Appendix 7.1.2-4

Disassembling Analysis and Evaluation of Fould Hollow Fine Fiber Membrane

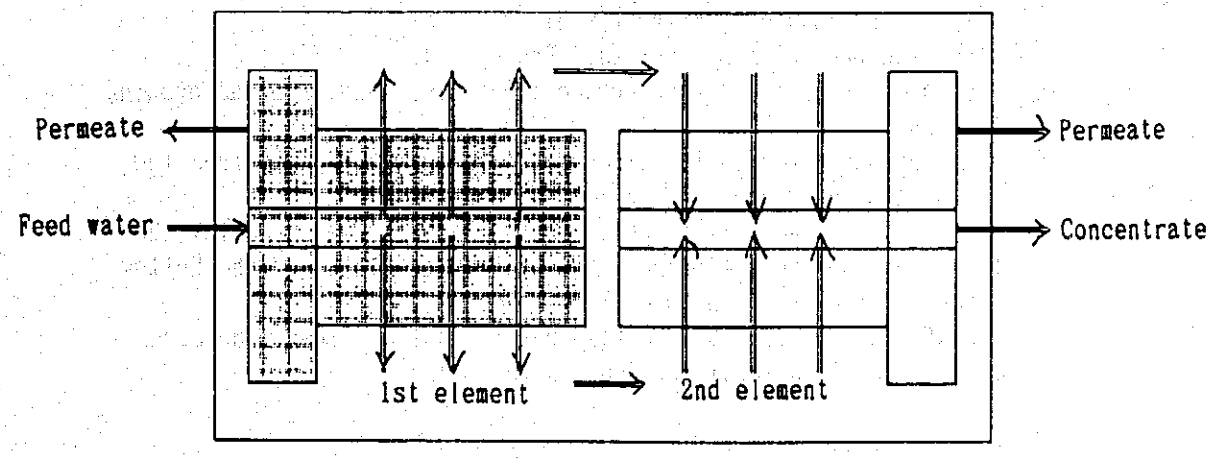
Disassembling, Analysis and Evaluation of Fouled Membrane

1. Objectives

One of the factors contributing to the deterioration of the performance of the module used for a long time is the adhesion of fouling substances to the membrane surfaces. Performance and life of the membrane, therefore, may be improved by analyzing those fouling substances and understanding their generating mechanism. Effective methods for analyzing fouling substances include (1) surface observation by SEM, (2) chemical element identification by EDX, and (3) qualitative analysis by IR. In the following, we would like to show the way we disassembled modules, took samples, and analyzed and evaluated them.

2. Sample Module

2-1 JD RO-1 E TRAIN Module No. 91
Serial No. HM10155 712103
1st element



2-2 Element profile

Start of service: March 25, 1989
End of service : August 22, 1993
(after care: preserved in a sealed container filled with formalin)
Duration of service: 38,666 hrs. (approx 4 years and 5 months)

3. Sampling Locations

Sample 1: A hollow fiber membrane in the inner layer of the element (near the feed tube)
Sample 2: A hollow fiber membrane in the middle layer of the element (about 28 mm away from the surface layer)
Sample 3: A hollow fiber membrane in the outer layer of the element (layer immediately below the surface layer)
Sample 4: Foul deposits on the feed tube

4. Disassembling the Module

4-1. Tools and Materials

① Olfa cutter
② Sealed bag for preserving samples
③ Formalin solution (5%)

4-2. Disassembling Procedure

<For the analysis by SEM and FT-IR methods>
① Extract the module from the vessel.
② Place the module on a sheet (see Photo.).
③ Make a notch on the circumference about 5 cm away from the opening (see Photo.).
④ Make another notch on the circumference about 3 cm away from the end plate (see Photo.).
⑤ Make a notch gradually along the shaft, and remove carefully the layers of the protection net, the protection cloth and the hollow fiber membrane (see Photo.).
⑥ Repeat the step ③ - ⑤ and take out the hollow fiber membranes of the specified locations (see Photo.).

<Sampling locations>
(i) A hollow fiber membrane in the layer immediately below the surface layer
(ii) A hollow fiber membrane in the middle layer (about a half of the module radius away from the surface layer)
(iii) A hollow fiber membrane near the feed tube

⑦ Put the removed hollow fiber membranes in the sealed bag while they remain wet.
⑧ Add the 5% formalin solution in the bag and keep the bag sealed.

<For the evaluation of the mini-module>
① Extract the module from the vessel.
② Put the module in a way that the opening comes at the bottom (see Photo.).

③ Make a notch on the circumference about 5 cm away from the opening (see Photo.).
④ Make another notch on the circumference about 3 cm away from the end plate, and remove the protection net and the protection cloth (see Photo.).
⑤ Make a notch gradually along the shaft, and unbind the hollow fiber membrane gradually (see Photo.).
⑥ Cut off the upper end of the hollow fiber membrane and take out the hollow fiber membrane of the specified location.

<Sampling locations>
(i) A hollow fiber membrane in the layer immediately below the surface layer
(ii) A hollow fiber membrane in the middle layer (about a half of the module radius away from the surface layer)
(iii) A hollow fiber membrane near the feed tube

⑦ Put the removed hollow fiber membranes in the sealed bag while they remain wet.
⑧ Add the 5% formalin solution in the bag and keep the bag sealed. (The structure of the hollow fiber membrane changes when it is dried, resulting in inaccurate measurement. So, be careful to keep it wet. Performance measurement must be taken immediately after sampling.)

* For the evaluation of the mini-module, the equipment shown in Fig. can be used.

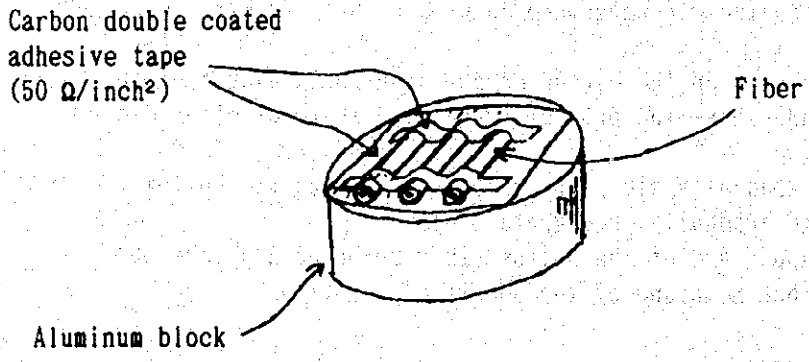
5. SEM-EDX Analysis

5-1 Tools and equipment for analysis

① Ion sputter	JFC1100E (made by JEOL)
② Carbon vapor depositor	JEE-400 (made by JEOL)
③ Scan electron microscope	JSM-5300LV (made by JEOL)
④ Computer for analyzing	Vectra 486/50U (made by HP)
⑤ Stub (stage to place samples)	Aluminum- or carbon-made
⑥ Desiccator	
⑦ Case for preserving samples	

5-1 Preparation of the sample for SEM-EDX analysis

① Dry a sample hollow fiber for 24 hours in a draft.
② Stick pieces of carbon double coated adhesive tape on the stub.
③ Cut the hollow fiber into pieces (the length of each piece being 80% of the stub diameter each), and stick 5 - 10 pieces in a row on the stub. (If the ends of the fibers tend to charge up, cover them by pieces of carbon double coated adhesive tape.)



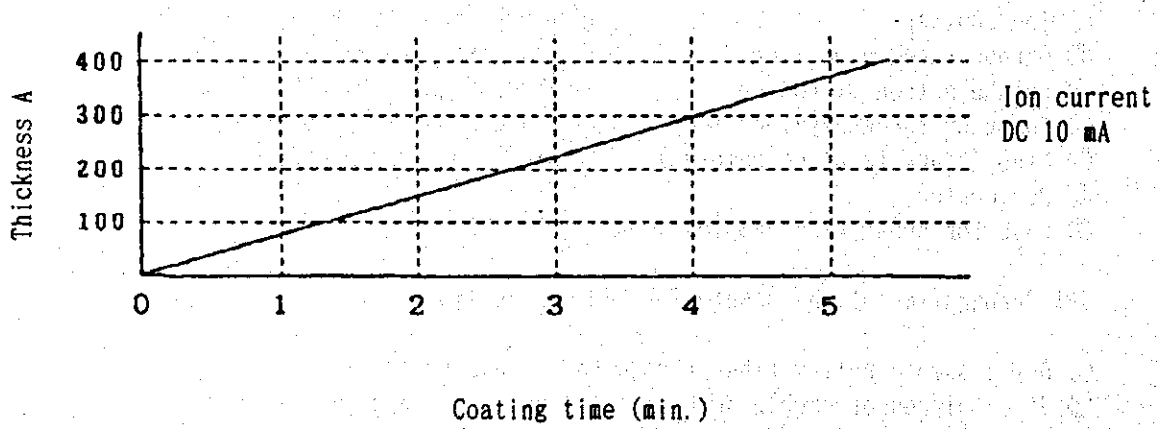
④ Carry out sputter coating with conductive metal.

Target thickness	Application	Coating
C	Excellent conductivity Suitable for complicated shapes	10 nm (100 A)
Au-Pd	Coating particle diameters are small Suitable for highly magnified SEM observation	10 nm (100 A)

Note 1: The hollow fibers stuck on the stub have uneven shapes. In addition, observation of more than 10000 magnification is not needed. We, therefore, recommend to apply C-coating.

Note 2: If charge up is great, or if SEM observation is to be carried out for the second time, some 10 A re-coating is recommended.

