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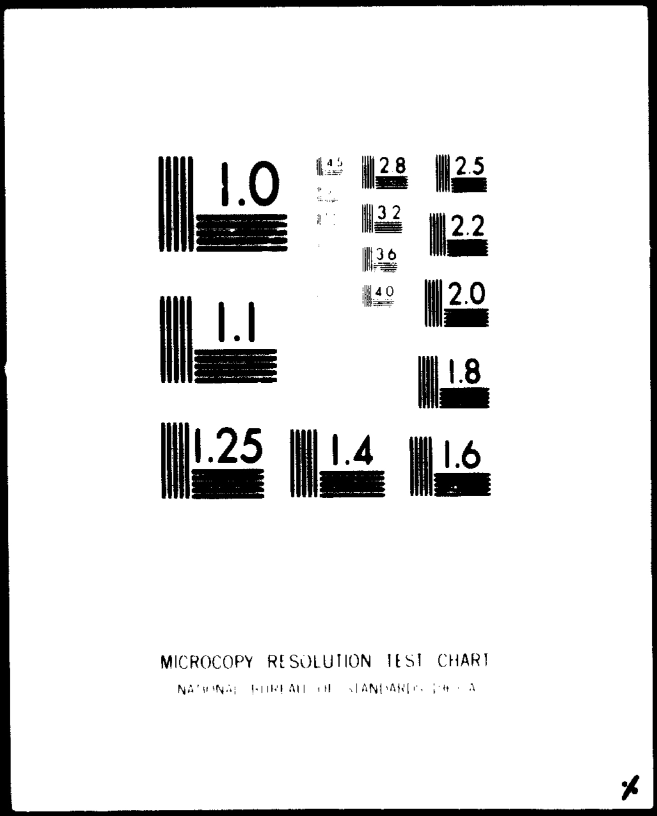
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Technical Seminar on Contracting Methods and Insurance Schemes for Fertilizer and Chemical Process Industries

Lahore, Pakistan, 25 – 29 November 1977

EXPERIENCE IN CONTRACTING FOR FERTILIZER AND CHEMICAL PLANTS IN PAKISTAN

Prepared By

BOARD OF INDUSTRIAL MANAGEMENT

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EXPERIENCE IN CONTRACTING FOR PAKISTAN FERTILIZER AND CHEMICAL PROJECTS

General Introduction

In Pakistan, the first contracts for the chemical industry were awarded in 1951; for the fertilizer industry in 1953 and there has been continous experience of contracting since that date. In this paper types of contracts are discussed, the problems in various contracts analysed, and subsequently detailed case histories of one older fertilizer plant (contracted 1957, and operated 1962) which never met time or production guarantees (Multan), and another plant recently constructed (operated 1971) which has had a good history (Chichoki Mallian) are detailed.

Types of Contract

The earliest Contracts made in Pakistan were for small Sulphuric Acid and Caustic Soda Plants and were purchased on a cash basis. The success or failure of these plants were largely based upon the reputation and standing of the plant suppliers.

The first major plant set up in the Chemical Industry was the fertilizer plant at Daudkhel, based upon coal and gypsum, contracted in 1953-54 and operation commenced in 1958. This was a coal and gypsum based plant to produce Ammonium Sulphate. The plant contract was with a foreign operating fertilizer company, who also had their own engineering organisation. The purchases were made competitively on a complete section basis (coal gasification, conversion, carbon dioxide removal, Nitrogen wash, Ammonia synthesis, Ammonium Sulphate from Gypsum). After initial teething troubles, due to the quality of the coal(see below) the plant operated very well, and in the first 5 years of production, production was consistently around 100% (see table I), Undoubtedly the extensive training, with in-plant training programmes overseas for engineers of upto 12 months, contributed to the sucesses of this public sector project. This training programme was only possible by the active association of an operating fertilizer company as the prime contractor.

The next major plant was another fertilizer plant set up at Multan. The contract for this was almost turn-key, It involved a complete

C&F supply of equipment at a fixed price, with cost-reimbursable civil engineering and erection contracts. The plant started up in 1962-63 was not a success and even in the 6th year of operation it was only operating at 74% of capacity. This project will be discussed in detail later.

The next contract was a large Caustic Soda Plant, put up in the private sector. The Contract was negotiated on a cash basis by a private company with a big and well-known supplier of equipment, on a total plant supply basis. The plant started-up in 1964, has worked very well and has been steadily expanded.

