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RECENT EXPORT EXPERIENCE IN SUBSTATION

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1 INTRODUCTION

In the sector of heavy electric equipment as those for substations, with first oil crisis and then a blow to our economic system from US president Nixon taken place ten and odd years ago as a turning point, though the export environment had become severe, owing to technical development and improvement, in addition to our effort for cost down and fortifying our corporate organization, thanks to the policy of investment increase for electric resources mainly in petroleum producing countries, we have once again become competitive in export market. However, there has been recently a sudden increase of yen rate, and the export environment has become once again severe, and this time so much as that it seemed that a mere effort for cost down simply will not do. What made the situation worse still is that due to oil shock in other way around, financial condition in oil producing countries showed some dark spots and the market itself is somewhat staggering.

Meanwhile, in such severe environment, Fuji Electric's Department of Substation Engineering has endeavored incessantly for improving its technological level and cultivated further its engineering capability, by arranging its organization and constitution for the better so that all manufacturing process from making estimates to designing and constructing can be accomplished and adminstrated globally and rationally, thus accumulating steadily our record of deliveries overseas of substation projects. *Table 1* shows the record of main recent overseas deliveries of substation equipment and installations. As can be seen from the *table,* Fuji Electric's Substation Engineering Department, to cope with the demand from our customers for substation plants that has become in recent years more and more exigent demanding higher degree and higher complexity with shorter terms of delivery, has succeeded in complying with their requirements cum high reputation. This report introduces the outline of the substation facilities destined to oversea electric power companies (including electric power public corporations and government entities for electric power and others).

2 FEATURES OF OVERSEAS PLANTS

Activities of overseas plants include duties particular to the locality that do not exist in the domestic plants, and even duties similar to those required in the national market, due to the difference in systems, customs and ideas, the procedure of carrying out may well be different. So much so that, without the knowledge of this difference, unexpected discrepancies in engineering and even troubles may be encountered while working on overseas proprojects. Here in this paper, due to space limitations, we like to mention some of such discrepancies but those representative only.

2.1 Standards

In recent years, as for standards to be applied, many customers designate IEC (International Electrotechnical Commission), however, there are some who designate BS (British Standards) or ANSI (American National Standards Institute) etc. also. Or, some who cite IEC as the principal standards but designate BS and ANSI as supplementary ones. Recently, the trend is that the industrial standards of each country go for a uniformity and would be provided with compatibility with IEC, but that uniformity cannot be expected to extend to details in the immediate future.

Countries of destination of the products can be roughly grouped into BS group countries or ANSI group countries depending on their historical background. But there are of course countries belonging to ANSI group and their technological philosophy greatly influenced by BS or vice versa. So that important thing is to understand thoroughly the situation of the country to which the products are destined.

2.2 Engineering

As mentioned above, due to low hovering of economy of the country of destination or by the national policy, cases are increasing in which, for the recent substation plant business, local traders act as the prime contractor. Fuji Electric also has a record, in the sector of substation of

