THE RESEARCH COOPERATION

FOR

THE PROJECT OF THE SEAWATER DESALINATION TECHNOLOGY

IN THE KINGDOM OF SAUDI ARABIA

FINAL REPORT

FEBRUARY 1995

JAPAN INTERNATIONAL COOPERATION AGENCY

SALINE WATER CONVERSION CORPORATION

PREFACE

In response to the request from the Government of the Kingdom of Saudi Arabia, the Government of Japan decided to implement the technical cooperation project for the seawater desalination technology, and entrusted the project to the Japan International Cooperation Agency (JICA).

JICA sent a team, consisting of researchers from the Water Re-Use Promotion Center, to the Saline Water Conversion Corporation (SWCC) of the Kingdom of Saudi Arabia from January 1992 to February 1995 for the collaborative research activity as the third stage of the extended period.

The team conducted four experimental research themes under close cooperation with researchers from SWCC, and those fruitful achievements are highly competent for the publication in international conferences.

I hope that this report will contribute to the advancement of seawater desalination technology in the Kingdom of Saudi Arabia and to enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Saudi Arabia for their close cooperation extended to the team.

February 1995

Kimio Fujita
President
Japan International Cooperation Agency

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<Structure of this Report>

In this report, chapter and section will be shown at the front contents and further detailed contents will be shown at the front of the sections and paragraphs.
The page number at the bottom of the page is a serial number of each paragraph, however, header showing section, chapter and paragraph is printed at the top of the page to avoid confusion and make it easy to access the searching pages.

1. Introduction

1. Introduction

This FINAL REPORT covers the results of the cooperative research work conducted for the purpose of facilitating mutual communication between the SALINE WATER CONVERSION CORPORATION in the Kingdom of Saudi Arabia (hereinafter referred to as "SWCC") and the research cooperation team nominated by JAPAN INTERNATIONAL COOPERATION AGENCY (hereinafter referred to as "JICA") for the execution of the research cooperation, schemed in the INCEPTION REPORT of the "RESEARCH COOPERATION FOR THE SEAWATER DESALINATION TECHNOLOGY BETWEEN SALINE WATER CONVERSION CORPORATION AND JAPAN INTERNATIONAL COOPERATION AGENCY" (hereinafter referred to as "INCEPTION REPORT") based on "the DOCUMENT ON THE THIRD EXTENSION OF THE TECHNICAL COOPERATION FOR THE PROJECT OF THE SEAWATER DESALINATION TECHNOLOGY BETWEEN SWCC AND JICA" (hereinafter referred to as "Third Extension R/D") and "the MINUTES OF MEETING ON RESEARCH COOPERATION FOR THE PROJECT OF THE SEAWATER DESALINATION TECHNOLOGY BETWEEN SWCC AND JICA" (hereinafter referred to as "the M/M"), signed between SWCC and JICA on 13 October, 1992.

2. Historical Background

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2. Historical Background

2.1 Outline

In its second five years plan in 1976, guidelines were established for large scale industrialization and the preparation of urban infrastructure in the Kingdom of Saudi Arabia and national construction has been promoted steadily ever since. Consequently, the securing of large quantities of water for industrial use as well as water for domestic purpose became a major problem. The geographical conditions dictate that the major part of the necessary water supplied must be derived from seawater so that the role of seawater desalination plants has become increasingly important in recent years.

In the light of this background, a round of preliminary negotiations between Japan and Saudi Arabia began in November 1975, during a visit to Japan by the Governor of SWCC, with his informal request to the Japanese Government for cooperation on seawater desalination technology.

In January 1982, JICA and SWCC signed a Record of Discussion concerning the implementation of this project (hereinafter referred to as the R/D) and the cooperation has started.

The period of cooperation has been extended to February 1984, re-extended to February 1992, and finally to February 1995. This final report covers the results of the research cooperation project conducted during the period of final extension, from March 1992 to February 1995.

2.2 Chronicle

The outline of the circumstances of the research cooperation project are as follows:

(1) January 1982 : SWCC and JICA signed R/D

(2) October 1987 : The period of cooperation has been extended for three years to February 1989.

(3) December 1990 : The re-extension for another three years has been discussed with the

scheme during the period and mutual understandings has been obtained.

(4) April 1991 : The re-extension up to February 1992 has been signed by both parties which was delayed by the Gulf War. Four research themes on MSF and seven research themes on RO has been conducted during this period.

(5) October 1992 : The M/M for the third extension has been signed by both parties. The period of cooperation was from March 1992 to February 1995 and two research themes on MSF and also two research themes on RO were selected.

2.3 Contents of Research Activities

Due to the consequence of the Gulf War as well as other causes, the pollution of seawater by oil became a crucial issue for seawater desalination at the discussion of the scheme of second and third extension. The SWCC strongly requested to include the study on countermeasures against oil contamination of desalination plant in the cooperative research, and such subjects were covered in the research themes.

The research themes conducted during the second extension period, up to February 1992, were as follows:

<MSF>

(1) M-1 Laboratory experiment on scale prevention
(2) M-2 Corrosion tendency for some kinds of materials
(3) M-3 Study on some materials by corrosion measurement apparatus
(4) M-4 Analysis of oil dispersed in raw seawater at the heat rejection section of MSF plants

<RO>

(5) R-1 Sterilization
(6) R-2 Pretreatment of seawater
(7) R-3 Pollution effect of membrane cleaning discharge
(8) R-4 Selection of membrane

(9) R-5 Chemical cleaning of the fouled membrane
(10) R-6 Selection of membrane for hybrid type RO
(11) R-7 Standardization of the main analytical methods

The research themes conducted during the third extension period, up to February 1995, were those extended from the previous M-1, M-4 R-2 and R-6. Those themes are as follows:

(1) Study on scale control for MSF process
(2) Study on countermeasures against oil contamination of product water in MSF process
(3) Study on selection of RO membrane for hybrid system
(4) Study on countermeasures against oil contamination for RO process

3. Objectives of the Research Cooperation

3. Objectives of the Research Cooperation

The objectives of this research cooperation are to have researchers of both Japan and Saudi Arabia conduct collaborative research activities on the 4 research themes related to seawater desalination technology and to transfer Japanese seawater desalination technology to Saudi Arabia.

4. Basic Policy for Implementation of Research Cooperation

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4. Basic Policy for Implementation of Research Cooperation

This research cooperation consists of two parts, firstly collaborative research activities and secondly supplementary arrangement of equipment and materials, details of which are given in the following chapters.