In the years between 1962 and 1966, three major plants were put up on the advice of a foreign technical mission. The first was an Acetate Rayon plant based on molasses and cotton linters; the second a polyethylene plant based upon alcohol, and the last a Soda Ash Plant. All three plants were contracted on a total C&F supply of equipment. While technically the first two plants worked well, they were uncompetitive largely due to the 300%-600% increase in the prices of the raw materials on which they were based. The contract for the third one(Caustic Soda) was placed with a company with little experience in the field, and has not worked well.

In 1968, a BHC plant was put up using the Stauffer high-gamma process. This plant was the first commercial plant in the world to use this process, and it was set up under a conscious decision of the advantages of the process. The pilot plant data (it was based on a 1000 tons/year pilot plant) was carefully examined and a highly respected French engineering contractor selected to engineer and procure the plant. The plant went into operation in 1968, and has worked to capacity making a high-gamma(24%-26%) BHC directly. This is a special type of contract, where there were little or no guarantees (the $2 million plant had a maximum liability on plant operation of $50,000), while this worked well, it cannot be said to be a recommended procedure for developing countries. In this contract all the utilities were locally engineered and fabricated.

Between 1968 and 1971 two major private sector fertilizer plants, with foreign participation went into production. The first was a plant pup up by an oil company which had recently moved in the fertilizer field. This was the last of a series of such plants put up by this company, and was the best of them. The owners used their own Engineering and procurement services and the plant has operated well (see table I).

The second of these plants was a 600 tons Ammonia/1100 tons Urea Plant, put up as a joint venture between a Pakistani Company, and a large transnational foreign chemical company. The Contract had an overall Engineeing Contractor, supervised by the Engineers of the foreign company, selected well-known sub-contractors for Ammonia and Urea plants, and equipment purchase under World Bank Rules. This was also is a very successful plant, and will be discussed later in some detail.

The success of these two plants may be indicated by the fact that their Rs.10 share on the stock market has been consistently around Rs.25 per share for the last 5 years.

From 1972 when the decision was taken to place heavy chemicals and fertilizers in the nationalised sector(a decision which has been reversed in October 1977), two major 1000 tons Ammonia plants with, in one case, Nitrophosphate and Ammonium Nitrate plants, and in the second one; a 1740 tons/year Urea plant have been contracted by the National Fertilizer Corporation. Both contracts are based upon fixed fees for the know-how, engineering, erection supervision, and procurement services with the plant equipment being purchased on Workd Bank/ADB conditions. In both cases part of the financing is from Arab sources, and in one case an Arab country (Abu Dhabi) is also a 48% partner in the project. One aspect of these contracts have been that there are absolute guarantees (without limitation of liability) for the capacity of the plant, the quality of the products, and the analysis of the effluents.

More recently contracts have been placed where only the know-how and basic engineering has been obtained from abroad, and all the detailed engineering and procurement done in Pakistan. Plants for Urea melting and prilling, Sulphuric Acid, Baker's Yeast, Soda Ash and oil hydrogenation have been, or are being, set up on this basis. This pattern is likely to grow in the future.

In looking back on the type of contracts it may be stated that:-

a) In large plants, the more successful contracts have been projects with fixed fee Engineering from well-known Contractors, supervised by experienced operating companies or advisors, and plant procurement on a tender basis, with rigidly prequalified bidders.

b) For small plants, complete purchase on a C&F basis has been successful only when the plant supplier had many years of experience in supplying plants of the type constructed.

For comparative purposes Table I shows the operational results of 4 Fertilizer Plants set up under different arrangements for their first 6 years of operation, and indicates the difference in early years of operation of the different plants.

In a paper of this nature it is not possible to discuss all the numerous contracts, but problem areas may now be identified.

TABLE I

Pakistan-Operating Nitrogenous Fertilizer Plants- Ist 6-years of Operation.

	I	II	III	IV
Ownership	Government	Government	Foreign Oil Co.	Joint venture with Foreign Chemical Co.
Product	Ammonium Sulphate	Amm.Nitrate) Urea)	Urea	Urea
Capacity Tons N/yr.	10,250	50,000	78,500	157,000
Raw Material	Coal/Gypsum	Natural Gas	Natural Gas	Natural Gas
Contract Type:	General Contract with foreign fertilizer operating Co. with own Engineering Offices	Total turn-key supply of equipment reimbursable Civil Engg. Cost.	CO's own process for ammonia, standard Urea process.	Overall Engineering Contract with supervision by foreign partner's Engineers. Standard processes for Ammonia and Urea purchased.
	Plant purchase by plant sections against international bids.	Plant supplied C&F by Contractor.	Plant purchased by owners.	Equipment purchased under world bank conditions.
Ist complete year of operation.	1959	1962-63	1969-70	1971-72
Operating Record (% of capacity)				
Ist Complete year.	87.8	54.9	95.5	82
2ns Complete yr.	93.3	63.1	108.3	104
3rd Complete yr.	96.6	73.9	96.0	102
4th Complete yr.	107.8	71.4	112.5	110.4
5th Complete yr.	107.5	78.8	115.5	106.2
6th Complete yr.	102.2	74.0	120.6	104.7

Problem of Contracts.

