# APPLICATION OF CORROSION PREVENTION TECHNOLOGY FOR SEA WATER PUMPED-STORAGE POWER PLANT

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## 1 INTRODUCTION

Pumped-storage power plant has been successfully installed having done its duty as peaking capacity and marginal supply. However, in Japan, the economically favourable river water pumped-storage scheme is expected to be exhausted for reasons of geographical restriction and difficulty of its siting. Therefore the development of sea-water pumped-storage was considered in early time.

Corrosion prevention technology about hydraulic machines have considerably advanced at present so that many corrosion control methods apply to tidalpower plant and pumping machines used at thermal plant. However, the Francis-type reversible pump-turbine intended to adopt in sea water pumped-storage scheme is required to possess the performance for stress caused by high water pressure, so the materials used in this equipment is required strength as well as corrosion endurance.

Pump-turbine is the most important equipment in plant different from cooling pump of thermal plant, so running cost and interval frequency for maintenance considerably raise the cost by value of project. To maintain the performance of plant equivalent to that of river water pumped-storage plant and to reduce the initial cost of development, many problems must be solved in selecting materials and determination for assembly structure of machines.

Concerning to technology of sea water pumped-storage plant, research and development program which is a government sponsored have been continued

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since 1981. In this paper, we introduce the investigations for sea water pump-turbine carried out this program.
These investigations mainly consist of three parts such as the selection of stainless steels by the corrosion and errosion test, the selection of suitable coating system for sea water pump-turbine by stepping test and estimation to crevice and galvanic corrosion used FEM analysis. Further, based on these experimental results, field test using small scale model pump-turbine which is similar to practical plant is carried out to verify the performance of materials and coatings.

## 2 CORROSION RESISTANCE OF MATERIALS

Corrosion resistance is the most important property of pump turbine materials for sea water pumped-storage power plants. And stainless steels are the most useful material because of their high corrosion resistance. High strength and excellent qualities of castability, weldability and economy in fabrication processes are necessary as well as high corrosion resistance for the materials used in the runner and guide vanes which are the most important parts of the pump turbine. It is necessary to choose the materials after considerations of these properties as a whole.
In this report, corrosion, sand erosion and cavitation erosion in substitute sea water were observed on martensitic stainless steel, austenitic stainless steel and duplex stainless steel, the first two are used for runner and guide vanes in river water pump turbines.

### Corrosion tests on stainless steels

Stainless steels are classified into three types of 13 Cr martensitic, 18Cr8Ni austenitic and 25Cr-6Ni ($\alpha+\gamma$) duplex steels based on their chemical composition and microstructures. Martensitic steel has a high yield strength but its corrosion resistance is poorer than other types of stainless steels, therefore the improvement of its corrosion resistance by addition of molybdenum is necessary.
On the other hand, austenitic steel and duplex steel have excellent corrosion resistance but their yield strength is relatively low, therefore improvement of the yield strength is necessary.
Corrosion tests, sand erosion tests, cavitation erosion tests and corrosion fatigue tests in substitute sea water were carried out as shown in Table 1. Figure 1 shows the testing apparatus for the dynamic corrosion and sand erosion tests.
In the dynamic corrosion tests, the corrosion resistance of 12Cr-0.6Ni steel is poorer than the other steels.
It is concluded that 13Cr-5Ni-2.1Mo martensitic steel, 18Cr-9Ni-2.5Mo austenitic steel and 24Cr-6Ni-3Mo duplex steel are suitable for runner and guide vane materials. These steels contain high amounts of molybdenum.

### Weldability test of duplex phase stainless steels

Welding may be required fabricating a sea water pumped-storage power plant where the duplex phase stainless steels are first designed for use. Thus, the welded joint of those steels should be characterized. The object of the experiments were to investigate the influence of welding methods on the corrosion resistance and the mechanical properties of duplex steels and to compare the characteristics with that of austenitic stainless steels.

In these experiment, the duplex phase stainless steels used were the type of Fe-25Cr-7Ni-3Mo. The microstructure of this type consisted of ferrite and austenite is approximately equal proportions.
Welding methods used here were shielded metal arc welding (SMAW), gas tungsten arc welding (GTAW) and gas metal arc welding (GMAW).
In welding of heavy plates, base and weld metals may be affected repeatedly with cyclic heating and cooling between low and high temperature. It is possible therefore that the characteristics of those metals may be under the great influence of welding. In order to synthesize heat-affected zone of base metals, test pieces in the form of 11 mm square and 100 mm long were employed in a heat cycle. After treatments, the corrosion resistance of steels were investigated in detail.
Pitting potential measurement by promoting potential method in substitute sea water and rotating bending fatigue testing under dropping of substitute sea water were carried out to evaluate corrosion resistance.
Metallographic evaluation using microstructure inspection and hardness testing and mechanical property evaluation using tensile and impact testing were carried out at the same time.
Joint of duplex phase stainless steel plates welded by SMAW, GTAW and GMAW respectively were equivalent in pitting potential at room temperature. Results of metallographic inspection and tensile testing were satisfactory in all welding methods. On impact testing, absorption energy of weld metals welded by GTAW showed higher values than those welded by the other methods.
In the synthetic heat-affected zone tests, pitting potentials of samples slow cooled in 500 sec from 800°C to 500°C were not reduced when measured at room temperature and 40°C.
Those were reduced and pitting occurred when rised measuring temperature up to 80°C and increased the corrosion rate.
Putting potential values of the joints of duplex phase stainless steel plates, duplex phase stainless steel castings and austenitic stainless steel castings welded by SMAW were measured. These values at room temperature were equivalent between three types of steel. Duplex phase stainless steels seem to be superior to austenitic stainless steel in pitting potential at 40°C. Corrosion fatigue strength of duplex phase stainless steels under dropping of substitute sea water showed values of approximately 30 kgf/mm$^2$ for plates and 20 kgf/mm$^2$ for castings. Those are higher than that of austenic stainless steel casting of approximately 15 kgf/mm$^2$. In all types of steel, there were no distinctions between base metals and welded joints. From these experimental result, it is found that the joint of duplex phase stainless steels welded in control of heat input, interpass temperature and soon, as well as the base metal, have good corrosion resistances and mechanical properties.