4.1 Collaborative Research Activities

The following four themes related to Multi-Stage Flash Distillation (MSF) and Reverse Osmosis (RO) have been implemented for collaborative research activities.

A. Study on Scale Control of MSF Process (MSF-1)
B. Study on Countermeasure against Oil Contamination of Product Water in MSF Process (MSF-2)
C. Study on Selection of RO Membrane for Hybrid System (RO-1)
D. Study on Countermeasure against Oil Contamination for RO Process (RO-2)

The expression of the research purpose and contents for these four themes described here is identical to that of M/M. Fig. 1 and Fig. 2 show the completed schedule for MSF and RO research activity, respectively.

A. Study on Scale Control for MSF Process (MSF-1)

(1) Purpose

Productivity deterioration of an MSF plant stems mainly from scaling of the heat transfer tubes. Thus, it has been studied how to control the scaling by chemical dosing for MSF plants in Saudi Arabia.

(2) Scope of Work

1) Investigation and Preparative Experiment

The effects of some scale inhibitors were compared by conducting scaling tests in a laboratory, in order to select promising candidates in addition to investigate for the status of productivity deterioration of MSF plants in Saudi Arabia.

2) Test with the Heat Transfer Test Equipment

Based on the preparative experiment, the effects of the selected scale inhibitors were tested under thermal flux using the heat transfer test equipment in order to evaluate the scaling rates under various conditions.

Based on these comprehensive data, the scale inhibitor to be tested with the MSF Test Plant were selected.

3) Tests with the MSF Test Plant

-The confirmation test of the selected scale inhibitor were carried out at the MSF Test

Plant.

-The effects of the scale inhibitor with and without simultaneous use of acid were compared.

4) Evaluation and Report

Data obtained from the test with the MSF Test Plant have been evaluated in order to obtain the followings:

-Data relative to the increase in the fouling factor of heat transfer tubes.

-Data relative to the efficiency of ball cleaning for scale removal and its adequate frequency.

(3) Essential Equipment and Materials

1) Equipment

a. Scale deposition test equipment (above 100℃)

b. Scale deposition test equipment (under 100℃)

-three neck flask with a cooler

c. Heat transfer test equipment

-modification of the equipment owned by SWCC

2) Materials

a. Scale inhibitors

b. Brine

c. Sulphuric acid

d. Anti-foaming agent

e. Acid cleaning agents

f. Sponge balls

B. Study on Countermeasures against Oil Contamination of Products Water in MSF Process (MSF–2)

(1) Purpose

In MSF desalination of oil contaminated seawater, contamination of the product water is expected. This study aims at proposing how to prevent such contamination.

(2) Contents of Study

1) Investigation and Preparative Experiment

Information on the seawater quality in case when contaminated by oil and the vapor–liquid equilibria of hydrocarbon and bromoform, were investigated through literature surveys. The preparative experiment on volatility of bromoform and hydrocarbon contained in oil were also carried out.

2) Measurement of Vapor–liquid Equilibria

The vapor–liquid equilibria of hydrocarbon and bromform under the desalination conditions has been measured.

3) Simulation and Prediction of Contamination

The behaviors of hydrocarbon and bromoform in the MSF Test Plant will be simulated and predicted by the combination of the data obtained in 1) and 2) with the characteristics of the MSF Test Plant.

4) Tests with the MSF Test Plant

The results of the computer simulation were confirmed by the experiment done at the MSF Test Plant.

5) Evaluation and Report

The countermeasures against contamination of product water were proposed by analysis and evaluation of the results obtained in 4).

(3) Essential Equipment and Materials

1) Equipment

a. Preparative experiment equipment

b. Vapor–liquid equilibrium measurement equipment with a cooler

c. Personal computer owned by SWCC

d. MSF Test Plant

2) Materials

a. Hydrocarbon, bromoform

b. Brine

c. Scale inhibitors

d. Anti–foaming agent

e. Acid cleaning agents

f. Sponge balls

C. Study on Selection of RO Membrane for Hybrid System (RO-1)

(1) Purpose

This study aims at the selection for a hybrid desalination systems of the most practical membrane module with a high permeate flux rate among commercially available RO modules to desalinate the high salinity Arabian Gulf seawater yielding product water of 1,000-1,500mg/l TDS.

(2) Scope of Study

1) Investigation and Preparative Experiment

a. Experiments on the performance and the effect of chemical cleaning of fouled membranes

b. Comparison of performance behaivior of several flat membranes with potentially performance were promising conducted to select membranes of high permeate flux rate. Experiment were carried out with clean seawater in conformity with the conditions of Practical temperatures and pressures (the first screening).

c. Tolerance tests of chlorine and turbidity were carried out selected on the membrane (second screening).

2) Experiment with RO Mini-module (1)

a. Further evaluation of the selected membrane selected from the flat membrane test were made using and RO mini-module test unit.

b. For selected modules, tests of chlorine and tolerance, washing, etc. were carried out.

3) Tests using the RO Test Plant

RO modules applicability to a MSF-RO Hybrid desalination system were confirmed by conducting tests on RO modules using RO Test Plant.

4) Evaluation and Report

The most suitable RO module for a MSF-RO Hybrid process and its usage were selected for practical use from among present modules.

(3) Essential Equipment and Materials

1) Equipment

a. SDI measurement equipment

b. Flat membrane tester owned by SWCC

c. Two flat membrane cells

d. **RO Mini-module tester (1)**
e. **RO Test Plant**

2) **Materials**

a. **Flat membranes**

The fouled membranes used in the SWRO plants were obtained with their operation histories through arrangement made by SWCC.

b. **RO Mini-modules**
c. **RO Modules for practical use**
d. **Chemicals such as ferric chloride and SBS**
e. **Anthracite and sand for laboratory scale sand filter test**

D. Study on Countermeasures against Oil Contamination for RO Process (RO-2)

(1) Objective

This study is aimed at proposing the best countermeasures against oil contamination of seawater RO feed, containing several tens of mg/l of oil. The main objective is to remove oil from an oil cotaminated seawater RO feed prior to its entry to SWRO membranes.

(2) Contents of Study

1) Investigation and Preparative Experiment

a. Literature survey of analytical data, solubility, analytical method and removal method of soluble and insoluble oil into seawater were carried out.

b. Literature survey of analytical data, solubility, analytical method and removal method of halogen compounds such as trihalomethane were carried out.

c. Literature survey of oil tolerance of RO module were carried out as well as literature survey and experiment on removal of halogen compounds such as trihalomethane.