2. The main problem areas which may be identified are:-

(a) Inadequacy of the Feasibility Reports with the result that the product mix is wrong. Thus even where the plants operated well, they were not a financial success.

(b) Improper raw material specifications.

(c) Choice of processes which had been inadequately tested, or where the Contractor was in-experienced.

(d) Inadequate specificatione for plant supply particularly for C & F cost projects.

(e) Inadeuqate design criteria.

(f) Inadequate check of the basic design and Engineering.

(g) Contract Provieion for Guarantees.

(h) Contract provieion for Guarantees tests

(i) Provisions for time-scheduling, and follow up of schedules.

(j) Financial problems of Contractors.

Theee represent the major areae of difficulties encountered in Contracts. There are others but those are more specific to individual contracte.

(a) Inadequacy of Feasibility Reports.

The problems of feasibility reports are not really part of a Contract. Yet the entire project depends on a feasibility report.

In Pakistan, as an example, one large project for the manufacture of man-made fibre went wrong because the wrong type of fibre was suggested. The plant worked well (to 110% of capacity) but could not market even 70% of its production. In the meantime raw material prices sharply rose, and the project became uneconomical.

In such cases often the Contractor is wrongly blamed for the unsuccessful project, although he would have had nothing to do with its economics.

It is essential also for the basic design of a project to have detailed market studies so that the plant product mix matches the market. This is particularly true of plastic plants, such as Polyethylene, Polypropylene, PVC etc.

(b) Improper Raw Material Specifications.

Two examples of this may be given:-

(i) In the case of a coal-based fertilizer plant, a large coal sample was sent for pilot plant tests. Unfortunately the sample was from a single seam in one mine. The sample had only 9% ash and no caking qualities. When the plant actually started and production of the coal had to be increased many times, smaller seams from three mines were used, with the result that ash went to 20% initially and even higher later, and some seams showed caking qualities. The plant therefore had nearly 8 months of modifications before proper commercial production could begin.

(ii) In a plant producing Sodium Sulphite(62%) from Sodium Sulphate, the guaranteed consumption of Sulphate was 1.4 tons Sulphate per ton Sulphide. The coal quality was based upon Anthracite with 5-6% ash. It had not been recognised that with higher ash contents, the consumption of Sodium Sulphate will go up due to side reactions. Since anthracitic coal is bulk imported in Pakistan, the available coal contained 20% ash and the Sulphate consumption went upto 2 tons/ton Sulphide, making the plant uneconomic, without heavy proe tection.

(c) Choice of Processes which had been inadequately tested or Contractor inadequately experienced.

Some examples of these were:-

(i) Two plants established to produce Ammonium Chloride and Sodium Sulphate from common Salt and Ammonium Sulphate. The plants were supplied by a German Contractor with experience in the chemical field but not in this process. Not only was the Ammonium Chloride not of specification grade, but the plants(constructed in stainless steel 316 L) severely corroded and ultimately had to be written-off.

(ii) A Soda Ash plant established under a German loan in Pakistan could find only one supplier in Germany. This supplier had previously built only one plant, but this was located in Taiwan and could not be easily examined, and it also used, coke-based Carbon Dioxide, as compared to gas-based Carbon Dioxide for this plant. The plant never worked well as the gas could not be cleaned wc well, nor could it attain its design of 26% Carbon Dioxide. The plant is now being expanded and modified by another Contractor.

(iii) As a contrast to this must be mentioned the BHC plant discussed above which uses the Stauffer high-gamma process and which was the first commercial plant using this process.

(d) Inadequate Specifications for Plant Supply.

This particularly applies to C&F contracts. There have been several cases where the material of construction has had to be changed after plant start-up, or where the equipment has been too small or too inefficient.

It is important to have such specifications examined by experienced Consultants or alternately a working plant using the sams process for some 3 years or so examined for sise and corrossion. The latter couras was adopted for a fertilizer plant, now in Bangladesh(then East Pakistan) in 1957 and the plant operated very successfully.