Table 1 Record of main recent deliveries overseas of substation equipment

Country	Customers	Installation	Year of delivery
Philippines	Philippines sinter Corp.	138/33kV power plant, conventional type	1976
Qatar	Ministry of Electricity and Water (Umum said industrial area)	132/66/33V substation indoor GIS type	1976
Indonesia	Perusahasn Umum Listrik Negara	66/11kV two substations, conventional type	1976
Qatar	(Qatar steel plant)	66/3.3kV substation, Cubicle type building 154/22/11kV substn, expansion	1976
Republic of Korea	Pohang Iron and steel Co.	Cubicle type building housed GIS 22kV flicker compensator	1977 1979
United Arab Emirates	Abu Dhabi, Water and Electricity Dapartment	132/33kV substation and 132/11kV substation, expansion indoor GIS type	1977
China	Asia Polymer Corporation	66/6.9kV substation cubicle type building	1987
Malaysia	National Electricity Board	66/11kV substation, conventional type	1979
Brunei	Brunei Electrical Department	66/11kV 5 substations, conventional type	1980
Indonesia	Perusahasn Umum Listrik Negara (Waru Substation)	140/70kV, Substation expansion, conventional type	1980
Oman	Ministvy of Electricity & Water (Al Faraji Substation)	132/33kV, Substation conventional type	1980
Indonesia	P.T. Indonesia Asahan Aluminum	275/33kV substation conventional type	1980–82
China	(Through Nippon Light Metal Co.)	220/0.774kV substation, conventional type	1980
Kuwait	Kuwait National Petroleum Co.	66/33kV, package housed GIS type	1981
Jordan	Jordan Electricity Authority	132/33kV 11 substations, new and expansion, conventional type 132/33kV substation indoor GIS type 33/11kV substation indoor type	1983
Iran	TAVANIR (Korasan Gas Turnbine Generating Plant)	11/13kV generating plant, conventional type	1983
Algeria	SNS	63/21kV, substation conventional type	1984
Singapore	Public Utility Board	66/22kV 2 substation indoor GIS type	1984
Indonesia	Plrusahasn Umum Listrik Negara (North Sumatra)	150/22kV 7 substations, new and expansion, conventional type	1984
Saudi Arabia	Savdi Consolidated Electric company, Central	132/13.8kV 3 substation indoor GIS type	1985
Indonesia	Perusahasn Umum Listrik Negara (Gresik)	150/70kV substation, new, conv. type 150/70kV 2 substations, expans. con. type	1985 1985
Brunei	Brunei Electrical Department	66/33kV substation, conventional type	1985–86
Brunei	Brunei Shell Oil	11/66kV substation, conventional type	1985–86
Saudi Arabia	Saudi Consolidated Electric Company-Region Central	132/13.8kV substation Indoor GIS type	1986
Saudi Arabia	Electricity Corporation Power Public Department (Tabouk District)	33/13.8/132kV substation, indoor, GIStype 132/33/13.8kV substation, indoor GIS type 132/13.8kV substation indoor GIS type	Under construction
Saudi Arabia	Electricity Corporation (Dawasir District)	33/132kV substation indoor GIS 132/33/13.8kV 2 substations, indoor GIS type 33/13.8kV 2 substations, indoor type	Under manufacturing
Bahrain	Electricity Directrate	220/66kV 5 substations, expansion, indoor GIS type	Under manufacturing
Bahrain	Electricity Directrate	66/12kV 9 substations, new, indoor GIS type	Under manufacturing

letting local traders besides of civil works and installation work, procurement from the local and thirdcountry markets, while Fuji Electric taking charge of delivering main electric equipment and global engineering in order to make a successful bid. It goes without saying that the premise has been that Fuji Electric should realize the engineering for that work.

2.3 Technical consultant

In some countries, often is the case that a consultants make technical specifications. Some customers use the service of one consultant for a long time, but in general, there are open bids for consultants for each project, and as the result, there come up different consultant at each different occasion and the technical specifications they elaborate are different also. Also, sometimes, the consultant may differ from ones at the time of bidding to those after signing the contract.

2.4 Inspecting company

Just as in case of consultants, inspection of products with customer's witness as a general rule, conducted by an inspector of Inspecting Department of the Consultants or inspector of Inspecting Company designated by Customers/

Consultants. Recently, in Japan also, these inspecting companies have established their branches and even in case of inspecting companies who have no branches in Japan ask Japanese inspecting companies to conduct inspection in their stead, so that it is rare to see the visit of inspectors coming directly from overseas to conduct in effect inspections in Japan.

2.5 Training

There are many cases technical training is demanded (in their country or during the installation work) at the time of delivery of the product to operating and maintenance personnel due to shortage of technicians and engineers.

3 CORPORATE FORMATION

3.1 Organization

Fuji Electric administrates its activities of export business on substation equipment destined to overseas electric power companies, as a rule, within a frame of organization shown in *Fig. 1* below. For coping with important/large-scale projects, a project manager/staff members are selected for the purpose from this cadre to organize a project team.