2) Experimental Oil Removal by Pretreatment

a. Preparative experiment

Laboratory experiment were carried out on removal of soluble and insoluble oil present in seawater by coagulation sedimentation and adsorption methods. The removal effect of coagulation–sand–filtration, adsorption by polymer, active carbon and combination of these methods have been studied.

b. Oil dosing experiment

The preparation of oil contaminated seawater model and the analysis oil content were studied.

c. Oil removal experiment

The removal of soluble and insoluble oil were studied by coagulation–sand–filtration, adsorption by polymer, active carbon method, etc.

d. Regeneration of oil removal equipment

The regeneration conditions of media and equipment used in the coagulation–sand–filtration, adsorption by polymer and active carbon were studied.

3) Oil Tolerance Test using a Flat Membrane Tester

Using a flat membrane test unit, experiment on the effect of oil (especially soluble oil) on membrane performance were carried out, using pretreated seawater as the feed water.

4) **Experiment with RO Mini-module (2)**

Oil tolerance of RO mini-modules were tested using pretreated feed seawater. Based on the results of 2) and 3) above, combination of pretreatment and oil-tolerant RO mini-module will be tested to design the process against oil contamination.

5) **Test with the RO Test Plant**

Confirmation of the process efficiency and oil tolerance of RO module was examined using the RO Test Plant with practical commercial modules.

6) **Evaluation and Report**

A combination of seawater pretreatment and use of oil-tolerant modules are at presently the best countermeasures against oil-contamination.

(3) **Essential Equipment and Materials**

1) **Equipment**

a. **Two flat membrane cells**
b. **Oil dosing preparation equipment**
c. **Oil adsorption equipment**
d. **Oil adsorption tower back-washing equipment**
e. **RO Mini-module testers (2)**
f. **RO Test Plant**

2) **Materials**

a. **Flat membranes**
b. **Dosing oil for preparation of contaminated seawater**
c. **RO Mini-modules**
d. **RO Modules for practical use**

