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Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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ASSISTANCE IN THE PRODUCTION OF CATALYSTS FOR THE PETROLEUM INDUSTRY

IS/IRA/74/042

IRAN

TERMINAL REPORT

Prepared for the Government of Iran by the
United Nations Industrial Development Organization,
executing agency for the
United Nations Development Programme

United Nations Industrial Development Organization

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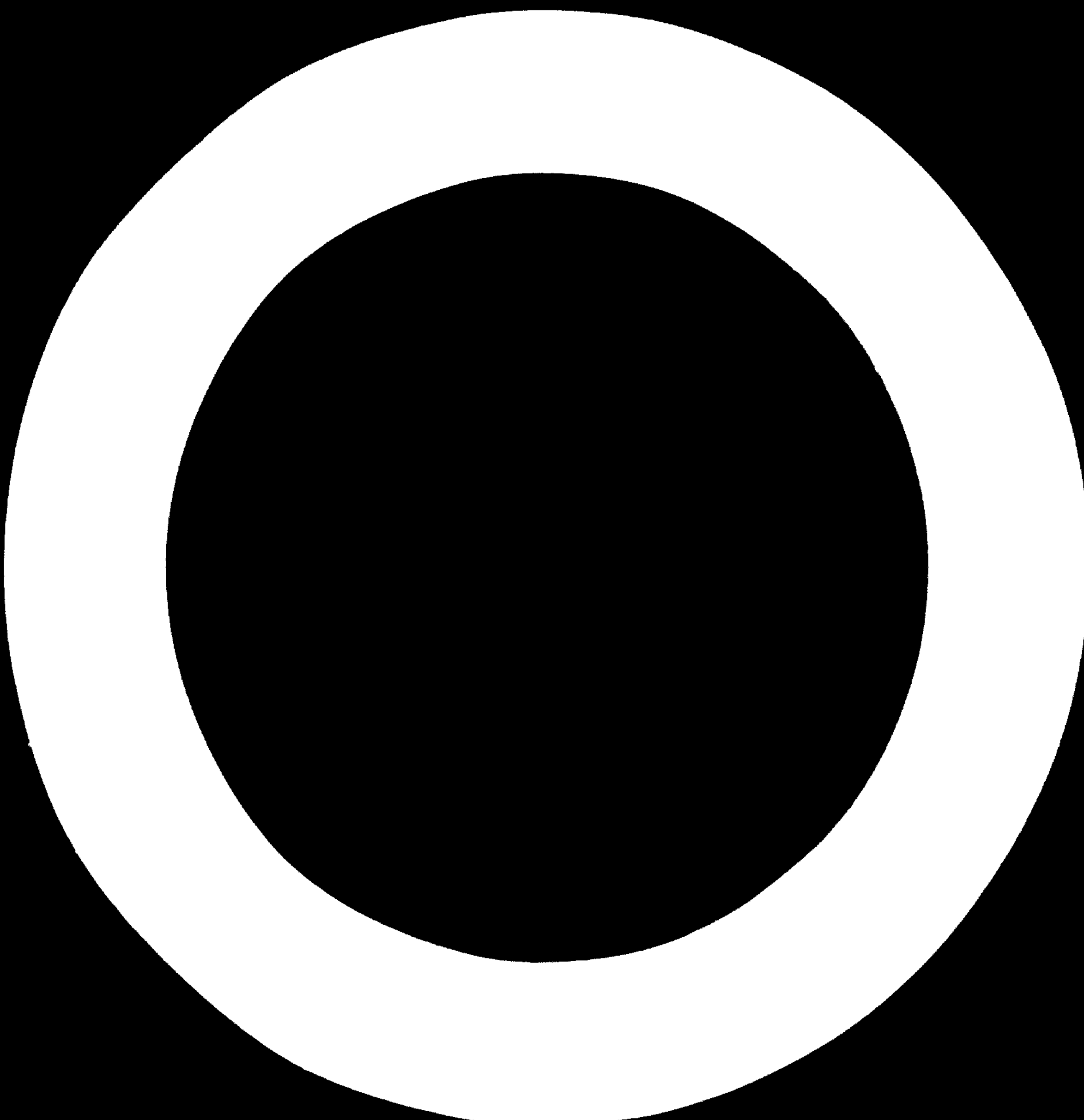


United Nations Development Programme

ASSISTANCE IN THE PRODUCTION OF CATALYSTS FOR THE PETROLEUM INDUSTRY

IS/IRA/74/042

IRAN

Project findings and recommendations

Prepared for the Government of Iran
by the United Nations Industrial Development Organization,
executing agency for the United Nations Development Programme

Based on the work of Otto F. Joklik, chemical engineer

United Nations Industrial Development Organization
Vienna, 1975

Explanatory notes

Reference to "tons" indicates metric tons, unless otherwise stated.

Reference to "dollars" ($) indicates United States dollars, unless otherwise stated.

The monetary unit in Iran is the rial (Rls). In April 1975 its value in relation to the United States dollar was $US 1 = Rls 66.5.

The following abbreviations are used:

Economic and technical abbreviations

BPSD	barrels per stream day
HTSC	high-temperature shift catalyst
LTSC	low-temperature shift catalyst
MMSCFD	million standard cubic feet per day
MTD	metric tons per day
MTY	metric tons per year
t/a	tons per year

Organizations and governmental bodies

IDRO	Industrial Development and Renovation Organization of Iran
NIOC	National Iranian Oil Company
NISCOR	National Iranian Steel Corporation
NPC	National Petrochemical Company of Iran

CONTENTS

Annexes

SUMMARY

The domestic production of catalysts for the petroleum industry in Iran is feasible, and planning for it should begin without delay. The present and future demand to 1985 for catalysts in Iran, a cumulative total of some 46,000 tons (table I and annexes IV-IX), is large enough to support a catalyst manufacturing industry, which, in turn, will have a stimulating effect on the development of all chemical industry in Iran (annex XIII).

A list of the catalysts that should be produced initially is given on page 15. The proposed programme of catalyst production involves a total investment cost of Rls 300 million. When in full operation, it would produce annually over 1,000 tons of catalysts.

An annual profit from sales of Rls 99 million can be expected (pages 17-18). The catalysts could be ready for the market in two to four years (pages 17 and 20 and annex XIV).

Planning for this industry should be concentrated in the Ministry of Industry and Mines and should be integrated into a larger programme for the design and engineering of complete chemical plants for domestic use and for export (annex XIII).

Financial resources for implementing the proposed programme are no problem. The largest stumbling block is the lack of know-how in Iran (pages 20 and 22). To obtain this know-how will require large amounts of outside technical assistance (annex XIII).

INTRODUCTION

Project background

The importance and necessity of manufacturing catalysts in Iran was mentioned in 1972 in the report, "The principal basic chemical products", by A. J. Prince, Ministry of Economy, Research Centre for Industrial Trade Development, Teheran, Iran (page 90):

> "Nearly all the chemical processes that are employed by NIOC [National Iranian Oil Company] and NPC [National Petrochemical Company of Iran] are based on catalytic reactions. The demand for catalysts, already large, is going to grow considerably. Neighbouring countries in the Gulf also require catalysts. All these are at present imported from Europe, America and Japan; the competition is naturally keen, but despite this the economics of local manufacture should be thoroughly investigated."

NIOC has been engaged since 1970 in catalyst research and development. In 1972 a team from the NIOC Research Centre participated at the UNIDO Expert Group Meeting on the Transfer of Know-How in the Production and Use of Catalysts, Bucharest, Romania, 26-30 June 1972, and presented a technical paper on hydrotreating and reforming.

At NPC, on the other hand, there is no research or development at all, and consequently no catalyst research and development. NPC acts merely as a purchaser of complete plants. There is also no development or research at the production plants, although there is quality control.

About a year ago the Iranian Minister for Industry and Mines wrote a letter to NIOC, stating that it was advisable and desirable to establish catalyst manufacturing in Iran, based mainly on Iranian consumption and to a smaller extent on exports, and recommending the organization of a manufacturing company for catalysts, possibly as a pure Iranian project or at least with most of the shares being Iranian, to demonstrate Iranian ability to manufacture catalysts and do research and development on them. A joint NIOC-NPC committee was organized, but little else happened.

Late in 1974, the UNIDO Project Manager of the Research Centre for Industrial and Trade Development Project at Teheran proposed, on behalf of the Ministry of Economy, that an expert be sent to undertake a feasibility study of catalyst production in Iran. That proposal led to the establishment of the present project.

Summary outline of official arrangements

The project data sheet was signed by UNIDO on 22 October 1974 and by the United Nations Development Programme (UNDP) on 2 November 1974. The expert arrived at his duty station, the Ministry of Industry and Mines, at Teheran, on 4 April 1975 and completed his work in Iran at the end of August 1975. After a trip to Western Europe to visit manufacturers of catalysts and catalyst equipment, he returned to Vienna during the last week of September to draft his final report.

A total of $18,[illegible] was allotted to the project.

The Job Description, information about the counterpart and information about fellowship arrangements are in annexes I, II and III, respectively.

Objectives of the project

Short-term objectives

The short-term objectives of the project were (a) investigation of the possibility and feasibility of manufacturing catalysts for the petroleum and petrochemical industry, (b) assessment of the present and future demand of catalysts in Iran, and (c) instruction and training of the counterpart in catalyst technology.

Long-term objectives

In the long term, the objectives are (a) implementation of a national catalyst manufacturing industry to supply the present and future demand of the petroleum and petrochemical industry of Iran, (b) utilization of indigenous raw materials for catalyst manufacture, (c) establishment of know-how and expertise in catalyst production with subsequent development and research to produce more sophisticated catalysts and to develop process technologies without outside help.

Significance to the country's economy

A national catalyst manufacturing industry would mean (a) independence from foreign supply, which is subject to interruption due to strikes, transportation problems, political pressure etc.; (b) import substitution, resulting in substantial savings of foreign currency; and (c) the possibility of exports, not only of catalysts, but later of technologies, processes and complete turnkey chemical plants using catalytic processes.

I. FINDINGS

The principal duty of the expert, according to the Job Description (annex I), was to make a pre-feasibility study on the production of catalysts for the petroleum industry in Iran. The first step in the study was to assess the present and future demand (to 1985) for catalysts in that industry, as well as in the petrochemical industry.

Assessment of demand for catalysts

Figure I shows the location and status of operating and planned plants using catalysts in Iran. Figures II, III and IV represent a further breakdown of these data and show the locations of refineries, petrochemical plants and ammonia synthesis plants, respectively.

The catalyst consumption forecast was based on two assumptions. First, it was assumed that the following production capacities would be achieved on schedule at the refineries of the National Iranian Oil Company (NIOC).

Place	Year	Production capacity (thousand barrels per stream day)
Teheran	1975	200
	1978	300
Shiraz	1975	40
	1978	80
Tabriz	1977	80
Isfahan	1978	200
Ahwaz	1980	350
Kermanshah	1980	80
Abadan	1975	450
	1978	600

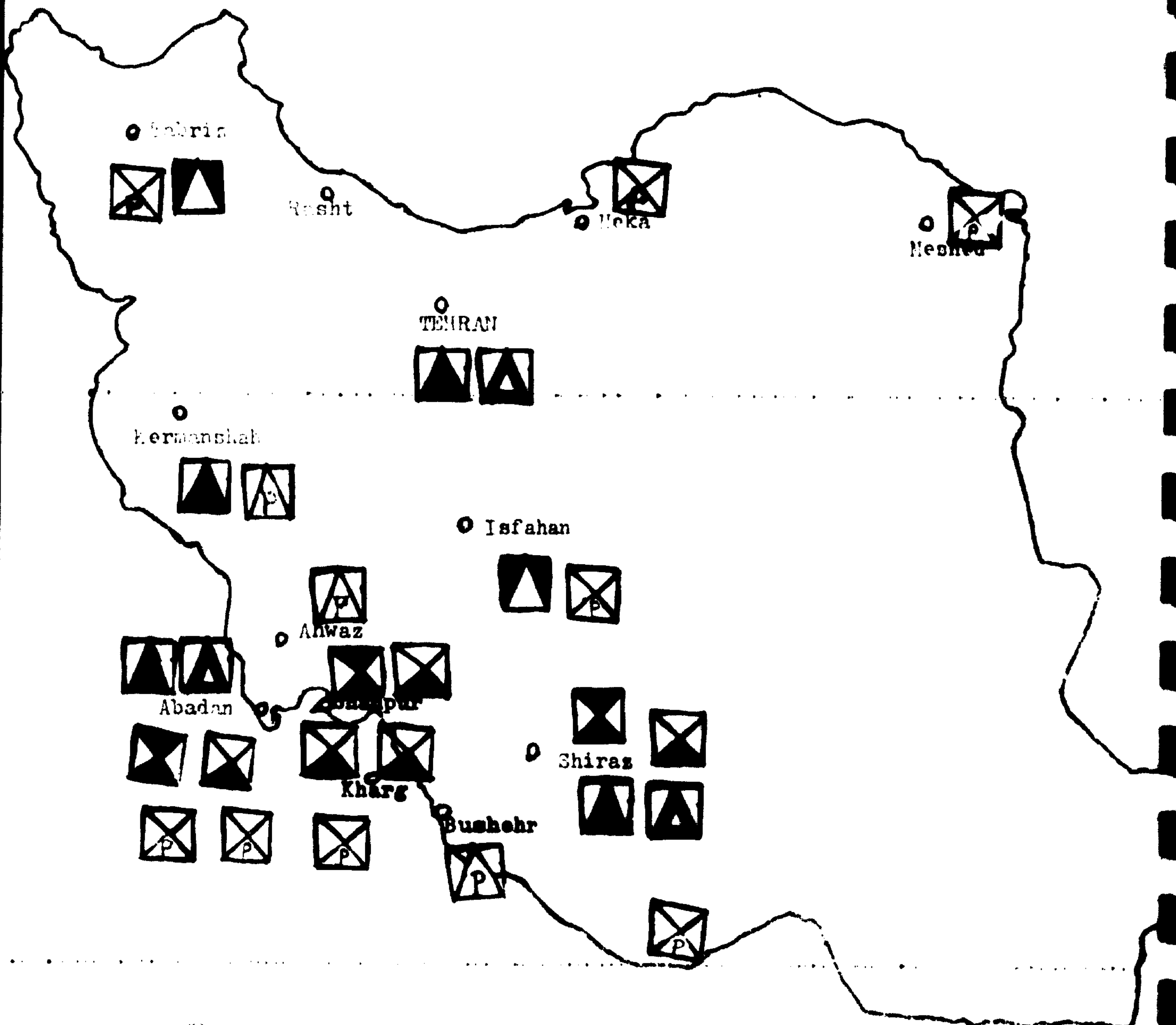
Secondly, it was assumed that by the end of 1980 the ten ammonia plants of the National Petrochemical Company of Iran (NPC) shown in figure IV would be operating at a capacity of 1,000 t/day each.