(e) Inadequate Design Criteria.

The site conditions, such as meteorlogical, soil data, acceptability of effluents should be carefully specified. Examples where difficulties aroae are:-

(i) A dry ice plant where the Carbon Dioxide cooling before "pressing" was with cooling water. As the critical temperature for dry ice is 28°C, and the cooling water in Pakistan(in summer) is, at best, 30°C-32°C, it is obvious that the plant could not work without refrigeration.

(ii) Many difficulties have arises in inland plants from inadequate effluent treatment facilities, particularly in Pakiatan where for 9 months in the year, nearly all river waters are used for irriga tion.

(f) Inadequate check of the basic design and Engineering.

This is a specific job of experienced personnel. It is not required where the main Contractor is well experienced in the processes offered and in the countries where the plants are being established.

Important in this connection are local rules and regulations particularly Boiler Acts.

(g) Contract Provisions for Guarantees.

This represents the most important area of contracts. Over the years a lot of experience has occurred in this in Pakistan, and since this is being discussed separately it need not be considered here.

However it should be mentioned that in Pakistan now it is customary to insist on absolute guarantees(without limitation of liability) for 95% of capacity, product quality and harmful effluent qualities.

With inflationary pressure time guarantees, as well as overall cost guarantees, for cost-reimbursable projects are also becoming important. These are discussed in a separate paper from Pakistan.

(h) Provisions for Guarantee Tests.

In Pakistan, 72-hours guarantec tests are no longer acceptable for large process plants. Tests for 7 to 15 days are normal, but only after the plant has been operating continuously at around 80% capacity for 20-25 days.

(i) Provisions for Time-Scheduling and follow-up.

One of the most difficult areas for cost-reimbursable projects have been time guarantees. The Engineering Contractor is naturally reluctant to give these except for turn-key projects and even then these are often hadged in.

This is a field in which no satisfactory solution has yet been found in Pakistan, and yet it is critical. In new contracts penalties for not meeting specific dates for various functions have been made but since this only increases the Contractor's liability, it also increases costs. This may make such guarantees meaningless.

Critical Path Networks(CPN) are now a regular feature of new projects. The importance of following these on a regular basis cannot be over-emphasised.

(j) Financial Problem of Contractors.

While this is not really a problem area, in one contract in Pakistan, a well-known Contractor went bankrupt after the Letter of Credit for a plant was established. Fortunately it wes little drawn upon. Performance bonds are therefore considered necessary where there is any large down payment involved.

While there are some of the problems involved in contracts in Pakistan, the list is by no means comprehensive, and the above examples should only be considered as some experience guidelines.

Specific case histories of two fertilizer projects- one that was not a success(Government plant at Multan) and one that was (D.H.Chemicals plant at Chichoki Mallian, are given below.

CASE HISTORY OF THE MULTAN PROJECT.

INTRODUCTION:

The Pakistan Industrial Development Corporation was established by the Government of Pakistan as a Public Sector company to develop the industrial sector of Pakistan.

In 1957 decision was taken to set up two fertilizer plants, one at Multan and the other at Fenchuganj in East Pakistan(now Bangladesh).The present case history pertains to the former project only.

The commercial offers for the project were received from the Italian,Dutch Japanese and French companies. These were examined by a PIDC technical committee who recommended the award to the Italian Company, or failing them the Dutch. However, in September 1957 the Government gave approval for the award of the contract to the French bidders. These Companies decided to form a consortium to handle the project. The consortium comprised of six major European firms, all of whom had prior contractual experiences in chemical process industries, but had never worked together before, thus PIDC fertilizer project was their first joint venture.

THE CONTRACTUAL WORK AND OBLIGATIONS:

A turn-key contract was awarded and signed with the Consortium in January,1958. Under the terms of the contract a complete fertilizer complex was to be supplied consisting of the following plants:

1. An Ammonia Plant having two streams each producing 102 metric tons per day.
2. A Nitric Acid Plant to produce 188 metric tons per day of 100 percent acid.

3. A unit to produce 300 metric tons per day of Ammonium Nitrate.

4. A Urea Plant for producing 180 metric tons per day of crystalline urea.

The Consortium was to carry out all works including soil and climatic studies. PIDC was to provide the site a gas line, process lines, railway lines and sidings and roads upto the battery limits.

The Government was to hand over a fully commissioned plant after having completed its guarantee tests within a specified time schedule. For this purpose all necessary supplies and services were to be provided by the Consortium inclusive of materials, equipment,utilities and all other ancilliary facilities. After the completion of the start-up tests the Consortium was to hand over the factory in a state ready for commercial production. According to the guaranteed time schedule the construction and start-up of the factory was to be completed by October 28,1960.