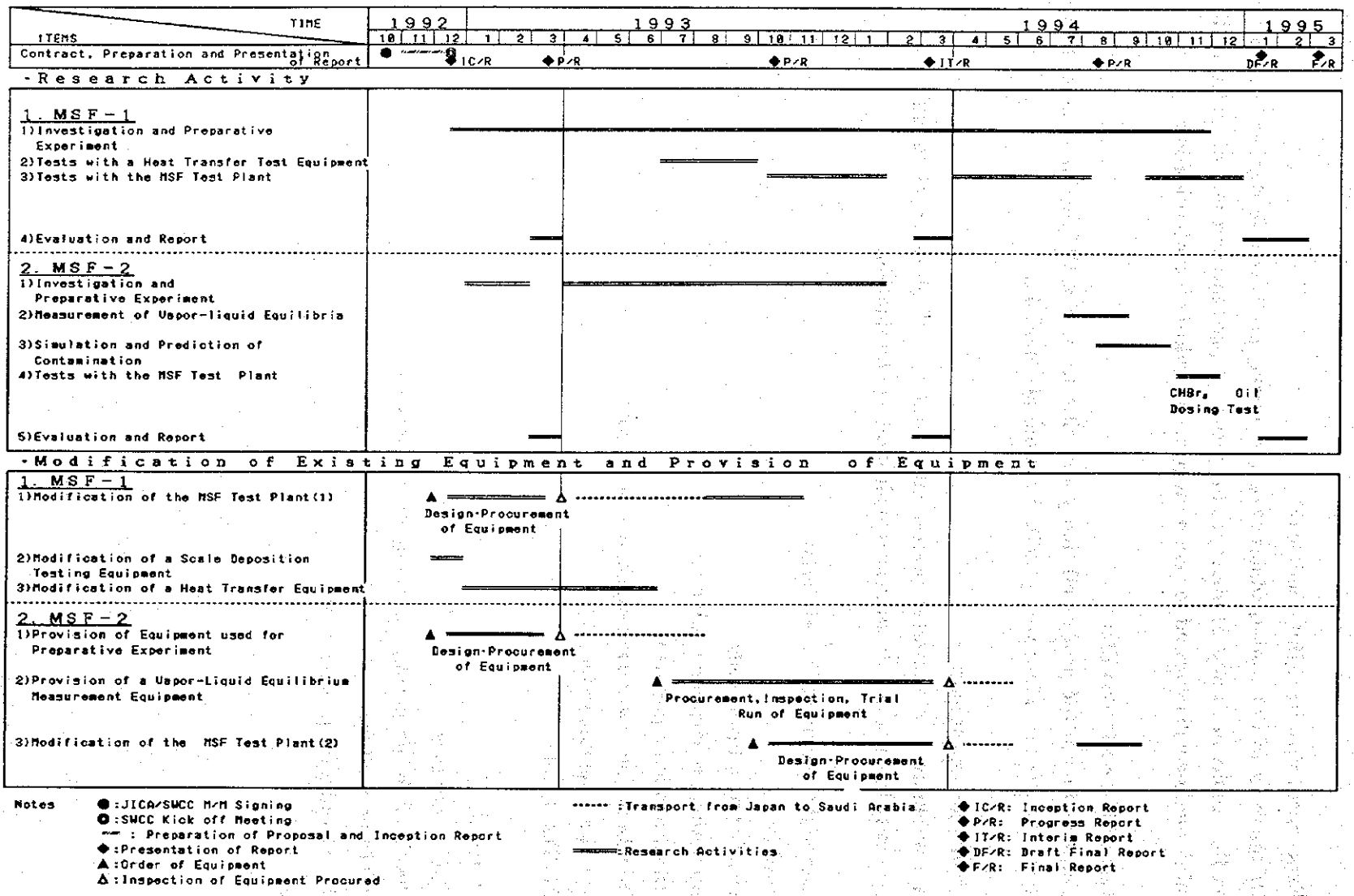

Fig. 1 Time schedule for Laboratory Equipment and MSF Test Plant

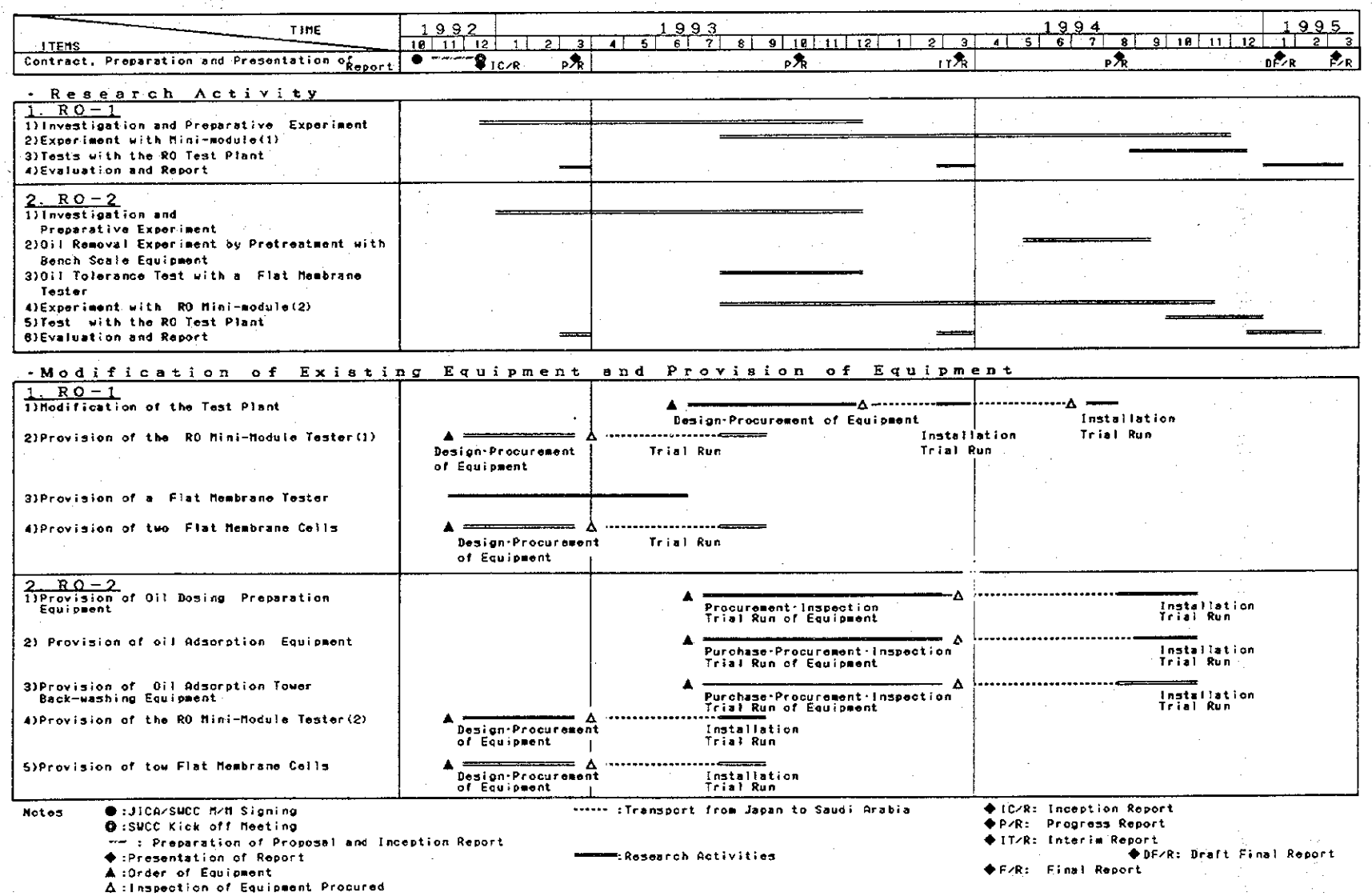

Fig. 2 Time Schedule for Laboratory Equipment and RO Test Plant

4.2 Work Plan

The working schedules and the research activities for each fiscal year are summarized in Fig. 3–Fig. 6.

Fiscal Year	1992					Remarks
Month	11	12	1	2	3	
1. Explanation and discussion of the inception report 2. Technological discussion with the counterpart 3. Transfer of the MSF & RO Test Plants and installation plan						
4. Implementation of collaborative research 1) Investigation and preparative experiment ①The status of productivity deterioration of MSF plants ②Selection of scale inhibitors ③Modification of the scale deposition test equipment 2) Tests with the heat transfer test equipment ①Modification of the heat transfer test equipment ②Selection of scale inhibitors 3) Tests with the MSF Test Plant ①Support for installation ②Trial runs ③Operation tests ④Water analysis ⑤Evaluation of fouling factor 4) Evaluation and report					◆P/R	
MSF-1						
1) Investigation and preparative experiment ①Investigation of the Arabian Gulf seawater ②Preparative experiment ③Water analysis 2) Measurement of vapor-liquid equilibria 3) Simulation and prediction 4) Tests with the MSF Test Plan ①Modification of the plant ②Operation tests ③Water analysis ④Evaluation of transferred substance to product water 5) Evaluation and report					◆P/R	
MSF-2						
1) Investigation and preparative experiment ①Survey on RO modules for hybrid system ②Performance evaluation of fouled membrane 2) Comparison tests of flat membranes 3) Tolerance tests with flat membrane in chroline and turbidity 4) Experiment with the RO mini-module tester (1) ①Selection of module ②Tolerance tests with flat membrane in chroline and turbidity 5) Experiment with the RO Test Plant ①Support for installation ②Experiment 6) Evaluation and report					◆P/R	
RO-1						
1) Investigation and preparativwe experiment 2) Oil removal experiment by pretreatment with bench scale equipment 3) Oil tolerance tests with a flat membrane tester 4) Experiment with the RO mini-module (2) 5) Test with the RO Test Plant 6) Evaluation and Report					◆P/R	
RO-2						

Notes : ——— Implementation by JICA ——— Implementation by SWCC ——— Implementation by JICA/SWCC