Table 1 summarizes the estimated catalyst requirements of all these plants over the period 1975-1985, for 15 different processes. The table also gives the value of the estimated consumption, based on the prices of the catalysts in 1975 in the United States of America. Since these prices will undoubtedly increase greatly in the period, an estimated grand total of $120 million may be more realistic than the $96 million shown in the table.

Table 1. Forecast of total catalyst consumption in Iran, 1975–1985

Process and catalyst	Consumption (tons)	Price[a/] (dollars/kg)	Value (million dollars)
Hydrogen plants of refineries (NIOC) and ammonia plants of petrochemical complexes (NPC)			
Sulphur absorption, ZnO	1 948	1.50	2.9
Hydro-desulphurization, Co-Mo	1 213	2.20	2.7
Dechlorination, modified Al	782	1.50	1.1
Primary reforming, NiO	2 791	4.00	11.2
Secondary reforming, NiO	1 283	3.50	4.5
High-temperature shift, Fe-Cr	5 062	1.50	7.6
Low-temperature shift, Cu-Zn	4 629	3.50	16.2
Methanation, NiO	1 315	3.00	3.9
Ammonia synthesis, promoted Fe	2 874	2.00	5.7
Subtotal	21 897		55.8
Sulphuric acid synthesis, V_2O_5	1 840	2.00	3.7
Total	23 737		59.5
Refineries (NIOC)			
Hydro-desulphurization, Co-Mo	140	2.20	0.3
Catalytic cracking, Al-Si	18 600	0.605	11.3
Hydrotreating	110	1.00	0.1
Hydrocracking	2 684	6.30	16.9
Platforming, Pt	1 015	8.00	8.1
Total	22 549		36.7
Grand total	46 286		96.2

a/ In 1975 in the United States of America.



The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations.

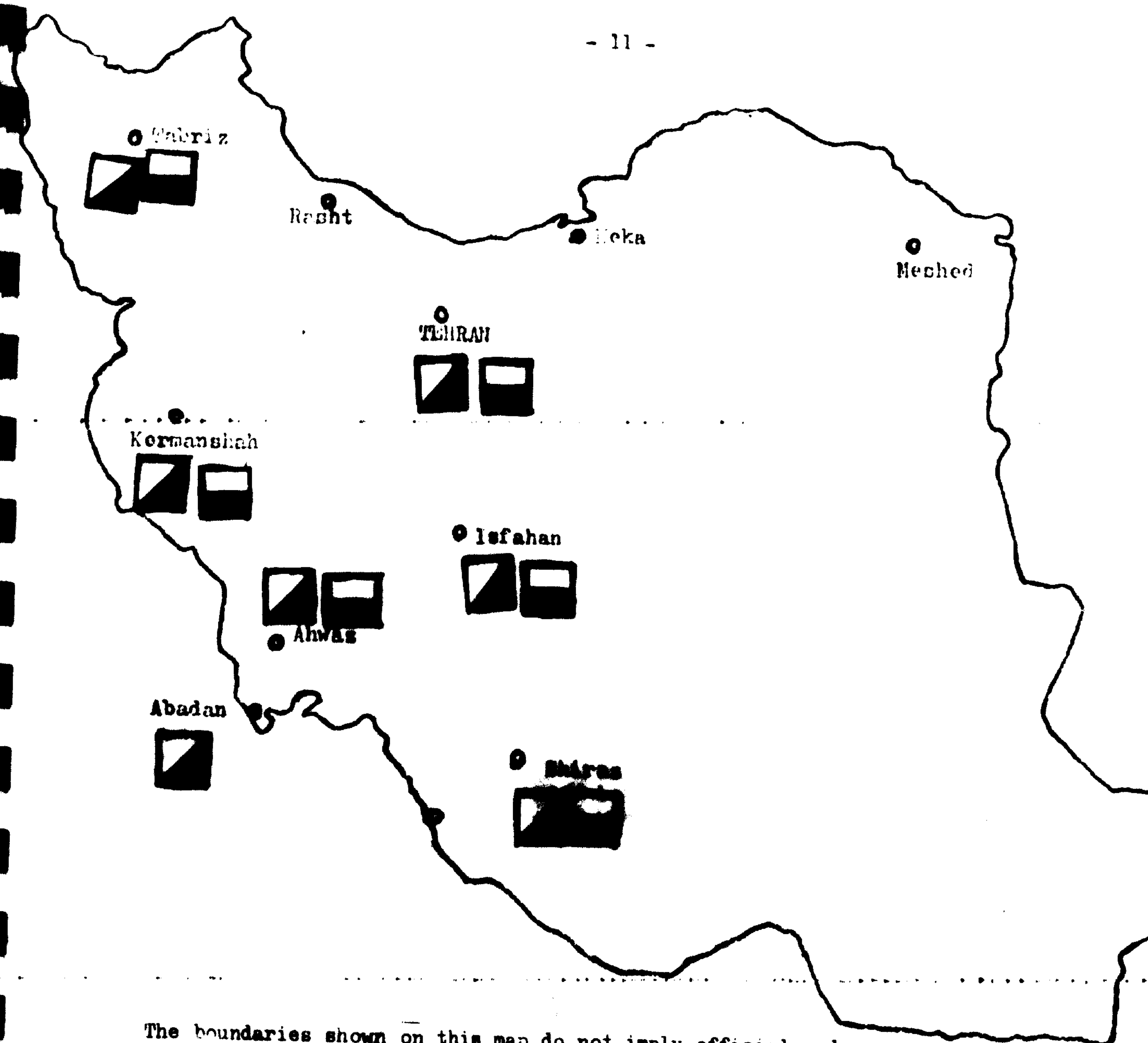
Refineries:

operating: **being implemented:** **expansion program:** **planned:**

Petrochemical plants:

operating: **being implemented:** **expansion program:** **planned:**

Figure I. Plants using catalysts



The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations.

- Petroleum refining catalysts

- Catalysts in the hydrogen plant

Figure II. Petroleum refineries using catalysts

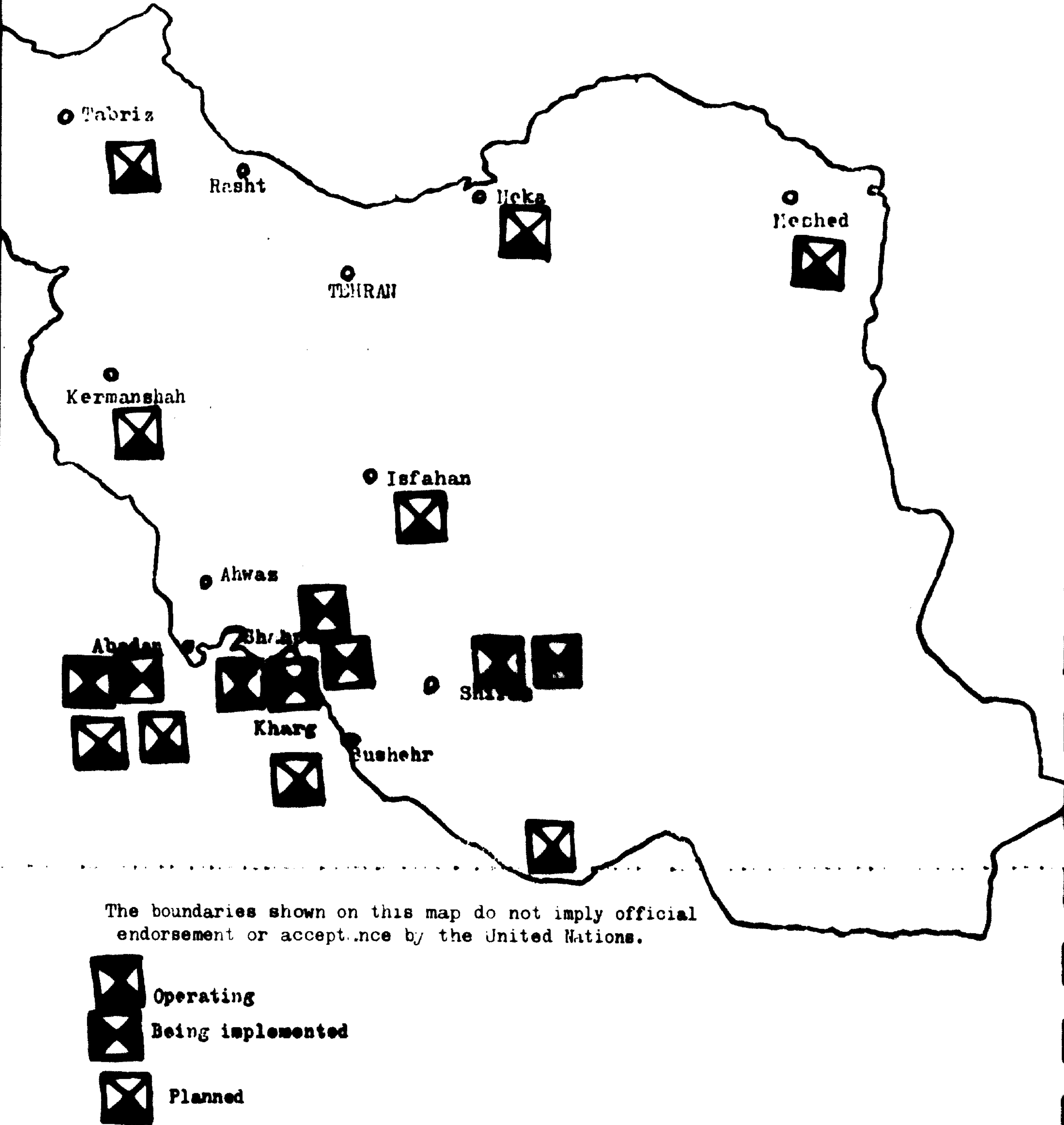
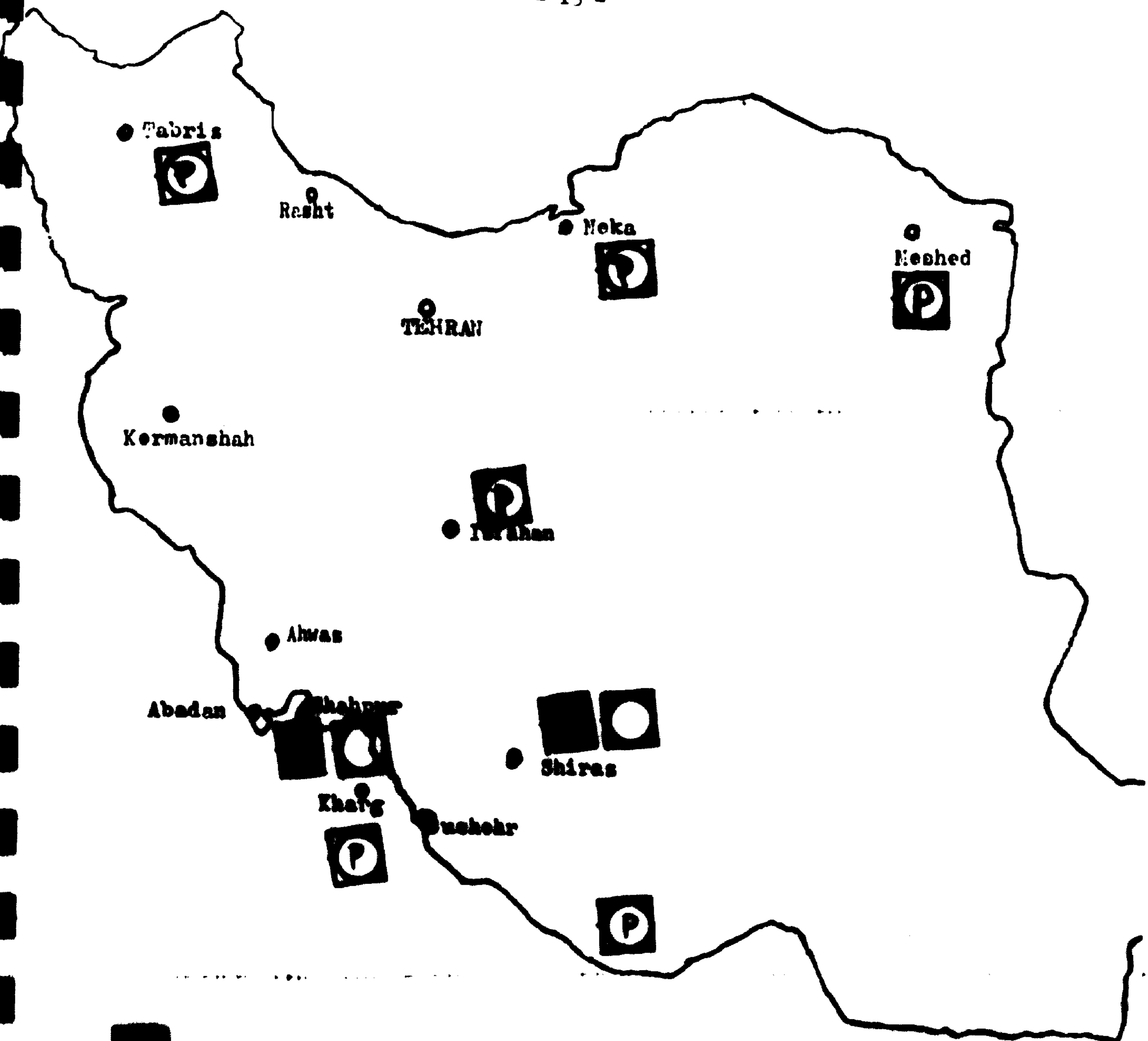
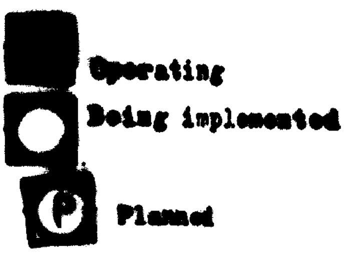


