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ASIAN EXPERIENCE IN PROCESS DEVELOPMENT AND MACHINERY SUPPLY FOR THE PHOSPHATE FERTILIZER INDUSTRY

by

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1. Introduction.

The purpose of this paper is to provide background information for a regional discussion on the Manufacture of Machinery in Asiatic Countries for the Phosphatic Fertilizer Industry and the availability of Process and Equipment as well as the technical and legal problems involved.

The basic reasons for this discussion are to provide African countries with information on the experience of Asian countries in manufacturing equipment for the Fertilizer Industry as well as to provide them with information on the availability of know-how and Equipment from Asian countries, with special emphasis on equipment for the manufacture of Phosphatic Fertilizers.

2. Phosphatic Fertilizers.

The main Phosphatic Fertilizers and Phosphatic Intermediates considered in this paper are:-

1) Single Superphosphate (SSP) sometimes called Normal Superphosphates.
2) Fused Calcium & Magnesium Phosphates.
3) Phosphoric Acid, (52-54% P_2O_5) Fertilizer grade.
4) Triple Superphosphate (TSP) sometimes called Concentrated Superphosphate.
5) Ammonium Phosphates, mainly Diammonium Phosphate (DAP) and Monoammonium Phosphate (MAP) and intermediate grades.
6) Nitrophosphates produced from Nitric Acid.
7) Granulated Phosphate fertilizers.

The production in Asiatic countries of different Phosphatic fertilizers is given in Table 2.1

3. Basic Steps in the Manufacture of Machinery.

In considering the manufacture of Machinery for a complete plant, the steps are:-

3.1. Availability of the know-how.
3.2. Basic Engineering.
3.3. Detailed Engineering.

TABLE - 2.1

PRODUCTION OF PHOSPHATIC FERTILIZERS IN ASIA

(1985-86)

(Metric tons P_2O_5)

	Ground Rock	SSP	TSP	Ammonium Phosphates	Other Complexes	Total Phosphates
Bangladesh	-	-	46,349	-	-	46,349
China	NA	NA	NA	NA	NA	1,830,300
Cyprus(1983-84)	-	7,310		4,107	-	*(3)
India	30,200	341,848	138	645,692	442,622	1,480,300
Indonesia(1985-86)	NA	NA	NA	NA	NA	463,300
(1983-84)	1,129	-	360,170	6,498	NA	-
Iran (1983-84)	-	-	-	3,882	-	~~3,882~~ *(3)
Iraq	-	NA	NA	NA	NA	196,200
Israel	33,000	*(1)	78,500	-	16,300	127,800
Japan	-	77,000	18,000	133,000	395,000	623,000
Jordan	-	-	-	248,860	-	248,860
Korea, DPR	-	NA	NA	NA	NA	135,000
Korea, Rep.	-	NA	NA	NA	NA	482,300
Lebanon(1984-85)	-	NA	NA	NA	13,900(2)	*(3)
Pakistan	-	19,087	-	-	73,920	92,957
Sri Lanka	3,400	-	-	-	-	3,400
Syria	-	-	85,477	-	-	85,477
Turkey	-	1,681	256,479	196,524	165,357	620,041
Viet Nam	-	NA	NA	NA	NA	50,000
					TOTAL ASIA:-	6,563,904
					TOTAL WORLD:-	34,627,024

Asia as % of World: 19.0 %

Source: FAO Fertilizer Yearbook, Vol.36 (1986)

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*(1) Israel produced 13,700 tons SSP in 1984-85 but there appears to be no production in 1985-86.

(2) Total Phosphate fertilizer production in 1984-85.

*(3) Production not available for 1985-86.

NA - Not Available.

3.4. Shop Drawings for Individual Static and Simple Agitating Equipment.

3.5. Manufacture of Rotating Equipment, mainly pumps and compressors.

3.6. Manufacture of auxiliary mechanical equipment; conveyors, packing equipment etc.

3.7. Manufacture of auxiliary electrical equipment, motors, transformers, sub-stations, HV Equipment etc.

3.8. Manufacture of Instruments and design of centralised instrumentation and instrument loops.

3.9. Transport Equipment (Pay loaders, Railroad tankers, trucks etc.)

The manufacture of items covered by 3.6 to 3.9 above really consists of equipment for all industries and the availability of such equipment is dependant upon the general level of development of machinery manufacture in a country. Therefore these are only briefly discussed in this paper.

There is a substantial grey area between know-how and basic engineering. Generally the two are purchased together. However know-how alone (sometimes only the use of patent) has been purchased. For instance in an Insecticides plant, Pakistan purchased only the know-how and results of pilot plant tests from an American company, the basic engineering and detailed engineering being done by another engineering company. Generally, however, the know-how and basic engineering is purchased from a single source or through an engineering company with experience of the process.

It is not necessary to define these terms, as they are well known in the Industry. However to complete the paper Annex I contains the relevant description contained in a UNIDO document [1/] as far as know-how and Basic Engineering is concerned which is equally applicable to the Fertilizer Industry.

[1/] UNIDO Model form of Agreement for the Licensing of Plants and Know-how in the Petrochemical Industry.

The conversion of basic engineering to detailed engineering represents the most difficult step, and the most important from the point of view of the successful engineering of the Plant.

The detailed engineering of the equipment for the Phosphate fertilizer industry primarily consists of engineering for static equipment, for conveyors and for slow moving equipment such as granulators. This does not represent very difficult detailed engineering.

However, it should be emphasised that detailed engineering skills cannot be developed for the Phosphatic Fertilizer Industry alone, particularly in LDCs as the annual volume would be too small to justify the required engineering office. The detailed engineering organisation must, therefore, be capable of undertaking detailed engineering of other types of chemical and/or fertilizer plants also.