* Relation between coating time and coating thickness



← Environment protection Prevention of charge up →

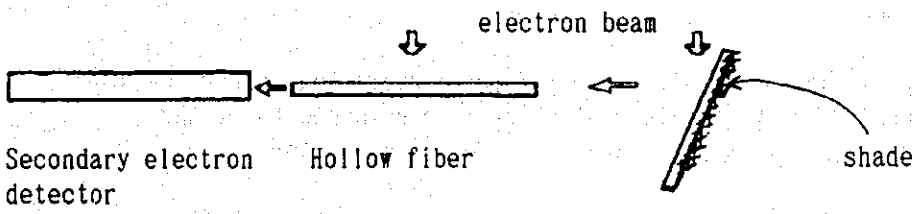
⑤ Put the samples into a plastic case, and keep it in a desiccator.

⑥ Conduct the SEM and EDX analysis.
The conditions for the analysis of hollow fiber membranes are shown in the following table.

	Sample current	Accelerating voltage	Remarks
SEM	10 -10 A	5 - 10 kV	To obtain surface data of fibers Damage to fibers is small
EDX	10 -12A	20 kV	X-ray detection amount (information) is large

* Location of the sample (hollow fiber membrane)

Set the axis of the sample to the detection end of the secondary electron detector as shown below.



(Good)

(Not good)
Image of the rear side is unclear

5-2 Results of analysis

① Fig. 1 shows the surface of unused hollow fiber membrane. The membrane surface is smooth.

② Fig. 2-4 shows the surface of an inner layer hollow fiber membrane. As seen in Fig., foul deposits have accumulated over the entire membrane surface. (The lower the applied voltage, the greater the amount of secondary electron signals (despite the low resolution) and hence the clearer the information about the membrane surface. This can be confirmed by comparing Fig. 2 and Fig. 3 that are taken from the same area).
Fig. 4 is a magnified image of the foul deposits.
Fig. 5 and 6 are the charts resulting form EDX analysis of inner layer foul deposits.
Fig. 5 is the result of X-ray irradiation on foul deposits spread over a wide area, showing mainly Fe-based oxides but also NaCl as well as S and Si (coming from sand in sea water) that are abundant in sea.

③ Fig. 7-8 show the surface of a middle layer hollow fiber membrane.
As seen in these figures, foul deposits are localized and far fewer than on the inner layer membrane.. A dent observed on the exposed deposit-free part of the membrane surface may have been caused during the sampling procedure.
(As is the case for the inner layer, the lower the applied voltage, the greater the amount of secondary electron signals (despite the low resolution) and hence the clearer the information about the membrane surface. This can be confirmed by comparing Fig. 7 and Fig.8 that are taken from the same area).

Figs. 10 and 11 are the charts resulting form EDX analysis of middle layer foul deposits.

Fig. 10 is the result of X-ray irradiation on foul deposits spread over a wide area, showing mainly Fe-based oxides but also NaCl as well as S and Si (coming from sand in sea water) that are abundant in sea.

Fig. 11 is the result of spot X-ray irradiation on particular deposits, showing mainly Si which is considered to be the deposition of crushed sand particles in sea water.

④ Fig. 12-13 show the surface of an outer layer hollow fiber membrane.

As seen in the figures, foul deposits are even fewer than on the middle layer membrane. They are scattered in various parts. As in the middle layer, a dent observed on the exposed deposit-free part of the membrane surface may have been caused during the sampling procedure.

Fig. 14 and 15 are the charts resulting form EDX analysis of outer layer foul deposits.

Fig. 14 is the result of X-ray irradiation on foul deposits spread over a wide area, showing mainly Fe-based oxides but also NaCl as well as Si, Al (coming from sand in sea water) and S that is abundant in sea.

Fig. 15 is the result of spot X-ray irradiation on particular deposits, showing mainly Si which is considered to be the deposition of crushed sand particles in sea water.

⑤ Fig. 16 shows foul deposits on the feed tube.
As in the case of the deposits on the inner layer membrane, bar-like aggregates of flaky substances (10 μm diameter) are observed.

Fig. 17 and 18 are the charts resulting form EDX analysis of feed tube foul deposits.

Fig. 17 is the result of X-ray irradiation on foul deposits spread over a wide area, showing mainly Fe-based oxides but also NaCl as well as Si, Al (coming from sand in sea water) and S that is abundant in sea.

⑥ Table 2 summarizes the these results.

6. Results of FT-IR Analysis

6-1 Tools and equipment

① FT-IR 1725X (made by Perkin Elmar)
② Constant-temperature drier
③ Mortar
④ Pestle
⑤ Tablet generator
⑥ KBr crystal
⑦ Ge prism
⑧ Attachment for transparent method
⑨ Attachment for ATR method
⑩ Pure water
⑪ Desiccator

(Diffuse reflection method and microscopic method)
① Attachment for diffuse reflection method)
② Optical microscope
③ Infrared microscope
④ Glass plate

6-2 Sampling of foul deposits and Measurement

① Method (m-1)
Sampling : Dry the hollow fiber membrane with foul deposits in a constant-temperature drier (6 hours at 110°C). After cooling it in a desiccator for 45 minutes, absorb the foul deposits with KBr powder. Then remove the membrane.
Measuring: Diffuse reflection method or tablet method (transparent method)

② Method (m-2)
Sampling : Wash the foul hollow fiber membrane with pure water, dry the removed substances, and mix them in KBr powder.
Measuring: Diffuse reflection method, tablet method (transparent method), or mircroscopic method

③ Method (m-3)
Sampling : Take a small amount of foul deposits using an optical microscope (by slicing), analyze them by irradiating with an infrared microscope.
Measuring: Microscopic method

④ Method (m-4)
Sampling : Wind the hollow fiber membrane around a Ge prism, making the interval as small as possible.
Measuring: ATR method

⑤ See Table for further detail.

Note 1: When mixing foul deposits with KBr powder, be careful about humidity and take a sample quickly lest KBr powder should absorb moisture and OH absorption spectrum appears on the chart.

* At present, SWCC R&D is equipped with facilities for the tablet method and ATR method. For the analysis of hollow fiber membranes, we recommend the diffuse reflection method (the attachment should be purchased).

6-3 Results of analysis

① Fig. 19 shows the results of the analysis by the diffuse reflection method (m-1).
From the inner to middle layer and to outer layer, absorption peaks become increasingly broad. This indirectly shows that the amount of foul deposits is at maximum in the inner layer but become fewer and fewer in the middle and outer layers. The result agrees with the fact that foul deposits are most likely to be trapped within the inner layer as feed water flows outwards from the feed tube to the inner, middle and outer layers (shown in the figure on P.1).

② Fig. 20 shows the results of the analysis of the diffuse reflection method and the microscopic method.
As shown in Fig. 20-1, the microscopic method (m-3) was applied to the middle layer where foul deposits is not relatively few, result being compared with that in the inner layer.
Compared to the middle layer, the inner layer shows the fall of deposit amount at the point of around 1100 cm^{-1}, which indicates a reduced presence of SiO_2 of silicates. This agrees with the result of the SEM-based observation.

③ Fig. 21 shows the results of the analysis of the composition analysis of foul deposits on the feed tube.
It is estimated that the dark brown substances shown in Fig. 21-1

contains mainly metallic oxides(from peaks at 700 cm^{-1} or below), carboxylates (from peaks between 1350 and 1450 cm^{-1} and at 1650 cm^{-1}), and silicates (from peaks between 1000 and 1100 cm^{-1} and at 3700 cm^{-1}9).
It is also estimated that the sticky gray substances shown in Fig. 21-2 contains SiOn (with peaks at 800 and 1100 cm^{-1}), or silicates (with peaks between 1000 and 1100 cm^{-1} and at 3700 cm^{-1}) and alkyl groups (oil components, with peaks at 1380, 2850 and 2950 cm^{-1}).
The black rubbery matter shown in Fig. 21-3 is considered to contain elastic substances resembling ethylene or propylene rubber (with peaks at 1350, 1420, 2850 and 2950 cm^{-1}).
The black mass shown in Fig.21-4 is considered to contain metallic oxides and silicates with alkyl groups (oil components, with peaks at 1380,1450, 2850 and 2950 cm-1).

④ Fig. 22 shows the results of the microscopic method using the sampling method m-2. As in Fig. 19, from the inner to middle layer and to outer layer, absorption peaks become increasingly broad. This indirectly shows that the amount of foul deposits is at maximum in the inner layer but become fewer and fewer in the middle and outer layers. Because of the use of the microscopic method, the charts have sharper peaks than those obtained by the diffuse refection method.

7. Conclusion

① The amount of foul deposits is the greatest in the inner layer of the hollow fiber membrane which is the first place to come in contact with feed water. Foul deposits becomes fewer in the middle and outer layers. It seems that hollow fiber membranes in the inner layer function as a filter to protect membranes in the subsequent layers.
② Foul deposits on fiber membranes contain mainly metallic oxides (corroded iron and sandy substances in sea water), silicates, and foreign substances in sea water (rubbery and oily matters).