Figure III. Petrochemical industries using catalysts





The boundaries shown on this map do not imply official endorsement or acceptance by the United Nations.

Figure IV. Ammonia plants using catalysts

In 1975, a joint-venture refinery for export was still under negotiation with a group in the Federal Republic of Germany. The new refinery, to be located in the Bushehr area, would be of optimal size, 500,000 barrels per day, and would be linked with a petrochemical complex also constructed to optimal size. However, by the end of the expert's assignment, no conclusive agreement had been reached by the negotiating parties. Therefore, the catalyst consumption of this complex was not taken into account in deriving the estimates of table 1. If it were, the total of table 1, 46,286 t, would be increased by 3,355 t, to 49,641 t. Details are in annex IV.

The catalyst requirements of some other plants were not included in the assessment: the petrochemical plant at Abadan, the Iran-Japan Petrochemical Company and the Iran-Nippon Petrochemical Company. It is estimated, however, that the second of these will use catalysts in these processes and amounts:

Process	Estimated annual catalyst consumption (thousand dollars)
Hydrotreating	35
Catalytic reforming	700
Hydro-dealkylation	40
Cyclohexane production	100
Xylene isomerization	150
Hydrogen production	50
Total	1 075

The Iran-Nippon Petrochemical Company will use a vanadium pentoxide catalyst in its phthalic anhydride plant. The initial charge is estimated to be approximately 40 t at an estimated cost of $900,000. The annual catalyst requirements are estimated to be 13-14 t at an estimated cost of $300,000

Harshaw catalysts are being imported into Iran; their value is expected to reach $300,000-$400,000 in 1975. (These catalysts are mainly Ni catalysts for fatty-acid hydrogenation.) The annual growth is expected to be 30-40%, so that the imports of Harshaw hydrogenation catalysts will thus amount to approximately $1 million annually by 1978.

The assessment was carried out on the basis of information received from the managers of the plants involved. No cross-check with effective annual purchases through the NIOC purchasing department was possible because of the unavailability of data from that department.

Detailed breakdowns of the consumption figures of table 1 by individual plants and individual catalysts are given in annexes V-IX.

The assessment clearly shows that there is a significant, expanding market for catalysts in Iran. Although they have not been investigated here, the possibilities are also excellent for export of catalysts to neighbouring countries. Iran, however, cannot take advantage of either market at present, since there is no local production of catalysts.

Types of catalysts to be produced

The conclusion of the expert is that it is feasible to manufacture the following types of catalysts and carriers in Iran:

- Desulphurization (ZnO, Co-Mo)
- Steam-reforming (NiO)
- CO conversion (Fe-Cr, Cu-Zn)
- Methanation (NiO)
- Ammonia synthesis (promoted Fe_3O_4)
- Ammonia dissociation (NiO)
- Methanol synthesis (CuO)
- Formaldehyde synthesis (mixed oxides)
- Sulphuric acid synthesis (V_2O_5)
- Phthalic anhydride synthesis (V_2O_5)
- Maleic anyhdride synthesis (V_2O_5, MoO_3)
- Al_2O_3 carriers

It is further concluded that the enterprises manufacturing them can be 100% Iranian. However, a large amount of outside technical assistance will be necessary to establish such enterprises, and the production of catalysts more sophisticated than those listed above, e.g., noble-metal catalysts, would require collaboration with a foreign manufacturer that specialised in such catalysts.

Detailed information about the processes of manufacture of the recommended catalysts can be found in the technical documentation prepared as part of this project and described in annex X.

The utilisation of indigenous raw materials for catalyst production is possible and should be the objective of a follow-up mission. From the preliminary survey carried out during this project it appears that certain carrier and active materials will be easily available after the refractory and ceramic material plants are built and operating.

Indigenous magnetite is plentiful and should be used to make the ammonia synthesis catalyst (Fe_3O_4). Once a magnetite concentrate is obtained in consistently good quality, one could even think of exporting the product in significant amounts.

The production steps in the production of magnetite suitable for catalysts are (a) purification, (b) concentration and (c) drying. Purification can be carried out either by electromagnetic separation or by wet chemistry. A detailed investigation has to be undertaken to analyse samples of the magnetite available in Bafqh near Yazd. (It was not possible to obtain such samples during the project.) The analysis is needed to determine the proper purification method needed to obtain the quality described in the specifications given in annex XI. Concentration and drying of the magnetite can be done by conventional processing methods using conventional machinery and therefore does not need to be described here.

Initially, there should be a production of approximately 1,000 t/a of purified, concentrated and dried magnetite. In a second, expansion phase (for exports), the annual production capacity could be increased to as much as 5,000 t, which, at the present world market price, represents a value of about Rls 40 million.

Annex XII gives suggestions for the preparation of ammonia synthesis catalyst from indigenous magnetite for trial purposes.

Catalogues and technical leaflets, as well as samples of the principal industrial catalysts were given to the counterpart during the project. Catalyst samples were also given to the NIOC Research Centre at Rey.

The establishment of catalyst production in Iran would have far-reaching effects on the entire Iranian chemical industry, and not just the petroleum and petrochemical parts of it. These effects are described in depth in annex XIII, in which a detailed proposal for a project for the design, engineering and construction of complete industrial chemical plants for home and export is also presented. The Government of Iran has, on various occasions, expressed the desire for just such a capability.

Assessment of the costs and profitability of catalyst production

Table 2 is an analysis of the estimated costs and profitability of a proposed programme of catalyst production, assuming single-shift operation. When market development is sufficient to require it, the capacity can be doubled by working two shifts. Included in the table are the investment costs for buildings, machinery and equipment, the production costs, and the sales and profits for these broad categories of catalyst: tabletted, extruded, coated and fused.

The space requirement is an area of 5,000 m^2, of which 1,200 m^2 should be covered space in buildings, as follows: 300 m^2 for the tabletting, extruding and coating machines; 200 m^2 in a separate building for the induction melting furnace for fused catalyst production; 500 m^2 for pilot plants; 200 m^2 for the laboratory. A set of drawings for the buildings was prepared as part of the technical documentation for the project (see annex X).

To achieve the proposed capacity, the production machinery listed in table 3 will be required.

The labour requirement for production is 4 persons per machine per shift, plus 4 more for preparation and miscellaneous production activities, making a total of 24. There will be additional personnel requirements, of course, for the pilot plants, laboratory and offices. The estimated total is 36 persons, equally divided among the plants, as indicated in table 2.

The breakdown of the annual raw-materials cost for the four categories of catalyst is given in table 4.

An implementation schedule for each category of production is contained in annex XIV. If these schedules are followed, sales of tabletted and extruded catalysts could begin by October 1977, coated by December 1976 and fused (ammonia synthesis) by June 1978.

Conclusions

From what has been said above, it is clear that there is a significant present and future market for catalysts in Iran, and one can expect the same to be true of the neighbouring countries. However, there is no local production to take advantage of these markets.

Table 2. **Summary of estimated costs and profitability of catalyst production**
(Million rials per year)

Item	Tabletted catalysts (300 t/a)	Extruded catalysts (300 t/a)	Coated catalysts (30 t/a)	Fused catalysts (450 t/a)	Total (1,080 t/a)
Investment costs					
Machinery and equipment	30	30	30	60	150
Buildings	30	30	30	30	120
Preparatory work					30
Total					300
Production costs					
Raw materials[a]	25	25	4.5	8	62.5
Wages[b]	2	2	2	2	8
Salaries[c]	3	3	3	3	12
Electricity and water	1	1	0.5	1	3.5
Allowance for unforeseen costs	1	1	1.5	1	4.5
Depreciation					
Equipment and machinery (20%)	6	6	6	12	30
Buildings (5%)	1.5	1.5	1.5	1.5	6
Repair and maintenance	1.5	1.5	3	1.5	7.5
Interest on capital (10%)	6	6	6	9	27
Laboratory, testing, research and development	5	5	5	2.5	17.5
Total	52	52	33	41.5	178.5
Profitability					
Sales	75	75	60	67.5	277.5
Net profit	23	23	27	26	99

a/ See text for breakdown into carriers and chemicals.

b/ For six persons.

c/ For three persons.

Table 3. Production machinery requirements

Machine or equipment	Capacity	Number required	Total electrical power requirement (kW)
Tabletting machine	50 kg/h	2	20
Extruding machine	100 kg/h	1	20
Coating machine	100 kg/day	1	10
Induction melting furnace	2 t/day	1	2 000
Total			2 050

Table 4. Breakdown of raw-materials cost

Catalyst category	Raw materials	Amount (t)	Cost (million rials)
Tabletted	carriers	300	10
	chemicals	50	15
Extruded	carriers	300	10
	chemicals	50	15
Coated	carriers	30	1.5
	chemicals	3	3
Fused	magnetite[a/]	600	6
	promoters[a/]	60	2
Total			62.5

a/ Imported.

The Ministry of Industry and Mines is well aware of the necessity for manufacturing catalysts in Iran, and not merely for economic reasons, but, more important perhaps, for strategic reasons: to be independent of foreign supplies and free from interruptions in supply caused by strikes, transportation problems, political pressure etc., any of which could paralyze production of refinery products and petrochemicals.

The study made by the experts also shows that catalyst production in Iran is feasible and economically justifiable. There are no financial problems in establishing such an industry in Iran. Assistance will be needed in training, however. Assuming the availability of that assistance and of the personnel experienced in the analytical part of catalyst testing at the [illegible] Research Centre at [illegible]. [illegible] catalysts produced in Iran could be reaching the market by the end of [illegible], sophisticated catalysts by the end of [illegible].

Unfortunately, though the need is recognized, there are certain hindrances to beginning systematic efforts to meet it. For example, there is no active co-operation or exchange of information between [illegible], [illegible], the Ministry of Industry and Mines and the private sector in projects of this kind. That leads to a waste of time, effort, money and manpower.

For its part, [illegible] does not at present have the capability or the intention of undertaking its own catalyst research and development. It is rather oriented towards a co-operation with a foreign firm in a joint venture. [illegible], on the other hand, has an interest in catalyst manufacture but is hampered by a unilateral approach and structural peculiarities.

Successful manufacture of highly sophisticated and sensitive catalysts requires mastery of production technique, which is almost an art in itself. Such know-how must be available, either developed independently after long experience or obtained by transfer through licensing or outright purchase from the few companies or independent consultants in the world that have it. The expertise available in Iran now is either insufficient or inadequate. Therefore, an intensive training abroad for the technical staff of any proposed catalyst manufacturing enterprise is absolutely necessary. This training should cover not only formulation and preparation techniques but also proper operation and maintenance of laboratory and production equipment and of pilot plants. It is in this area that outside assistance is urgently needed. Unfortunately, the necessity for anterior intensive training for technical personnel is being underestimated.

II. RECOMMENDATIONS

1. The production of the catalysts listed under "Types of catalysts to be produced" in chapter I should be initiated in Iran at the earliest possible date.