3.2 Engineering schedule control

For project control, the schedule control at the engineering stage to exerts a large influence the manufacturing and delivery of the equipment, and to the global progress of the work. In particular, in case of overseas plants, the most important thing would be arrange well all conditions and terms at an early stage of the project regarding the agreement on the fundamental specifications and confirmation on the responsible scope of work between other contractors, subcontractors, customer, and consultants having different technical background and life style.

In the substation engineering department of Fuji Electric, the control of this engineering schedule is effectuated by using personal computer, aiming thus, perfection and simplification of the control.

This is carried out by first choosing the most suitable model among models studied and registered before-hand for the project, then after an additional studies and discussion, an engineering schedule will be elaborated, and inputted into personal computer in order to carry out the control and admnistration. By outputting of this personal computer, each person in charge of the project will confirm the progress of the schedule periodically and the control will be carried out by feeding them back to computer.

In case of the substation plant, repetition of regularized engineering items is comparatively frequent and the term of delivery is so limited that a rapid countermeasures are required. So that, for this, an administration by a personal computer is most suitable for the case.

3.3 Installation work

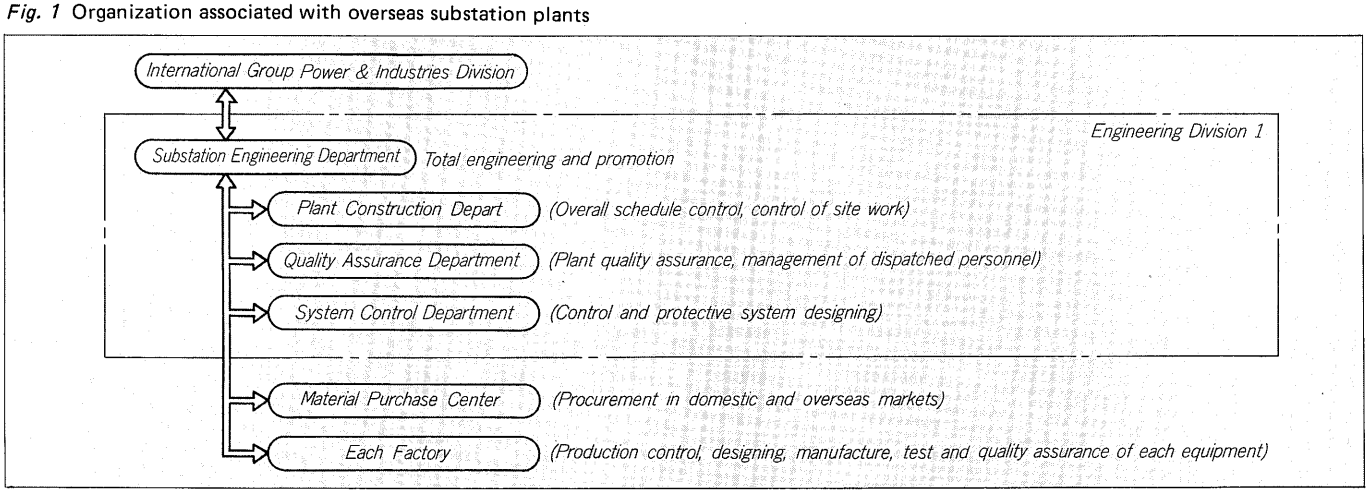
As general features of difference in overseas installation work, we can cite (1) difference in climate, (2) difference in political conditions, (3) difference in religion and (4) technical foundation. In addition to this, in case of overseas substation plants, work sites are distributed sparsely over a vaste region with a distance one from another exceeding 100 km to 500 km, as a case may be.

Important thing in executing the installation work is how to make the construction plan taking into consideration of the above-mentioned conditions, construction plan such as setting the base, administration of all construction facilities, dispatch of engineers, supply of labor force and their management, procurement and control of materials—all these to be put into practice.

In order to achieve this goal, Fuji Electric develops the following policies.