Table 2 Hollow Fiber Membrane Analysis Results

Sampling location	SEM analysis	EDX analysis ◎› ○› △› ▽ – : N D									IR analysis	Overall assessment
		Na	Mg	Al	Si	P	S	Cl	Ca	Fe		
Inner layer	·Entire membrane surface covered by foulants ·Aggregate of fibrous and flaky substances	△	–	△	△	△	△	○	▽	◎	·Metallic oxides ·Silicates ·Carbohydrates	·Fe-based oxides ·Sea sand
Middle layer	·Sparsely deposited ·Particulate matter present ·Fibrous matter present ·Damage to the membrane surface Particle	△ –	– –	▽ △	△ ◎	△ –	△ –	○ ▽	– –	◎ –	·Metallic oxides; metallic hydroxides ·Silicates ·SiO_2 ·Carboxylates *Microscopic method used to small quantities	·Fe-based oxides ·Sea sand
Outer layer	·Sparsely deposited ·Particulate matter present ·Fibrous matter present ·Damage to the membrane surface Particle	▽ –	○ –	△ △	○ ◎	△ –	△ –	○ ▽	– –	◎ –	·Metallic oxides; metallic hydroxides ·Silicates ·SiO_2 ·Carboxylates *Microscopic method used to small quantities	·Fe-based oxides ·Sea sand
Deposits	·Aggregate of fibrous and flaky substances	○	○ ◎	○	○ ◎	○	○	○		◎	①Thick sticky substance (gray): silicates (SiO_2 family) Alkyl group(oily matter) ②Rubbery matter: Ethylene /propylene rubber ③Black mass: Metallic oxides; aromatic polyester (PET) Alkyl groups (oily matter): silicates	·Fe-based oxides ·Sea sand ·Rubbery and oily substances deposited from sea water

N.B.
Silicates: 1000 -1100, 3700 cm^{-1}
SiO_2: 800, 1100 cm^{-1}
Alkyl groups: 1380, 1450, 2850 and 2950 cm^{-1}
Ethylene/propylene rubber: 1350, 1420, 2850, 2960 cm^{-1}
Carboxylates: 1350 - 1450, 1650 cm^{-1} COO-

Table 1 FT-IR Sample Preparation and Analysis Method (For hollow fiber membranes with foulant deposits)

Case	Pre-treatment Method	Single Crystal	Sample Preparation Method	Measuring Method	Remarks
1	·Dry hollow fiber membranes with foulant deposits in thermostatic dehydrator. (110°C x 6 Hrs.) ·Let it cool in a desiccator (45min.)	KBr	①Cut hollow fiber membranes with foulant deposits to 3cm lengths. ②Pulverize KBr crystal in mortar. (KBr is highly absorbent. If some KBr is leftover, store in desiccator. Do not store it for a long time.) ③Put hollow fiber membranes with foulant deposits into KBr powder and scrape off foulant deposits with pestle. ④Remove hollow fiber membranes.	<Tablet Method> ①Prepare sample tablets with tablet forming machine. ②Put sample into transmission method attachment. ③Use IR spectrum measuring method.	*Make the grain sizes in each sample uniform, as the IR spectrum is heavily effected by different grain sizes of KBr powder.
				<Diffuse Reflectance Spectroscopy> ①Fill mixed powder of KBr and foulant deposits into sample cup. ②Attach sample to diffuse reflectance spectroscopy attachment. ③Use IR spectrum measuring method.	
		Ge	①Cut hollow fiber membranes with foulant deposits to 5cm lengths. ②Wind hollow fiber membranes around Ge-prism covering whole prism. (Try to minimize space between follow fiber and prism.)		
		-	①Put hollow fiber membranes with foulant deposits onto glide slide. ②Use optical microscope on portion you want to analyze for sampling.	<Microscopy> ①Focus on sample on glass slide with infrared microscope. ②Use IR spectrum measuring method.	
	·Wash hollow fiber membranes containing foulant deposits with pure water and dry the foulants dislodged from washing.	KBr	①Thoroughly dry the foulants which were dislodged from washing hollow fiber membranes. ②Pulverize KBr crystal in mortar. (KBr is highly absorbent. If some KBr is leftover, store in desiccator. Do not store it for a long time.) ③Mix KBr crystal and above dried foulants thoroughly.	<Tablet Method> ①Prepare sample tablets with tablet forming machine. ②Put sample into transmission method attachment. ③Use IR spectrum measuring method.	
				<Diffuse Reflectance Spectroscopy> ①Fill mixed powder of KBr and foulant deposits into sample cup. ②Attach sample to diffuse reflectance spectroscopy attachment. ③Use IR spectrum measuring method.	
		-	①Put hollow fiber membranes with foulant deposits onto glide slide. ②Use optical microscope on portion you want to analyze for sampling.	<Microscopy> ①Focus on sample on glass slide with infrared microscope. ②Use IR spectrum measuring method.	