2. The production should be based on standard formulations and then developed by independent research and development to highest international standards.

3. The catalyst production must be accompanied by pilot-plant testing facilities.

4. The testing of catalyst properties should follow standard methods using testing equipment in the catalyst production plant itself.

5. A multipurpose combined catalyst production plant should be established with an initial production capacity as follows:

Catalyst type	Capacity (t/a)
Extruded	300
Tabletted	300
Coated	30
Fused	450
Total	1 080

6. The catalyst plant should be organised either at the NIOC Research Centre at Rey or at the Industrial Develpoment and Renovation Organisation of Iran (IDRO).

7. For more sophisticated catalysts, particularly noble-metal catalysts, a collaboration with a foreign catalyst manufacturer that specialises in them should be sought.

8. Independent research, development and production should be organized and implemented by all means, even in the case of a joint venture with a foreign catalyst manufacturer, to give the country an absolute independence in this vital and strategically important field.

9. The utilisation of indigenous raw materials for catalyst production, mainly magnetite, aluminium oxides, ceramics etc., should be investigated in depth, perhaps in a follow-up project.

10. Catalyst technology should be introduced in the training courses of the higher educational institutions in Iran. It should not be limited to the theory of catalysis and the preparation and use of catalysts, but should also emphasize catalyst development and testing in pilot plants, catalytic reactor engineering and process development.

11. A complete documentation on catalysts, including not only books and papers, but also patent documentation, current catalogues and samples, is indispensable and should be organized as first step of any training and education programme in catalyst technology.

12. A necessary factor in the successful marketing of catalysts, apart from price and product acceptability, is the capability of the catalyst manufacturer to provide prompt, competent technical service during the design and engineering stages of a chemical plant, at the time of catalyst loading, during initial plant start-up and throughout the lifetime of the catalyst, sometimes on short notice. The catalyst manufacturer should also provide acceptable performance and life guarantees for his catalysts.

13. The final objective should be the independent development not only of good catalysts but also of proprietary processes. That means that in the final stage of development, emphasis should be laid on process development and engineering of complete plants (refineries, petrochemical plants etc.), on their construction in Iran and, finally, on their export to other countries. For this broad activity, catalyst development and production is a prerequisite.

14. It is highly recommended that the Ministry of Industry and Mines organize and have concentrated within it all planning efforts in the catalyst development field within its competence, to avoid the disadvantages of having multiple, non-coordinated and sometimes contrary programmes in this important field. The same should apply also to the general planning for the final objective given in the preceding recommendation.

Annex I

JOB DESCRIPTION

IS/IRA/74/042/11-01/05

POST TITLE	Expert on Catalyst Production for the Petroleum Industry
DURATION	Six months
DATE REQUIRED	As soon as possible
DUTY STATION	Teheran, with travel to Abadan, Kermanshah, Shiraz, Tabriz and Isfahan
PURPOSE OF PROJECT	To assist the Iranian Government to elaborate a pre-feasibility study on catalyst production for the petroleum industry
DUTIES	The expert will be assigned to the Ministry of Industry and Mines, where in co-operation with local experts, he will be expected to carry out a pre-feasibility study on catalyst production for the petroleum industry including the following relevant aspects:

1. An assessment on the catalysts demand for the petroleum industry in Iran at the present time, and for the next ten or fifteen years;

2. An evaluation of the types of catalysts to be produced, including the sizes of plants and processes involved;

3. An assessment on the fixed and working capital requirements including the needed building construction, land, equipment, processes, utilities and transportation, also estimation of labour requirements, production costs, selling prices and foreign exchange components;

4. Elaboration of tenders specification for know-how, process and equipment.

QUALIFICATIONS

Chemical engineer with extensive practical experience in the manufacture and utilization of catalysts.

BACKGROUND INFORMATION

At present there are, besides the big Abadan refinery, the refineries at Kermanshah, Teheran and Shiraz. Two more refineries are now under construction at Tabriz and Isfahan. Future expansion programme includes a large component for export. Already an agreement has been made with foreign partners to construct two refineries that will be catering primarily to the export market. Additionally, chemical and petrochemical industries in Iran are envisaged to grow at a high rate; during the 5th Plan period the investment programme of the National Petrochemical Company of Iran (a public sector company) will exceed $1 billion.

CANDIDATES REQUESTED BY 11 FEBRUARY 1975

Annex II

COUNTERPART

Name of counterpart:	Manoucher JABERI M. Sc. chem. eng.
Location:	Chemical and Petrochemical Industries Section, Ministry of Industry and Mines
Length of assignment:	Full time, 6 April - 28 August 1975

Annex III

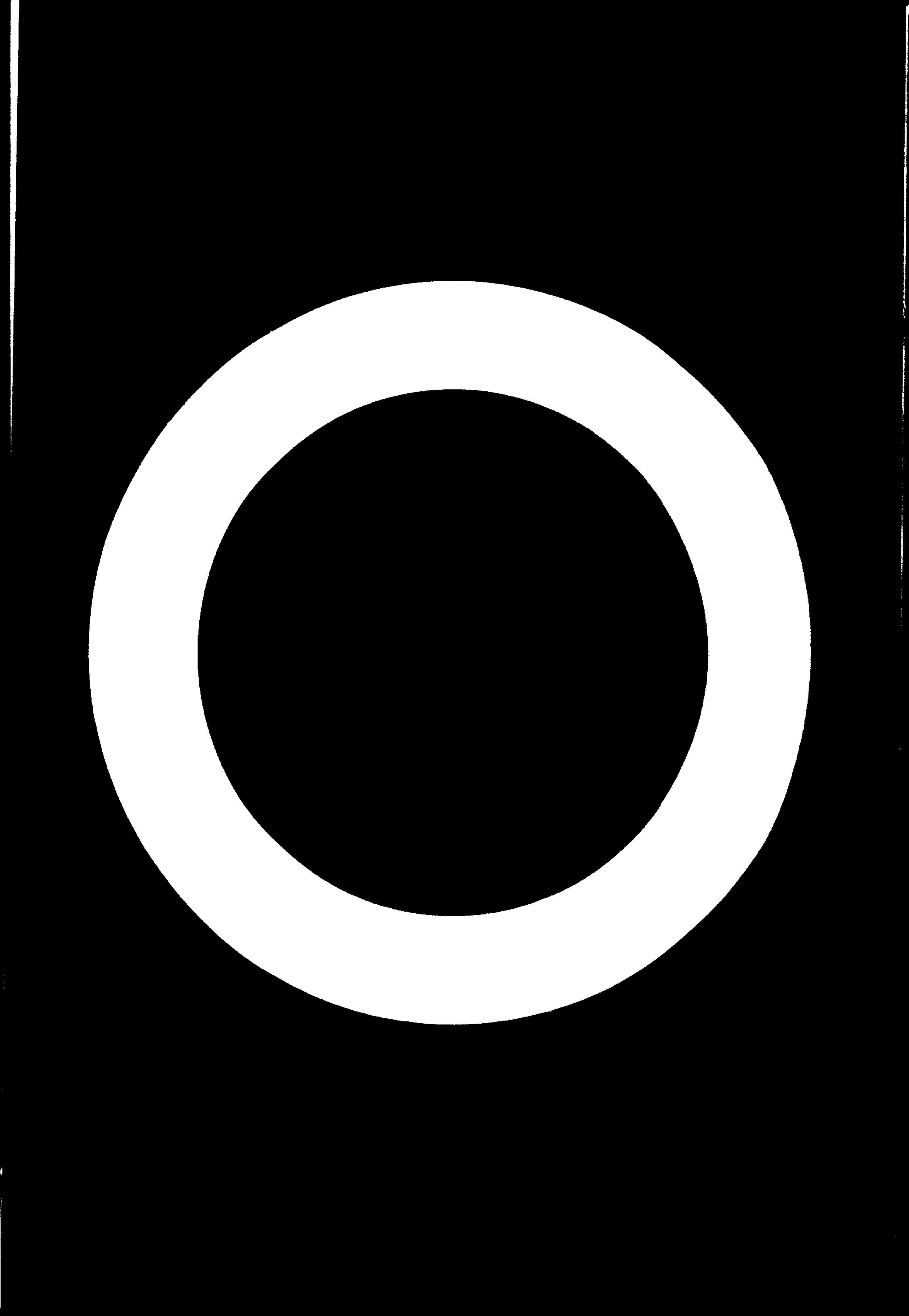
FELLOWSHIPS

The counterpart, M. Jaberi, was nominated for a fellowship in the UNIDO in-plant group training programme in petrochemical industry, to take place in Romania, 1 September to 7 November 1975.

Annex IV

FORECAST OF TOTAL CATALYST CONSUMPTION IN IRAN, 1975-1985, INCLUDING BUSHEHR

Process and catalyst	Consumption (tons)		
	Excluding Bushehr	Bushehr	Total
Hydrogen plants of refineries (NIOC) and ammonia plants at petrochemical complexes (NPC)			
Sulphur absorption, ZnO	1 948	-	1 948
Hydro-desulphurization, Co-Mo	1 213	90	1 303
Dechlorination, modified Al	782	240	1 022
Primary reforming, NiO	2 791	360	3 151
Secondary reforming, NiO	1 283	-	1 283
High-temperature shift, Fe-Cr	5 062	375	5 437
Low-temperature shift, Cu-Zn	4 629	825	5 454
Methanation, NiO	1 315	75	1 390
Ammonia synthesis, promoted Fe	2 874	-	2 874
Subtotal	21 897	1 965	23 862
Sulphuric acid synthesis, V_2O_5	1 840	-	1 840
Total	23 737	-	25 702
Refineries (NIOC)			
Hydro-desulphurisation, Co-Mo	140	-	140
Catalytic cracking, Al-Si	18 600	-	18 600
Hydrotreating	110	30	140
Hydrocracking	2 684	930	3 614
Platforming, Pt	1 015	330	1 345
Total	22 549	1 290	23 839
Grand total	46 286	3 355	49 641



Annex V

FORECAST OF CATALYST CONSUMPTION IN IRAN, 1975-1985:
BREAKDOWN BY PLANT AND PROCESS

TOTAL CATALYST CONSUMPTION IN IRAN 1975 - 1985 (in metric tons)

I. HYDROGEN PLANTS IN REFINERIES (NIOC)

Place	Hydro-desulphurisation	Dechlorination	Reforming (primary)	High-temperature shift	Low-temperature shift	Methanation	Total
Shiraz	418	152	494	1.026	532	304	2.926
Tehran	82	232	352	379	829	79	1.953
Tabriz	27	72	108	207	252	27	693
Isfahan	48	128	192	200	440	40	1.048
Ahwaz	60	150	240	252	600	60	1.362
Kermanshah	18	48	72	138	168	18	462
TOTAL	653	782	1.458	2.202	2.821	528	8.444

II. AMMONIA PLANTS IN PETROCHEMICAL COMPLEXES (NPC)

Place	Hydro-desulphurization	Sulphur absorption	Primary reforming	Secondary reforming	High-temperature shift	Low-temperature shift	Methanation	Ammonia synthesis	Total
Shiraz	52	220	152	144	324	208	88	288	1.476
Shahpour	235	573	383	383	845	508	237	1.074	4.238
NPC-ANIC	39	165	114	108	243	156	66	216	1.107
NPC-Gardin.	39	165	114	108	243	156	66	216	1.107
NPC-Neka	39	165	114	108	243	156	66	216	1.107
NPC-Egypt	39	165	114	108	243	156	66	216	1.107
Tabriz	39	165	114	108	243	156	66	216	1.107
Meshed	39	165	114	108	243	156	66	216	1.107
Isfahan	39	165	114	108	243	156	66	216	1.107
TOTAL	560	1.948	1.333	1.283	2.860	1.808	787	2.874	13.453

III. **REFINERIES (NIOC)**

Place	Hydro-sul-phurisation	Catalytic cracking	Hydro-treating	Hydro-cracking	Plat-forming	TOTAL
Abadan	140	18.600			84	18.824
Tehran			28	868	308	1.204
Shiraz			27	216	63	306
Tabriz			9	216	72	297
Isfahan			16	496	176	688
Ahwaz			24	744	264	1.032
Kermanshah			6	144	48	198
Total	140	18.600	110	2.684	1.015	22.549

Total I	8.444
Total II	13.453
Total III	22.549
Subtotal	44.446
Sulphuric acid synthesis	1.840
	46.286

Annex VI

**FORECAST OF CATALYST CONSUMPTION IN IRAN, 1975-1985:
HYDROGEN PLANTS OF INDIVIDUAL REFINERIES
(BREAKDOWN BY PROCESS AND YEAR)**

CATALYST CONSUMPTION IN THE HYDROGEN PLANT OF TEHRAN REFINERY 1975, 1976-1985 (tons)

Design capacity 1975: 2000.000 BPSD, 1978: 300.000 BPSD

Hydrogen production 1975: 60 MMSCFD = 1,700.000 m^3/d, 1978: 90 MMSCFD = 2,550.000 m^3/d