(1) In close cooperation with Fuji Electric Construction Co., Ltd., a subsidiary of Fuji Electric Co. engaged in construction works, perfection of construction engineering taking full advantage of its experience in past overseas construction works.
(2) Sharing of experience and unification of construction work of substation among substation, thermal and hydraulic power plant construction departments.
(3) Training of capable site managers.

Fig. 1 Organization associated with overseas substation plants



(4) Training of site engineers and instructing them for the versatile.
(5) Concentrated control and efficient use of machineries and equipment destined to the site.
(6) Optimum and economical construction designing.

Further in order to execute the site work with efficiency in low cost, it is very useful to utilize the service of local constructors or constructors of the third country with an abundant experience. Though they may be useful, in this case, care should be taken since it would be difficult to appreciate correctly the technological ability and capacity for carrying out the work and their reliability as well as language problem, so that a greater care should be taken for employing them than the case of utilizing the service of Japanese constructors.

Fuji Electric with its Plant Construction Department as the central force, together with Overseas Purchase Department and Sales Department, endeavors for arranging and unifying the forms of business transaction documents, contract documents, manuals and technical literatures for overseas work.

Also, whenever there is occasion, we keep a close contact with these constructors and promote our policy of establishing advance base for the constructing companies.

In the future, we believe it necessary to accumulate all these experiences in work with overseas contractors and execute the work recruiting labor force of the locality in direct form, in brief, to cope with the problem with a new form of ordering the work and a new form of concluding contracts.

4 AN EXAMPLE OF DELIVERY-A TYPICAL CASE

We like to present a typical case of recent delivery in the following.

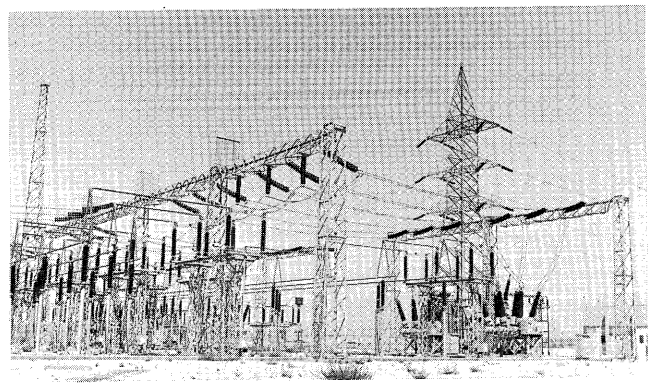
4.1 132 kV Substation Project for Jordan Electricity Authority

This is a full turn-key project by which six 132-kV substations are newly constructed, six existing 132-kV substations are expanded and reinforced and one 33-kV substation is newly constructed as a part of the Transmission Network Expansion Project in the north and the south of Jordan, that is, covering almost all of the Kingdom of Jordan. Fuji Electric in specialization with Japanese trading company and construction company, has taken of delivery of main electric equipment and dispatch of instructors and inspectors for the installation work at site. The delivery is completed toward the end of 1984, and the installation is under operation in good conditions, and we have high reputation from Jordan Electricity Authority.

One of the newly built substations is a semi-indoor type substation composed of 5 units of 132 kV single bus bar type SF_6 gas insulated switchgear (GIS), 2 units of 132/33 kV 63 MVA transformers for outdoors, and 8 units of 33 kV cubicles.

The other newly built five 132-kV substations are the 132/33 kV conventional type substations, being composed, respectively, of 1 to 2 units of outdoor transformers, 2 to 8 132-kV circuits and 2 to 11 33 kV circuits. *Fig. 2* shows the outer view of the Queen Alia Internal Airport 132-kV Substation.

Fig. 2 Queen Alia International Airport 132 kV Substation



The newly built 33 kV substations are the semi-indoor type substations being composed, resepctively, of two 33/11 kV 25 MVA outdoor transformers, six 33 kV circuits and seven 11 kV circuit cubicles. Theese constitute important substations for supplying power source to the newly built airport.