## 3 STEEPING TEST OF COATING IN SEA WATER

Purpose of Experiment

In order to select the anti-corrosion coating systems having excellent durability and the effective cathodic protection systems for use in sea water, the test pieces coated with various anti-corrosion materials were placed in static substitute sea water and flow of the actual sea water with performing the cathodic protection by impressed current method for some of the test pieces in flow and the effects for corrosion prevention were

compared.

Method and Equipment

As test pieces, organic and inorganic zinc rich paints, which aim at producing the sacrificial anode effect, epoxy, coal tar epoxy, polyurethan and polyester coatings, which isolate metallic surfaces from outside, and anti-fouling paints for preventing adhesion of marine animals and plants were combined and applied to the base metals of carbon steel and austenitic stainless steel in different thickness. The shapes of test pieces are shown in Fig. 2. The test pieces to be steeped in static sea water, except some pieces, have a cut of the coating film reaching the base metal on one side in order to simulate defects happening during coating work or injuries given during operation. The lower half of them was steeped in sea water. The test rig for the steeping in sea water flow consists of the portion pumping up actual sea water to the tank and testing circuits. There are four circuits where tests with cathodic protection and tests without it are carried out simultaneously in two flow speeds – 2.5 m/sec and 10 m/sec. The test in static water was continued for 360 days. For the test in flow, the test pieces were steeped in intermittent flow for 210 days.
After the steeping, surfaces of the test pieces were observed and changes of the film thickness and film impedance ($\tan\delta$) were investigated.

Results

In the test in static water, blisters of the film occurred around the cut of the film in both steeped and air-exposed portions of the test pieces coated with organic zinc rich paint plus epoxy and of the test pieces coated with coal tar epoxy only.
In the test in flow, blisters and peeling-off of the film occurred on every test piece coated with coal tar epoxy only.
There was not any apparent change from the initial values on both film thickness and film impedance.
Blisters which occurred around the cut of the film in the test in static water was caused by the corrosion of the base metal and it should be considered that sea water came through the cut.
In the test in static water, blisters of the film occurred around the cut of film on the test pieces which are under-coated with organic zinc rich paint, while on the test pieces under-coated with inorganic zinc rich paint, any apparent defect was not recognized and the film held its condition good in both static water and flow.
Zinc rich paints protects the base metal because it produces the effect of sacrificial anode.
In this study, the superior effect of inorganic zinc rich paint was proved.
Undesirable effect was not produced on any piece by the cathodic protection. In test pieces coated with coal tar epoxy, blisters and peeling-off of the film were observed even with the cathodic protection as same as the case without it. However, the corrosion around peeling-off area was slighter in case with the cathodic protection.
The cathodic protection does not produce any undesirable effect on the coating systems mentioned above and it is effective to protect the surface where the coating film is injured.
No apparent influence of difference in velocity was recognized on any coating system in the test in flow.

## 4 FUNDAMENTAL STUDIES FOR GALVANIC AND CREVICE CORROSION UNDER SEA WATER ENVIRONMENT

Galvanic corrosion and crevice corrosion have been considered to be typical corrosion problems under sea water environment, especially for pump-turbine due to its complicated structure. So, to design these component, it will be important to grasp these kind of corrosion properties and its countermeasure. Some corrosion studies have been carried out for galvanic and crevice corrosion under sea water environment using FEM analysis method.

Concerning to crevice corrosion, test result was compared to FEM analysis. This analysis were carried out according to the process which is showed in Fig. 3.

On the other hand, model tests for crevice corrosion were carried out. Typical test result were shown in Fig. 4 (for galvanic corrosion) and Fig. 5 (for crevice corrosion).

Comparatively good correlation between analysis and test result were observed. Based on these studies, to avoid crevice corrosion under sea water condition, it will be effective countermeasure to use material with low depassivation pH as structual material.

## 5 FIELD TEST USING SMALL SCALE MODEL PUMP-TURBINE

For the purpose of verifying the performance of sea water pump-turbine, the field test have been intended to carry out using small scale pump-turbine. In this model, the material of every part of assembly was selected by the results of fundamental investigations which mentioned above. And the test conditions are considered to realize the actual conditions of pumped-storage plant concerning cavitation, characteristics of sea water, structure of machines, materials and coatings.

Crevice corrosion and galvanic corrosion must be investigated with the similar structure of pump-turbine such as joints and holes. Add to these corrosion, the performance reduction which is made by staining with marine animals.

It is estimated that the elimination of sessile marine animals and durability of coating have a great influence to the maintenance cost of power plant. To estimate these maintenance risks, this model test have a great significance.

Three sets of model pump-turbines were manufactured and installed in 1985 and operating test is intended to in Okinawa island from 1985 to 1990.

## 6 CONCLUSION

In the basic investigations about materials and coating, superior materials were selected for using actual pump-turbine. And by model plant test started from 1985, many problems such as errosion and corrosion of metals, stain with marine animals, endurance of coating, maintenance informations expected to be solved. Based on these technology, we are expected to construct the project of sea water pumped-storage scheme in the near future.

Table 1. The outline of various tests

| Tests | Test Condition | Observations & Measurements |
|---|---|---|
| Immersion test | Substitute sea water, 25°C, 50 - 2000 h | Appearances, Weight loss |
| Salt spray test | 5%NaCl, 35°C, 1.3 - 1.5 ml/80cm$^2$.h, 50 - 500 h | Appearances, Weight loss |
| Polarization curve measurement | Substitute sea water, 25°C 60 mV/min. | Corrosion rate Pitting potential |
| Dynamic corrosion test | Substitute sea water, 25°C 7 m/s, 100 - 500 h | Appearances, Weight loss |
| Sand erosion test | Substitute sea water, Sand 30 g/l, 25°C, 7 m/s, 100 - 500 h | Appearances, Weight loss |
| Rotating corrosion fatigue test | Substitute sea water drop 0.25 ml/min, 3600 rpm | S-N Curves, Fatigue strength at $10^8$ cycles. |
| Cavitation erosion test | Substitute sea water, 25°C, 6.5 kHz, 60, 120 $\mu$m | Appearances Weight loss |