Process	1975	1976 - 1985										TOTAL
		1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	
Desulfurisation	6	6	6	8	8	8	8	8	8	8	8	82
Dechlorination	16	16	16	23	23	23	23	23	23	23	23	232
Reforming	24	24	24	35	35	35	35	35	35	35	35	352
HTSC	25	25	25	38	38	38	38	38	38	38	38	379
LTSC	55	55	55	83	83	83	83	83	83	83	83	829
Methanation	5	5	5	8	8	8	8	8	8	8	8	79
TOTAL	131	131	131	195	195	195	195	195	195	195	195	1.953

CATALYST CONSUMPTION IN THE HYDROGEN PLANT OF SHIRAZ REFINERY 1975, 1976-1985 (tons)

Design capacity 1975: 40.000 BPSD, 1978: 80.000 BPSD

Hydrogen production 1975: 17 MMSCFD = 415.000 m^3/d, 1978: 34 MMSCFD = 830.000 m^3/d

Process	1975	1976 - 1985										TOTAL
		1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	
Desulfurization	22	22	22	44	44	44	44	44	44	44	44	418
Dechlorination	8	8	8	16	16	16	16	16	16	16	16	152
Reforming	26	26	26	52	52	52	52	52	52	52	52	494
HTSC	54	54	54	108	108	108	108	108	108	108	108	1026
LTSC	28	28	28	56	56	56	56	56	56	56	56	532
Methanation	16	16	16	32	32	32	32	32	32	32	32	304
TOTAL	154	154	154	308	308	308	308	308	308	308	308	2.926

CATALYST CONSUMPTION IN THE HYDROGEN PLANT OF TABRIZ REFINERY, 1977 - 1985 (tons) estimate

Design capacity 1977: 80.000 BPSD

Hydrogen production : 34 MMSCFD = 954.200 m^3/d

Process		1977 - 1985									TOTAL
		1977	1978	1979	1980	1981	1982	1983	1984	1985	
Desulfurization		3	3	3	3	3	3	3	3	3	27
Dechlorination		8	8	8	8	8	8	8	8	8	72
Reforming		12	12	12	12	12	12	12	12	12	108
HTSC		23	23	23	23	23	23	23	23	23	207
LTSC		28	28	28	28	28	28	28	28	28	252
Methanation		3	3	3	3	3	3	3	3	3	27
TOTAL		77	77	77	77	77	77	77	77	77	693

CATALYST CONSUMPTION IN THE HYDROGEN PLANT OF ISFAHAN REFINERY, 1978 - 1985 (tons) estimate

Design capacity 1978: 200.000 BPSD

Hydrogen production : 60 MMSCFD = 1,700.000 m^3/d

Process	1978 - 1985									TOTAL
		1978	1979	1980	1981	1982	1983	1984	1985	
Desulfurization		6	6	6	6	6	6	6	6	48
Dechlorination		16	16	16	16	16	16	16	16	128
Reforming		24	24	24	24	24	24	24	24	192
HTSC		25	25	25	25	25	25	25	25	200
LTSC		55	55	55	55	55	55	55	55	440
Methanation		5	5	5	5	5	5	5	5	40
TOTAL		131	131	131	131	131	131	131	131	1048

CATALYST CONSUMPTION IN THE HYDROGEN PLANT OF AHWAZ REFINERY, 1980 - 1985 (tons) estimate

Design capacity: 350.000 BPSD

Hydrogen production: 105 MMSCFD = 3,200.000 m^3/d

Process	1980 - 1985						TOTAL
	1980	1981	1982	1983	1984	1985	
Desulfurization	10	10	10	10	10	10	60
Dechlorization	25	25	25	25	25	25	150
Reforming	40	40	40	40	40	40	240
HTSC	42	42	42	42	42	42	252
LTSC	100	100	100	100	100	100	600
Methanation	10	10	10	10	10	10	60
TOTAL	277	277	277	277	277	277	1362

CATALYST CONSUMPTION IN THE HYDROGEN PLANT OF KERMANSHAH REFINERY, 1980 - 1985 (tons) estimate

Design capacity: 80.000 BPSD

Hydrogen production: 34 MMSCFD = 954.000 m^3

Process	1980 -1985						TOTAL
	1980	1981	1982	1983	1984	1985	
Desulfurization	3	3	3	3	3	3	18
Dechlorination	8	8	8	8	8	8	48
Reforming	12	12	12	12	12	12	72
HTSC	23	23	23	23	23	23	138
LTSC	28	28	28	28	28	28	168
Methanation	3	3	3	3	3	3	18
TOTAL	77	77	77	77	77	77	462

CATALYST CONSUMPTION IN THE HYDROGEN PLANT OF BUSHEHR REFINERY

Design capacity 1980 ? : 500.000 **BPSD**

Hydrogen production 150 **MMSCFD** = 4,250.000 m^3/d

Process	1980	1981	1982	1983	1984	1985	TOTAL
Desulfurization	15	15	15	15	15	15	90
Dechlorination	40	40	40	40	40	40	240
Reforming	60	60	60	60	60	60	360
HTSC	62.5	62.5	62.5	62.5	62.5	62.5	375
LTSC	137.5	137.5	137.5	137.5	137.5	137.5	825
Methanation	12.5	12.5	12.5	12.5	12.5	12.5	75
TOTAL	327.5	327.5	327.5	327.5	327.5	327.5	1.965

Annex VII

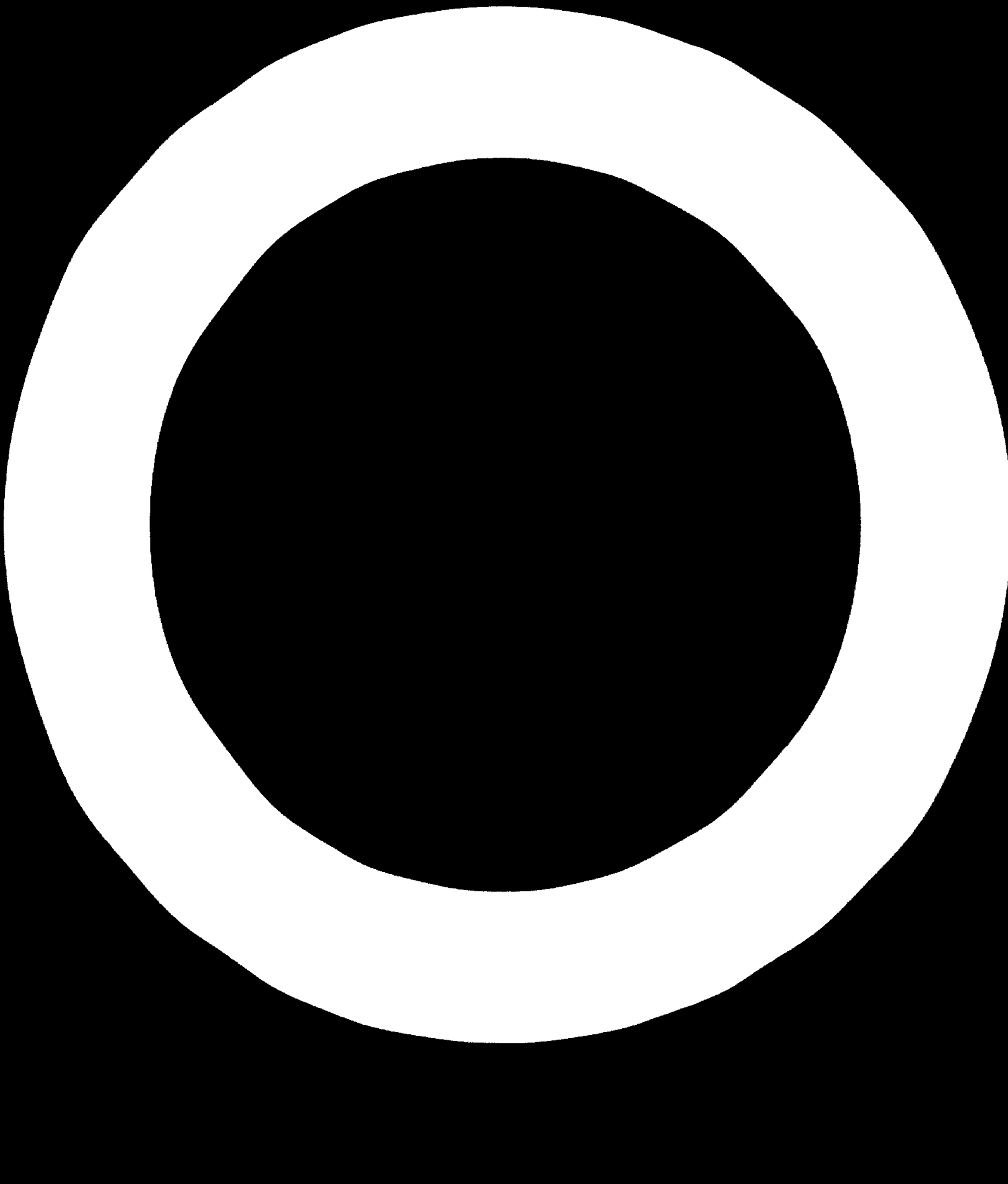
FORECAST OF CATALYST CONSUMPTION IN IRAN, 1975-1985: AMMONIA PLANTS OF SHIRAZ AND SHAHPOUR FERTILIZER COMPLEXES (BREAKDOWN BY PROCESS AND YEAR)

CATALYST CONSUMPTION AT SHAHPOUR FERTILIZER COMPLEX - AMMONIA PLANTS, 1975, 1976-1978 (t)

Process	1975	1976 - 1985										TOTAL
		1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	
Hydrodesulfurization	13.5	20	20	20	20	20	20	20	20	20	20	235
Sulfur absorption	18	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	573
Primary reforming	17.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	36.5	382.50
Secondary reforming	15.9	34	34	34	34	34	34	34	34	34	34	383
HTSC	40	80.5	80.5	80.5	80.5	80.5	80.5	80.5	80.5	80.5	80.5	845
LTSC	22.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	48.5	507.50
Methanation	11.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	22.5	236.50
Ammonia synthesis	74	100	100	100	100	100	100	100	100	100	100	1.074

CATALYST CONSUMPTION AT SHIRAZ FERTILIZER COMPLEX - AMMONIA PLANT, 1978 - 1985 (t)

Process	1978 - 1985								TOTAL
	1978	1979	1980	1981	1982	1983	1984	1985	
Hydrodesulfurization	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	52
Sulfur absorption	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	220
Primary reforming	19	19	19	19	19	19	19	19	152
Secondary reforming	18	18	18	18	18	18	18	18	144
HTSC	40.5	40.5	40.5	40.5	40.5	40.5	40.5	40.5	324
LTSC	26	26	26	26	26	26	26	26	208
Methanation	11	11	11	11	11	11	11	11	88
Ammonia Synthesis	36	36	36	36	36	36	36	36	288



Annex VIII

FORECAST OF CATALYST CONSUMPTION IN IRAN, 1975-1985:
INDIVIDUAL REFINERIES
(BREAKDOWN BY PROCESS AND YEAR)

CATALYST CONSUMPTION AT TEHRAN REFINERY, 1975, 1976 - 1985 (tons)

Design capacity 1975: 200.000 BPSD: 1978: 300.000 BPSD

Process	1975	1976-1985										
		1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
Hydrotreating UOP S6	2	2	2	3	3	3	3	3	3	3	3	28
Hydrocracking UOP Isomax	62	62	62	93	93	93	93	93	93	93	93	868
Reforming Platforming UOP R 11,16	22	22	22	33	33	33	33	33	33	33	33	308

CATALYST CONSUMPTION AT SHIRAZ REFINERY, 1975, 1976-1985 (tons)

Design capacity 1975: 40.000 BPSD; 1978: 80.000 BPSD

Process	1975	1976-1985										
		1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	TOTAL
Hydrotreating UOP S 6	1.5	1.5	1.5	3	3	3	3	3	3	3	3	27
Hydrocracking UOP Isomax	12	12	12	24	24	24	24	24	24	24	24	216
Reforming Platforming UOP R 11	3.5	3.5	3.5	7	7	7	7	7	7	7	7	63

CATALYST CONSUMPTION AT TABRIZ REFINERY, 1977 - 1985 (tons)

Design capacity 1977: 80.000 BPSD

Process	1975	1977 - 1985									TOTAL
		1976	1977	1978	1979	1980	1981	1982	1983	1984	1985'	
Hydrotreating UOP S6			1	1	1	1	1	1	1	1	1	9
Hydrocracking UOP Isomax			24	24	24	24	24	24	24	24	24	216
Reforming Platforming UOP R			8	8	8	8	8	8	8	8	8	72

CATALYST CONSUMPTION AT ISFAHAN REFINERY, 1978 - 1985 (tons)

Design capacity 1978: 200.000 BPSD

[illegible]	1975	1978 - 1985										
		1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	T O T A L
Hydrotreating UOP S6				2	2	2	2	2	2	2	2	16
Hydrocracking UOP Isomax				62	62	62	62	62	62	62	62	496
Platforming UOP R				22	22	22	22	22	22	22	22	176

CATALYST CONSUMPTION AT AHWAZ REFINERY, 19-80 - 1985 (tons)