The development of detailed engineering in Asiatic countries have followed various patterns. Japan developed its detailed engineering capabilities between the two World Wars when such capabilities for the chemical industry, at least, were closely guarded secrets of an International cartel. China developed it after 1962 also in semi-isolation. However since World War II in Japan and since 1972 in China there has been an increased reliance in purchasing know-how as well as technologies for difficult equipment (such as Centrifugal compressors and Steam turbines for Ammonia Plants) and for plants where corrossion problems are severe.

On the other hand in India, and in other Asian countries the first detailed engineering was conducted by joint venture engineering companies formed by European and American companies in association with local companies. Later on, in India, at least all the detailed engineering was undertaken by totally local companies.

In India, in China and to some extent in other countries (Pakistan, for instance) the larger fertilizer plants have been engineered by public sector organisations. This is probably due to the fact that the customers were also public sector organisations. Where, as in Pakistan, Government policies resulted in a change from the public to the private sector, public engineering comapnies suffered without a great increase in private engineering companies. On the other hand, as in Japan or Korea (Rep. of) and wherever private engineering in the mechanical industries has been well established, the extension to the Chemical Industry has been smooth and relatively easy.

A substantial part of all chemical plants consist of equipment which is common to many industries, for instance: pumps, compressors, conveyors, packing machines which are basically part of the mechanical industry and sub-stations, cables, motors etc which are part of the Electrical Industry. Instrumentation is now largely electronic, and, often Logical Programme Controlled, a field which is related to the Electronic and Computer industry. The growth of these depend on the growth of industries outside the Chemical Industry.

Once the detailed engineering for chemical equipment is available it must be converted to shop drawings, and this can be relatively easily undertaken by most competant Workshops with an engineering office at least for Phosphatic Fertilizers. Such shops exist throughout the region.

However, the Chemical industry often requires special materials of construction which must be specially treated. For instance stainless steel dish ends need subsequent solution annealing which is expensive for a few pieces of equipment. In such a case it may be cheaper to buy semi-fabricated equipment such as dish ends from a developed country.

However, basically there should be little difficulties in the fabrication of SSP, TSP, DAP or Granulation Plants in most developing countries. It would be much more difficult to manufacture Phosphoric Acid or Nitrophosphate plants (largely because of the corrossion problems involved) even when based upon purchased technology.

The availability of know-how for processes and the availability of equipment for Phosphate Fertilizer Industry may now be discussed.

4. Asian Experience in Phosphatic Fertilizers.

4.1. Single Superphosphate.

The major producers of SSP in the World in 1980 are given in Table 4.1.

TABLE - 4.1

MAJOR SSP PRODUCERS IN THE WORLD- 1980

	SSP Production million tons/year	Percentage of total P_2O_5 production (%)
China	6.4	68
Australia	4.6	100
Poland	2.78	60
New Zealand	2.05	100
USA	1.74	4
Brazil	1.20	19
India	0.84	22
Hungary	0.78	69
Italy	0.71	23
Spain	0.51	21

(Source: Shu Lin Peng, prepared for UNIDO, 1982)

The above table shows that, in some countries of the World, SSP is a significant factor in Phosphate fertilizer production. For instance in countries with large pasturelands, such as Australia and New Zealand 100% of the Phosphate fertilizer production in 1980 was SSP.

In Asia, the two major producers are China and India. While China did not have any Phosphate plants at Liberation (1949) and started it's first Phosphate plant in 1955, by 1982 it had over 700 Phosphate plants of which around 70% were SSP Plants.

In India, an SSP Plant was installed about 80 years ago, and by 1981 there were 46 SSP plants, of which 36 plants had capacities below 200 tons/day. The number of plants has substantially increased since then and as if 1st October, 1987 India had 80 SSP units.

In consequence of this development of the SSP Industry in China and India both have developed their own technology for the manufacture of Single Superphosphate and complete plants are available from both countries. China, for instance, exported a plant for manufacture of SSP to Albania as long ago as 1963. India has developed a standard package of a 200 tons/day SSP Plant and this has been developed in the public sector.

SSP technology and complete plants are also available from Japan, where a substantial production of SSP still exists (see Table 2.1) and such plants should also be available from Korea.

In Pakistan, the first indigenously built SSP plant is under construction, although the technology was obtained from Europe.

The SSP process is a relatively simple one and can easily be duplicated in most developing countries with a mechanical industry, particularly an industry specialised in conveyor systems. Combined SSP and TSP Plants can also be built and technology for this is available.

The production of SSP requires Sulphuric Acid plants. Such plants have been indigenously built in near all the main countries of Asia, and equipment is available from most countries of the region; for instance; Japan, China, India, Korea(Rep. of), Turkey, Pakistan etc. In some of the countries, however, technology for DCDA (low pollution) systems is not available but pollution can be overcome by Hydrogen Peroxide wash of the exit gases, and these plants can be made in most Asiatic countries.

4.2. Fused Calcium Magnesium Phosphates (CMP)

These are specialised products manufactured in Japan, China and Korea in Asia, although a well-known process is based upon TVA (American) know-how.

Know-how is available from Japan and China and equipment from Japan, China and Korea (Rep. of).

The production of CMP can be from Phosphate Rocks and any major Magnesium mineral. Commonly used are Olivine and Serpentine but Magnesite can also be used.

4.3. Phosphoric Acid.

Phosphoric Acid is prepared by the action of strong acids (Sulphuric or Hydrochloric) on Phosphate rocks. In general Sulphuric Acid is used because the co-produced Gypsum is insoluble and can be easily removed.

The capacity of Phosphoric Acid Plants in Asiatic countries is given in Table 4.2.

TABLE - 4.2

ASIA: WET-PROCESS PHOSPHORIC ACID CAPACITY, 1976-90

(thousand metric tons P_2O_5)

Country	1976	1986	1990(est.)
Bangladesh	56	56	56
China	40	76	136
Cyprus	0	0	40
India	287	665	804
Indonesia	0	180	360
Iran	215	0	0
Iraq	0	146	416
Israel	32	267	267
Japan	932	668	634
Jordan	0	410	410
Korea S.	239	391	391
Lebanon	99	0	0
Philippines	81	458	458
Syria	0	160	160
Taiwan	43	43	43
Turkey	323	543	543
ASIA:	2,347	4,333	4,718

Source: Tennessee Valley Authority, July 23, 1987

The trends in Phosphatic Acid capacity in the different regions of the world are given in Table 4.3.

TABLE - 4.3

PHOSPHORIC ACID REGIONAL CAPACITY

(thousand metric tons P_2O_5)

Region	1973	1980	1986	1990(est.)
North America	7,139	10,273	11,221	10,318
Latin America	595	796	1,233	1,734
Western Europe	3,685	4,548	4,197	4,029
Eastern Europe	948	1,850	2,045	2,283
U.S.S.R.	1,529	3,244	5,845	6,265
Africa	971	2,647	4,313	5,563
Asia	1,844	2,867	4,333	4,658
Other[a]	226	200	296	296
TOTAL WORLD:-	16,937	26,425	33,483	35,206
Asia as % of world total:	10.9%	10.9%	12.9%	13.2%

a. Oceania.

Source: NFDC/TVA, July 23, 1987.

An examination of tables 4.2 and 4.3 will show that on a world-wide basis Phosphatic Acid is stagnant in areas with small Phosphate rock resources (Europe, excluding USSR) or where economic rock phosphate deposits are largely exploited (North America) and is going up in regions with large Phosphate deposits (Africa, USSR).

The same situation exists in Asia also, with Phosphate rock producers increasing capacity and developed countries reducing capacity. Thus Jordan has increased capacity from 0 in 1976 to 410,000 tons P_2O_5 in 1986, whereas Japan has reduced its capacity from 932,000 tons P_2O_5 in 1976 to 668,000 tons in 1986. This trend is likely to continue, and gives substantial opportunities for African countries to extend their Phosphoric Acid capacity. However foreign exchange shortages in countries such as India would still permit expansion of Phosphoric Acid capacity in such countries, although even in such countries, such as for instance in Pakistan, imports of Phosphoric Acid are preferred for TSP/DAP projects.

In Asia, the only indigenous process for manufacture of Phosphoric Acid with widespread acceptance is the Nissan process from Japan. This technology and complete plants based upon it are available from Japan as well as from other countries. Plants based upon other technology are also available from India, where about 12 plants are in operation.

The production of Phosphoric Acid is an extremely corrossive process and special materials of construction are required in most sections of the plant, particularly the reactors. Such equipment should be imported as "proprietory equipment" when the manufacture of Phosphoric Acid plant and machinery is contemplated. When inferrior materials are used, very considerable corrossion can occur in a short time as happened to the first (relatively small) plant installed in Bangladesh about 20 years ago.

It should be emphasised that the manufacture of Phosphoric Acid even when using Sulphuric Acid is a sophisticated process and the manufacture of plant and machinery for this process should be the last step contemplated in machinery manufacture for the Phosphate Fertilizer industry in a developing country.

The manufacture of Phosphoric Acid from Phosphate Rock using Hydrochloric Acid which has been developed in Israel, is an even more difficult and corrossive process. Since the co-produced Calcium Chloride is highly soluble, the Phosphoric Acid must be solvent extracted from the reaction mixture. This produces a very pure Phosphoric Acid more suitable as a feed grade acid rather than as a fertilizer grade acid. The very corrossive nature of this process has not allowed widespread acceptance even though high purity hydrochloric acid at very low cost is available in several Asian countries.

Phos Acid
by HCl.
Acd/
Plant built
– Isr.

The Phosphoric Acid process has to be modified to suit the quality of Phosphate Rock available. In fact some rocks, such as Pakistani Phosphate Rock, have been found unsuitable for the manufacture of Phosphoric Acid. In this case, the impurities in the rock are such that at 34%-36% P_2O_5 the Phosphoric Acid forms a gel and it is hard to concentrate the acid thereafter.

In Asia generally Moroccan, Jordanian or West African rocks have been used, although other rocks have also been used including Florida rock. However, Phosphoric Acid processes have not generally been specifically designed to suit a particular type of rock such as occured in Tunisia (SIAPE process). However in both China and India, local rocks have been tried for Phosphoric Acid manufacture, and experience exists in Japan as well for modifying available processes for the use of unfamiliar rocks.

4.4. Triple Superphosphate.

Table 2.1 shows that the Asian countries with substantial TSP production are Indonesia, Syria, Turkey and Bangladesh. Both India, which has a single TSP plant started in 1968, and China have concentrated on SSP and DAP rather than TSP, and Japan on DAP and Complex Fertilizers.

Now 3 plants.

The TSP process is a simple process, particularly when combined with granulation. If the Phosphate Rock is reactive it can be digested with the Phosphoric Acid in digester(s) and the mixture fed to the granulation plant where the reaction is completed. If the Phosphate rocks are less reactive then a conveyor belt-den or pile storage can be used before granulation.

Japan has built TSP plants and wherever SSP and granulation plants have been built (China, India, Korea) TSP plants can also be built. Turkey also has the capability to build TSP Plants. The technology for TSP manufacture is simple and can be easily obtained.

4.5. Ammonium Phosphates.

The reaction of Phosphoric Acid with Ammonia first produces Monoammonium Phosphate (MAP, 11-56-0) and on further ammoniation Diammonium Phosphate (DAP, 18-46-0). MAP is highly acidic and it is not marketed as such but can be easily be blended to produce NPK fertilizers. DAP is often marketed. Both MAP and DAP as well as Intermediate grades (to suit particular requirements for NPK fertilizers) can be made in the same plant.

Until the eighties MAP/DAP plants were relatively complicated but with the development of the TVA pipe-cross reactor most plants with capacities below 50 tons/hour DAP use this process. It is simple to operate and has low capital costs. Pipe-cross reactor plants are available from Japan, India (where there are 9 plants) and also China. They can also be manufactured in Korea (Rep. of), Turkey and almost in all countries which can fabricate chemical equipment.

Larger plant sizes may require neutralisation technology. Indigenous technology exists for this purpose in Japan. The manufacture of such equipment is also simple.

4.6. Nitrophosphates.

The reaction of the highly corrosive Nitric Acid with Phosphate Rock is the basis of the Nitrophosphate process. Because of the corrosive nature of the process, the reaction equipment has to be built with special stainless steels.

Not available for China

The process itself is also complicated as the reaction mixture consists of Phosphoric Acid, unreacted Nitric Acid and Calcium Nitrate which is soluble at room temperatures. The removal of Calcium Nitrate is undertaken by crystallisation, filteration or centrifugal action. The lower the crystallisation temperature, the less the Calcium Nitrate remains in the solution.

After Calcium Nitrate removal, the mixture is Ammoniated to produce a mixture of Ammonium Phosphates and Ammonium Nitrate which is the Nitrophosphate of commerce (generally 22-23%N and an equivalent amount of P_2O_5). However the residual Calcium Nitrate gradually reacts with the Ammonium Phosphates, producing a less water soluble Calcium Phosphate. Thus the water solubility of the finished product depends upon the removal of Calcium Nitrate.

Of course, where by-product Ammonium Sulphate is available, this can be used to precipitate the Calcium Nitrate and this is easier when a high water soluble product is desired. This process can only be used in developed countries where by-product Ammonium Sulphate is available in quantity.

The advantage of manufacturing Nitrophosphates is that no Sulphur is required and for countries which import Sulphur, the production of Nitrophosphates appeared attractive. Therefore in the early Seventies both Pakistan and India decided to establish Nitrophosphate plants, the former with 80% water solubility guarantees, and the latter with 60% water solubility. Dutch technology was used for both plants and both plants on startup gave troubles which was not solved for several years. The plants are now operating satisfactorily. However, only European technologies (Norwagian and Dutch) are available for this type of process when water solubilities more than 55% are required. India building a Plant. (German tech)

low
China [illegible]?
[illegible]
[illegible].
water

Another problem in producing Nitrophosphates is that the ratio of Nitrogen: Phosphorus is 2:1 in the process. If a 1:1 Nitrogen:Phosphorus ratio is desired in the Nitrophosphates, co-product Ammonium Nitrate has to be marketed. The co-product Ammonium Nitrate formed by this process has been found, in Pakistan at least, to cake easily during the rainy season.

As a result, both in the India and Pakistan no Nitrophosphate plants have been built since the first ones and the tendency has been to produce DAP and DAP-Urea blends when N:P fertilizers are required. However, a new plant using a German process is under construction in India.

4.7. Development of Complex Fertilizers.

The replacement of pure Phosphatic Fertilizers by Complex (NP, DAP and NPK) Fertilizers has become marked in most countries. In a developed country such as Japan, in 1985-86, Ammonium Phosphates and complex fertilizers accounted for 85% of the production. Even in a developing country such as Pakistan, in 1986-87 only 28,395 tons of P_2O_5 as pure Phosphates was used as against 405,533 tons (93%) of NP and NPK fertilizers, although these were largely

Nitrophosphates and DAP and NPK fertilizers only consumed 2% of the Phosphate demand.

Fig.4.1 shows the consumption of straight Phosphate as compared to the Phosphate content of NP and NPK fertilizers, in terms of P_2O_5, in India. It will be seen that the consumption of the latter crossed the consumption of pure Phosphates in 1969-70 and is now more than 4 times as much. The same pattern is likely to develop in other LDC's. However, where a plantation economy exists, this change can occur earlier.

4.8. Granulated Phosphate and Complex Fertilizers.

In early days of the development of the Nitrogenous Fertilizer industry, because of fears of admixture, crystalline fertilizers were preferred, at least in Pakistan. Thus crystalline Urea was first produced. However, later it was found that these crystalline products were mixed in turn into high priced products such as sugar.

Therefore, in general, during the sixties and seventies, the tendency was to have fertilizers in a prilled form. This was reasonably satisfactory for Nitrogen fertilizers and for Nitrophosphates (except for Ammonium Nitrate in hot-humid climates). Pure Phosphates were often marketed in run of pile form, at least until the sixties.

Since the seventies in South Asia, and earlier in Japan, the tendency has been to produce granulated fertilizers for Phosphates and NPK fertilizers. Although in U.S.A. 60% of all fertilizers are bulk blended and this is also the practice where ground Phosphate Rock is used, as for instance in Sri Lanka, there is a general tendency to produce granulated fertilizers.

Granulated Urea - DAP fertilizers have been produced in India since 1970 , and several plants now produce them. Technology is available from India and Japan for this purpose and is being developed in other countries. Equipment, generally using processes essentially similar is available from India, Japan, China, Korea (Rep. of) and several countries such as Turkey, Pakistan and Indonesia are capable of making such equipment. Recently a granulation plant based on American technology has been built in Malaysia.

CONSUMPTION OF COMBINED AND PURE PHOSPHATE FERTILIZERS IN INDIA
(TONS P_2O_5)

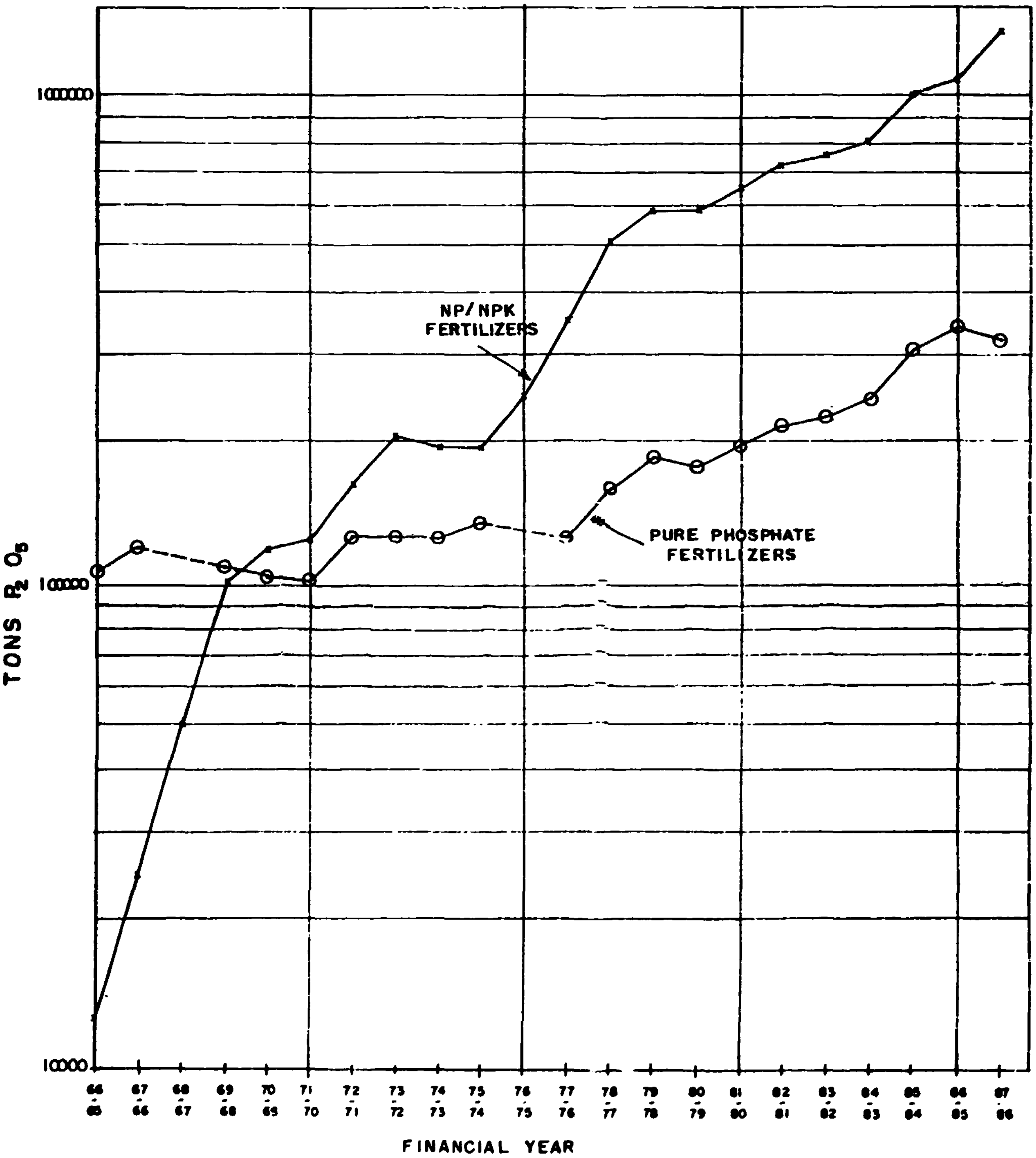

Fig: 4·1

CHEMCON

Know-how for the granulation of TSP-Urea, while maintaining a high water solubility has not yet been developed in Asia, probably because high water solubility is not generally required in the Far East. However technology for granulating SSP-Urea is available in India.

The production of granulated NPK fertilizer using Urea is basically an extension of DAP-Urea granulation technology and equipment is available from the same countries.

5. Technical Problems.

Where machinery is manufactured in a developing country based on know-how from another country, the first and most difficult problem arises in the responsibility for meeting plant guarantees.

The suppliers of know-how alone are hesitant to take on a large liability for meeting plant performance guarantees. In fact they generally limit their liability to 50% of their fees, if their process is a proven one.

In the conditions prevailing, at present, Purchasers want much larger liabilities, if not absolute guarantees for the capacity and quality of the product. Basically such liabilities have to be largely carried by the Engineering companies involved. Where the engineering companies are public sector companies and so are the Purchasers of the plant, this can be settled at the Government level.

The difficulties arise in the case where one or both companies belong to the private sector. It is for this reason that the begining of engineering and equipment supply work for chemical and fertilizer plants has been first undertaken by joint venture companies with mixed foreign-local holdings. As soon as local personnel have acquired the necessary experience, private sector companies gain increasing confidence, and as they grow they can take over much greater liabilities for performance guarantees.

This occurred in India and is happening in many of the Asiatic countries. For simple Phosphatic fertilizer plants: SSP, TSP, DAP, Granulation this represents little difficulties at present. In the case of Phosphoric Acid and Nitrophosphate plants there would be more difficulties in obtaining satisfactory guarantees, particular, if in the letter, a high water solubility was desired.

UN contracts call for Absolute Guarantees i.e. unlimited liability guarantees for Plant Capacity and Product Quality. In the case of the simpler Phosphatic Fertilizer plants these would be available, but in the case of more sophisticated plant, such as Ammonia plants or even Nitrophosphate plants, these could only be obtained from Japan or from countries with large public sector engineering companies such as China or India. The extent to which they are available in Asia is an important topic to discuss at the current meeting.

Where part of the equipment is made in a developing country and part comes from another country, often the plant guarantees can be taken over jointly by the companies involved. This has been the case for instance in Pakistan. Where only a small part of the plant (say 20%) is being manufactured in an LDC, the foreign plant supplier often takes over the plant guarantees but not necessarily the mechanical warranties.

In general equipment mechanical warranties are given by the manufacturers of the equipment, whether local or foreign. A difficulty arises where part of a piece of equipment is local and part foreign. The mechanical warranties can then be unnecessary complicated and this should be avoided unless one or the other supplier takes over warranties for the entire piece of equipment.

It should be emphasised that the problems mentioned in this section arise in the early stages of development of local machinery manufacture. As soon as sufficient confidence is developed by the local machinery manufacturing industry they can and do take over all the guarantees, as has occurred for Sulphuric Acid plants in many of the countries of the region.

6. Legal Problems.

There are, of course, legal problems involved in Contracts where know-how comes from abroad and a substantial part of the equipment is built locally.

The know-how Supplier would only take over liabilities to the extent of around 50% of his fees. Even where he takes over liabilities for 90% of his fees, even then the amount is small when compared to the total cost of the Plant and Equipment.

It should be emphasised that these liabilities cannot be automatically drawn upon if a locally constructed plant does not meet its guarantees. If the know-how supplier can show that a similar plant is working well elsewhere, the presumption will be make that the fault lies in the detailed (local) engineering.

It is therefore essential that know-how should be purchased from licensors who have several working plants using the same know-how, and access is available to, at least, one of these plants when undertaking the detailed engineering.

A degree of legal risk undoubtedly exists when part of the equipment is made locally and part overseas. The legal problems involved become complicated when the laws of two countries get involved. It is important in such cases to have one law apply to all Contracts and Arbitration should also be in the same country. If a single contract can be drawn up with either the local supplier or the foreign suppliers being the primary contractor this is better legally but not always the best solution technically because direct contact with one or the other is lost. If the parties can be "jointly and severally" responsible for the entire plant this has some legal and technical advantages.

A question that is often asked is the degree to which plant defects can be insured. Insurance is not yet available for the technical operation of a process, although UNIDO has done much work in this connection.

However insurance is available for:-

(a) Design Mistakes. It should be emphasised that this is for mistakes and not for bad design defects.

(b) Erection mistakes are covered by an Erection All Risks (E.A.R. policy) and this policy can have endorsements for faults in the erection drawings also.

Some insurance could be available from a company's corporate liability but companies do not give details about such liabilities. However if a company does not carry corporate liability or has been refused such liability such companies should be avoided where part of the equipment is being supplied and/or part of the detailed engineering is being done by them.

ANNEXURE-I

SCOPE AND CONTENT OF THE PROCESS ENGINEERING DESIGN PACKAGE

Scope of work of the LICENSOR

The LICENSOR shall supply the Process Engineering Design Package which shall provide sufficient process and mechanical design data such that a qualified engineering contractor can carry out the following:

(a) Execution of detailed engineering design;

(b) Procurement of all equipment and materials required for the construction of the Plant;

(c) Construction of the Plant;

(d) Start-up and commissioning of the Plant; and

(e) Prepare safety and maintenance instructions for the Plant.

1.1 The LICENSOR shall provide all data for the Process Engineering ign Package in the (English) language. All data will be specified in ( ) Units.

1.2 The LICENSOR shall approve as agreed with the LICENSEE:

(a) The Contractor's detailed engineering design for the Plant;

(b) Specifications for the procurement of critical items of equipment.

Contribution of the LICENSEE

2.1 The LICENSEE shall supply the LICENSOR with the Basic Design Data according to the description in Annexure 6.

Content of the Process Engineering Design Package (check-list)

3.1. Basis of design and process description

This section of the package shall have information contained under the following headings:

3.1.1. Basis of design for all cases.

3.1.2. Feed and product specifications and properties.

3.1.3. Battery limit conditions.

3.1.4. Description of flow; this includes normal operations, start-up, shutdown and alternative operations.

3.1.5. Design features of process.

3.1.6. Physical and chemical properties; for streams whose properties have not been defined in 3.1.2. (Feed and product specifications and properties) and are considered essential within the process, e.g. reactor effluent streams will have their physical and where relevant chemical properties listed. Hazardous materials used within the unit will have their properties listed within this section.

3.1.7. Summary of estimated utilities, including electrical power, steam, condensate, boiler feed water, fuel, cooling water, process water, plant air, etc. This will be a schedule of estimated individual users, totalling up to the maximum estimated utility quantities for the unit. This over-all maximum will be for one consistent case for each utility. Where the estimated maximum utility quantity for a particular item of equipment is not part of this consistent case, this maximum will be stated separately.

3.1.8. Estimated catalyst and chemical consumption. Initial catalyst charge and subsequent catalyst and chemical consumption will be tabulated for each unit.

3.1.9. List of effluent streams. Liquid and gaseous effluents requiring further treatment before disposal will be tabulated. This listing would be limited to streams produced from the process only and would not include furnace effluents.

3.1.10. Process flowsheets.

These diagrams will contain the following information:

. All process equipment shown diagrammatically marked with an equipment number;

. Operating temperature and pressure of equipment;

. Main process lines (shown marked with a stream number where applicable to the mass balance) including direction of flow;

. Main process controls;

. All lines, essential for understanding the mass balance around each piece of equipment will be shown (and only those);

- All figures will be given in the defined units of measurement;
- Heat and Material Balance, and Pressure Balance.

  For each stream number on the Process Flowsheet, the following information shall be given where required for complete understanding of the heat and material balance, and pressure conditions.

  Total hourly flow rate (mass/volume);

  Hourly molar flow rate for each major components;

  Molecular weight;

  Pressure;

  Temperature;

  Density.

3.1.11. Materials of construction flowsheet. There will be included a "Materials of Construction Flowsheet" to provide the information (as described in Exhibit).[1]

3.2. Process and engineering design specifications

The information contained within this section will be presented under the following headings, details of which are further developed in this section.

3.2.1. Equipment list

This will include at least the following:

- Equipment identification letter and number;
- Equipment description.

3.2.2. Equipment data sheets and specifications.

3.2.2.1. Vessels

A standard process sketch will be provided showing:

- Maximum operating temperatures and pressures;
- Mechanical design temperature and pressure;
- Materials of construction and corrosion allowance;
- Diameter and height or length;
- Number, type and spacing of trays for towers;
- Number, size, rating and location of nozzles (location of nozzles will only apply to special height requirements of nozzles; orientation is not part of this scope unless for process design purposes);
- High and low liquid levels;
- Insulation requirements;
- Details of special internals such as pans, distributors, mist eliminators, supports, etc.;
- Catalyst type, size of bed, bulk density and design.

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[1] Sample exhibits to be added where required. It is recommended that such exhibits should be provided by LICENSOR and checked by LICENSEE.

Where applicable, tray process information will be provided. See "Exhibit - Trays Process Specification Sheet".

Specific design and fabrication requirements will be detailed, e.g. regular temperature/pressure cycles will be specified.

3.2.2.2. Heat exchangers and air coolers

Specification sheets will be provided giving all process and mechanical design data which is required. See "Exhibit - Shell and Tube Exchanger Process Specification Sheet" and "Exhibit - Air Cooled Exchanger Process Specification Sheet" for data requirements.

Further specific design information which would be provided if necessary to establish the design includes, for example:

- Limiting transfer rates where applicable;
- Limiting viscosities and pour points;
- Vaporization and condensation curves;
- Restrictions on combining air fin services;
- Alternative specifications for individual services;
- Specific design and fabrication requirements.

In general, all necessary data to prepare ratings will be provided, however complete ratings will not be provided.

Where kettle type exchangers are to be used, the specification shall include a sketch or specific information giving:

- Vapour space;
- Surge volume required;
- Nozzles;
- Instrumentation, etc.

Generally only the Materials of Construction will be given in the "Construction" Section of the specification sheets.

3.2.2.3. Fired heaters

Specification sheets will be provided giving all process and mechanical design data which is required. See ("Exhibit - Fired Heater Process Specification" for data requirements.) 1/

Further specific design information which will be provided includes, for example:

- Vaporization curves;
- Limiting fluid peak temperatures;
- Limiting transfer rates or velocities;
- Type of heaters and coil arrangement;
- Control specifications;
- Firing equipment;
- Whether steam - air decoking is required;

1/ See note on page 120.

- Specific design and fabrication requirements;
- Whether coil temperature and pressure profile required from vendor;
- Type of terminal fittings;
- Fuel type and conditions.

3.2.2.4. Pumps

Specification sheets will be provided giving all process and mechanical design data which is required.

Data will be included for alternative duties.

Further specific design information which may be provided includes, for example:

- Corrosion allowance;
- Alternative specifications if necessary for individual services;
- Sealing requirements;
- Flushing requirements;
- Specific design and fabrication requirements.

3.2.2.5. Compressors

Specification sheets will be provided giving all process and mechanical design data which is required. (All design cases will be included).

Further specific design information which will be provided includes, for example:

- Materials of construction;
- Corrosion allowance;
- Special mechanical features required;
- Control requirements;
- Specific design and fabrication requirements.

3.2.2.6. Miscellaneous equipment

This includes all mechanical handling equipment, package units such as inert gas generators, driers, specialities such as scrubbers, cycle timers and vacuum equipment and miscellaneous items such as filters, strainers and process steam traps. Complete duty specification sheets will be provided which would include all process and mechanical design data as required for the equipment. Such specifications may include design and fabrication requirements.

3.2.2.7. Relief valves

Specification sheets will be provided giving all process design data which is required.

Certain emergency risks as identified in Exhibit may require review by detailed engineering contractor after equipment selection. The relief header will normally be designed by the engineering contractor.

3.2.2.8. Instruments

Specification sheets will be provided giving all process design data which is required. Data for any special instruments required for start-up, shut-down and safety, will be included.

Further specific design information which will be provided includes, for example:

- Material of construction;
- Vaporization across valves, sealing, purging or flushing requirements, including any special process design considerations, i.e. pour point;
- Alternative operating conditions (specifically for minimum and maximum flow, to ensure proper control and readability of all instruments);
- Specific mechanical design and fabrication requirements will be detailed.

This information will be supplied for all major instruments. Detailed data on minor instruments, e.g. pressure gauges, level gauges, etc., will not be included.

3.2.3. Relief valve loading listing

A summary will be provided of the loads from each relief valve for each emergency condition under which the relief valve opens, e.g. fire, power failure, steam failure (and other utility failures), blocked in condition, etc.

3.2.4. Process line summary list

A summary will be provided for all process lines . However, it will be the responsibility of the engineering contractor to check the hydraulics of the unit.

3.2.5. Preliminary engineering flowsheets (P and ID)

This will be a complete first issue of the Engineering Flowsheet and will include:

- All process equipment;
- Line size and material specification for all lines;
- Maximum operating temperatures, insulation tracing and jacketing requirements of lines (heat conservation, personnel protection, process stabilization or "not insulated" only);
- All valves and check valves;
- Significant equipment details;
- Tower and vertical drum tangent line elevations;
- Horizontal drum minimum elevations and slope;

- Relative elevations of all equipment and piping where gravity or 2-phase flow is taking place, e.g. reboilers, condensers, seal pots;
- Direction of flow on lines;
- Required line slope, relative location of equipment or special conditions such as required vertical loop dimensions, gravity lines with or without pockets, etc.;
- Vents and drains additional to Engineering Standards required for process reasons;
- Steam, hot water or solvent tracing of lines and instruments;
- Gas or liquid purging or flushing of control valves, instruments or relief valves;
- All start-up, bypass, shutdown and emergency lines and lines for alternate operations;
- All instruments required for proper operation of the plant (indicating any special types required);
- Instrument numbers;
- Any special instructions, e.g. dead leg distances on slurry lines;
- Utility distribution systems would not be included on these flow sheets.

3.2.6. Preliminary plot plan

This will be a suggested plot plan based on the LICENSOR's know-how of requirements of normal and emergency operation, safety and maintenance requirements. It will include preliminary layout of the equipment and elevation diagrams.

- Special requirements (analysers, sample connection);
- Recommended suppliers.

3.2.7. Drainage and effluent disposal

This will cover the suggested layout and materials of construction.

3.2.8. Basic data for piping

- Fluid handled;
- Operating pressure and temperature;
- Design pressure and temperature;
- What phase? Liquid, vapour or both?;
- Specific gravity and viscosity;
- Construction materials;
- Insulation required;
- What kind of test is necessary for the pipe (pneumatic or hydrostatic) if any special test is required, explain it;
- List of the main lines.

3.2.9. Auxiliary services

Steam (all the pressure levels), cooling water, process water, inert gases, plant and instrument air, chemicals, etc. consumed in each equipment and a summary.

3.2.10. Catalyst, chemicals

- Specific characteristics, name, size, quantity.
- Recommended suppliers. Preferred supplier. State reasons.

3.2.11. Vent system

- Equipment required, fluid, flow, temperature and pressure.
- Special requirements.
- Suggested piping arrangement where required.
- The materials of the pipe and equipment must be referred to the ASTM code.

3.2.12. Safety requirements

- Equipment required.
- Monitors, eyewashers, shower and sprinkles location.
- Special requirements.

3.2.13. Building specifications

- Suggested layout of the plant building, control room, electrical switch room, and other building.
- Indicative sizes of the respective buildings.
- Type of construction in each case.

3.3.[1] Basic data for operating manual

The operating guide will include an outline of start-up, shutdown and alternative operations. It will also indicate emergency procedures covering utility failures and major operating upsets. Its scope will be sufficient for the engineering contractor to prepare a comprehensive operating manual. In addition, this section will describe special safety features incorporated in the design of the unit. Data will include:

. Start-up procedures;

. Normal operation procedure;

. Normal shutdown procedure;

. Emergency shutdown procedure;

. Reduced drawings of heaters, vessels, towers and reactors;

. Reduced drawings of process and mechanical P and I drawings;

. Data sheets of mechanical equipment.

with the following details:

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[1] The Operating Manual will usually be prepared by a representative of the LICENSOR and will be revised if necessary by the Contractor (Article 6). This Manual should be revised and approved by the LICENSOR.

3.3.1 Description of process:

(a) Description of Process - A brief discussion of process flow to provide adequate background to the plant operating personnel.

(b) Process specifications and Process Flow Chart - Quality of feedstocks, composition of various streams and designed yields and qualities of products, intermediates and by-products.

3.3.2 Process Operating Conditions:

A simplified discussion of cause and effect, exemplified where possible, of operating variables with consequent changes in yields, purities etc.

3.3.3 Details of Operating Procedures:

(a) Preliminary operations - preparation and inspection of equipment before start-up. Run in procedure on pumps, compressors etc.

(b) Start-up procedures.

(c) Normal operation.

(d) Shut down procedure.

(e) Special operations - Catalyst regeneration, switching of cyclic systems, steam air decoking etc.

(f) Emergency Procedure - anticipated emergencies and recommended procedures to result in maximum safety of personnel and equipment.

(g) Detailed flow charts and process equipment.

3.3.4 Control Systems:

Employed with details on any special provisions and its bearing on the operations.

3.3.5 Equipment Summary:

Details on equipment by categories and in accordance with the agreed coding system.

3.3.6 Utility and Utility Summary:

On the basis of utility levels agreed to for the plant, utility requirements on guaranteed and expected figures for both plant and its auxiliary/off-site facilities.

3.3.7 Operating Records:

The suggested format for proper maintenance of operating records through:

a. Daily log sheet.

b. Management control - exception reports.

c. Product test record for quality control at various stages in the plant.

3.3.8 Personnel required for operations and maintenance:

Suggested organization for operations and maintenance of the plant giving:

a. Supervisory Staff - with duties and responsibilities.

b. Operating staff - duties, responsibilities and operating positions.

3.3.9 Safety of plant and personnel:

Rules and regulations governing conduct in the operating area with special precautions to be followed. First aid facilities to be provided shall be discussed e.g. eye baths, emergency showers etc. The proper use of special safety equipment will be described.

3.4 Basic data for maintenance manual

- Particular emphasis: preventive maintenance;
- Maintenance instructions for each equipment, including specific types of lubricant/grease required; [1]
- Periodicity of major shutdown for regular overhead/ maintenance.

3.5 Analytical Methods Manual describing in detail all the methods of analysis for all raw materials, process streams products, by-products, catalysts and chemicals required for the efficient operation of the Plant.

3.6 List of catalysts and chemicals required for the initial operation of the Plant and for one year's production, indicating specifications, quantities, recommended source of procurement and packing, storage and handling instruction.

3.7 General design information

The information contained in this section will essentially be akin to the data supplied by the LICENSEE as outlined in 2.2. However, as some data may be supplied by the LICENSOR, the total design information is reproduced for the benefit of the engineering contractor.

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[1] This may be restricted to critical items. This will in any case be checked by the Contractor.

This data will include but not necessarily be limited to:

- Outlet steam conditions for equipment feeding steam into Plant headers;
- Inlet steam conditions of equipment using steam from Plant headers;
- Battery limit conditions for boiler and steam generator feedwater;
- Battery limit conditions for condensate return systems;
- Voltage and frequence for electrical power;
- Analyses of available water streams;
- Fuel data;
- Other available utility data;
- Climatic data;
- Site information;
- Equipment design information (e.g. preferred tube lengths, philosophy for design conditions, etc.);
- Relief and blowdown philosophy.

3.8 LICENSOR's standard drawings

The standard drawings will be referenced in the Process and Engineering Design Specifications and represent design details and practices which are part of the mechanical specifications.

3.9 Name of vendors of critical equipment

No.	Equipment	Possible vendors	References

3.10 Mechanical specifications

The mechanical specifications will represent LICENSOR's or LICENSEE's current standard practice for design and installation of the equipment in the particular process unit.