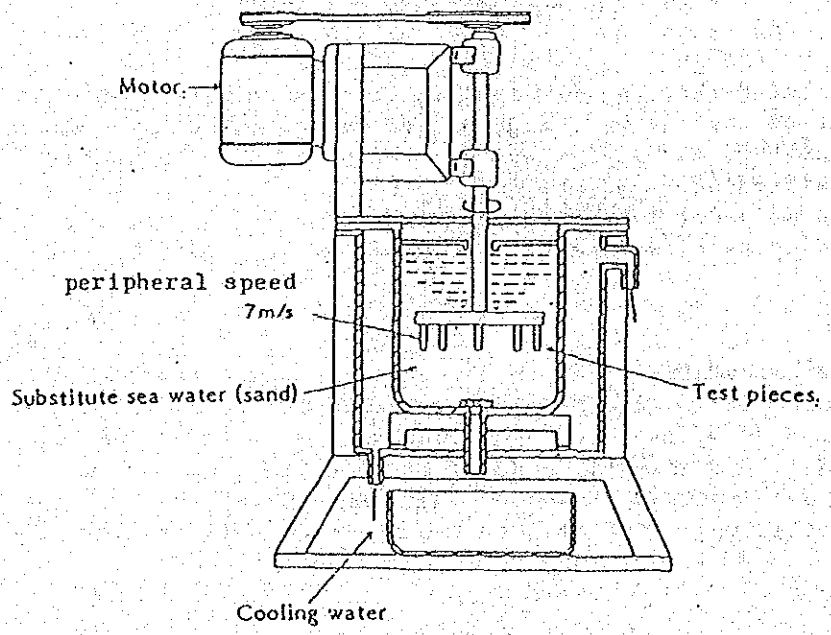


Fig. 1 Test apparatus for dynamic corrosion tests and sand erosion tests

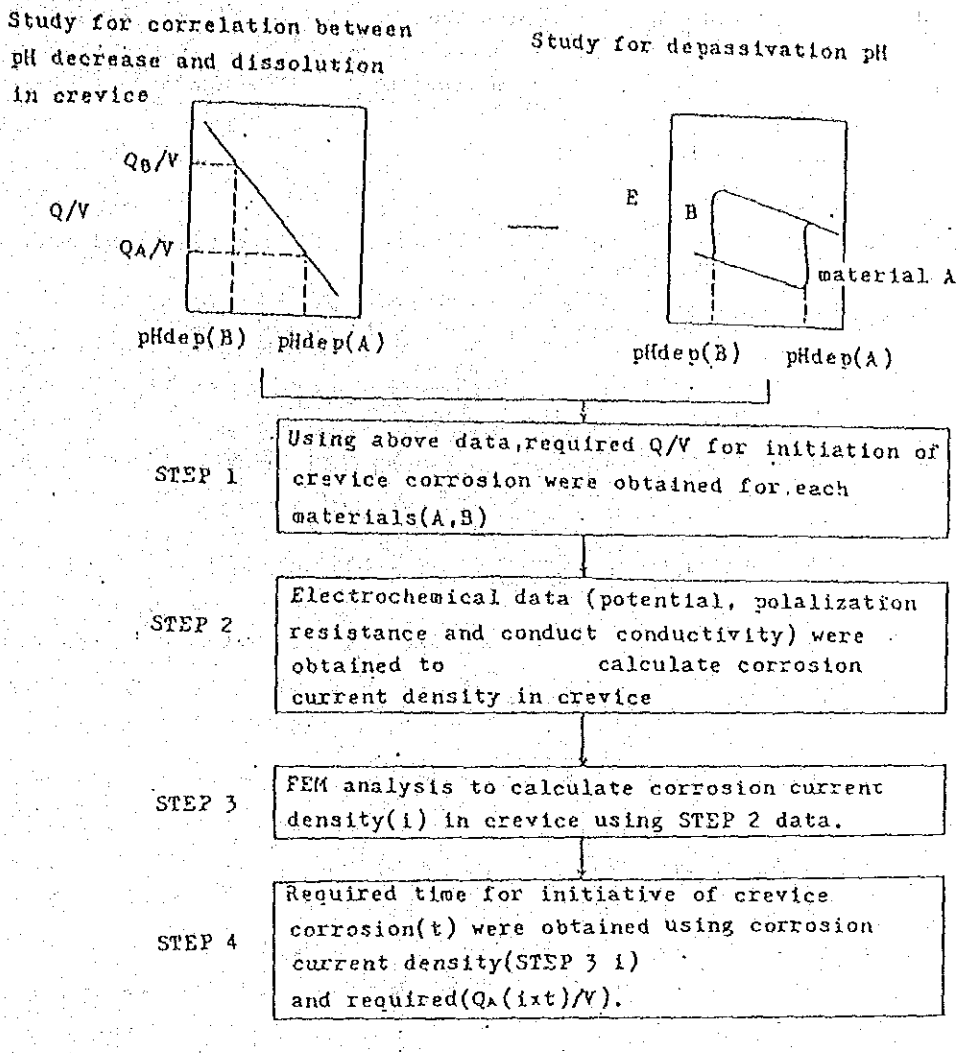


Fig.3 Estimation method of crevice corrosion

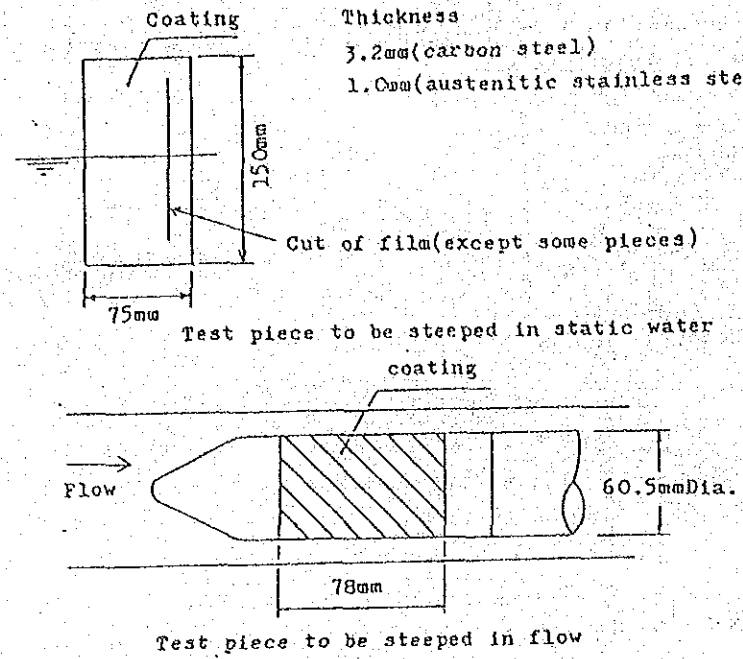


Fig.2 Shapes of Test Pieces

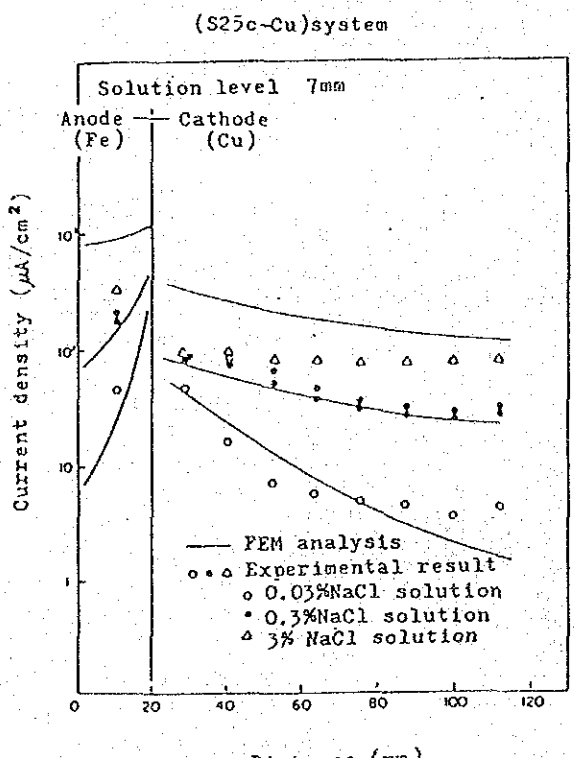


Fig.4 Correlation between FEM analysis and test results for galvanic corrosion

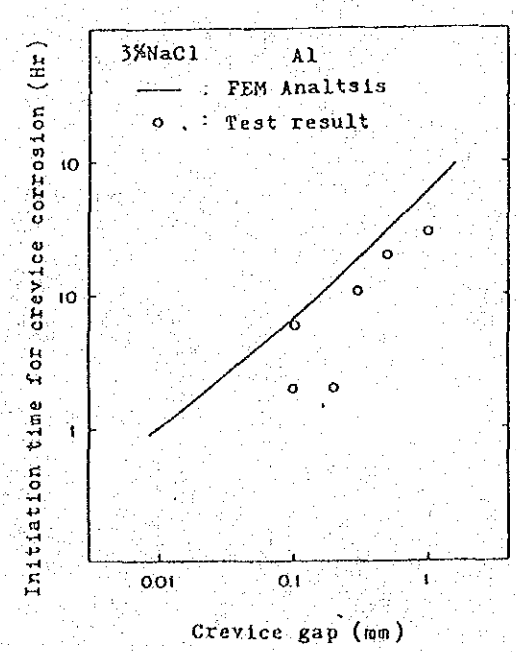


Fig.5 Correlation between FEM analisis and test results for crevice corrosion

別添－4　インド宛提出レポート

17th August, 1985

Dear Mr. Dewan,

It is our great pleasure to submit herewith our Summary Report of the Technical Follow-up Team for the ex-participants of the Group Training Courses in Hydro-Electric Power Engineering, Thermal-Electric Power Engineering, Electric Power Distribution Engineering and Electric Power Management Engineering.

As is well known, Japan International Cooperation Agency has been conducting a number of training courses in various disciplines year after year, and also dispatching follow-up teams in order to expand and improve those training programs.

Concerning the 4 above mentioned Group Training Courses, about 23 years have passed since they were started. Seizing this occasion, we hope to make these courses better than before with the benefit of the advice and suggestions from the ex-participants of these courses and the authorities concerned.

The team members would like to express their deepest gratitude to the ex-participants as well as the authorities concerned for the warm welcome and kind cooperation extended to them during the whole period of their stay in the Republic of India.

Yours sincerely,

Sumio Ogawa

(Sumio Ogawa)
Team Leader

Encl: as stated above.

Mr. Parvez Dewan
Under Secretary
Department of Economic Affairs
Ministry of Finance
New Delhi.

SUMMARY REPORT

I. Team Members:

1. Mr. Sumio Ogawa
   Deputy Director
   Engineering Works Department
   Electric Power Development Company

2. Mr. Eiji Hiraoka
   Section Chief
   Technical Division
   Public Utilities Department
   Agency of Natural Resources and Energy
   Ministry of International Trade & Industry (MITI)

3. Mr. Masayuki Nakagawa
   Researcher
   Development Cooperation Department
   Japan Electric Power Information Centre Inc.(JEPIC)

4. Mr. Shinji Kondo
   Training Officer
   Third Training Division
   Training Affairs Department
   Japan International Cooperation Agency (JICA)

II. Schedule:

(August, 1985)

| | | |
|---|---|---|
| 12th (Monday) | 0355 | Arrive at New Delhi by JL-491<br>Stay at Hotel Kanishka |
| | 1030 | Visit to the Embassy of Japan & JICA New Delhi Office |
| | 1200 | Visit to the Department of Economic Affairs, Ministry of Finance, Government of India.<br>Meeting with:-<br>Mr. S.S. Ahluwalia<br>Deputy Secretary |
| 13th (Tuesday) | 1430 | Visit to Central Electricity Authority (CEA), Sewa Bhavan, R.K. Puram, New Delhi.<br>Meeting with:-<br>Mr. S.A. Subramaniam<br>Member (Thermal)<br>and<br>Ex-participants of Thermal-Electric Power Engineering<br>(Mr. V.J. Talwar, CEA, Ex-participant of Electric Power Distribution Engineering Course will also participate in the meeting) |

| | | |
|---|---|---|
| | 1500 | Meeting with:-<br>Mr. Bahadur Chand<br>Member (Operations) |
| | 1530 | Meeting with:-<br>Mr. T.A. Deodas<br>Chief Engineer (HTD II)<br>and<br>Ex-participants of Hydro-Electric Power Engineering |
| 14th (Wednesday) | 1130 | Visit to Delhi Electric Supply Undertaking (DESU), Shakti Sadan, New Delhi<br>Meeting with:-<br>Mr. P.S. Sawhney<br>Additional General Manager (Technical)<br>and<br>Ex-participants of Electric Power Distribution Engineering and Electric Power Management Engineering |
| | 1500 | - Seminar with Ex-participants and concerned officials<br>- Film show on (i) Electric Industry in Japan (ii) New Hydro Generating Technology in Japan<br>- Reception<br>At Hotel Kanishka (Banquet Hall |
| | 1800 | |
| 15th (Thursday) | | National Holiday |
| 16th (Friday) | 1000 | Visit to Indraprastha Power station of Delhi Electric Supply Undertaking (DESU) |
| 17th (Saturday) | --- | Preparation of Report |
| 18th (Sunday) | 0050 | Leave for Bangkok by TG-915 |

III. Meeting with

III. Meeting with the Ex-participants and Others:

During the four working days at New Delhi, 12th (Monday) to 16th (Friday) August, 1985, the team was able to meet 11 out of 18 ex-participants from the Republic of India and some officials of the authorities concerned. The names of the ex-participants and officials interviewed are given in the list attached.

IV. Lecture-Discussion Meeting:

The Lecture-Discussion Meeting was carried out with the presence of 11 ex-participants and 5 officials of the authorities concerned at Hotel Kanishka on 14th August, 1985.

At the meeting two subjects ("Electric Power Industry in Japan" and "New Hydro Generating Technology in Japan") were introduced by lectures and a film show, and active exchange of opinions on the subject was made between the team and the ex-participants.

V. Main Findings and Recommendations:

(a) The Team was gratified to note that the authorities concerned are highly appreciative of the usefulness of the courses and keenly interested in getting increasing opportunities to participate in them.

(b) The Team was also pleased to know from the ex-participants that they thought the courses had been useful in making them better equipped in performing their work.

(c) In addition, they offered a number of appreciable comments and suggestions to improve the performance of the courses, as enumerated in the following:

1. Course Programming:

(i) The visits to the qualified coal-fired power stations should be increased.

(ii) The group of each training course should be divided into several sub-groups for the last one week of the course schedule so that the participants could meet their respective interests.

(iii) More days

(iii) More days should be allocated to the simulator Operation training.

(iv) Longer time should be allocated to visit to one power station instead of visiting many power stations for a short time in each of them.

2. Subjects to be included:

- Pollution control equipments/coal fired.
- Trouble shooting of power station.
- Combined cycle and co-generation.
- Condensate Polishing system
- Remote Control operation system.
- Phylosophy of pomped storage power plant in operation.
- Computalization/Mycro processor.
- Excitation System.
- Protection schemes and application for transmission lines.
- Criteria of selection for the parameters.
- Data logging
- Electric energy conservation
- New energy sources (Solar, Wind and Geothermal).
- Maintenance of distribution to minimize the loss.
- System analysis.

3. Follow-up services:

(i) Sending of the up-to-date information in the field should be continued to the ex-participants.

(ii) Re-training opportunity should be given to the ex-participants interested in gaining deeper knowledge in a specific subject.

(VI) Concluding Remarks:

Although the team could not meet all the 18 ex-participants of the courses, it could make contact with all the ex-participants living in New Delhi.

The meetings

The meetings and discussions with them were very cordial and productive, leading to a number of useful suggestions and recommendations as enumerated in 5 above.

It is sincerely hoped that these suggestions and recommendations will be given due consideration by the authorities concerned so that steps are taken accordingly, to the utmost extent possible, for the betterment of the courses in the future.

VII. List of ex-participants and officials interviewed by the team:

(EX-PARTICIPANTS) I. Hydro-Electric Power Engineering:

1. Mr. D.V. Khera
   Director
   Hydro-Technology Development VII
   Central Electricity Authority
   Sewa Bhavan
   R.K. Puram
   New Delhi.

2. Mr. L.S. Bageshwar
   Deputy Director
   NESOO Directorate
   Central Electricity Authority
   B-6-7/19, Safdarjang Enclave
   New Delhi.

3. Mr. S. Santhanam
   Director
   Hydro-Construction Monetaring II
   Central Electricity Authority
   Sewa Bhavan
   R.K. Puram
   New Delhi.

II. Thermal-Electric Power Engineering:

4. Mr. M.A. Ramanan
   Director, TAS I
   Central Electricity Authority
   Sewa Bhavan
   R.K. Puram
   New Delhi.

5. Mr. M.G. Jain
   Director
   Thermal Planning Directorate
   Central Electricity Authority
   Sewa Bhavan
   R.K. Puram
   New Delhi.

6. Mr. K. Venugopal
   Deputy Director
   TEAS Directorate
   Central Electricity Authority
   Sewa Bhavan
   R.K. Puram
   New Delhi.

7. Mr. G.V. Singh
Director (TRM-III Directorate)
Central Electricity Authority
West Block II
R.K. Puram
New Delhi.

8. Mr. M.L. Sharma
Deputy Director
T.S. Directorate
Central Electricity Authority
Sewa Bhavan
R.K. Puram
New Delhi.

III. Electric Power Distribution Engineering:

9. Mr. V.J. Talwar
Deputy Director
SPS Cell
Central Electricity Authority
R.K. Puram
New Delhi.

10. Mr. S.L. Khurana
Superintending Engineer
(Construction South III)
Delhi Electric Supply Undertaking
33KV Sub Station Building)
C.G.O. Complex
Lodhi Road
New Delhi.

IV. Electric Power Management Engineering:

11. Mr. A.K. Bhargava
Additional Chief Engineer
Rajghat Power House
Rajghat
New Delhi.

(OFFICIALS CONCERNED)

V. Department of Economic Affairs, Ministry of Finance:

1. Mr. S.S. Ahluwalia
Deputy Secretary

2. Mr. Parvez Dewan
Under Secretary

3. Mr. Sarup Singh
Section Officer (CP)

VI. Central Electricity Authority:

1. Mr. S.A. Subramaniam
Member (Thermal)

2. Mr. Bahadur Chand
Member (Operations)

3. Mr. T.A. Deodas
Chief Engineer (HTD II)

VII. Delhi Electric Supply Undertaking (DESU):

1. Mr. P.S. Sawhney
   Additional General Manager (Technical)

2. Mr. Satchida Nand
   Additional Chief Engineer (Generation)
   Indraprastha Thermal Power Station

VIII. Embassy of Japan:

1. Mr. S. Heriuchi
   Minister

2. Mr. Y. Nishikawa
   First Secretary

3. Mr. T. Miyanaga
   First Secretary

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August 25,1985

To Whom It May Concern:

It is our great pleasure to submit herewith our Summary Report of the Technical Follow-up Team for the ex-participants of the Group Training Courses in Hydro Electric Power Engineering, Thermal Electric Power Engineering, Electric Power Management and Electric Power Distribution Engineering.

As is well known, Japan International Cooperation Agency has been conducting a number of training courses in various disciplines year after year, and also dispatching follow-up teams in order to expand and improve those training courses.

Concerning the above four Courses, twenty-three years have passed since they were started. Seizing this occasion, we hope to make these Courses better than before with the benefit of the advice and suggestions from the ex-participants of the Courses and the authorities concerned.

The Team members would like to express their deepest gratitude to the ex-participants as well as the authorities concerned for the warm welcome and kind cooperation extended to them during the whole period of their stay in the Kingdom of Thailand.

Sincerely,

Sumio Ogawa

Sumio Ogawa
Team Leader

Encl: as stated above.

Summary Report

I. Team Members

1. Mr. Sumio Ogawa
   Deputy Director
   Electric Engineering Department
   Electric Power Development Company

2. Mr. Eiji Hiraoka
   Deputy Director
   Thermal Electric Technology Division
   Public Utilities Department
   Agency of Natural Resourses and Energy

3. Mr. Masayuki Nakagawa
   Researcher
   Development Cooperation Department
   Japan Electric Power Information Center

4. Mr. Shinji Kondo
   Training Officer
   Third Training Division
   Training Affairs Department
   Japan International Cooperation Agency

II. Schedule:

(August, 1985)

| | | |
|---|---|---|
| 18th(Sunday) | 0600 | Arrive in Bangkok |
| 19th(Monday) | 1030 | Visit to JICA Bangkok Office |
| | 1400 | Visit to Electricity Generating Authority of Thailand(EGAT)<br>Meeting with Mr. Kamthon Sindhuwanon, General Manager |
| | 1500 | Visit to North Bangkok Thermal Power Station, EGAT |
| | 1600 | Visit to Central Dispatching Liaison Office, EGAT |
| 20th(Tuesday) | 0930 | Visit to Provincial Electricity Authority(PEA)<br>Meeting with Mr. Surasakudi Senavangce, Assistant General Manager |

(August, 1985)

| | | |
|---|---|---|
| 20th(Tuesday) | 1415 | Visit to Metropolitan Electricity Authority<br>Meeting with Mr. Amnuay Udomsilpa, General Manager |
| | 1530 | Visit to Chidlom Terminal Station |
| 21bh(Wednesday) | 0900 | Seminar-Discussion Meeting at MEA<br>1. Electriv Power Industry in Japan<br>2. New Hydro Generating Technology in Japan |
| | 〃 | |
| | 1200 | Reception at Restaurant CHIPOCHAMA |
| 22th(Thirsday) | 1000 | Visit to Department of Technical Cooperation and Technical Cooperation<br>Meeting with Mr. Kasem, Deputy Director General |
| | 1400 | Visit to JICA Bangkok Office |
| 23th(Friday) | | Report Making |
| 24th(Saturday) | | Visit to Srinagarind Hydro Power Station |
| 25th(Sunday) | 1100 | Leave for Jakarta |

III. Meeting with ek-participants and Others:

During the seven working days in Bangkok, 18th(Sunday) to 24th (Saturday) August, 1985 the Team was able to meet twenty six ex-participants from the Kingdom of Thailand and some officials of the authorities concerned.

IV. Lecture-Discussion Meeting:

The Lecture-Discussion Meeting was held with the presence of twenty three ex-participants and fourteen officials of the authorities concerned at MEA conference room.

At the meeting, two subjects ( 1. Electric Power Industry in Japan, 2. New Hydro Generating Technology in Japan ) were introduced by the Team. During the meeting, active exchange of opinions was made between the Team and the participants.

V. Main Findings and Recommendations:

1. The Team was gratified to note that the authorities concerned are highly appreciative of the usefulness of the courses and keenly interested in getting increasing opportunities to participate in them.

2. The Team was also pleased to know from the ex-participants that they thought the courses has been useful in making them better equipped in performing their work.

3. In addition, they offered appreciable comments and suggestions to improve the performance of the courses, as enumerated in the following:

   i) Individual training in specific subjects should be combined with group training so that the participants would be able to get deeper knowledge in their expertising subjects after getting general information through the group training.

   ii) Sending materials should be continued so that the ex-participants could refresh their knowledge on Japan's Electric Power Industry.

4. EGAT expressed its strong request for Japan's cooperation in provision of training opportunity to its training centers' instructors in Japan, sending of Japanese specialists in curriculum arrangement of its engineers' training and donation of training equipments.

5. PEA requested for Japan's assitance in sending materials to its training centers and in improvement of its distribution automation system and energy conservation.

6. MEA submitted the attached list of subjects of its interests for Japan's assistance.

VI. Concluding Remarks:

Through the meetings and discussions with the ex-participants and officials of the authorities concerned, the Team was provided with a number of useful suggestions and recommendations for the improvement of the courses and new requests for Japan's assistance in the field of training.

It is sincerely hoped that these suggestions and recommendations will be given due consideration by the authorities concerned so that steps are taken accordingly, to the utmost extent possible, for the improvement of the courses and progress of technical cooperation between Japan and the Kingdom of Thailand.

## MEA.'S ASSISTANCE FOR TRAINING AND APPRENTICESHIP

1. Statistics & Research

   - Business Research
   - Research Analysis in Economics
   - Training & Educational Evaluation
   - Statistics Analysis for Decision Making
   - Statistics for Measurement and Behavior
   - Evaluation
   - Behavioral Research
   - Methodology of Research

2. Project & Plan

   - Project Evaluation

3. Organization Development Techniques

4. Management Development

   - Management Development Techniques
   - Apprenticeship in Management Development Science

5. JICA's consultant in technical Training and career development

6. Scholarship for training officer in related fields as follows

   - Training Management
   - Career Development
   - Information processing personnel (Instructor or Management) or
   - Any subjects in the area of Human Resources Development

7. Hospital

- Medicine and Water Quality Control
- Haematology
- Blood Bank
- Industrial Medicine
- Medical Management in Industrial
- Occupational Health

8. Architecture

- Geographical Architecture
- Sanitary Engineering

9. Power System

- Advance Power System Engineering
- Power System Control
- Power System Analysis and Design
- Power System Analysis & Computer Application
- Relay Application and Design
- Surge and Lightning
- VHF & UHF Communication System
- Load Dispatching Center (SCADA, Hardware and Software)

10. Net Work Modification

- Net Work Analysis & Synthesis

11. Project Management

- Engineering Management
- Inventory Control

12. Cable

- Power Cable Application and System Design
- Power Cable Testing

13. Conductor

- Sag & Tension Cable Calculation, Current Carrying Capacity of Conductors
- Connector and Line Hardware Application

14. Technical Terms in Banking

15. Quantity Economics

16. Project Analysis

17. System Protection & Relaying & Insulation Coordination of Electrical Equipment

18. Transmission and Distribution

- Transmission and Distribution System
- Distribution System Analysis & Computer Application

19. Substation Equipment

- Insulation Coordination
- Substation design and Equipment Testing

20. Training Aids

- One set of Video (U - Matic System)
- Language Lab. Equipment for 30 persons.
- Overhead Projector
- Slide Projector

§1. Training Requirements on Modern Operating Budget Control & Analysis

- Management and control in a Public Enterprise
- Modern Budgeting techniques and the operating budget process
- The operating budget as part of management information system
- Long and short terms planning and the annual operating budget
- Approaches to long term Planning
- Computer as and aid to planning and budgeting
- Interpretation of actual V.S. Budget and varience analysis

§2. Training Requirements on Automated Accounting System

- Modern approach to accounting system automation
- The operation and control of computerised Accounting System from the user perspective
- The management of computerised Accounting System
- The use of computer a tool in the management process
- The use of a micro computer
- Skill requirements for the operation of a computerised Accounting System

29th August, 1985

TO WHOM IT MAY CONCERN

It is our great pleasure to submit herewith our Summary Report of the Technical Follow-Up Team for the ex-participants of the Group Training Courses in Hydro-Electric Power Engineering, Thermal-Electric Power Engineering, Electric Power Distribution Engineering and Electric Power Management.

As is well known, Japan International Cooperation Agency has been conducting a number of training courses in various disciplines year after year, and also dispatching follow-up teams in order to expand and improve those training programs.

Concerning the 4 above mentioned Group Training Courses, about 23 years have passed since they were started. Seizing this occasion, we hope to make these courses better than before with the benefit of the advice and suggestions from the ex-participants of these courses and the authorities concerned.

The team members would like to express their deepest gratitude to the ex-participants as well as the authorities concerned for the warm welcome and kind cooperation extended to them during the whole period of their stay in the Republic of Indonesia.

Yours sincerely,

Sumio Ogawa

Sumio Ogawa
Team Leader

Encl: as stated above.

# SUMMARY REPORT

## 1. OBJECTIVES

The main purposes of the dispatch of this team were:

a) To measure and evaluate the extent of utilization of what the ex-participants had gained in Japan and inquire the opinions and suggestions of themselves and their superior officials so that we can make the future program more effective and fruitful.

b) To hold a lecture - discussion meeting on some topics of Electric Power Engineering not only with the ex-participants but also with all staffs who are concerned about our work.

## 2. TEAM MEMBERS

" Refer to the MEMBERS LIST "

## 3. MEETING WITH THE EX-PARTICIPANTS AND OTHERS

During the two working days at Jakarta, 27 (Tuesday) and 28 (Wednesday) of August, 1985, the team was able to meet 16 out of the 28 ex-participants from Indonesia and some officials of the Perusahaan Umum Listrik Negara (PLN).

## 4. LECTURE DISCUSSION MEETING

The lecture - discussion session was held at a conference room of the PLN on the 28th of August.

At the session, 2 lectures on "Electric Power Industry in Japan" and "New Hydro Generating Technology" were presented with the Presense of 16 ex-participants and 13 other staffs of the PLN.

5. MAIN FINDINGS AND RECOMMENDATIONS

a) The team was gratified to note that the PLN is highly appreciative of the usefulness of the courses and keenly interested in getting increasing opportunities to participate in them.

b) The team was pleased to know from the ex-participants that they thought the courses had been useful in making them better equipped in performing their work.

c) In addition, they offered a number of useful comments and suggestions to improve the performance of the Courses, as enumerated in the following :

1. It will be very helpful to the ex-participants if an information system can be made a build-in part of the courses, whereby materials on recent progress of Japan's Electric Power Engineering are made available to interested ex-participants.

2. There should be a follow-up training for interested ex-participants which will give them an opportunity to acquire more detailed knowledge on a specific subject in the field of Electric Power Engineering. Such a follow-up training will give the ex-participants more leverage to occupy higher and strategic positions in their respective duties.

3. The portion of practical training should be increased and well-combined with the lectures, which would enable the participants to have a firmer grasp of several subjects of the Courses.

4. It will be extremely valuable for the PLN if a training course is established for the instructors of its schools to get the knowledge on curriculum arrangement and management of training school for electric power engineers.

## 6. CONCLUDING REMARKS

During its stay in Jakarta, the team was able to meet many of ex-participants and other concerned officials. The meetings and discussions between them and the team members were very cordial and productive, leading to a number of useful suggestions and recommendations.

It's sincerely hoped that these suggestions and recommendations will be given due consideration by the authorities concerned so that steps are taken accordingly, to the utmost extent possible, for the betterment of the courses in the future.

MEMBERS LIST

| | |
|---|---|
| Leader | : Mr. Sumio OGAWA<br>Deputy Director,<br>Electric Engineering Department,<br>Electric Power Development Co., Ltd. |
| Member | : Mr. Eiji HIRAOKA<br>Deputy Director,<br>Thermal Power Technology Division,<br>Agency for Natural Resources<br>and Energy. |
| Member | : Mr. Masayuki NAKAGAWA<br>Researcher,<br>Development Cooperation Department,<br>Japan Electric Power Information<br>Center, Inc. |
| Member | : Mr. Shinji KONDO<br>Training Officer,<br>Third Training Division,<br>Training Affairs Department,<br>Japan International Cooperation Agency. |

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