Design capacity 1980: 350.000 BPSD

Process	1980 - 1985						TOTAL
	1980	1981	1982	1983	1984	1985	
Hydrotreating UOP S6	4	4	4	4	4	4	24
Hydrocracking Isomax UOP	124	124	124	124	124	124	744
Platforming UOP R	44	44	44	44	44	44	264

CATALYST CONSUMPTION AT KERMANSHAH REFINERY, 1980 - 1985 (tons)

Design capacity 1980: 80.000 BPSD

Process		1980 - 1985						
		1980	1981	1982	1983	1984	1985	TOTAL
Hydrotreating UOP S6		1	1	1	1	1	1	6
Hydrocracking UOP Isomax		24	24	24	24	24	24	144
Platforming UOP R		8	8	8	8	8	8	48

CATALYST CONSUMPTION AT ABADAN REFINERY 1975, 1976 - 1985 (tons)

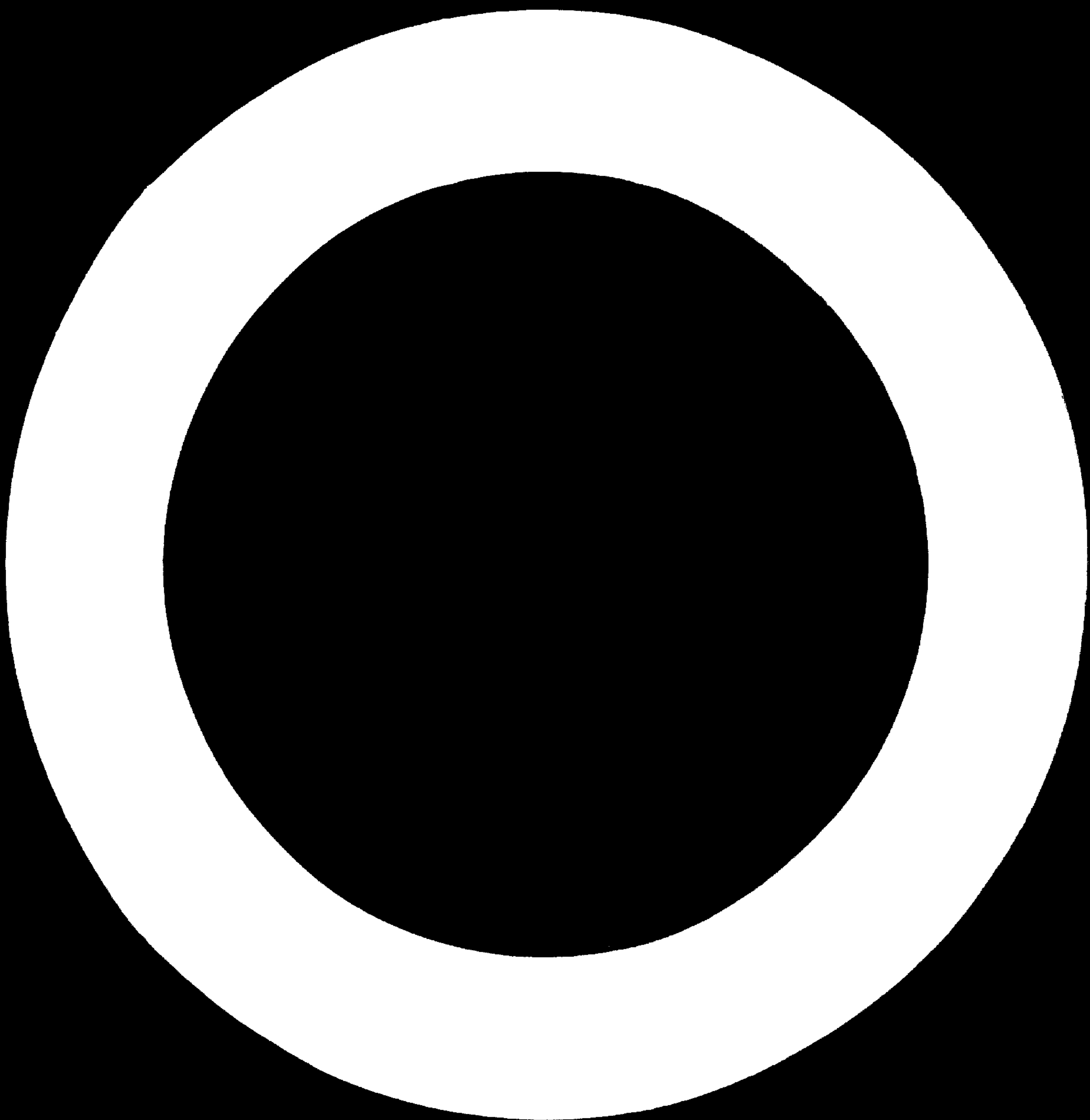
Design capacity 1975: 450.000 BPSD; 1978: 600.000 BPSD

Process	1975	1976 - 1985										TOTAL
		1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	
Hydrodesulfurization UOP Co-Mo	10	10	10	15	15	15	15	15	15	15	15	150
Cat-Cracking Al-Si	1.300	1.300	1.300	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	19.900
Platforming UOP R 11	6	6	6	9	9	9	9	9	9	9	9	90

CATALYST CONSUMPTION (PETROLEUM REFINING CATALYSTS) AT BUSHEHR EXPORT REFINERY

Design capacity 1980 ? : 500.000 BPSD

Process	1980	1981	1982	1983	1984	1985	TOTAL
Hydrotreating UOP S 6	5	5	5	5	5	5	30
Hydrocracking UOP Isomax	155	155	155	155	155	155	930
Platforming UOP R	55	55	55	55	55	55	330



Annex IX

FORECAST OF CATALYST CONSUMPTION IN IRAN, 1975–1985:
ANNUAL CONSUMPTION OF INDIVIDUAL CATALYSTS AT
TEHRAN AND SHIRAZ REFINERIES AND AT
SHAHPOUR AND SHIRAZ AMMONIA PLANTS

YEARLY CATALYST CONSUMPTION AT TEHRAN REFINERY

Catalyst	Charge		Yearly consumption 1975			1978
	cu. ft.	m^3	cu. ft.	m^3	t	t
Hydroben S 6 **UOP**	700	20		4		
Isomax DHC-2, **DHC**-5 UOP	11.500	320		80		
Platforming R 11, R 16 GM, UOP	5.500	156		40		
Sulphur guard ICI 32-A, G 72 B	500	14		5	5.5	8
Dechlorination ICI 59-3	500	14		14	15.5	23
Reforming ICI 57-1, G 56 A, CCI 11-9	1.500	42.5		21.5	23.5	35
HTSC ICI 15-4, G 3 B, CCI 12-1	1.300	37		19	25	37.5
LTSC ICI 52-1, G 66B CCI ~~C-18~~	1.900	54		54	55	82.5
Methanation [illegible] 65, CCI C-13-3	900	25.5		5.1	5	7.5

YEARLY CATALYST CONSUMPTION AT SHIRAZ REFINERY

Catalyst	Charge		Yearly consumption 1975			1978
	cu.ft.	m^3	cu.ft	m^3	t	t
Hydrobon S-9L UOP	105	3	210	6		
Hydrobon S6 1/16" UOP	351	10	702	20		
Hydrobon S6 1/8" UOP	11	0.3	22	0.6		
Isomax DMC-2 UOP	3000	85	600	17		
Platforming R 11 UOP	975	28				
Merox No.1 UOP	72 lb		280 lb			
Merox No.2 UOP	13 lb		600 lb			
Sulphur guard ICI 32-4	710	20	720	20.5	22	44
Dechlorination ICI 59-1	117	3.3	234	6.6	7.3	14.6
Reforming ICI 57-5	410	11.6	820	23.2	25.2	51
HTSC ICI 15-4	562	16	1124	32	53.2	106.4
LTSC ICI 52-1	540	15.3	1080	30.6	27.6	55.2
Methanation ICI 11-3	246	7	492	14	15.4	30.8

YEARLY CATALYST CONSUMPTION AT SHAHPOUR FERTILIZER COMPLEX - AMMONIA PLANTS.

(consumption in 1975 and 1976)

Production capacity 1975: 1000 MTD Ammonia; 1976: 2000 MTD Ammonia

Catalyst	Charge		Consumption 1975			+ 1976			TOTAL
	cu.ft.	m^3	cu. ft.	m^3	t	cu.ft.	m^3	t	t
Hydrodesulfurization CCI C 49-1	1050	29.75	525	14.9	13.5		7	6.5	20
Sulfur absorption CCI C 7-2	1155	32.50	577.50	16.3	18		25	27.5	45.5
Primary reforming CCI C 11-9	1110	31.50	555	16	17.5		17	19	36.5
Secondary reforming G 31B, G 56	1130	31.70	565	15.9	15.9		18	18	34
HTSC CCI C 12-1	2080	59	1.040	29.5	40		30	40.5	80.5
LTSC CCI C 18-1	1750	50	875	25	22.5		29	26	48.5
Methanation CCI C 13-4	735	20.80	387.50	10.4	11.5		10	11	22.5
Ammonia Synthesis CCI C 73-1/2	2624	74.25	875	24.75	74		12	36	100
Total	11.634	329.5	5.400	152.75	212.9		148	184.5	387.5

Sulphuric acid prod. Monsanto 210		94.25		48	36.5		48	36.5	73
Monsanto II		134.75		69	55.5		69	55.5	111
Total		232		117	92		117	92	184

YEARLY CATALYST CONSUMPTION AT SHIRAZ FERTILIZER COMPLEX - AMMONIA PLANT

(consumption in 1978, and consumption 1978 - 1985)
Production capacity 1978: 1000 MTD Ammonia

Catalyst	' Charge		Yearly consumption 1978 - 1985			
	cu. ft	m^3	cu.ft.	m^3/y	t/y	Total t
Hydrodesulfurization ICI 41-3		12.75		7	6.5	52
Sulfur absorption ICI 32-4		50.5		25	27.5	220
Primary reformer ICI 57-5		32.65		17	19	152
Secondary reformer ICI 54-2,90-1		32.75 1.50		18	18	144
HTSC ICI 15-4		60		30	40.5	324
LTSC ICI 52-1		58.50		29	26	208
Methanation ICI 11-3		23.50		10	11	88
Ammonia synthesis ICI 35		45.10		12	36	288
Total		317.25		148	184.5	1.476

Annex X

TECHNICAL DOCUMENTATION PREPARED DURING THE PROJECT

Part I **Catalyst Technology - Introduction**
Introduction into the catalyst technology; description of catalyst preparation, testing, selection, evaluation. Description of main industrial catalysts. (2? May 1975, 25 pages)

Part II **Catalyst manufacturers - commercial catalysts**
List of catalyst manufacturers, divided into countries, processes and specialized catalysts. List of processes, catalysts and manufacturers. (2? May 1975, 57 pages)

Part III **Catalyst carriers**
Detailed description of catalyst carriers, their specification, manufacturing processes, use and testing. The role of catalyst carriers in catalysis. (30 May 1975, 113 pages)

Part IV **Catalysts in catalytic processes**
Detailed description of industrial catalysts and their use in catalytic processes. Manufacturing techniques. Testing and evaluation. Bibliography. (30 May 1975, 95 pages)

Part V **Catalysts in petroleum industry of Iran**
Description of NIOC refineries, operation steps and use of catalysts therein. (15 June 1975, 51 pages)

Part VI **Catalysts in petrochemical industry in Iran**
Description of NPC petrochemical plants, operation steps and use of catalysts therein. (30 June 1975, 94 pages)

Part VII **Ammonia synthesis catalysts**
Description of ammonia synthesis catalysts, specifications, manufacturers. (15 July 1975, 57 pages)

Part VIII **Methanol synthesis catalysts**
Description of methanol synthesis catalysts, specifications, manufacturers. (20 July 1975, 25 pages)

Part IX — Formaldehyde synthesis catalysts

Description of formaldehyde synthesis catalysts, specifications, manufacturers. (25 July 1975, 21 pages)

Part X — Sulfuric acid synthesis catalysts

Description of sulfuric acid synthesis catalysts, specifications, manufacturers. (30 July 1975, 29 pages)

Part XI — Catalysts for hydrogen production and for ammonia synthesis

Detailed description of catalysts for hydrogen production and for ammonia synthesis. Manufacturers. (10 August 1975, 134 pages)

Part XII — Catalysts for the petroleum industry

Detailed description of catalysts for the petroleum industry, hydrotreating, reforming, etc. Specifications. Manufacturers. (15 August 1975, 153 pages)

Part XIII — Manufacture of catalysts - Basic equipment

Detailed description of process steps in the manufacture of catalysts. Detailed description of equipment for the manufacture of catalysts. Catalyst testing. Pilot plants. Catalyst development and research. (20 August 1975, 243 pages)

Part XIV — Main Industrial Catalysts and their manufacturers

Tabulated summary of main industrial catalysts and their manufacturers. (30 August 1975, 25 pages)

Part XV — Present and future consumption of catalysts in Iran

Tabulated figures indicating present and future consumption of catalysts in Iran. (30 August 1975, 43 pages)

Part XVI — Buildings for catalyst plant

Drawings for buildings for production, laboratory and offices for a catalyst production plant. (30 August 1975, 7 pages)