Fig. 3 The First Research Activities in Saudi Arabia

Fiscal Year	1993												Remarks
Month	4	5	6	7	8	9	10	11	12	1	2	3	
4. Implementation of collaborative research													
1) Investigation and preparative experiment													
①The status of productivity deterioration of MSF plants													
②Selection of scale inhibitors													
③Modification of the scale deposition test equipment													
2) Test with the heat transfer test equipment													
MSF-1 ①Modification of the heat transfer test equipment													
MSF-1 ②Selection of scale inhibitors													
3) Tests with the MSF Test Plant													
MSF-1 ①Support for installation													
MSF-1 ②Trial runs													
MSF-1 ③Operation tests													
MSF-1 ④Water analysis													
MSF-1 ⑤Evaluation of fouling factor													
4) Evaluation and report							◆P/R						
1) Investigation and preparative experiment													
MSF-2 ①Investigation of the Arabian Gulf seawater													
MSF-2 ②Preparative experiment													
MSF-2 ③Water analysis													
2) Measurement of vapor-liquid equilibria													
3) Simulation and prediction													
4) Tests with the MSF Test Plant													
MSF-2 ①Modification of the plant													
MSF-2 ②Operation tests													
MSF-2 ③Water analysis													
MSF-2 ④Evaluation of transferred substance to product water													
5) Evaluation and report							◆P/R						
1) Investigation and preparative experiment													
①Survey on RO module for hybrid system													
②Performance evaluation of fouled membranes													
2) Comparison tests of flat membranes													
RO-1 3) Tolerance tests with flat membrane in chlorine and turbidity													
RO-1 4) Experiment with the RO mini-module tester (1)													
RO-1 ①Selection of module													
RO-1 ②Tolerance tests with flat membrane in chlorine and turbidity													
5) Experiment with the RO Test Plant													
①Support for installation													
②Experiment													
6) Evaluation and report							◆P/R						
1) Investigation and preparative experiment													
RO-2 2) Oil removal experiment by pretreatment with bench scale equipment													
RO-2 3) Oil tolerance tests with a flat membrane tester													
RO-2 4) Experiment with the RO mini-module (2)													
5) Test with the RO Test Plant													
6) Evaluation and report							◆P/R						

Fig.4-1 The Second Research Activities in Saudi Arabia

Month	4	5	6	7	8	9	10	11	12	1	2	3	Remarks
1. RO-1 : Analysis of fouled membranes													
2. Preparation of the interim rep.												◆IT/R	

Notes: ——— :Implementation by JICA ═══ :Implementation by SWCC ═══ :Implementation by JICA/SWCC

Fig.4-2 The Second Research Activities in Japan

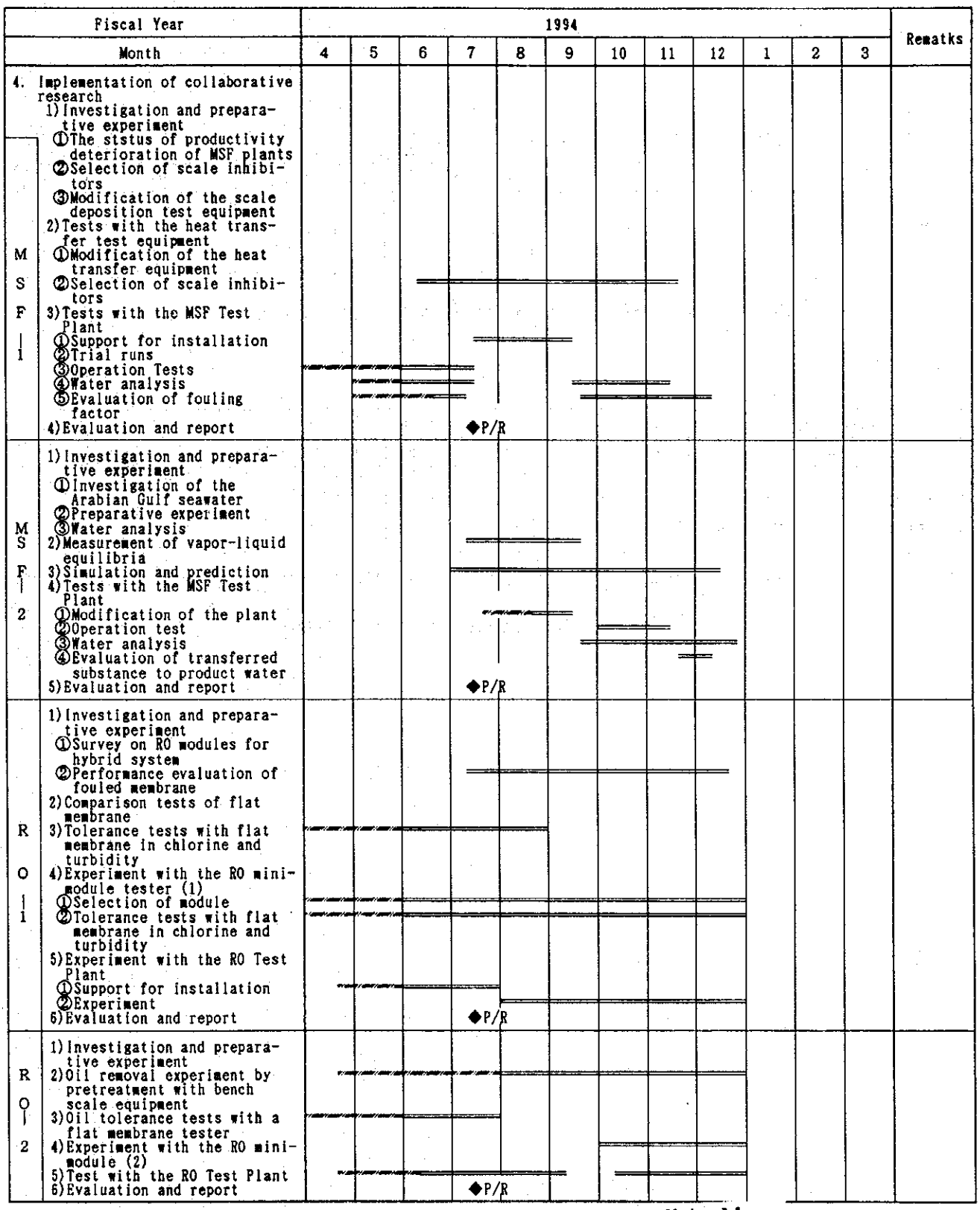

Fig.5–1 The Third Research Activities in Saudi Arabia

Fiscal year 1994	4	5	6	7	8	9	10	11	12	1	2	3	備 考
4. Preparation of the draft final report													

Notes: ——— :Implementation by JICA ═══ :Implementation by SWCC ═══ : Implementation by JICA/SWCC

Fig.5–2 The Third Research Activities in Japan

Fiscal Year	1994												Remarks
Month	4	5	6	7	8	9	10	11	12	1	2	3	
5. Explanation of the draft final report											◆DF/R		

Fig.6-1 The Fourth Research Activities in Saudi Arabia

Fiscal Year	1994												Remarks
Month	4	5	6	7	8	9	10	11	12	1	2	3	
5. Preparation of the final rep.											———		
6. Sending the final rep. to SWCC												—	

Notes: ——— :Implementation by JICA ——— :Implementation by SWCC ═══ : Implementation by JICA/SWCC

Fig.6-2 The Fourth Research Activities in Japan

4.2.1 The First Research Activities in Saudi Arabia (January–March, 1993)

(1) **Explanation and discussion of the Inception Report**

In January, 1993, JICA team explained the Inception Report at SWCC head office in Riyadh and confirmed the division of responsibility for the work between JICA and SWCC.

(2) **Technical meeting between SWCC and JICA**

Based on the Inception Report, SWCC and JICA discussed the technical aspects of the research themes in detail at SWCC's R&D Center. On this occasion, it was agreed that if there were a request to change the plan, appropriate modification could be made within the M/M limitation.

(3) **Plans for the transportation of MSF and RO Test Plant**

The MSF and RO Test Plants had been stored at Yanbu, but in January–February 1993 they were moved to Al Jubail.

(4) **Implementation of collaborative research**

Collaborative research activities were undertaken in the R&D Research Center according to the scheme mentioned in 4.1.

(5) **Preparation of progress report**

The progress report covering the results of the literature survey and the preparative experiments mentioned above have been published, March, 1993.

4.2.2 The second Research Activities in Saudi Arabia (April 1993 – March 1994)

(1) Supplementary chemical analysis equipment arranged in this period were as follows:

A : X–ray diffractometer,
B : Ion chromatography,

Concerning A, the equipment, including a supply of parts, has been assembled, inspected and operated and technical guidance has been given on its operation and maintenance as well as guidance on application technology.
Concerning B, assembly and installation were completed in the previous period. In this

period, training has been given on analytical operations to promote proficiency in the operation of the equipment and, at the same time, guidance has been given in care and maintenance technology and application technology so that those involved will be fully informed.

(2) Implementation of collaborative research
Collaborative research activities were undertaken in the R&D Research Center according to the scheme mentioned in 4.1.

(3) Preparation of progress report
The progress report on the research work during this period have been published on October, 1993.

4.2.3 The Second Research Activities in Japan

(1) Publication of Interim Report
The interim report on the results of the research work during the first and the second research activities periods have been published on February, 1994.

(2) Explanation and discussion of the Interim Report
In March, 1994, JICA team discussed the Interim Report at SWCC.

(3) Analysis of fouled membrane
The analysis of the collected fouled membranes have been conducted both at Saudi Arabia and Japan as part of the RO-1 project.

4.2.4 The Third Research Activities in Saudi Arabia (April 1994 – Feb. 1995)

(1) Implementation of collaborative research
Collaborative research activities were undertaken in the R&D Research Center according to the scheme mentioned in 4.1.

4.2.5 The Third Research Activities in Japan (April 1994– Feb. 1995)

(1) Preparation of draft final report
The collaborative research was completed at the end of December 1994, after which the JICA team returned to Japan, taking with them the data required for the preparation of the draft for the final report to be completed in Japan. This report summarizes the results of the collaborative research which has been made up to that

time, at all times in collaboration with SWCC.

(2) Explanation to SWCC

For a period of nine days in February 1995, JICA team explained the draft for final report for the benefit of SWCC and its contents were discussed.

4.2.6 Preparation of Final Report

The final report was prepared jointly by SWCC/JICA researchers within the last one month.

4.3 Undertaking of JICA and SWCC

(1) Undertaking of JICA and SWCC has been established for the following items.

1) Laboratory equipment
2) Materials
3) Test Plant
4) Personnel required
5) Others

(2) JICA has provided the following experimental equipments and SWCC has provided the utilities for them and also provided necessary manpower for the installation and commissioning:

1) Mini-Module Tester (1)
2) Mini-Module Tester (2)
3) Cooling Water Cycling Equipment for SWCC's Flat Membrane Tester
4) Cooling Water Cycling Equipment for Mini-Module Tester (1)

(3) JICA and SWCC have made an agreement as relate to the responsibility undertakings for the main equipment used for this research activities.

(4) SWCC provided the following:

1) Six separate office spaces and one meeting room for the members of JICA team
2) A fully furnished accommodation for the members of JICA team according to SWCC's standard during their stay in the Kingdom of Saudi Arabia
3) Vehicles with drivers for the JICA team during working hours including commutation
4) Expenses and necessary duties on the internal business trip in the Kingdom of Saudi Arabia for the members of JICA team
5) Customs formalities and their necessary charges, if any, as may be imposed upon the equipment and/or materials to be provided by JICA to SWCC
6) Expenses and necessary duties on the domestic transportation for the equipment and/or materials to be provided by JICA to SWCC
7) Expenses on the telephone and fax from SWCC Research Center to the offices in Japan for the JICA team to send important information with permission of the coordinator of SWCC Research Center
8) Chemical and physical analysis
9) Pretreated seawater feed

4.4 Organization

The organization and division of responsibilities are shown in Fig.7 and Table 1.

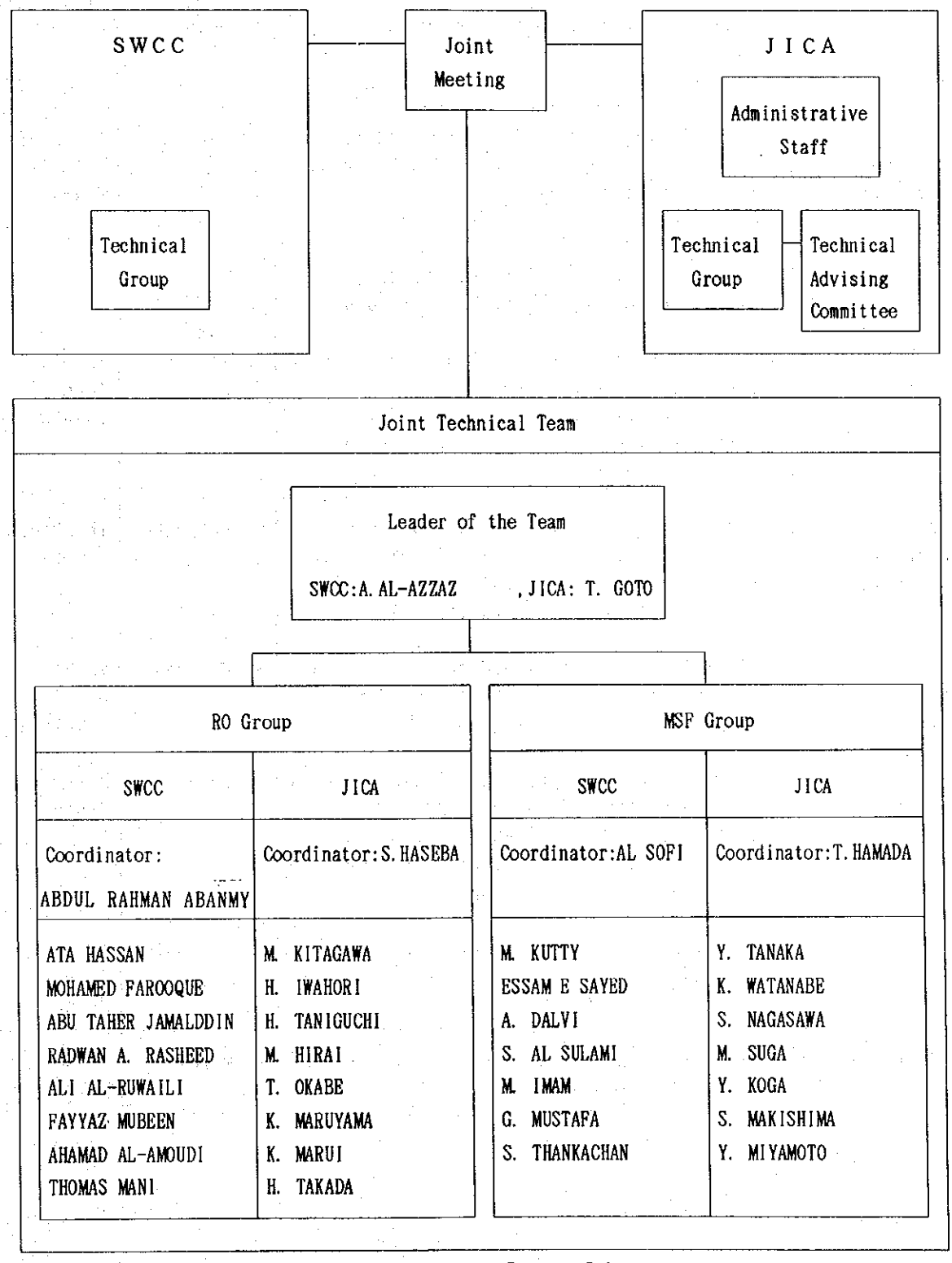

Fig. 7 Organization Chart of the Project

Table 1-1 Division of Responsibilities

Responsibilities	Contents of Work	Name	
		JICA	SWCC
General Management	・Management and planning for research activity ・Negotiation with counterpart	T. Goto	A.A.Al-Azzaz
MSF-1, MSF-2 (Research and Coordination)	Implementation of experimenntal research in Saudi Arabia and evaluation of the results ・Scale inhibitor selection ・Characteristics of the test plant for simulation of oil behavior ・Evaluation of chemistry related data ・Evaluation of heat transfer related data	T. Hamada	A.K.Al-Sofi M.Kutty Essam
MSF-1, MSF-2 (Analysis)	・Implementation of chemical analysis for seawater, brine and scale ・Evaluation of chemical analysis data ・Assistance for implementation of experimental research	Y. Tanaka M. Suga	S.Sulami Imam Thankachan
MSF-2 (Vapor-Liquid Equilibrium-1)	・Implementation of bench-scale preparative experiment for oil behavior in MSF plant ・Investigation of physical properties for analysis of oil contaminants behavior	K. Watanabe	Thankachan A.G.Dalvi
MSF-2 (Vapor-Liquid Equilibrium-2)	・Obtaining of Vapor-Liquid equilibrium data ・Determination of given condition for computer simulation programs	S. Nagasawa	M.Kutty Dalvi Thankachan
MSF-2 (Computer Analysis)	・Preparation of computer simulation program Hard Ware: NEC PC98 & IBM-PS/2 Soft Ware: BASIC, FORTRAN & C or C++ ・Amendment of computer simulation programs based on experimental results	Y. Koga	M.Kutty Essam
MSF Test Plant (1)	・Supervision for the test plant assembly and installation	S. Makishima	Al-Sofi, M.Kutty, Essam
MSF Test Plant (2)	・Supervision for trial runs, operation and maintenance of the test	Y. Miyamoto	Al-Sofi, M.Kutty, Essam

Table 1-2 Division of Responsibilities

Responsibilities	Contents of Work	Name	
		JICA	SWCC
RO-1, RO-2 (Research and Coordination)	Implementation of experimental research in Saudi Arabia and evaluation of the results ・Prior investigation for RO-1 ・Evaluation of preparative experiment results for RO-2 ・Evaluation of mini-module test results for RO-1 & RO-2 ・Evaluation of the test plant results	S. Haseba	A. Abanmy A. Hassan
RO-1, RO-2 (Analysis-1)	・Water quality analysis needed for flat membrane tests, mini-module tests and the test plant tests ・Mini-module tests for membrane selection in hybrid system ・Tolerance tests with mini-modules in chlorine and turbidity ・Support for information retrieval from Japan	M. Kitagawa Y. Taniguchi	M. Farooque A. Jammaldin A. R. Ali M. Fayyaz
RO-1, RO-2 (Analysis-2)	・Investigation of fouling for used RO membrane and study of cleaning method ・Implementation of RO system performance analysis and hybrid system simulation calculation ・Evaluation and selection of membrane for hybrid system	H. Iwahori K. Marui	Nomani Ata Hassan A. Jammaldin A. R. Ali M. Fayyaz
RO-1, RO-2 (Membrane Evaluation-1)	・Comparison tests with flat membrane tester to select membranes for hybrid system ・Tolerance tests with flat membrane tester in chlorine ・Operation of the test plant for RO-1 and evaluation of the results ・Assistance for implementation of experimental research	M. Hirai	Nomani Ata Hassan M. Farooque A. R. Ali M. Fayyaz
RO-1, RO-2 (Membrane Evaluation-2)	・Comparison tests with mini-module tester to select membranes for hybrid system ・Tolerance tests with flat membrane tester in turbidity ・Operation of the test plant for RO-2 and evaluation of the results	T. Okabe	Ata Hassan M. Farooque A. Jammaldin A. R. Ali M. Fayyaz
RO-2 (Pretreatment)	・Removal tests of oil from seawater by coagulation & filtration and adsorption ・Studies and tests on preparation artificially oil contaminated seawater ・Literature survey on analytical methods oils and organic halogen compounds such as trihalomethane in seawater ・Literature survey on tolerance tests with RO modules in oils and separation capacity of membrane for organic halogen compounds ・Experiments for oil removal by pretreatment	K. Maruyama	Ata Hassan M. Fayyaz M. Farooque A. Jamalddin A. R. Ali
RO Test Plant	・Supervision for the test plant assembly, installation, trial runs, operation and maintenance	H. Takada T. Yago	A. Hassan A. Abanmy

4.5 Supplementary Arrangement of Equipment

The work of setting up common materials (research instruments, the MSF Test Plant, and the RO Test Plant) in the assigned locations and making adjustments was carried out and the plan for the preparation of common materials was implemented. Within this period supplementary parts for the installation/ modification of MSF and RO test plants and supplementary laboratory equipment for the preparative experiments were supplied.

4.5.1 Supplementary Arrangement of Chemical Analysis Equipment

Within this project period, dispatching engineers to take charge of the following items (Table 2), the supplement to the common materials plan was implemented and guidance on operation and maintenance technologies were made.

(1) Chemical Analysis Device A
- Implementation of assembly, installation and inspection
- Guidance on operation and maintenance technology for electron probe micro-analyzer.
- Implementation:from October 1994 to November 1994

(2) Chemical Analysis Device B
- Implementation of assembly, installation and inspection
- Guidance on operation and maintenance technology for ICP emission spectrometer, infra-red spectrometer and spectrophotometer.
- Implementation:from October 1994 to November 1994

(3) Chemical Analysis Device C
- Implementation of assembly, installation and inspection
- Guidance on operation and maintenance technology for X-ray diffractometer.
- Implementation:in January, 1992

(4) Chemical Analysis Device D
- Guidance on operation and maintenance technology for the ionchromatograph
- Implementation:in April, 1992 and September, 1993

English version of operation manual for ion chromatograph IC-500PS was prepared and submitted.

4.5.2 Supplementary Supplied Parts and Laboratory Equipment

Supplementary supplied parts for the installation of the Test Plants and equipment for the preparative experiment are listed in Table 3.

Details of the installations work are described in the following sections.

a.	**Installation of the MSF Test Plant**	**:5.3.1**
b.	**Modification work of the MSF Test Plant**	**:6.4.1**
c.	**Installation of the RO Test Plant**	**:7.3.1**
d.	**Installation of Pretreatment of Oil Removal Experiment**	**:8.2.1**
e.	**Installation of the Mini-module Tester**	**:7.2.1**

Table 2 Division of Responsibilities for Chemical Analysis Equipment

Responsibility	Contents of Work	Name	
		JICA	SWCC
Chemical Analysis Equipment A	• Implementation of assembly, installation and inspection • Guidance on operation and maintenance technology for Electron Probe Microanalyzer	Y. Tanehata	Nausha Asrar T. Prakash John O' hara Ismail Andijani Mohd Ismail Noor Ahmed
Chemical Analysis Equipment B	• Implementation of assembly, installation and inspection • Guidance on operation and maintenance technology for ICP Emission Spectrometer, Infrared Spectrometer and Spectrophotometer	M. Inoue	S. Sulami A. G. Dalvi M. A. Javeed Radwan Rasheed
Chemical Analysis Equipment C	• Implementation of assembly, installation and inspection • Guidance on operation and maintenance technology for X-ray diffractometer	S. Sakano	Andijani Al-Fozan Shahreer
Chemical Analysis Equipment D	• Implementation of assembly, installation and inspection • Guidance on operation and maintenance technology for Ionchromatograph • Preparation of English Version of Operation Manual	N. Kawashima H. Ohtsuka	S. Sulami A. G. Dalvi Azhar A. Nomani Radwan Sulaiman

Table 3 Parts and Equipment Supplied by JICA

No.	Description
1.	Additional Parts for MSF test Plant
1.1	Pumps & Motor for Distilate Sampling
1.2	Prefab Piping for Distilate
1.3	Pump & Motor for Brine Samoling
1.4	Prefab Piping for Brine Sampling
1.5	Boss for Probe Sampling
1.6	Oil Tank(100 liter)
1.7	Pump & Motor for Oil Feed
1.8	Oily water Sepatrator
1.9	Piping Materials for Oil Feed and Oily Water Separator
1.10	Pump Suporter
1.11	Resistance Bulb
1.12	Hybrid Recorder
1.13	Control Panel
1.14	Cable (CVV-5), Cable(CV600V)
1.15	Glove Valve etc.
2.	Vapor/Liquid Equilibrium, Main Equuipment and Mounting Suport Frame
3.	Mini-module Test Equipment(1)
4.	Mini-module Test Equipment(2)
5.	Full Automatic Water Chilling Unit
6.	Equipment for Preparative RO Experiment(1)
6.1	Disperger
6.2	Coagulation Tank
6.3	Stirrer
6.4	Ultra High Purity Water System
6.5	Gas Chromatograph Column
6.6	Laboratory Stand
6.7	Column Holder
6.8	Boiling Stone
6.9	Attachments for TOC
6.10	Sand Filter Column
7.	Equipment for Preparative RO Experiment(1)
7.1	Ultrasonic Homogenizer
7.2	Quartz Cell for Oil Measuring Equipment
7.3	Roller Pump
8.	Parts for EPMA
9.	Parts for Infrared Spectrophotometer
10.	Accessories for 2pen Recorder
11.	Parts for X-ray Diffractometer D/MAX
12.	PR Gas (Proportional Gas)

Table 3 Parts and Equipment Supplied by JICA

No.	Description
13.	Additional Parts for RO test Plant
13.1	Pumps for RO Test Plant
13.2	Belt Cover of High Pressure Pump
13.3	Terminal Box
13.4	UV Sterilizer
13.5	Victaulic Joint
13.6	Junction Box Case
13.7	Conduit Pipe
13.8	Ragging Materials
13.9	Tightening Bolts for M10-01
13.10	Tightening Bolts for HE-201
13 11	Pressure Gauge
13.12	Pneumatic Operated Butterfly Valve
13.13	Manual Valve
13.14	Piping Materials
13.15	Spare Parts for Pumps, Electric Equipment
13.16	Analytical Equipment
14	Pretreatment Equipment of Oil Contaminated Seawater
14.1	Oil Addition Adjusting Equipment
14.2	Adsored Oil Removing Equipment
14.3	Adsorbed Oil Recovery Equipment