Appendices

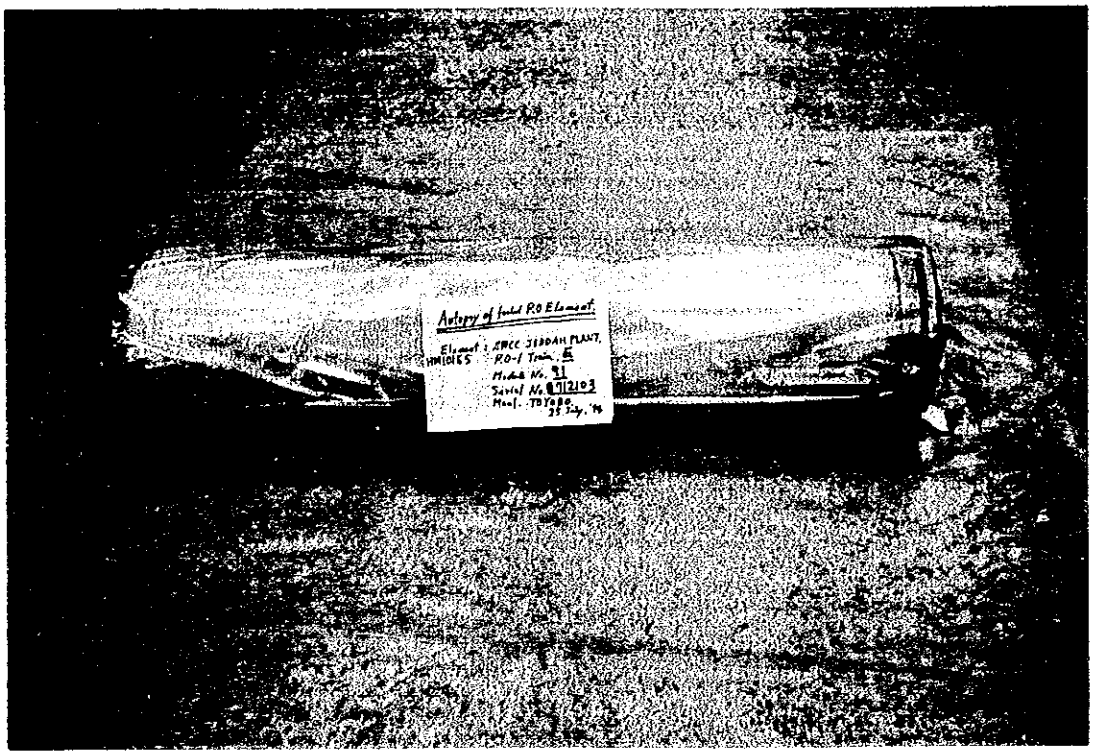


Photo. 1

Photo. 2

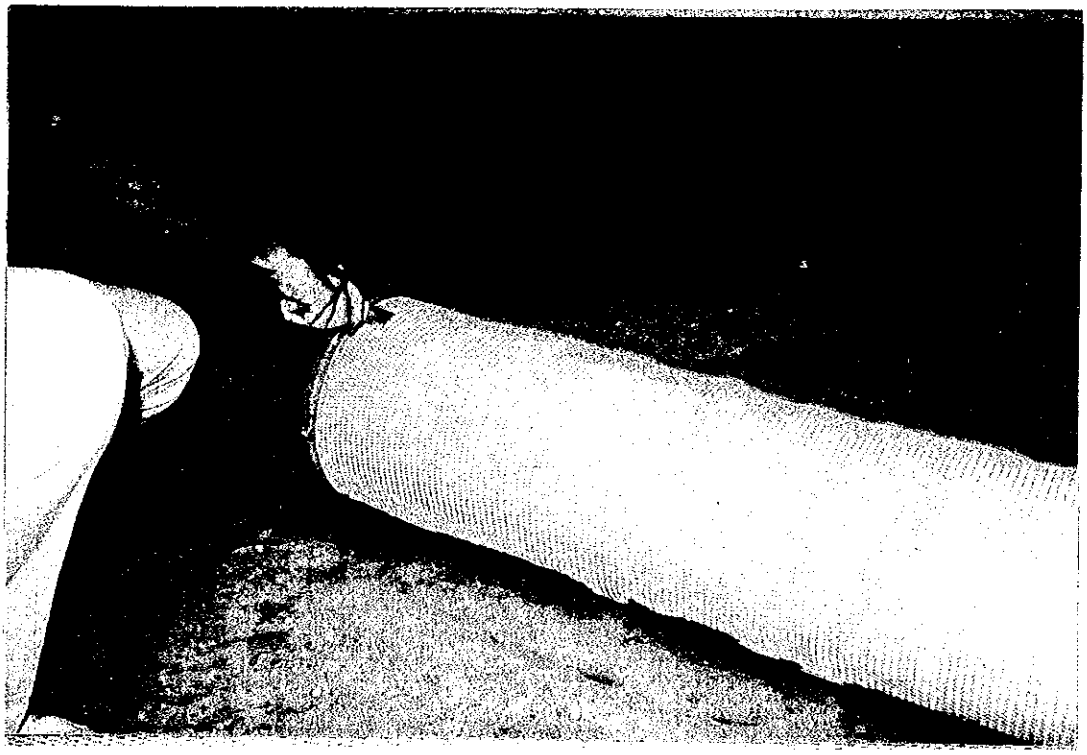


Photo. 3

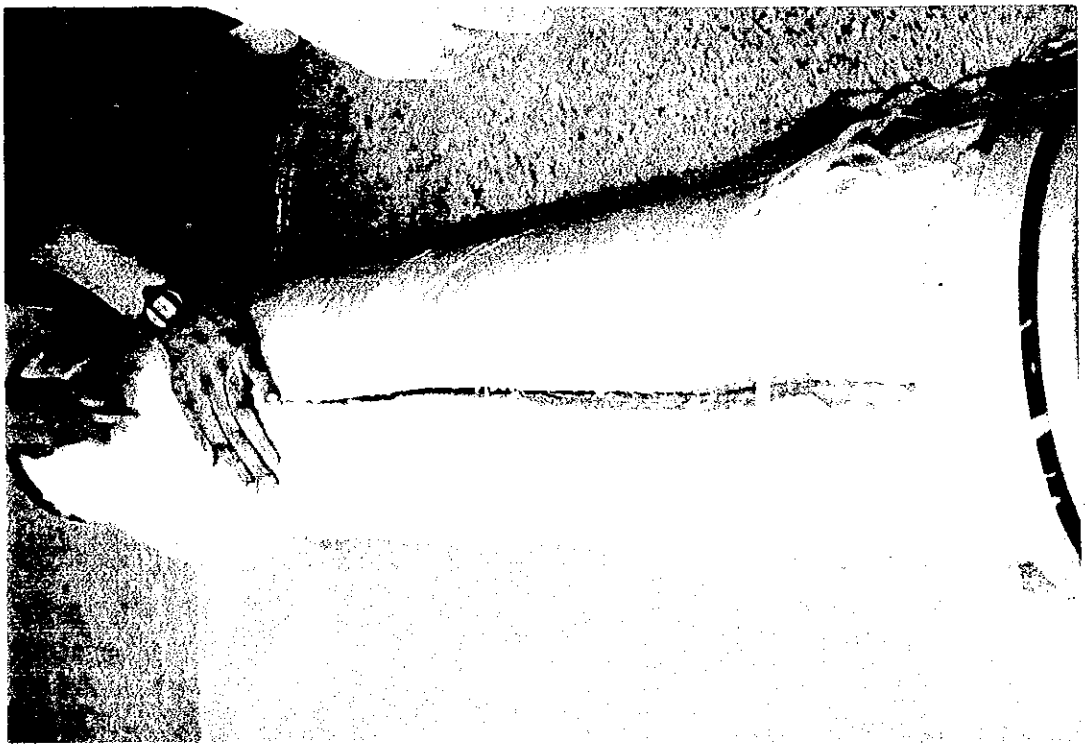
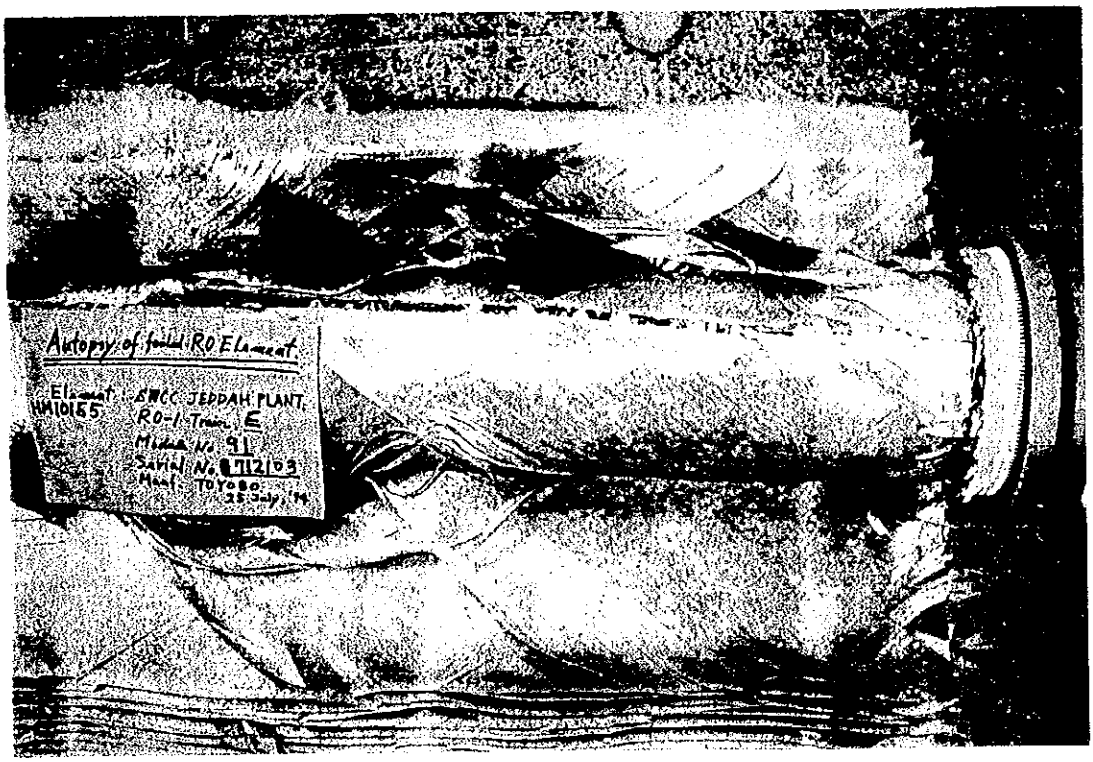


Photo. 4


Autopsy of fouled RO Element
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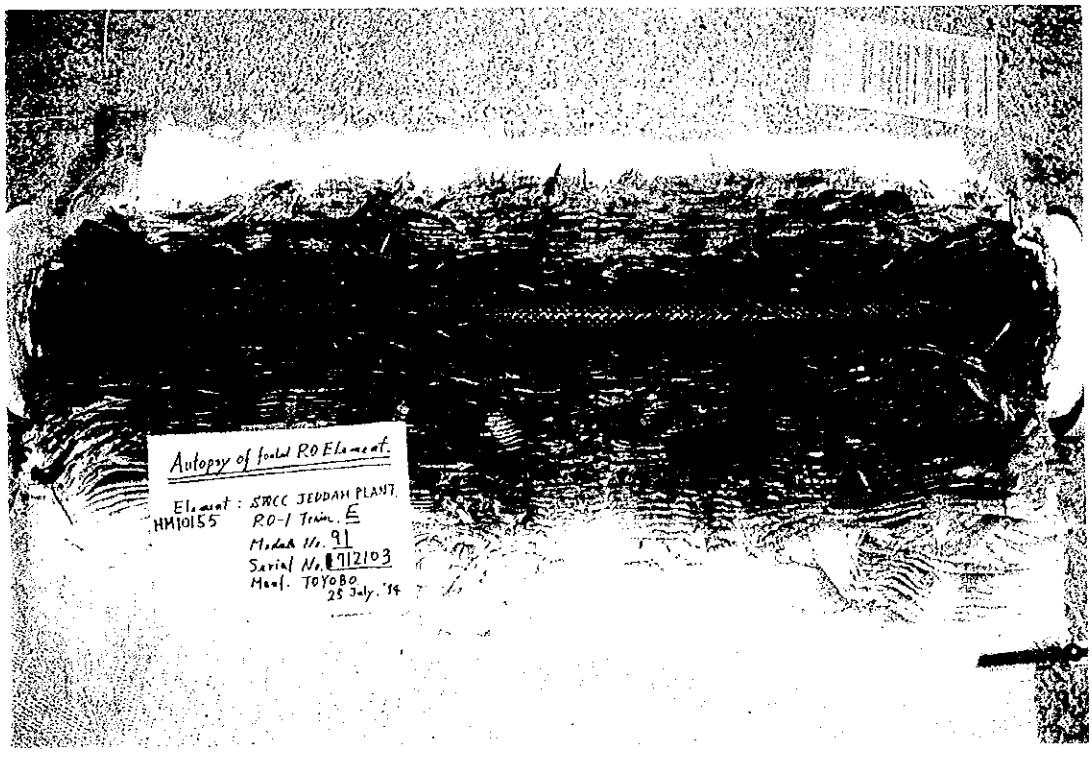
HM10155 RO-1 Train. E
Module No. 91
Serial No. 7112103
Manf. TOYOBO
25 July. '14


Autopsy of fouled RO Element
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Module No. 91
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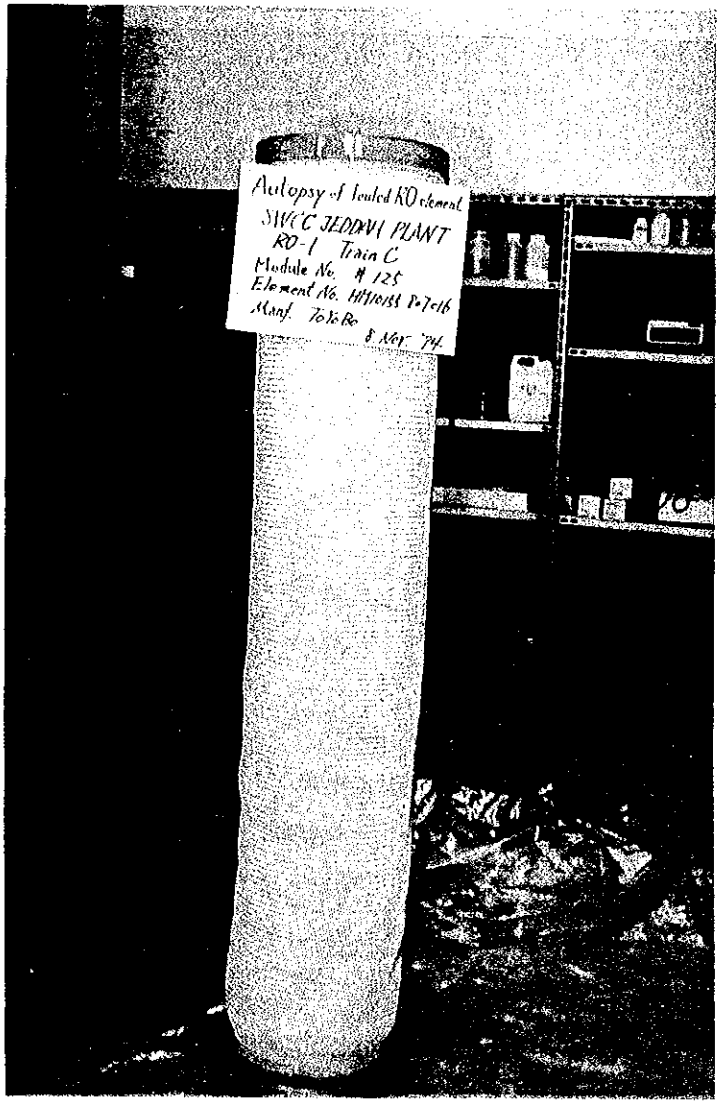
Manf. TOYOBO
25 July. '14