Annex XI

SPECIFICATIONS FOR MAGNETITE CONCENTRATE

Dried and bagged high-grade concentrate

Chemical analysis

Fe_3O_4	98.00 %
Fe_2O_3	2.50 %
MnO	0.05 %
CaO	0.10 %
MgO	0.30 %
Al_2O_3	0.30 %
SiO_2	0.45 %
TiO_2	0.25 %
V_2O_5	0.20 %
P_2O_5	0.02 %
CO_2	0.05 %
Na_2O	0.05 %
K_2O	0.05 %
CuO	< 0.01 %
Total	100.33 %

Fe	71.20 %
Mn	0.04 %
P	0.01 %
S	0.01 %

Density: 5.1 g/cm^3

Bulk density: 2.8-3.1 g/cm^3

Specific surface: 950 cm^2/g

Screen analysis

Screen opening mm	Mesh Tyler	%	Cumulative %
> 0.21	65	6	6
0.15	100	10	16
0.10	150	10	26
0.07	200	12	38
0.04	325	24	62
< 0.04	325	38	100

Annex XII

SUGGESTIONS FOR THE PREPARATION OF AMMONIA SYNTHESIS CATALYST

An experimental preparation of ammonia synthesis catalyst for trial purposes can be implemented in Iran without the usual industrial fabricating equipment by following these suggestions and recommendations:

1. Order experimental quantity of magnetite from Sweden (200-400 kg) to carry out preliminary formulations.
2. Prepare preliminary formulations with subsequent melting in pilot furnace at melting furnaces manufacturing plant.
3. Test the samples in appropriate laboratories abroad.
4. Prepare the magnetite concentrate from Bafqh either in Iran or abroad (200-400 kg).
5. Prepare comparative preliminary formulations with subsequent melting in pilot furnace as under 2.
6. Test the samples made from Iranian magnetite for comparison.
7. Order commercial quantity magnetite (10,000-20,000 kg) from Sweden for industrial-scale testing.
8. Prepare preliminary formulations with subsequent melting in an industrial furnace at a melting furnaces manufacturing plant.
9. Carry out industrial-scale testing in ammonia synthesis plant abroad.
10. Carry out industrial-scale testing in Shiraz Fertilizer Company ammonia plant at Shiraz.

All the above-mentioned steps can be done abroad so that, aside from the cost of the preparation and testing, no expenditure of funds for a production plant would be necessary before positive results were obtained from the pilot and industrial-scale testing.

Estimate of costs:	20,000 kg of magnetite	200 000 rials
	Preparation and melting	350 000 rials
	Testing	350 000 rials
	Transport, packing etc.	100 000 rials
	Total	1 000 000 rials

Estimate of time requirements: 3-4 months for preparation, 2-3 months for testing.

Annex XIII

PROPOSAL FOR A PROJECT TO PARALLEL THE ESTABLISHMENT OF CATALYST PRODUCTION IN IRAN: THE DESIGN, ENGINEERING AND CONSTRUCTION OF COMPLETE CHEMICAL PLANTS

The research on, development of and production of catalysts cannot be considered to be an isolated project. Each catalyst has a certain environment - a catalytic reactor - and this in turn has its environment - a catalytic process plant. Consequently, every catalyst development leads invariably to process-development and process-engineering activities; successful catalyst development without such activities is unthinkable.

Parallel with catalyst development, therefore, an advanced expertise in reactor design and engineering as well as process engineering has to be acquired. That, in turn, leads to the design, engineering and construction of complete oil refineries, petrochemical and other chemical plants, not only to satisfy the needs of fast-growing indigenous industry in Iran, but also to export to other developing countries, where prefabricated "package plants" will always be needed.

Co-operation with other developing countries at a similar level, such as Brazil or Mexico, is highly recommended. Co-operation with a developing country like India, where a large number of technologists, chemists and engineers are available for employment in such projects, would fill the gap in the present shortage of technicians in Iran and thus contribute to the improvement of the technological standard and an amelioration of the socio-economic situation in both countries.

In view of the abundent natural resources in Iran and the planned development of the chemical industry - oil refineries, petrochemical plants, combined chemical complexes, fertilizer plants, organics and inorganics production, plastics and synthetic fibres etc. - a development of a national industrial chemical engineering activity is of utmost importance and should be given priority. The objective of the envisaged activities should be the design, engineering and construction of complete industrial chemical plants for the future requirements of Iran and for export later on. This long-range objective requires the development of Iranian expertise in the management and execution of desing, engineering and construction of industrial chemical plants. The short-range objective should be the establishing of a sound base for the indigenous design, engineering and constructing enterprise.

The economic advantages and consequences for Iran would be independence from foreign technology, with substantial savings in foreign currency, independence from foreign supplies of equipment and machinery for chemical plants, also with substantial savings of foreign currency, and finally, exports of complete prefabricated package plants to other countries. The implementation of the project as a whole will increase the technical standards of the country and will contribute significantly to the positive development of the national economy. The independence and self-reliance of the country would be markedly increased.

The first step must be extensive training of technical staff abroad, followed by the erection and operation of several semi-industrial pilot plants, possibly in close co-operation with the technical university or advanced chemical engineering students. A well-organized and up-to-date documentation with patents, literature, commercial documentation etc. is indispensable and must also be taken into consideration.

To stress the indigenous component of the project in question, the enterprise should be an entirely Iranian undertaking, but it should avail itself of the consulting and expert services available through UNIDO.

Starting from a relatively small basis - to be considered as a crystallizing point for further growth and development - this effort should first concentrate on particular selected projects and plants needed for the industrial development of Iran. Later on, larger projects can be handled successfully, eventually in partnership with, not dependence on, specialized foreign companies. Such a partnership would be particularly interesting and useful for projects in third-party countries.

It is suggested that the first step in this development should be the utilization of the coke-oven by-products from the Aryamehr Steel Plant of the National Iranian Steel Corporation (NISCOR) in Isfahan, where a series of valuable and easily marketable chemical intermediates can be obtained from the large quantities of coal tar that have hitherto not been chemically utilized.

It is also suggested that a pilot-plant department be organized and established within the Industrial Development and Renovation Organization of Iran (IDRO), where the main industrial processes used in coal-tar utilization can be reproduced, further developed and adapted to the particular conditions prevailing in developing countries. This selected process development based on coal-tar utilization is particularly interesting inasmuch these processes can also be used - with only minor modifications - for the utilization of petroleum refinery by-products. From the pilot-plant stage, indigenous process development and engineering would lead towards the construction of complete prefabricated package plants for Iran and further to a successful exportation of these plants to other developing countries that are at the beginning of their industrialization but are not so far advanced. After that, more sophisticated plants that could be exported even to industrialized countries could be conceived and developed.

The whole process, of course, requires the existence of modern, well-organized and competitive manufacturing facilities for chemical plant equipment. The existing facilities in the Iran-Arak Machine Manufacturing Plant (Machine Sazi Arak) is not usable for such an undertaking because at present its product would not be competitive in terms of quality, cost or delivery time. As there appears to be no chance to improve the over-all efficiency of Machine Sazi Arak without changing both the system and the management (which appears to be impossible), another manufacturing enterprise must be built in Iran, one specializing in producing chemical equipment to the highest international standards and so economically as to be able to compete in international markets.

The initial pilot plants to be erected at IDRO should be for the following processes and products:

- High-temperature vapour-phase air oxidation of hydrocarbons to polycarboxylic acids
- Phthalic esters (dioctyl phthalate etc.) directly by condensing raw phthalic anhydride vapour from the oxidation reactor with alcohol to form the raw ester, with subsequent purification by distillation
- Plasticizers (phthalates, adipates, sebacates etc.)
- Synthetic resins (alkyds, polyesters, formaldehyde resins etc.)
- Formaldehyde by total oxidation of methanol
- Methanol
- Ammonia
- Adipic acid
- Sebacic acid
- Alkylated phenols as inhibitors and antioxidants for gasoline, rubber and plastics
- Special paints based on synthetic resins

Insecticides

Fungicides

Chlorinated hydrocarbons

Pharmaceutical intermediates

Benzoic acid and benzoates

Anthraquinone

Synthetic dyes

Furfural and its derivatives, starting from agricultural wastes

Catalysts required for some of the above-mentioned catalytic processes

The estimated cost of these pilot plants is approximately $950,000, including basic literature, patents and products documentation.

The space required is approximately 100 m^2 for each pilot plant, including storage of raw materials. For the energy requirements approximately 150 kW of electrical power should be provided. An adequate quantity of tap water and industrial water for cooling purposes is also an important requirement.

In each pilot plant, two technicians per shift will be needed. The continuously operating pilot plants (most of those listed) will require eight technicians. Several pilot plants can be grouped together, so that a total of 32-40 technicians will be required for efficient operating of the pilot-plant department. That number will eventually have to be increased to 50 or 60.

Apart from the operating personnel for the pilot-plant runs the following highly qualified personnel will be required:

Managing director	1
Magisters	3
Chemical engineers	12
Chemists	3
Physical chemists	3
Control engineers	3
Mechanical engineers	3
Electrical engineers	3
Technicians	5
Draughtsmen	5
Auxiliary personnel	3
Librarian	1

Besides the pilot-plant department, an efficient designing and engineering department, together with material procurement and marketing experts, would be necessary. These personnel can be recruited from TECHNICON or TECHNOLOG, IDRO.

The proposed project will require the following items of outside technical assistance:

(a) Training of Iranian technicians abroad, in-plant training etc.;

(b) Supply of the pilot plants, including literature, patents etc.;

(c) Provision of the following experts for a period of 2-3 years to assist in the implementation of the project:

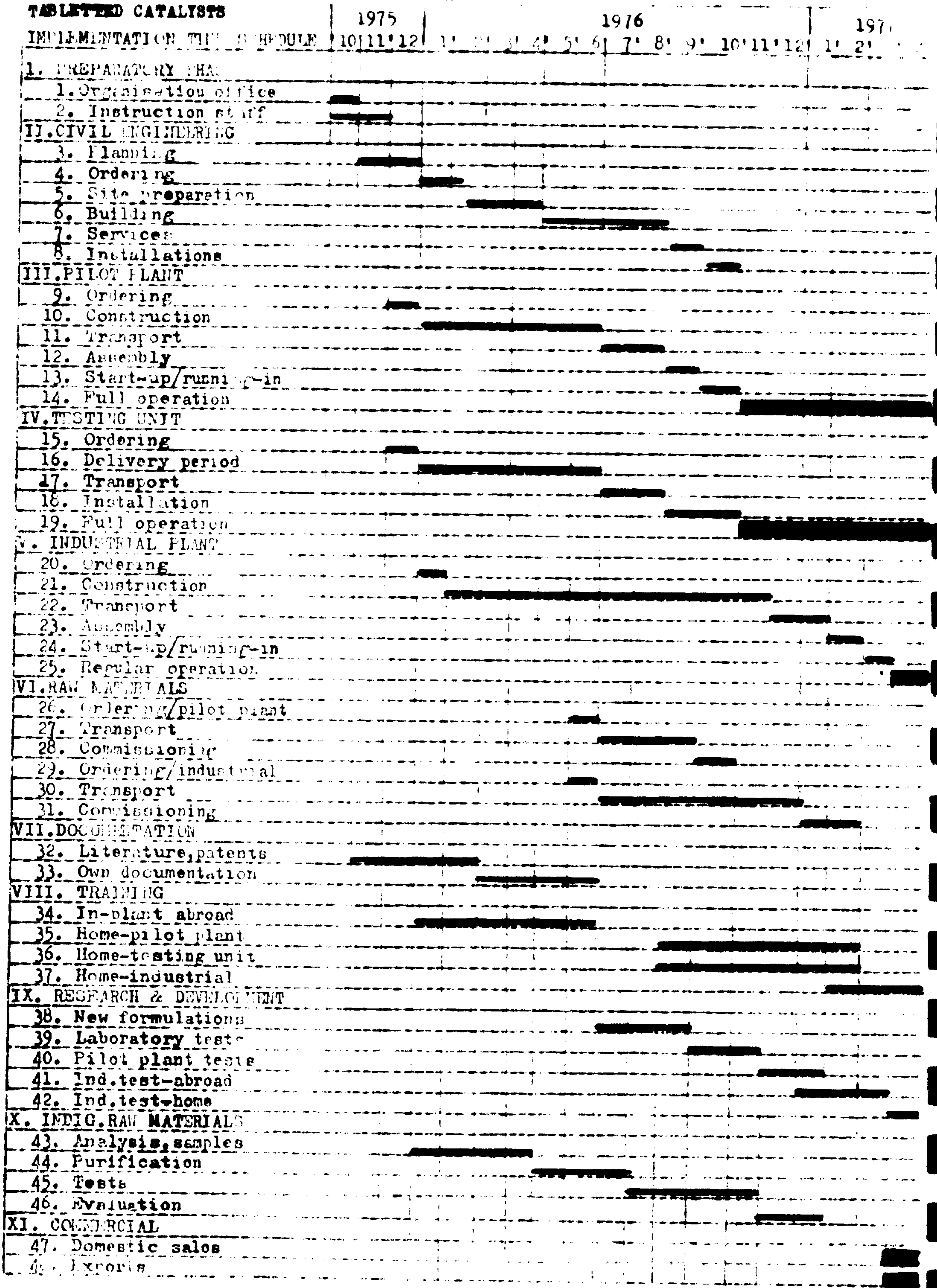
	Time requirement (man-months)
One project manager (may be a non-resident)	24-36
Chemical engineers	12-18
Control engineers	12
Mechanical engineers	8
Total	56-74