The other existing substations are those constructed by European manufacturers as BBC, GEC, ELECTROBAU and CALOR-EMAG, and for these, Fuji Electric has carried out expansion of transformers and circuits depending on the substation.

4.2 66 kV Substations for Public Utility Board of Singapore

This is a project by which Fuji Electric has constructed two 66 kV substations in the central part of Singapore. The substation building is fundamentally layout planned by Housing Development Department of Singapore according to the demand from the Public Utility Board, on basis of which, Fuji Electric has presented required data from equipment as well as detailed foundation layout drawings. Then, the infrastructrues have been constructed by the Housing Development Department by using local construction enterprises. Chander Road Substation is housed in a three-storied building of exclusive use for substation, while that of Raffles Substation, in a four-storied building used in common with other commercial shops.

Fuji Electric has realized deliveries of all principal electric equipment such as 66/22 kV main transformers control and relay panels and installation work including the global engineering as carrying out interface with all equipment. Since there was no consultants of Customers, technical consultation has been conducted all directly between Customers and Fuji Electric.

66 kV systems for both substations are of single bus bar, composed of 66/22 kV 75 MVA transformers, 2 units per each, (3 units for future expansion), all housed in indoor type substation building. 22-kV switchgear and 20/0.4 kV transformer have been delivered under separate

contract, but as for Chander Road Substation, 22 kV switchgear was ordered to Fuji Electric, so that installation work including that for 22 kV switchgear was undertaken by Fuji Electric.

Since all transmission lines were in cable system, we have delivered protection of pilot wire relay system to each phase. Chander Road Substation was completed in December, 1984 and Raffles Substation, in August, 1985, before their scheduled time. In particular, in case of Raffles Substation, the completion of building construction lagged behind the schedule greatly and Fuji Electric had to start the installation work before the taking-over of the building, but in spite of these unfavorable conditions, Fuji Electric could have completed the whole work before the schedule. This effort has been greatly appreciated by the Public Utility Board of Singapore.

4.3 Tabouk Project for Electricity Corporation of Saudi Arabia

This is a full turn-key project to construct three 132-kV substations in the District of Northwest Coast of Saudi Arabia. A local enterprise acted as prime contractor and Fuji Electric took charge of delivery of 132 kV SF_6 GIS, control and protective panel and DC power supply facilities, and overall engineering including their other associated electric equipment and installation work. At present, manufacture of equipment is almost completed and it is scheduled to deliver them at site from Jan. to May, 1987. *Fig. 3* shows the outer view of 132-kV SF_6 GIS destined for Al Bida Substation. Tender specification was elaborated by Power Department of Ireland, but after signing the contract, the facture of equipment has been completed and it is scheduled to install them at site from Jan. to Sep., 1987. *Fig. 3* shows the outer view of 132-kV SF_6 GIS destined for Al Bida Substation. Tender specification was elaborated by Electricity Supply Board of Ireland, but after signing the contract, the consultant was switched to Al-Hejailan, local consultants backed TMSI group of USA.

Duba Substation is a substation adjacent to Duba Generating Plant for distributing and transmitting power and is composed of 132 kV indoor type SF_6 GIS in 1.5 CB system, 33 kV double bus bar type cubicle, 13.8 kV single bus bar type cubicle, two outdoor type 33/132 kV 50 MVA transformers, and two 33/13.8 kV 20 MVA transformers. It is forecast that 380 kV substation will be constructed and will be linked to this substation. Control will be carried out by mosaic panel locating in the control room of the generating plant about 200 m away from the substation. This time, the delivery includes up to interface panel so that in future, remote control (SCADA) can be attained. For protection of 132 kV transmission lines, power line carrier permissive overreach system is adopted for both main and back-up protections. The protective relays are all designated as static type suitable for the ambient temperature of 55 °C.

Fig. 3 132 kV SF_6 GIS for Al Bida Substation

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Both Al Bida Substation and Haql Substation are single bus bar type semi-indoor substations. Control is, as in case of Duba Substation, carried out by means of mosaic panel (in the substation control room), however, in the future, it will be done by remote control system (SCADA) thus making the substation unmanned. Haql Substation will be interlinked with an existing generating plant of small capacity, aiming local power supply only.

As for lightning arresters, an optimum configuration has been studied by effectuating surge calculation by EMPT for all 132, 33, 13.8 kV circuits as a part of engineering.

For all substations, a cable room is located under the 132, 33, 13.8 kV switchgear room, and under the comtrol room, there is a free-access floor. High-voltage cables are separated per each circuit, and the control cables are laid within ducts made of nonflamable materials.

Mesh earth is provided for all substations, however, since Al Bida Substation is located a little further in hinterland, and the soil resistivity is high, earth rods are used.

For above-mentioned 132-kV SF_6 GIS, an internal arc test according to IEC517 has been conducted in presence of representatives of Customers on the exactly the same equipment as those to be delivered.

4.4 Dawasir Project for Electricity Corporation of Saudi Arabia

This is a full turn-key project to construct three 132-kV substations and two 33-kV substations in the central southern hinterland of Saudi Arabia. Fuji Electric has organized the same organization and assigned with the same assignment as those of Tabouk Project mentioned in the preceeding section. At present, the equipment are schedule to be shipped in March 1987, and expected to complete their installation in 1987. In this case also, the tender specification has been elaborated by Kennedy and Donkin, an English consultant company, but after signing contract, consultants have been switched to Saud Consultants which is in technical cooperation with Merz and McLellan in UK.

Al Juba substation is a substation adjacent to Al-Juba generating plant used for power transmittion and the substation comprises a 132-kV double bus bar type indoor SF_6 GIS and two 33/132 kV 150 MVA outdoor transformers.

A remote control equipment (SCADA) will be delivered

by another contractor more or less the same time as the substation itself, so that this substation will be operated unmanned upon the completion of this project. For protection of 132 kV transmission lines, the same system as that of Tabouk Project is adopted. However, as for the power line carrier singal, while the Tabouk Project adopts the two-line/ground coupling system, this substation adopts single-line/ground coupling system. These are considerable difference between two projects in those concerned with panel construction and control system.

As Sulayyil Substation and Sharafa Substation are composed, respectively, of 132/33/13.8 kV single bus bar system, and two 132/33 kV and 33/13.8 kV transformers.

Tamrah Substation is of 33/13.8 kV single bus bar system while Khamasin Substation, 2 bank-unit system substation.

At the sites of As Sulayyil Substation and Tamrah Substation, the soil resistivity is so high that in order to obtain the predetermined earth resistance it is necessary to bury the asphaltwound earth rods down to several tens of meters from the ground level.

5 CONCLUSION

Here in this paper, we have introduced the outline of substation plant for overseas electric power of Fuji Electric. In concluding this paper, we feel it necessary to state that from the observation of the recent export situation, we would have to reply with engineering with higher still pertinence than that has been up to now and have to deliver plants with still higher reliability.

Fuji Electric, we are determined to enhance still further its technological level with steady pace and to endeavor for improving reliability so that we can deliver substation plants that can be appreciated by customers.

TOPICS

Japan Industrial Fair in Moscow

The Third Japan Industrial Fair was held in Moscow from October 15 to October 24, 1986. This fair, held after an interval of 16 years as a Japanese independent fair, was favored by citizens of the U.S.S.R.; 550 thousand people, far more than the expected 300 thousand, visited the fair. The visitors were particularly interested in TVs, videos, radio-cassettes, cars, robots and other items, for which Japan is as the world top level in quality.

Fuji Electric exhibited panels of factory automation and energy technology arranged around a large map of the U.S.S.R., showing Fuji's vast experience in this country. So many Soviet specialists asked questions and for the exhibit materials that a part of the materials ran out and had to be supplied from Japan when only one third of the exhibition period has passed.

The active response of the visitors showed the great interest of the Soviet people in Japan and Japanese manufactured products.