The factory was to be managed by the Consortium personnel upto the completion of the start-up and commercial production after which only technical guidance was to be provided for the guarantee test period.

Unfortunately the reforming section of the Ammonia process selected by the Consortium was one which had not been used in a plant of this size before,and, therefore,to that extent was an unproven one.

In addition all purchase of equipment, including that of the critical items was totally left to the Contractors.

THE GUARANTEES:

The Guarantees section of the Contract included two forms of bonus/penalty clauses. The first bonus/penalty clause was for the time schedule which was to be adhered by the Consortium. It was specified that if the completion of the start-up was delayed beyond November 28, 1960(34 months from the signing of contract) the Consortium was to pay a penalty of US $ 5600 per clandar day subject to a maximum amount of US $448,000.However, if the start-up was completed prior to September 28th,1960, PIDC was to pay a bonus of US $ 5600 per calendar day to the Consortium upto a maximum amount of US $ 448,000.

The guaranteed time schedule provided a four month period between the FOB delivery of equipment and its arrival at site. If the transportation period exceeded four months the total project time in the penalty clause was to be extended by an equal time period. This clause was baised against PIDC as the Consortium had the responsibility to arrange the transportation of the equipment to the site.

The inspection of equipment prior to shipment was to be carried out by the Consortium as well. All equipment was guarenteed against any manufacturing defects by the Consortium and was liable for the replacement of any defective items.

TIME EXTENSIONS:

In 1959 the completion dates for the project were rescheduled due to the strikes in the steel manufacturing industry in the United States . A supplemental contract was signed on 28th November 1959 extending the final handing over date by six months from October 28,1960 to March 28,1961. The bonus clause was waived in view of the time extension penalty clause was retained for any further delays.

The time schedule guarantees were once again extended through another supplemental contract which was signed on 22nd April,1961. The completion date was once again advanced by seven months to October 28, 1961 after a break-down of the gas supply line to Multan. After the second extension the penalty clause was invoked, a payment of US $224,000 in Pakistani currency was made to PIDC by the Consortium. This sum was half the total sum specified in the penalty clause of the main contract. With the extension of the time schedules the equipment guarantee dates were also extended.

START-UP AND ARBITRATION:

The plant was started on 3rd July, 1961. During the construction and initial start-up (1961-62) of the plant doubts were expressed by the local engineers and the consultants about the mechanical soundness and commercial operatability of the plant. These doubts were conveyed to the Consortium. PIDC's consultants and engineers felt that the plant needed additional equipment to the extent of $2.5 million to make it work properly.

The Consortium and PIDC agreed to consult a third party for resolving their differences and doubts. A European chemical company was chosen as an Arbitrator. A questionnaire was prepared by the local engineers high lighting the most probable plant operational problems. An inspection team of the Arbitrator was sent to the project to assess the mechanical soundness and commercial operability of the plant. In the appraisal report the Arbitrators confirmed the mechanical soundness of the plant but expressed apprehension over the plants capacity to meet the productions guarantee. The Arbitrators recommended inclusion of a second air compressor and suggested a few other modifications of the plant. The total value was $ 1.2 million. The Consortium agreed with the arbitrators' recommendations and made the necessary changes.

PROBLEMS AND COMPROMISES AFTER START-UP:

On July 3, 1961, the startup of the plant had commenced. The reforming section failed to attain the process design conditions; the Contractor attempted to improve the performance by increasing the operating temperatures and pressures which were outside the designed condition. This resulted in the rupture and creeping of the reformer tubes. The high pressure operation also damaged the Ammonia synthesis catalyst which had low mechanical strength.

The reformer tube problems continued for two years, the tubes had to be finally replaced in February, 1963. In March 1963 the plant was ready for the thirty day Guarantee tests. The plant operated on full load for 18 day but on the 19th day of the tests, the packing of the high pressure 4th stage Hyper compressor leaked and the cylinder had of the Hyper compressor cracked causing the tests to be abandoned.

In April 1963 the plant was handed over by the Consortium to PIDC without any successful Guarantee tests. The guarantee tests for the ammonium nitrate and the Urea Plants could not be completed either because of lack of ammonia.

After the take over of the plant by PIDC a technical advisory team of the Consortium stayed back. The representatives of the compressor manufactures were called who made the necessary chang es and repairs after which the compressors were restarted at full load in July,1963. By 1964 the plant was entirely in the hand of Pakistani engineers, who managed to operate it at 74% of capacity in 1964-65.

During the period 1963-1966,PIDC faced various mechanical and process difficulties: the low mechanical strength of the catalysts forced frequent catalyst changes, the heat recovery system of the copper liquor system turned out to be inefficient and finally the reformer tubes ruptured once more. These tubes were replaced with larger diameter tubes to enable higher conversion rates. Nevertheless, during all this period the rated capacity of 20 M.Ton per day of Ammonia could never be achieved.

The plant record may be seen from the following data:-

	% capacity
1961-62	5.0
1962-63	54.9
1963-64	63.1
1964-65	73.9
1965-66	71.4
1966-67	78.8

Examination of the plant in 1965 showed that it would not be possible to operate the Ammonia Section of the plant at more than 85% of capacity without major breakdowns,and it was suggested that this plant(ammonia)should be de-rated to this capacity.

SKID MOUNTED AMMONIA PLANT CONTRACT:

The capacity of the ammonium nitrate and the urea plant was being under-utilized due to the deficiency of ammonia. In order to utilise the full capacity of these plants it was decided to add another ammonia production unit of 60 metric tons per day. A European company specialising in skid mounted ammonia was awarded the contract in November 1966 to supply a 60 metric tons per day ammonia plant.

The contract for the skid mounted ammonia plant was awarded in preference to other lower offers on the basis of the short delivery time quoted. A delivery period of 90 days from the signing of the contract to the start up of the plant was agreed upon. All the other offers had delivery times varying from 12 to 18 months.

SUB-CONTRACTS:

PIDC also negotiated two sub-contracts for the supply of the actual plant and the compressors. Unfortunately the Compressors were gas engine-compressors mounted on a single crank shaft. The responsibility of the engineering and process guarantees rested with the main Engineering Contractor while the sub-contractors were responsible only for the supply of the equipment.

This type of skid mounted plants had been in operation in different parts of the world with the exception that none of them had compressors with a gas engine drive. Since PIDC was not familiar with gas engine operations it was negotiated in the contract that a gas engine engineer would be sent for one year to supervise the operations and train the local engineers.

THE GUARANTEES PERIOD:

The final acceptance of the skid mounted plant was to be made after a fifteen day guarantee test period during which the plant was to produce 63 metric tons per day of anhydrous ammonia with the cooling water temperature at 85°F.

In 1967 the plant and machinery shipments of the ammonia plant was delayed due to the Middle East War. The shipment was held up enroute and finally had to be routed via the Cape. The 90 day delivery time schedule guarantee could not be invoked due to Force Majeure.

AMMOPAC START-UP:

In April 1968, the skid mounted plant was erected next to the existing plant. After a few days operations for the startup tests by the Contractors personnel, the roof of the primary furnace collapsed. This was attributed to the faulty design which was later rectified by changing the inlet manifolds and the pig-tails. The pig-tails were replaced with French horn design inlets and the guarantee tests were resumed. The guarantee tests had to be abandoned once again because the multi-purpose compressors with the gas driven engines failed. Severe corrosion was noticed in the compressor inlets and ovalatics had occured in the main crank shaft of the gas engine which had to be replaced.

During 1968 and 1969 meetings were held with the Contractors representatives regarding the plants problems. A computer study was carried out on the design and operation of the plant which showed that no defect in the design of the plant existed. However, the plant would not work continuously. PIDC demanded that a third electrically driven compressor be supplied as a stand-by compressor. The contractor agreed to supply a third compressor however, quoted a long delivery period for the machine. In May 1971, the guarantee tests were again started after some process modification but again could not be completed due to the mechanical problems with the compressor. The Contractor left the plant in May 1971 without completing the guarantee tests. In the meanwhile correspondence continued with the Contractor for the supply of the third stand-by compressor. In 1973 the Contractor agreed to supply a third gas engine compressor on the condition that it will be used only as standby and the acceptance tests will be carried out using only two compressors; if the tests proved successful the third compressor would be returned to the Contractor otherwise machine would be given free of cost to PIDC.

The third compressor was installed in November, 1973. Again the plant was commissioned under the contractor's supervision. The contractors personnel left the plant in December 1973 without performing the acceptance tests; they later returned in August, 1974 to start the third standby machine. By this time the engineering Contractors' firm had been sold to another international corporation.

The Contractors personnel started the third machine in August, 1974 but left the plant without the final acceptance tests and have not returned since then.

CURRENT STATUS.

The 60 tons per day plant has been operating since October, 1974 at 75 per cent of its capacity. Serious problems still exist with its reformer design and with the maintenance of the gas engine driven compressors.

Since the Multan Plant is being totally replaced by a 1000 tons/day plant, the plant is being allowed to "limp along" until that time.

CASE HISTORY OF THE DAWOOD HERCULES PLANT AT CHICHOKI MALLIAN

The Dawood Hercules Fertilizer Complex was designed to produce 200,000 metric tons of ammonia to be processed into approximately 345,000 metric tons of urea fertilizer annually.

The plant facilities include an Ammonia Unit with a daily design capacity of 625 metric tons, a Urea Unit with a design capacity of 1100 metric tons, bagging and storage facilities, plant offices, a power generating station to take care of the total power requirements of the entire complex, and a housing colony for essential personnel.

The local partner received sanction from the Government of Pakistan for setting up a fertilizer complex in 1966. A U.S. Company decided to join as an equity partner in the project in 1968. The plant site preparations begun in February 1969, the first prills were made in October 1971 and all performance tests and guarantees were completed in November 1971.

The mechanical completion of the project was in July 1971 in 36 months (fifteen days later than scheduled) and the entire complex was in operation by October 1971. The Ammonia Plant was commissioned in 23 days, a record time for developing countries.

Sources of Funds

Equity investment was divided equally between foreign and local parties, with the partners in the joint venture holding the majority. The remainder of necessary funds were in the form of loans from recognized sources.

A U.S. firm was appointed as Consultant and Engineer for the entire project. They were responsible for the setting up for Owner a complete and operable fertilizer complex designed to have the capability of producing prilled, uncoated urea conforming to Owner's specifications at a design rate of 345,000 metric tons per calender year, generally in conformity with Owner's Design Criteria. The fertilizer complex included ammonia and urea production facilities complete with adequate facilities for utilities storage, packaging, shipping, maintenance, administration, housing and other auxiliary facilities necessary for Owner to operate, service, maintain and support production facilities and sustain the work force which needed to staff and operate the completed installation.

Scope of Consultant/Engineer's Work

The Consultant was responsible for performing and providing, outside Pakistan, all engineering work, documents, and services required for, (a) carrying out the complete process and mechanical design and (b) producing all drawings, specifications and other documents for the procurement of materials, equipment and services necessary to complete the fertilizer complex. The Consultant was required to carry out this work based upon Owner's Design Criteria and any other instructions issued by the Owner as the work progressed and included:-

1. Performing all work necessary, in addition to the work required to be carried out by sub-contractors for Ammonia and Urea plants, to complete the necessary engineering, produce the documents and provide the required services.

2. Correlating the design of the battery limits ammonia and urea process units with all other parts of the fertilizer complex in order to provide proper flows of process, product and utilities streams, adequate provisions for utilities, and for storage of process materials and product.

3. Assist Owner in arranging a training programme for Owner's operating personnel in the proper operation of the ex-battery limits facilities.

4. Provide Engineer with the services for the procurement of up to sixty experienced technical personnel to be seconded to and employed by Owner to assist Owner in the engineering, supervision, procurement and construction of the fertilizer complex during the period of construction, start-up and initial operation of the plant.

A subsidiary of the U.S. firm registered in Pakistan specially to undertake the construction of the fertilizer complex included performing, providing and directing all work and services necessary within Pakistan to accomplish physical construction of the fertilizer complex in accordance with Owner's Design Criteria and the drawings, specifications and data furnished by Owner. The work included the necessary arrangements for the receipt, transportation and handling of all materials and equipment furnished by Owner. In addition, Engineer was required to perform all services necessary to accomplish the physical construction of the complete fertilizer complex and his obligations included:-

1. Maintaining complete control of its employees and work, and furnishing adequate and efficient administration of its obligations.

2. Furnishing at the required time and places all persons with appropriate skills, as necessary for the performance of Engineer's work. The obligation included arrangements for training necessary for construction craft workmen.

3. Receiving materials and equipment furnished by Owner for the work at designated destinations in Pakistan, and make all arrangements necessary to clear such materials and equipment through customs, and transport such materials to the construction site.

4. Co-ordinating, supervising, controlling and performing all construction work in accordance with the drawings and specifications furnished by Owner.

5. Furnishing necessary advice to Owner in connection with the procurement of materials, and equipment by Owner within Pakistan as directed by Owner.

6. Furnishing assistance requested by Owner during plant start-up, initial operation and performance testing of the completed facilities and conducting performance tests of the ex-battery limits facilities in accordance with directions from Consultant.

7. Performing corrective work as directed by Owner relative to the plant and the necessary expediting inspection services relative to such orders and sub-contracts.

Ammonia Plant

Ammonia production for the fertilizer complex was accomplished in the battery limits ammonia process units based upon and incorporating know-how and design. Consultant sub-contracted the process and mechanical design, and certain procurement and other work, including production of drawings, specifications and other documents, necessary for Owner to procure equipment, construct, test, service, maintain and operate the battery limits ammonia process unit.

Obligations of Ammonia Sub-Contractor

1. Provide Owner written notification prior to Owner's acceptance of the ammonia plant at mechanical completion of said plant that no deviations were found in the ammonia plant as erected by Engineer.

2. Submitted process flow diagrams, material balances, process description, equipment load sheets and vessel sketches, plot plans, utility balances, engineering flue diagrams, equipment data sheets and other planning and analytical design work directly to Owner for his review and comments.

3. Performed process design, detailed mechanical design, engineering and drafting, and prepare complete construction drawings and specifications, and related detailed information as required to provide completely engineered and designed ammonia plant. They were also responsible for compiling operating instruction manual, spare parts list and plant manuals necessary for erection, maintenance, start-up and operation of Ammonia Plant.

4. Responsible for providing procurement services for all the equipment and materials relative to the Ammonia Plant.

5. Guarantee that the Ammonia Plant shall meet Licensor's Warrantees regarding product quality, production capacity, delivery conditions, and cost of feed and utilities.

Urea Plant

Urea production for the fertilizer complex was accomplished in a battery limits urea process unit sub-contract.

Obligations of Urea Sub-Contractor

1. Responsible for preparing and furnishing the basic design for the urea plant in accordance with the Design Data furnished by the Owner.

2. Prepare and furnish analytical procedures, provide supervision of technicians and engineers, train Owner's operating personnel, inspect the plant before mechanical completion and give Owner written notification of Toatsu's verification to the effect that the urea plant has been constructed in accordance with the Basic Design Package.

Engineering Assistance

The foreign partner provided competent staff to act on behalf of the joint venture to supervise and direct the design, procurement and construction of facilities and in this connection:-

1. Prepared, assembled, made available and delivered all such design criteria, specifications and other data in such form and as may be required to enable competent engineering contractors to finalize the design and then construct production facilities.

2. Supervised the preparation of engineering design, equipment specifications and gave technical approval, before their issuance, to all purchase orders prepared for procurement of equipment and materials from the plant.

3. Provided continuing supervision for the work in progress to ensure that the plant is being constructed according to the Basic Design Criteria.

4. Arranged the services of technically competent personnel for assisting the commissioning, start-up and post-start-up operation, and maintenance of the plant facilities, the marketing of the product and the management of the Company during the first three years.

Plant Performance

The commissioning of the plant was carried out according to a start-up schedule which was made early in 1971. The sequence of events was broken down into 90 events from the time the first tubewell was started until the time the prill plant went into production. Each sequence was carefully studied and various services and utilities required for its commissioning pre-arranged. The production Department also used the sequence write-ups as a basis for making punch lists, comparing actual construction to process and mechanical flow sheets etc. This procedure proved very helpful in reducing the bottlenecks, correcting construction errors and enabling orderly commissioning of the plant.

The plant start-up commenced on 24th April, 1971, and ended with the production of the first prills on 12th October, 1971. Feed was introduced to the Ammonia Plant primary reformer on the 16th September. Flows were through the catacarb system by the 21st. On the 5th October aqua ammonia was made. This was only 20 days after feed was introduced. By the end of September the urea plant was on a water run and on the 12th October feed was introduced to the urea reactors and shortly afterwards the first prills were produced.

The mechanical commissioning of the plant was completed on 15th July, 1971, while the process commissioning was accomplished three months after the mechanical completion.

The basic decision to utilise proven processes for ammonia and urea and to purchase only that equipment which had two years proven performance in similar applications proved very sound. In addition standardisation of equipment throughout the plant was very helpful in the initial check-out and plant start-up.

All foreign national personnel had a well diversified experience in various fields and had full command over their areas of responsibility. They also carried out the training programme for local engineers and technicians in a well co-ordinated and organised manner.

Initially eleven foreign nationals were assigned for the management of the Company; but this number was gradually reduced to four towards the end of 1973 when the management was Pakistanised.

The success of the project can be gauged by its performance during the last six years' operation.

	% of Design
1971-72	82
72-73	104
73-74	102
74-75	110.4
75-76	106.2
76-77	104.7

Acknowledgements

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