Annex XIV

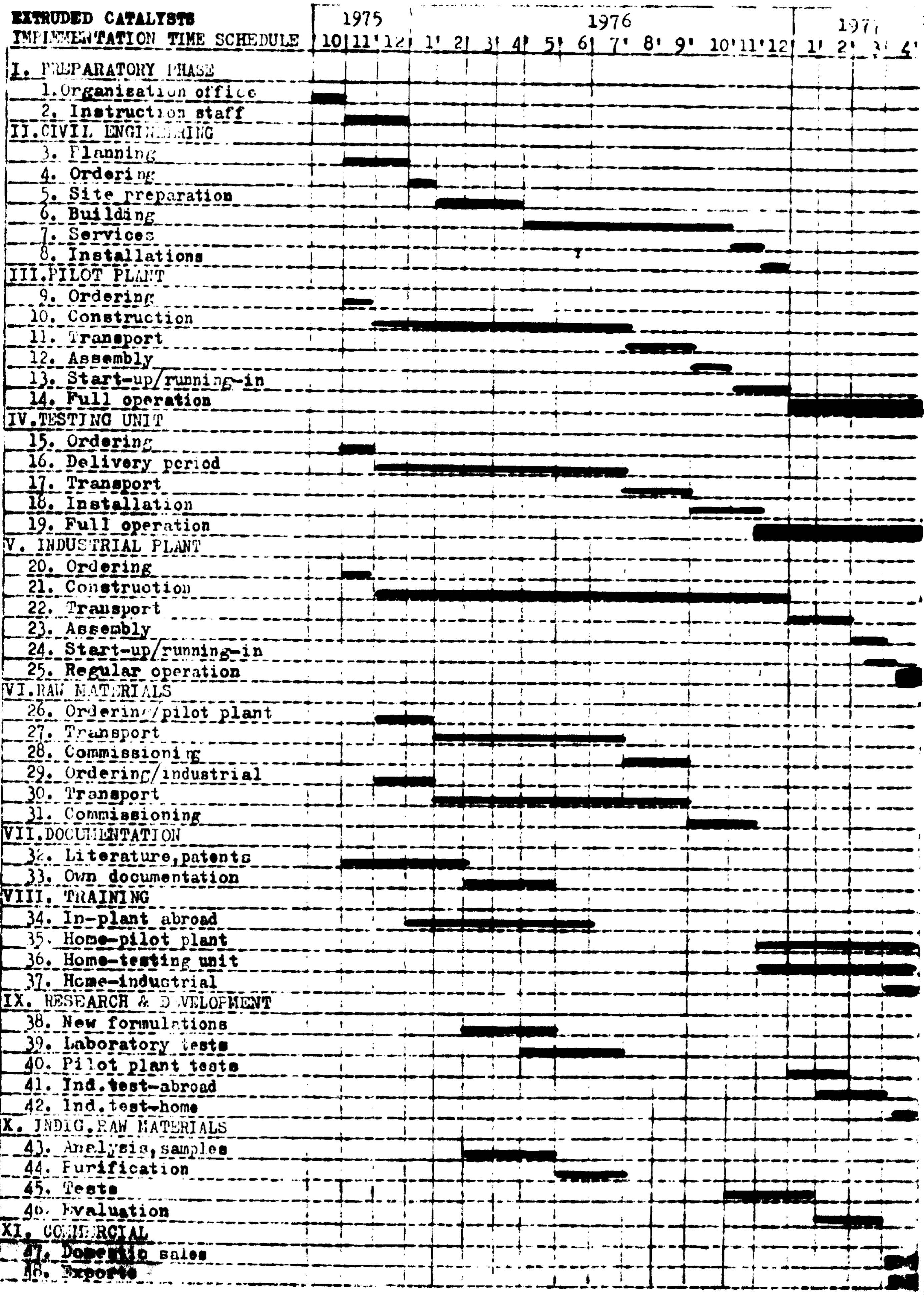
IMPLEMENTATION TIME SCHEDULES

TABLETTED CATALYSTS

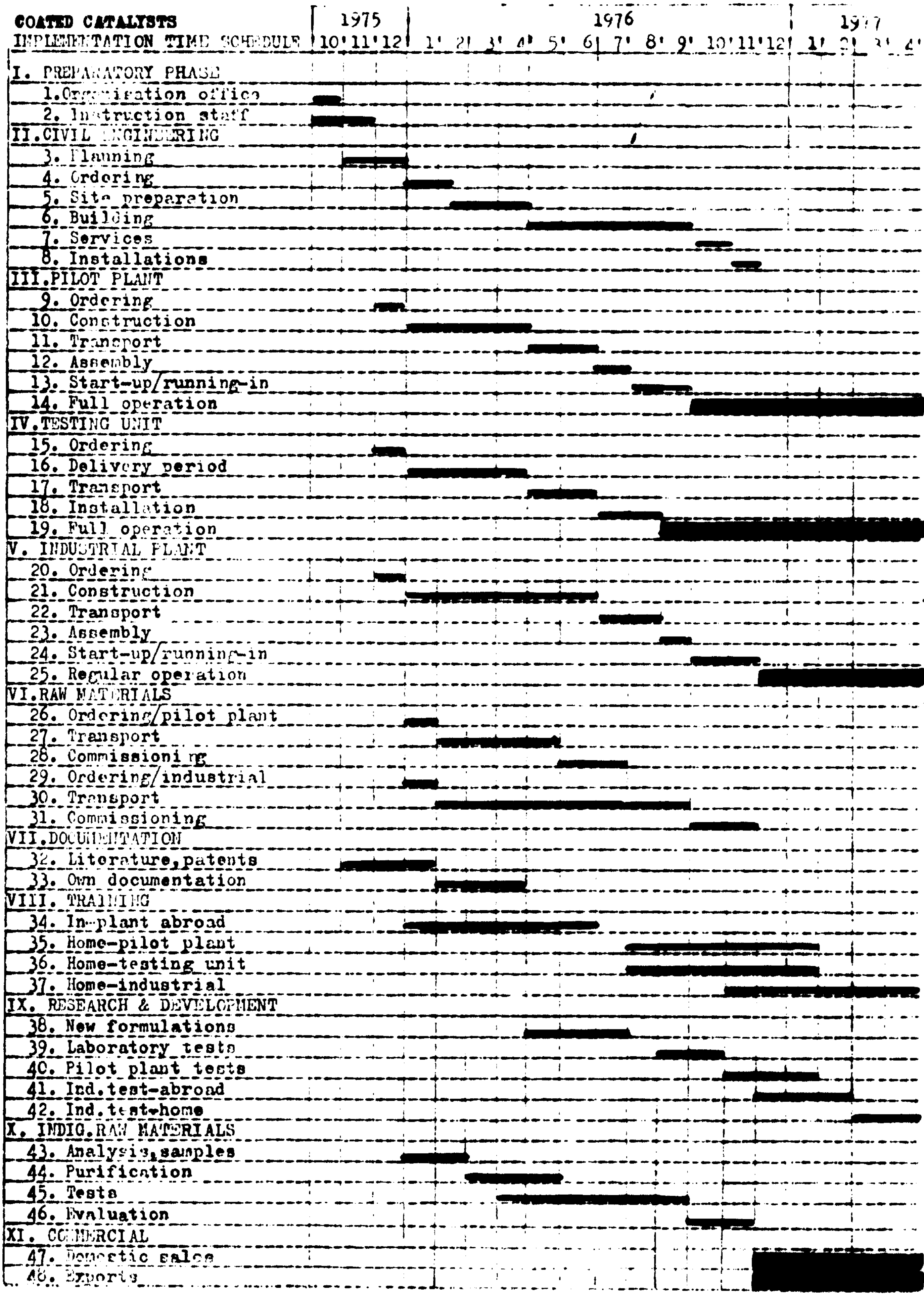
IMPLEMENTATION TIME SCHEDULE

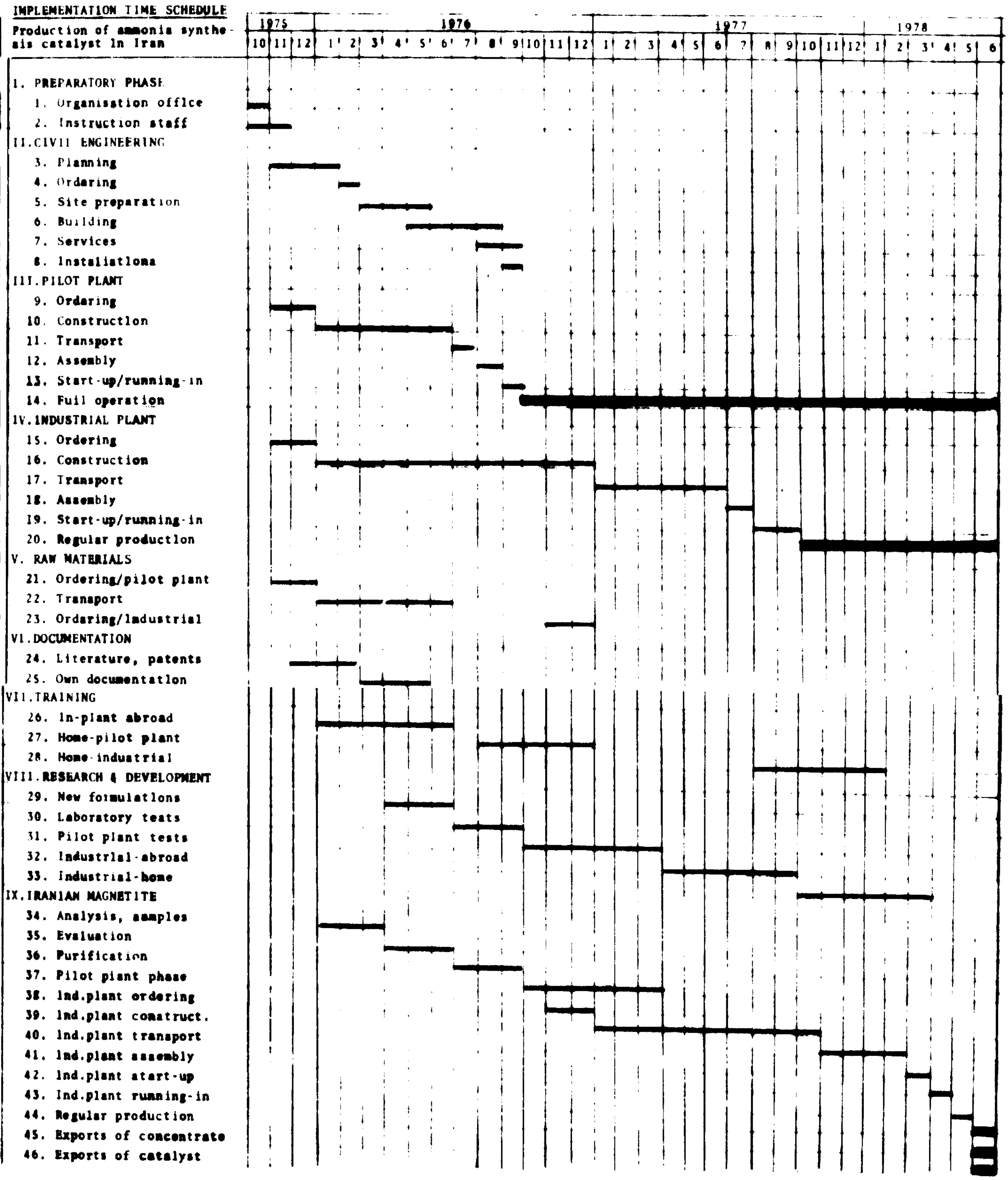


EXTRUDED CATALYSTS
IMPLEMENTATION TIME SCHEDULE



COATED CATALYSTS
IMPLEMENTATION TIME SCHEDULE




IMPLEMENTATION TIME SCHEDULE
Production of ammonia synthesis catalyst in Iran
1975
1976
1977
1978
10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6
I. PREPARATORY PHASE
1. Organisation office
2. Instruction staff
II. CIVIL ENGINEERING
3. Planning
4. Ordering
5. Site preparation
6. Building
7. Services
8. Installations
III. PILOT PLANT
9. Ordering
10. Construction
11. Transport
12. Assembly
13. Start-up/running-in
14. Full operation
IV. INDUSTRIAL PLANT
15. Ordering
16. Construction
17. Transport
18. Assembly
19. Start-up/running-in
20. Regular production
V. RAW MATERIALS
21. Ordering/pilot plant
22. Transport
23. Ordering/industrial
VI. DOCUMENTATION
24. Literature, patents
25. Own documentation
VII. TRAINING
26. In-plant abroad
27. Home-pilot plant
28. Home-industrial
VIII. RESEARCH & DEVELOPMENT
29. New formulations
30. Laboratory tests
31. Pilot plant tests
32. Industrial-abroad
33. Industrial-home
IX. IRANIAN MAGNETITE
34. Analysis, samples
35. Evaluation
36. