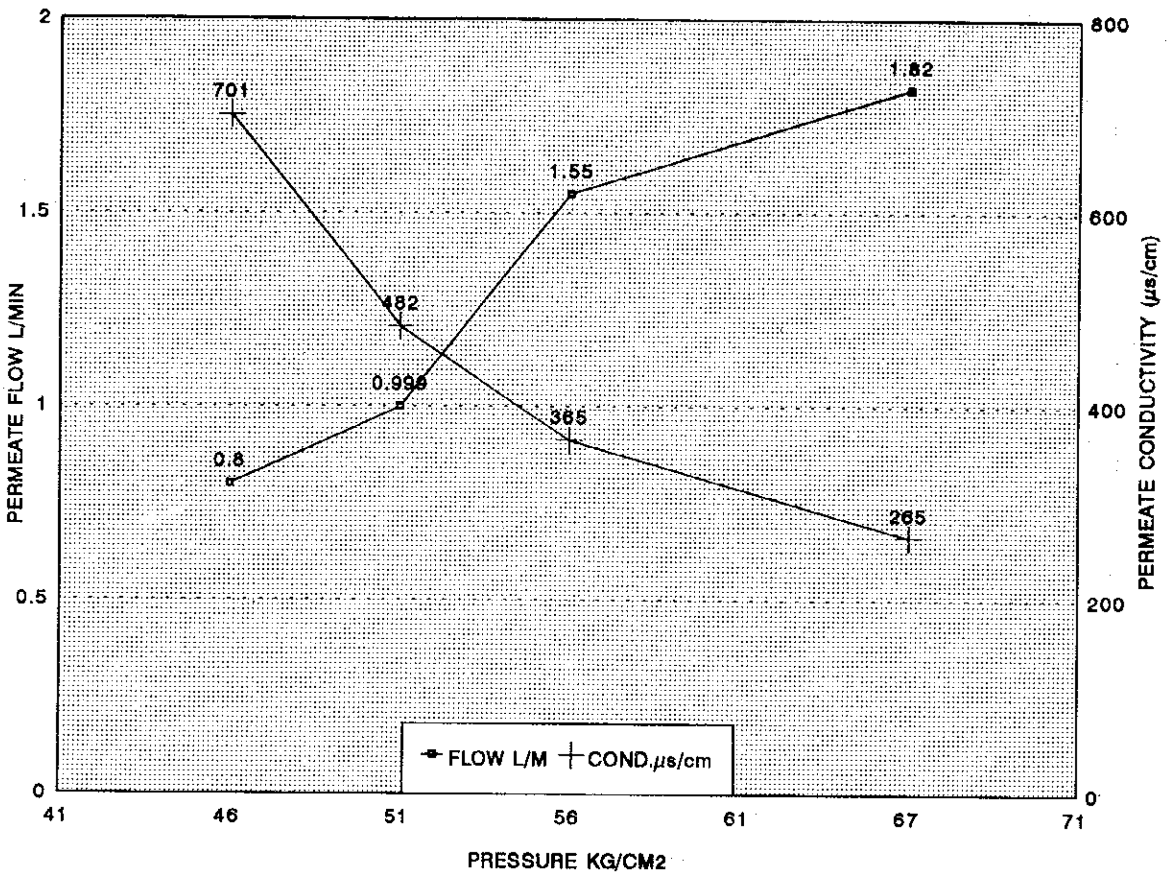

Fig. 12-A Performance of Filmtec SW 30HR-2540 SWRO Membrane

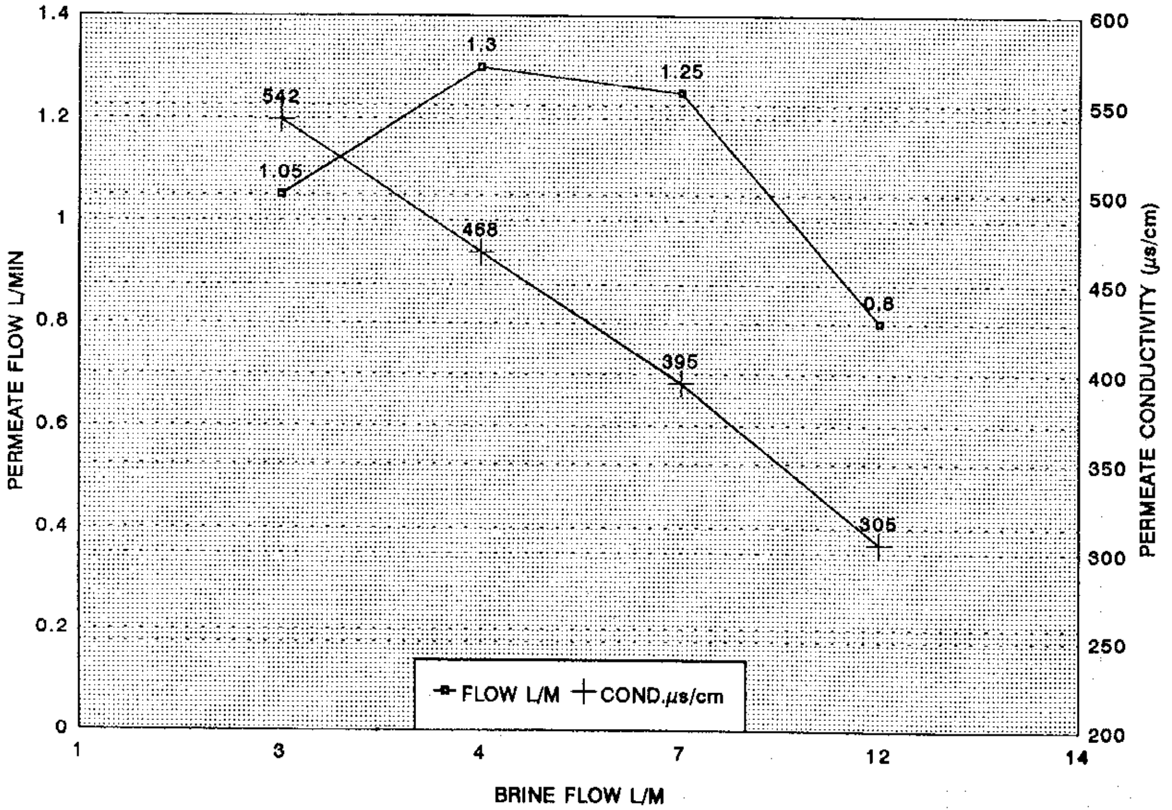

Fig. 12-B Performance of Filmtec SW 30HR-2540 SWRO Membrane

(OPERATION CONDITIONS:FEED SDI= 2.5±0.5, pH= 6.8±0.2, TEM=25±2°C,TWO ELEMENTS IN SERIES)

7.2.3 Tolerance Test in Chlorine and Turbidity with Mini–Module

Contents

List of Figures

1. Objectives

Chlorine tolerance tests for Mini-modules were scheduled in the initial plan. Results of the tolerance tests for chlorine conducted with flat sheet membranes showed that performance variation of SWRO membranes were deteriorated drastically in presence of chlorine in seawater feed at concentration of 0.3 to 10 ppm. It was concluded that it will not be wise to perform the chlorine tolerance test using the limited number of RO mini-module samples. It was decided that chlorine tolerance test with mini-modules is to be canceled and only turbidity tolerance test with mini-module to be performed. As no exact informations concerning RO module tolerance for turbidity are available.

Long run tolerance test operation for turbidity with mini-modules was performed and effects of turbidity on the performance of RO modules were measured. Turbid materials in seawater were collected and analyzed to determine the composition.

2. Experimental Methods

2.1 Experimental equipment:

Same equipment as in chapter 7.2.2

2.2 Feed:

Pretreated seawater, SDI<3,pH$\simeq$6.8, continuously supplied from SWCC pretreatment plant

2.3 Test Conditions:

Pressure=56Kg/cm2, Feed flow to each series= 10L/min.

2.4 Analytical methods

same as chapter 7.1.5A

3. Experimental Results

3.1 Turbidity tolerance test operation data:

The result of the long run turbidity tolerance test operation for 4570 hours with Mini-module tester(1) is shown on Fig. 1, Fig. 2, Fig. 3 and Fig. 4.

3.2 Analysis of raw seawater, RO feed water, permeate and concentrate

Analysis data obtained was shown in chapter 7.1.5.

3.3 Analysis of seawater turbid materials accumulated on Milli Pore Filter

Analysis data obtained was shown in chapter 7.1.5.

4. Discussion

Evaluation of Toray and Membrane:

Toray SU-806 and Nitto Denko NTR 70SWC-S2 were operated continuously. Membranes were tested placing three elements of each membrane in a series of the two parallel lines. Fig. 1 and 2 are the plots of permeate flow vs time and conductivity vs time for three Toray elements while Fig. 3 and 4 are the plot of permeate flow vs time and permeate conductivity vs time for three Nitto Denko elements, respectively.

As expected, in both systems the highest permeate flow is obtained from the lead element followed by from second element and is the least permeate flow was obtained from the third element. Moreover, the flow is substantially higher from the Toray system(compare Fig. 1 and 3). Again as expected, permeate conductivity is the highest for the product obtained from the third element followed by that from the second element and is the least for permeate obtained from the lead element. This was the case for the Nitto Denko elements, while unexpectedly the permeate from the Toray membrane lead element has higher conductivity than that of the second element permeate(Fig. 2), presumably due to their initial characteristic and salt rejection behavior. The Nitto Denko membrane tends to have a higher salt rejection than that of the Toray SU 806(Fig. 2 and 4)which may partially explain the lower permeate flow obtained from the Nitto Denko membranes as compared to the

Toray membranes.

Result of the test (feeding pre-treated seawater(SDI<3, pH=6.8) to RO mini-module tester continuously) shows, that SWRO membrane Toray and Nitto Denko can be operated for more than 5,000 hours satisfactorily using coagulation/filtration pre-treatment.

5. Conclusion

The product flow obtained from Toray SU-806 element is higher than that of Nitto Denko NTR 70S SWC-S2 element at same operating conditions and same feed flow and feed quality, reasonably due to high nominal surface area of Toray SU-806 (2.6 M^2/element) compared to Nitto Denko NTR 70SWC-S2 (1.2M^2/element). In order to conduct further investigation on all the membranes, it is necessary to obtain actual membrane area/element as well as standard linear velocity. However, Nitto Denko 70S SWC-S2 membrane have higher salt rejection compared to Toray SU-806 under the same conditions.

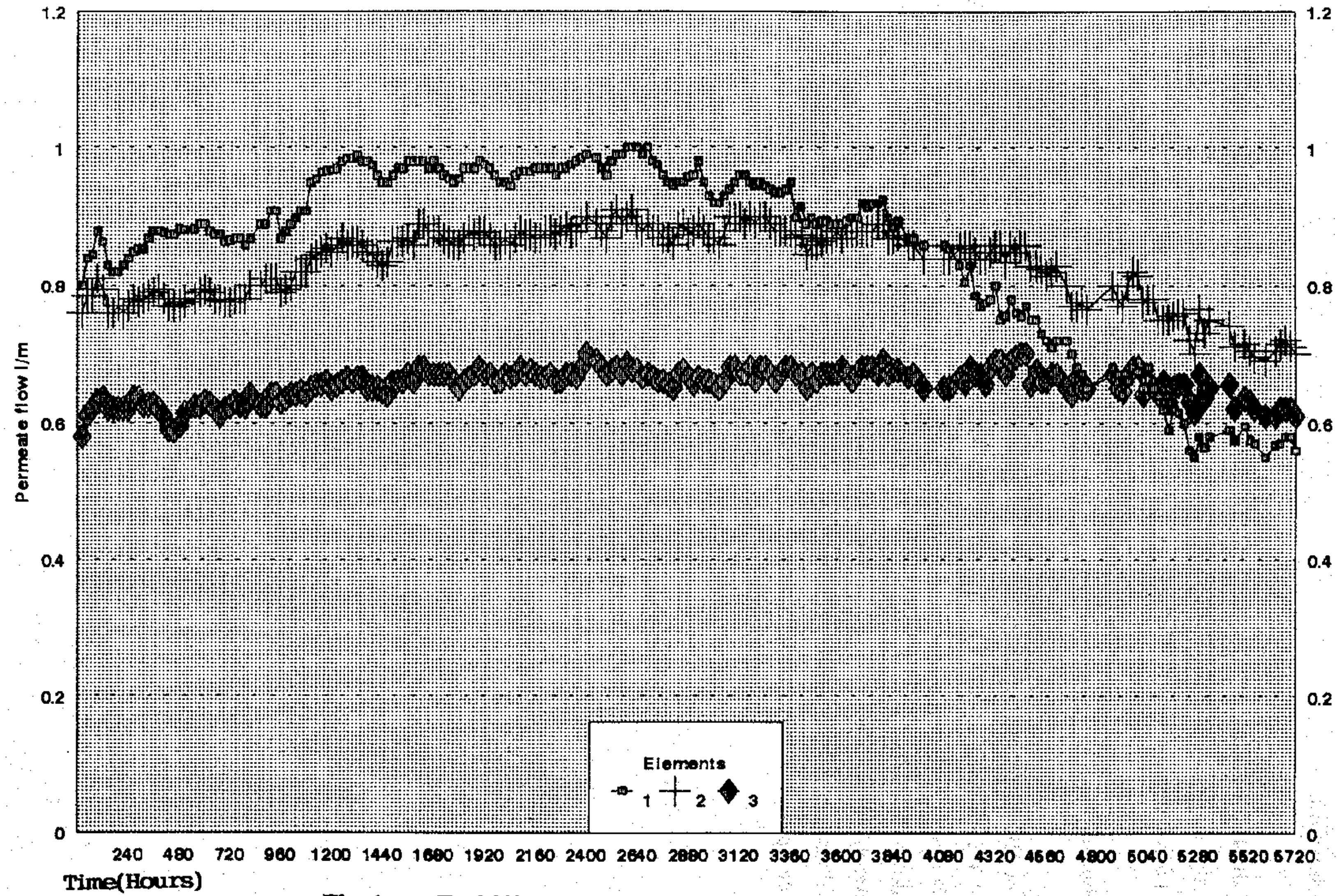

Fig. 1 Turbidity Tolerance Test, Permeate Flow vs Time

(Toray 2.5 Inch Elements SU 806 (Type–1)

(TEST CONDITIONS: THREE ELEMENTS, 25 EACH ARRANGE IN SERIES; SEA WATER SDI<3, pH=6.8, PRESSURE=56 kg/cm^2)

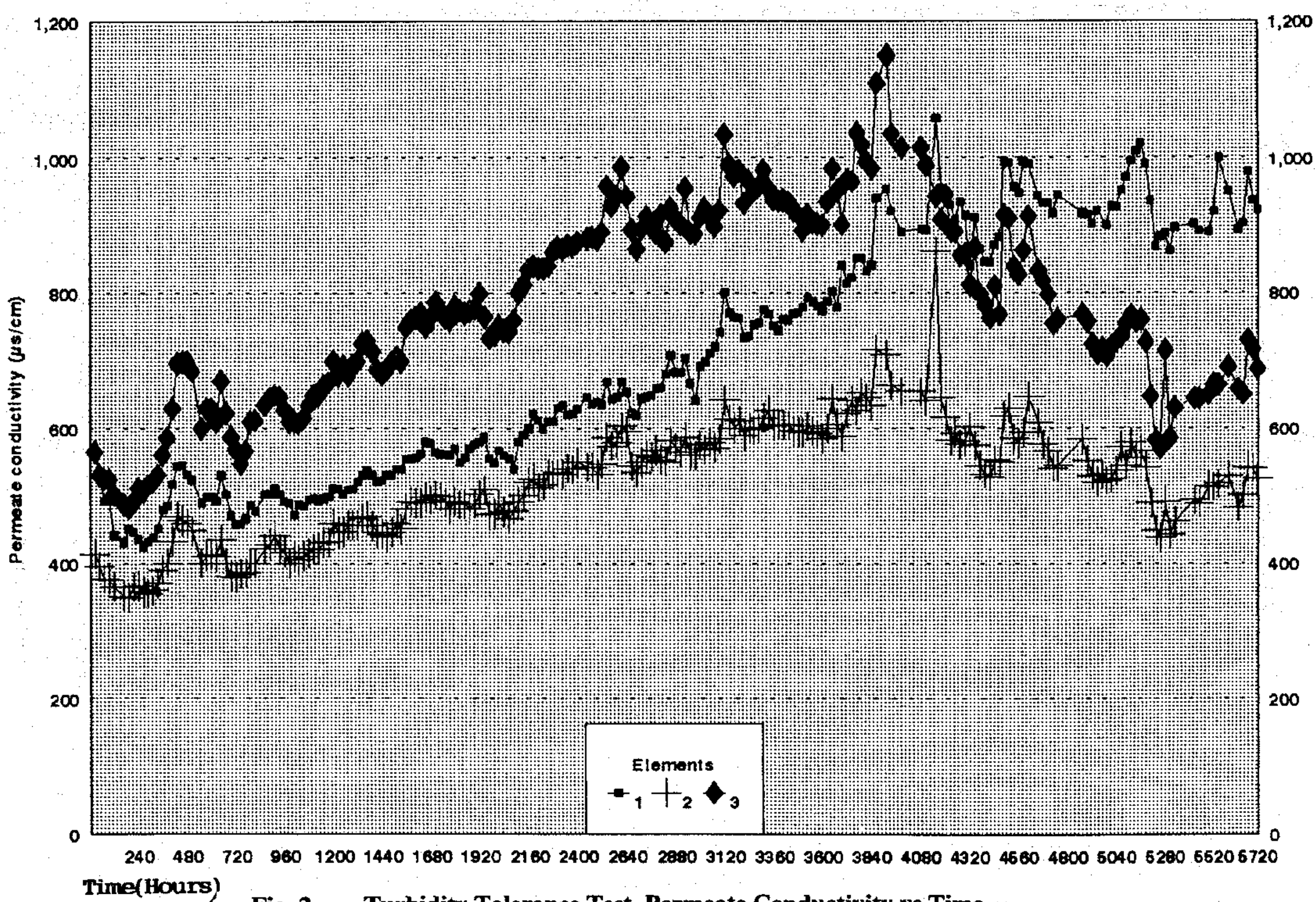

Fig. 2 **Turbidity Tolerance Test, Permeate Conductivity vs Time**
(Toray 2.5 Inch Elements SU 806 (Type–1)

(TEST CONDITIONS: THREE ELEMENTS, IN SERIES; SEA WATER SDI<3, pH=6.8, PRESSURE=56 kg/cm²)

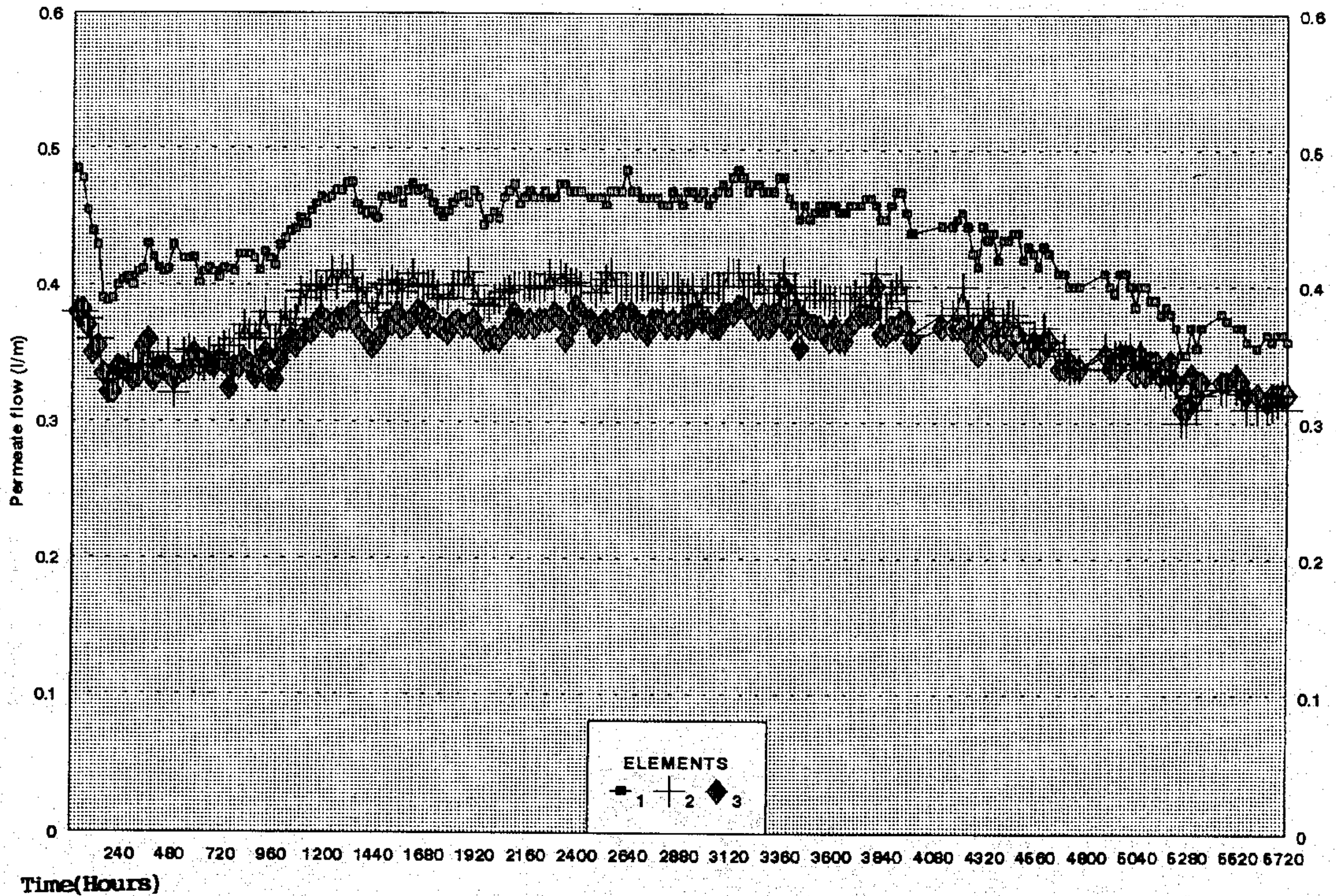

Fig. 3 **Turbidity Tolerance Test, Permeate Flow vs Time**

(Nitto Denko 2.5 Inch Elements NTR 70S SWC-S2)

(TEST CONDITIONS: THREE ELEMENTS, ARRANGED IN SERIES, FEED SDI<3, pH=6.8, PRESSURE=56 kg/cm^2)

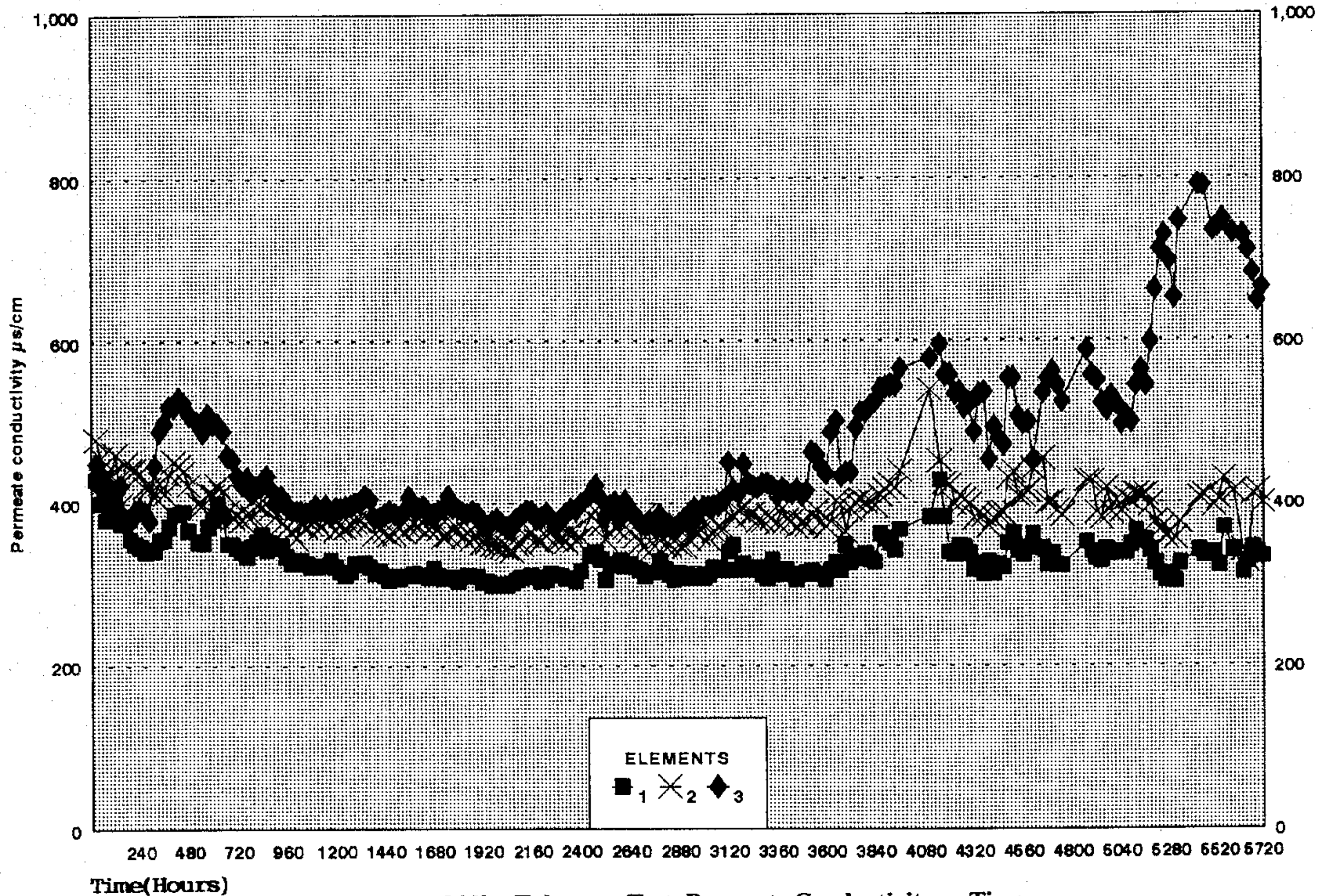

Fig. 4 **Turbidity Tolerance Test, Permeate Conductivity vs Time**
(Nitto Denko 2.5 Inch Elements NTR 70S–SWC–S2)

(TEST CONDITIONS: THREE ELEMENTS, ARRANGED IN SERIES, FEED SDI<3, pH=6.8, PRESSURE=56 kg/cm²)