Photo. 5


Autopsy of fouled RO element
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Manf. Toray
8 Mar 74

Photo. 6

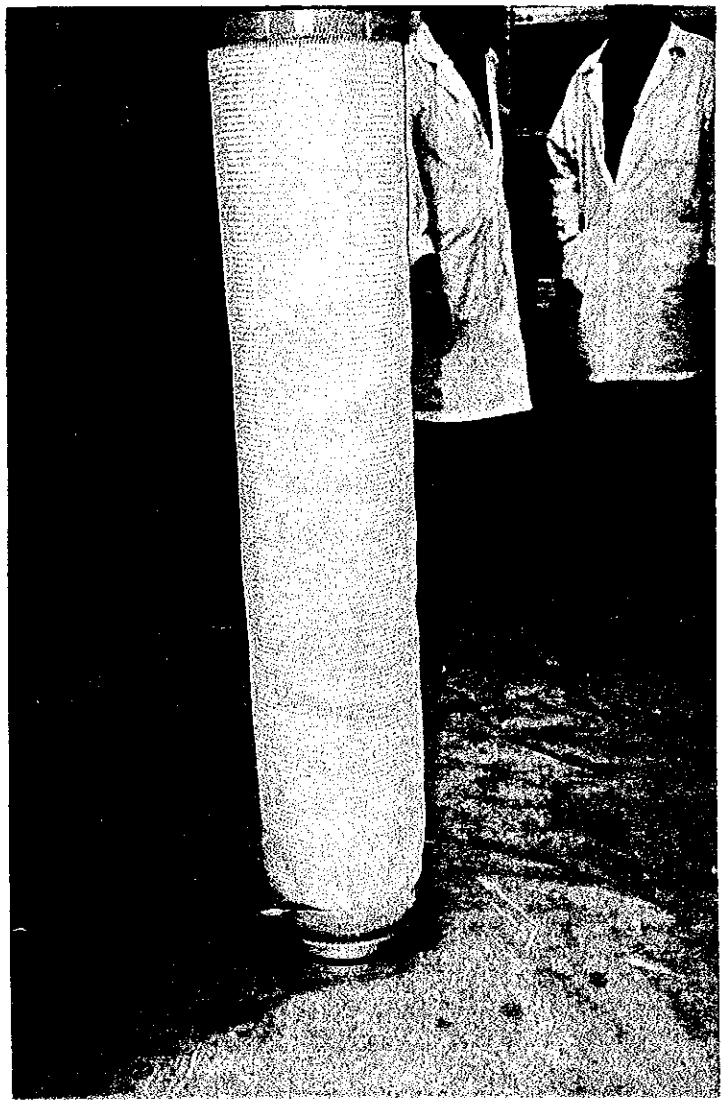


Photo. 7

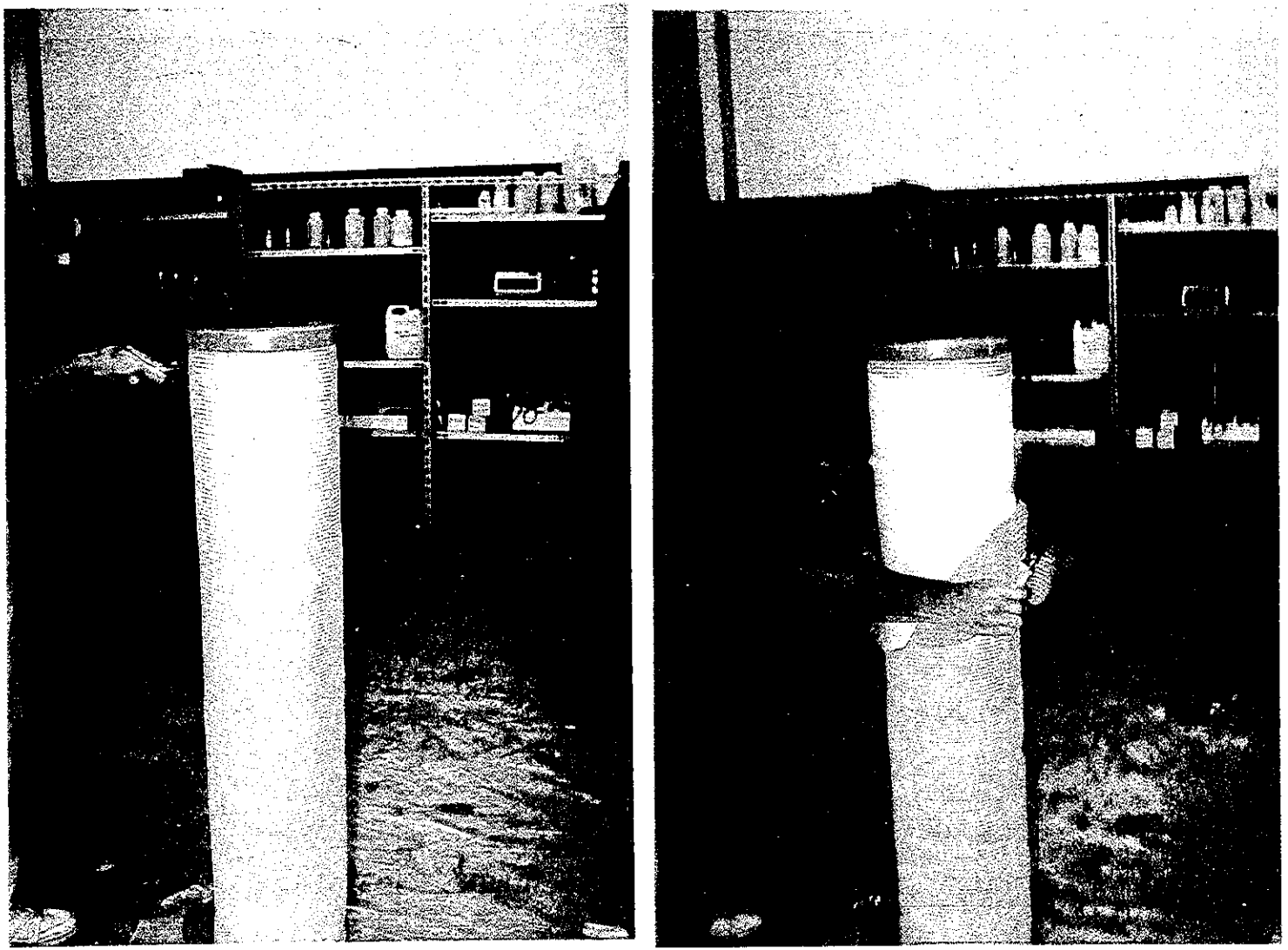


Photo. 8

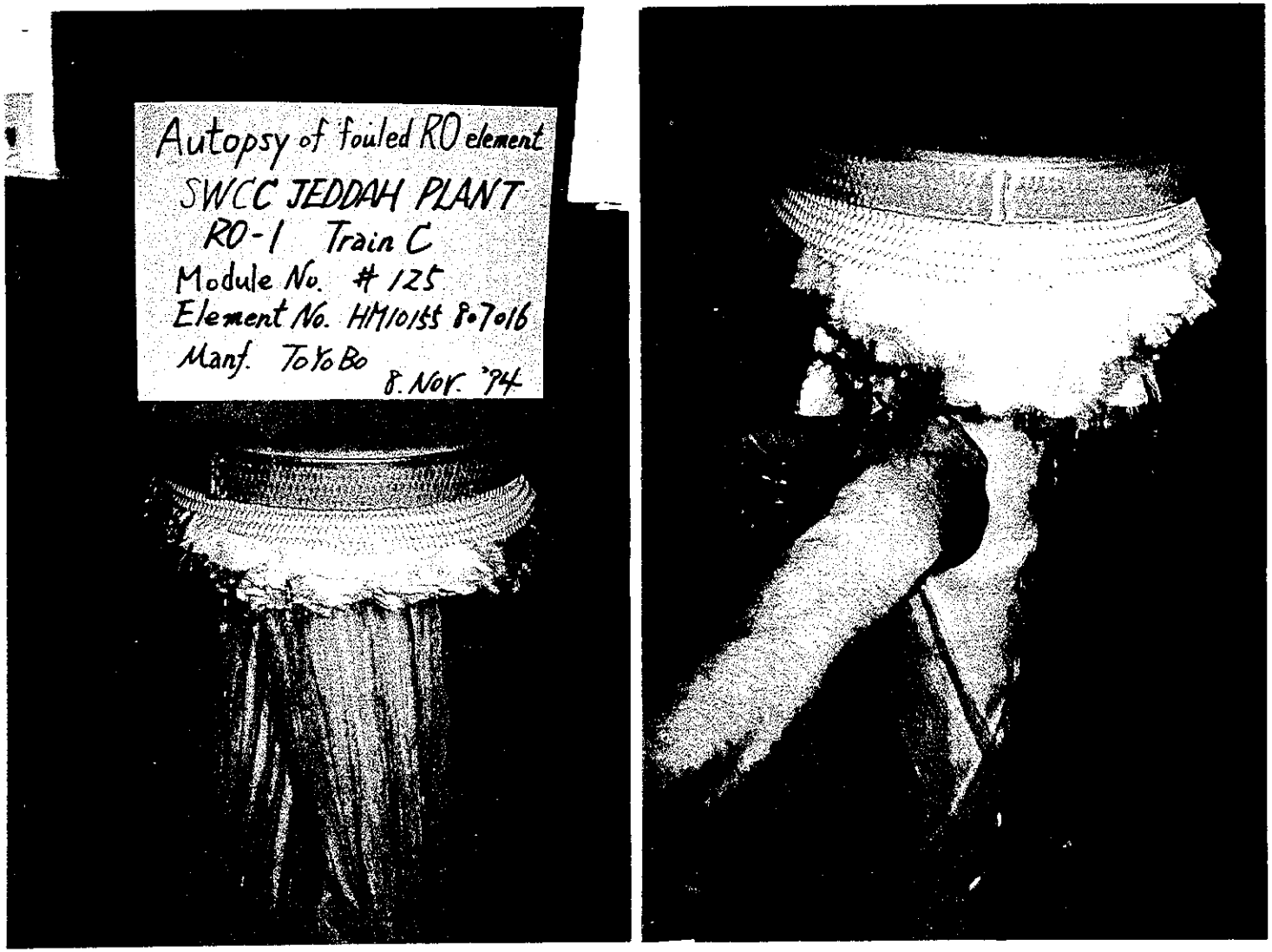

Autopsy of fouled RO element
SWCC JEDDAH PLANT
RO-1 Train C
Module No. # 125
Element No. HM10155 8.7016
Manf. Toyobo
8. Nov. '94

Photo. 9

Fig. 1

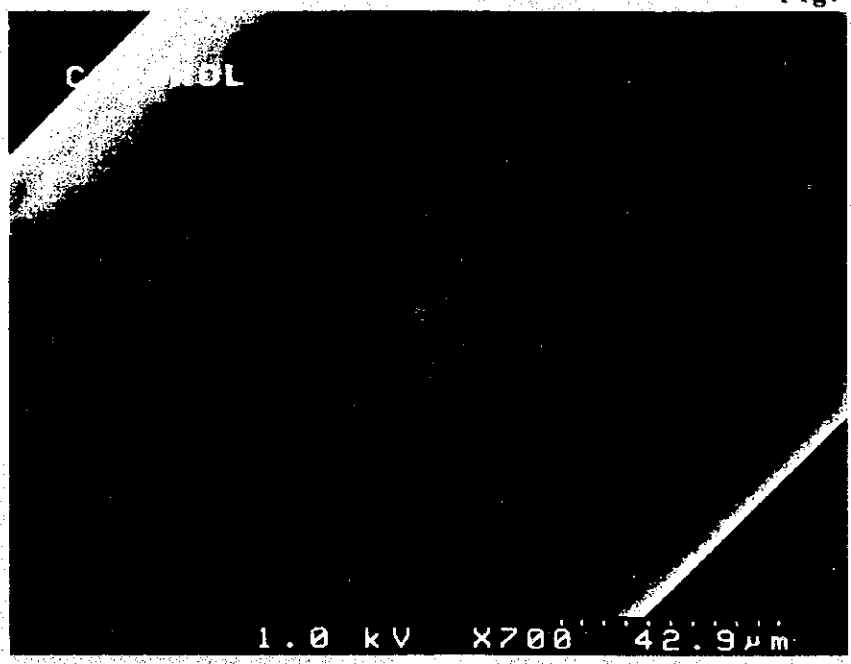


Fig. 2

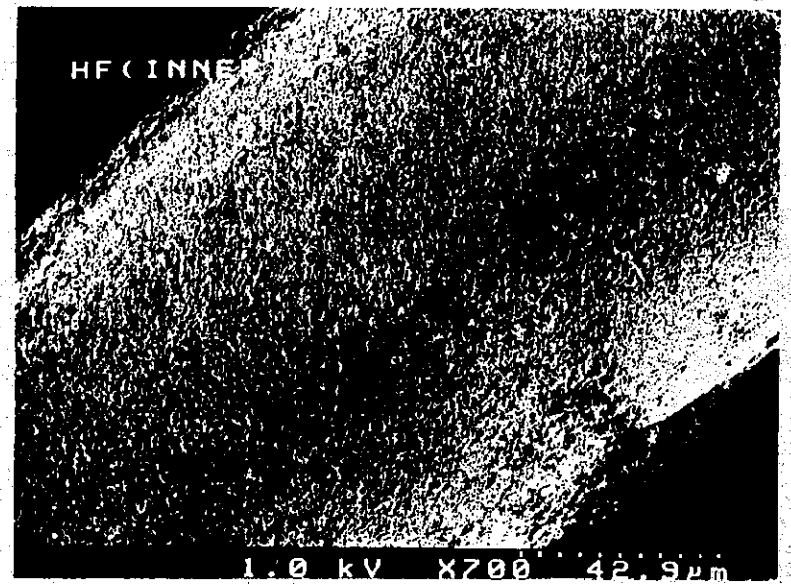


Fig. 4

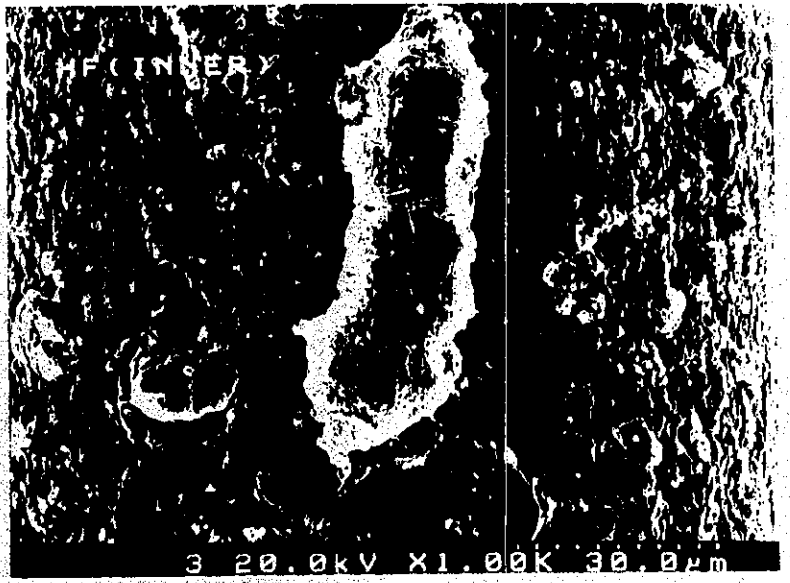
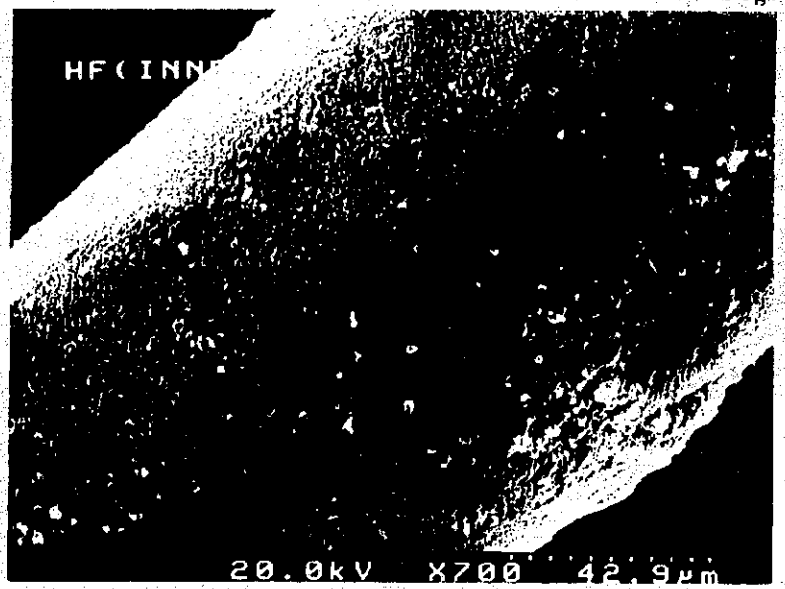


Fig. 3



内層中空糸のＥＤＸ分析結果

11:50 94/08/25

〈 自動定性判定結果 〉

hf(inner) SEM 7

測定日付 : 94/08/25
測定時間 : 100 s

【元素判定結果】

○－可能性高い
？－判定不能

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1	1.30	60	As	Lα1	○
			Dy	Mα	
2	1.50	96	Al	Kα1	○
			Br	Lα1	
			Tm	Mα	
			Yb	Mα	
3	1.76	117	Si	Kα1	○
			W	Mα	
			Zr	Lι	○
4	2.04	115	P	Kα1	
			Zr	Lα1	○
			Pt	Mα	
5	2.33	124	S	Kα1	○
			Pb	Mα	
6	2.65	156	Cl	Kα1	○
7	6.40	922	Fe	Kα1	○
8	7.08	141	Fe	Kβ1	○

【ＢＧサーチ結果】

	ｴﾈﾙｷﾞｰ値 (keV)	ｶｳﾝﾄ数 (カウント)
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BG点 2	8.88	308

11:51 94/08/25

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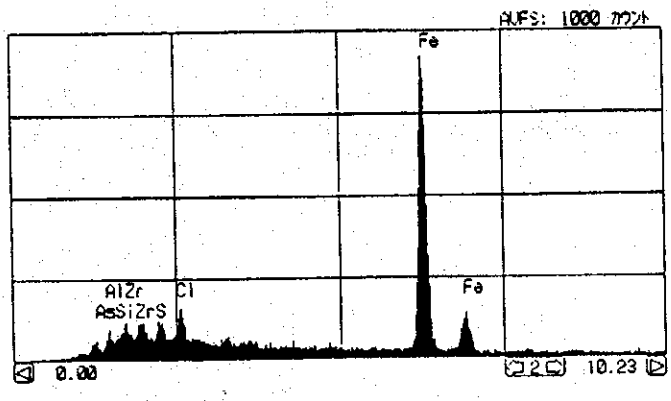


Ｆｉｇ．５　30×170μｍ範囲分析（中空糸表面付着物）

（ 自動定性判定結果 ）　　12:16 94/08/25

hf(inner) SEM 8

測定日付 : 94/08/25
測定時間 : 100 s

【元素同定結果】

○－可能性高い
？－同定不能

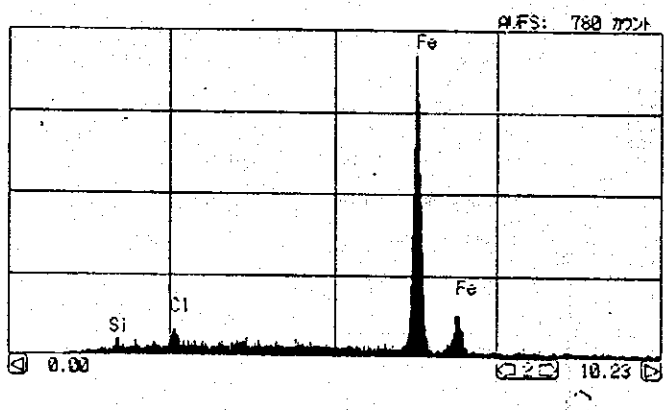
番号	ｴﾈﾙｷﾞｰ値 (keV)	ｶｳﾝﾄ数 (ｶｳﾝﾄ)	元素	線種	存在
1	1.73	32	Si	Kα1	○
			Ta	Mα	
2	2.64	64	Cl	Kα1	○
3	6.41	701	Fe	Kα1	○
4	7.05	125	Fe	Kβ1	○

【ＢＧサーチ結果】

	ｴﾈﾙｷﾞｰ値 (keV)	ｶｳﾝﾄ数 (ｶｳﾝﾄ)
BG点 1	3.91	415
BG点 2	8.87	196

12:16 94/08/25

1:hf(inner) SEM 8　　測定時間: 100 s



Ｆｉｇ．６　□15×15μｍ範囲分析（付着物のみ）

Fig. 7

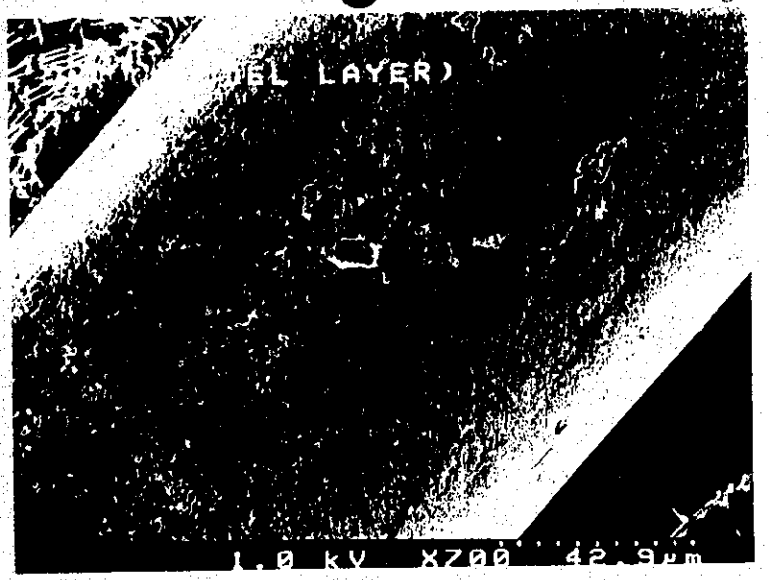


Fig. 8

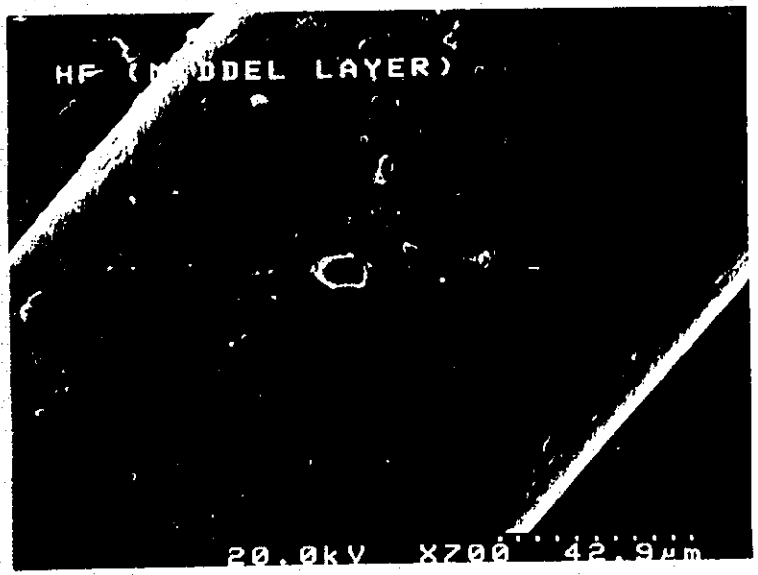
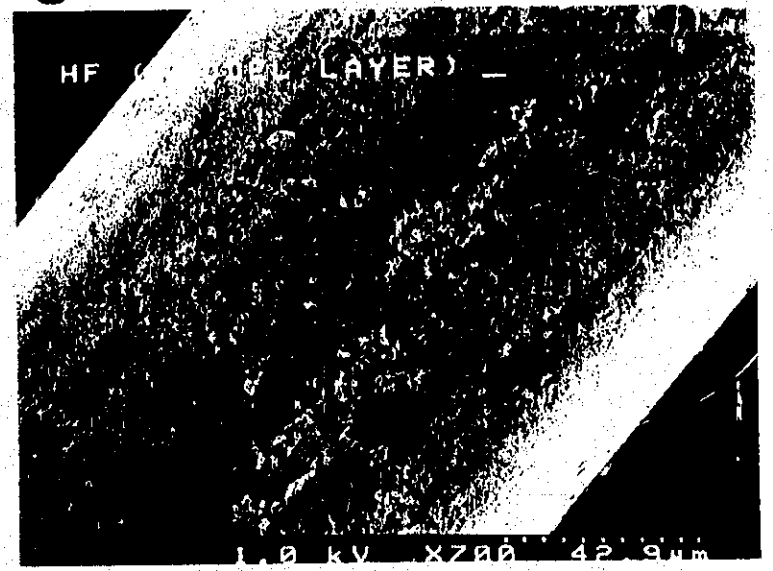


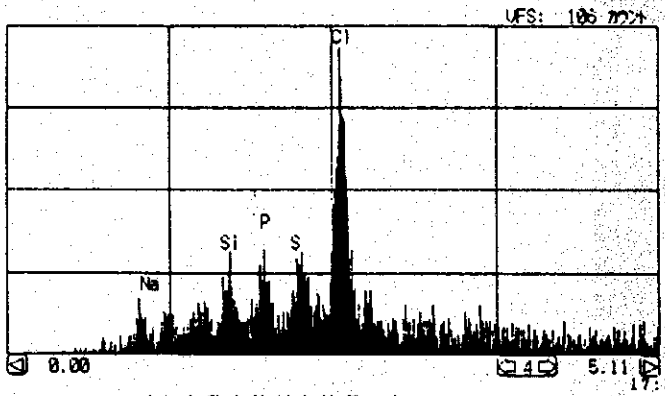
Fig. 9



中層中空糸のＥＤＸ分析結果

17:29 94/08/23

1:HF (middel layer)<spot>　　測定時間：　100 s



Fe
検出

17:30 94/08/23

（　自動定性判定結果　）

HF (middel layer)<spot>

測定日付　：94/08/23
測定時間　：　100 s

【元素同定結果】

○－可能性高い
？－同定不能

番号	ｴﾈﾙｷﾞｰ値 (keV)	ｶｳﾝﾄ数 (ｶｳﾝﾄ)	元素	線種	存在
1	1.04	13	Na	Kα1	○
			Zn	Lα1	
2	1.76	33	Si	Kα1	○
			W	Mα	
3	2.00	29	Mo	Lι	○
			P	Kα1	
			Ir	Mα	
4	2.30	29	S	Kα1	
			Mo	Lα1	○
			Tl	Mα	
5	2.63	89	Cl	Kα1	○
6	6.39	156	Fe	Kα1	○
7	7.08	20	Fe	Kβ1	○

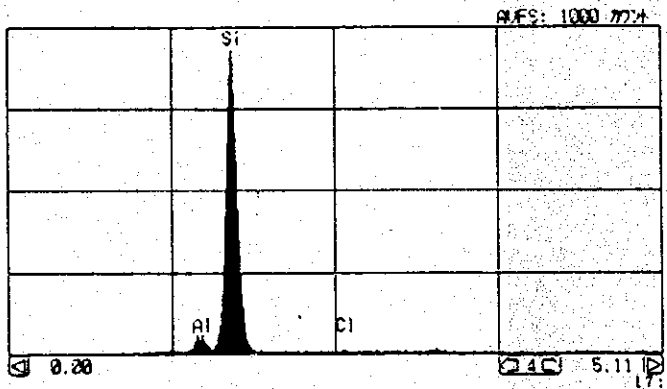
【ＢＧサーチ結果】

	ｴﾈﾙｷﾞｰ値 (keV)	ｶｳﾝﾄ数 (ｶｳﾝﾄ)
BG点 1	3.91	106
BG点 2	8.87	45

Ｆｉｇ．１０　中層中空糸（付着物全体）

17:15 94/08/23

1:HF (middel layer)<spot>　　測定時間: 100 s



17:16 94/08/23

〈 自動定性判定結果 〉

HF (middel layer)<spot>

測定日付 : 94/08/23
測定時間 : 100 s

【元素判定結果】

○－可能性高い
？－判定不能

番号	ｴﾈﾙｷﾞｰ値 (keV)	ｶｳﾝﾄ数 (ｶｳﾝﾄ)	元素	線種	存在
1	1.48	59	Al	Kα1	○
			Br	Lα1	
			Tm	Mα	
2	1.75	932	Si	Kα1	○
			Ta	Mα	
3	3.34	21	K	Kα1	○

【ＢＧサーチ結果】

	ｴﾈﾙｷﾞｰ値 (keV)	ｶｳﾝﾄ数 (ｶｳﾝﾄ)
BG点 1	4.25	85
BG点 2	8.50	40

Ｆｉｇ．１１　中層中空糸（粒子状付着物）

Fig. 12

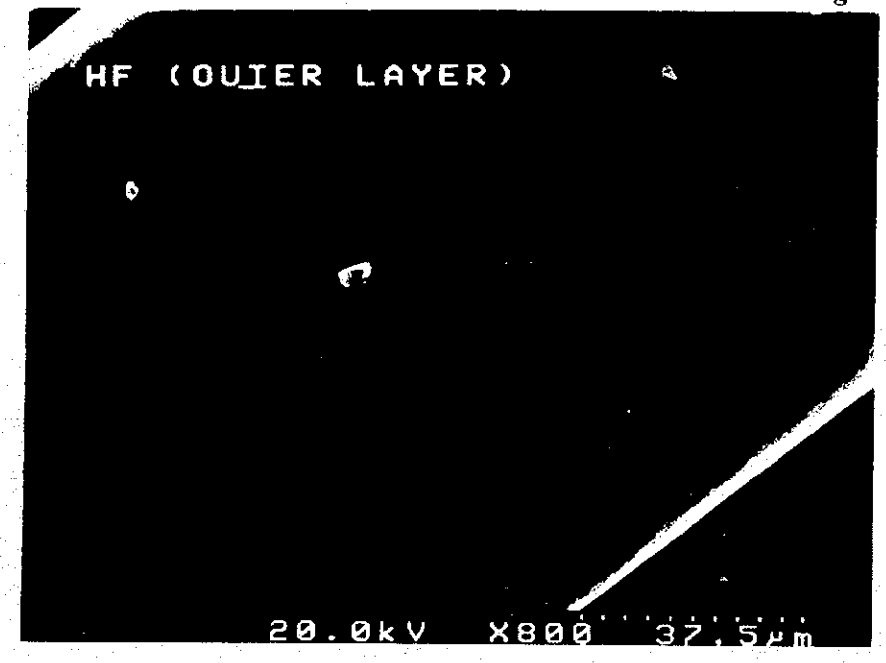
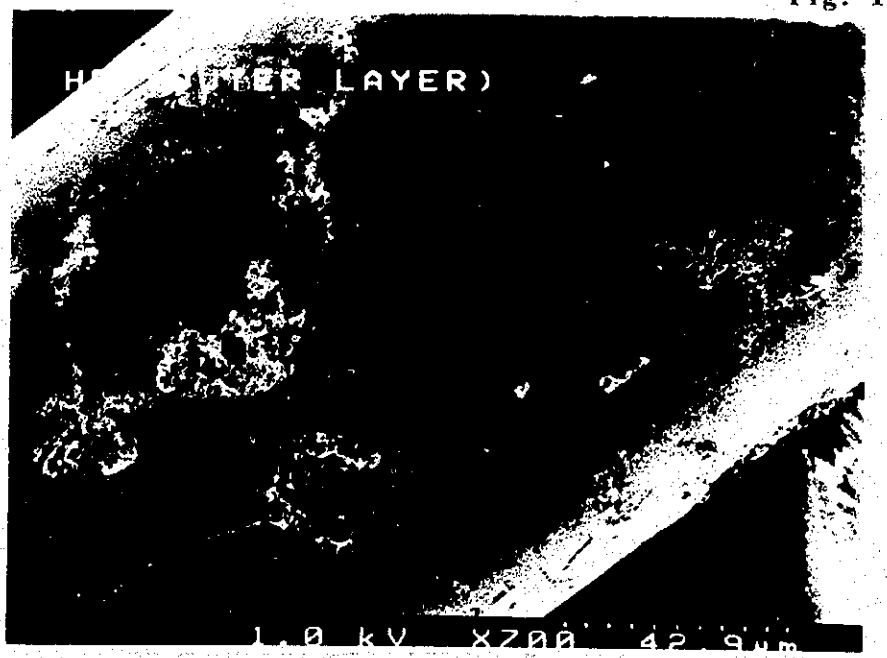


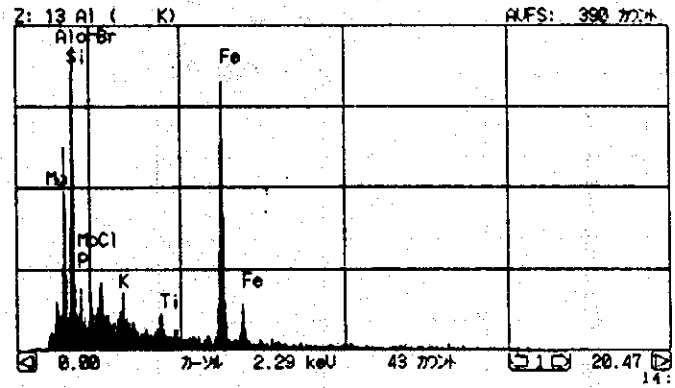
Fig. 13



外層中空糸のＥＤＸ分析結果

14:58 94/08/23

1:HF (outer layer) <spot>　　測定時間: 100 s



14:59 94/08/23

〈 自動定性判定結果 〉

HF (outer layer) <spot>

測定日付 : 94/08/23
測定時間 : 100 s

【元素同定結果】

○－可能性高い
？－同定不能

番号	エネルギー値 (keV)	カウント数 (カウント)	元素	線種	存在
1	1.25	51	Mg	Kα1	○
			Tb	Mα	
2	1.49	177	Al	Kα1	○
			Br	Lα1	
			Tm	Mα	
3	1.74	405	Si	Kα1	○
			Ta	Mα	
4	2.00	76	P	Kα1	○
			Ir	Mα	
			Mo	Lι	○
5	2.31	53	S	Kα1	
			Mo	Lα1	○
			Pb	Mα	
6	2.63	115	Cl	Kα1	○
7	3.31	70	K	Kα1	○
			In	Lα1	
8	4.54	57	Ti	Kα1	○
9	6.41	313	Fe	Kα1	○
10	7.05	47	Fe	Kβ1	○

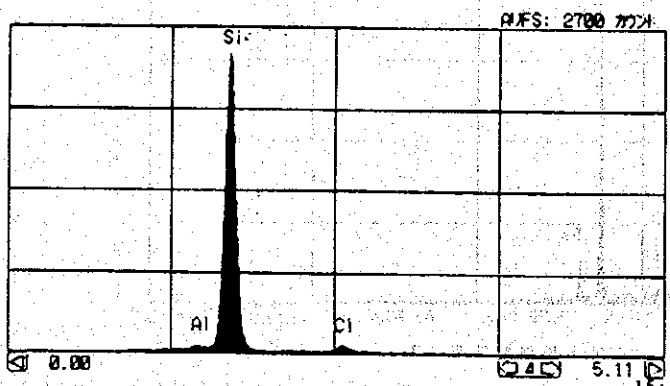
【ＢＧサーチ結果】

	エネルギー値 (keV)	カウント数 (カウント)
BG点 1	5.28	265
BG点 2	15.00	55

Ｆｉｇ．１４　外層中空糸（付着物全体）

15:19 94/08/23

1:HF (outer layer) <spot>　　測定時間: 100 s



15:20 94/08/23

(自動定性判定結果)

HF (outer layer) <spot>

測定日付 : 94/08/23
測定時間 : 100 s

【元素同定結果】

○－可能性高い
？－同定不能

番号	エネルギー値 (keV)	カウント数 (カウント)	元素	線種	存在
1	1.50	65	Al	Kα1	○
			Br	Lu1	
			Tm	Mα	
			Yb	Mα	
2	1.75	2451	Si	Kα1	○
			Tm	Mα	
3	2.62	84	Cl	Kα1	○

【ＢＧサーチ結果】

	エネルギー値 (keV)	カウント数 (カウント)
BG点1	3.91	278
BG点2	8.50	131

Ｆｉｇ．１５　外層中空糸（粒子状付着物）

Fig. 16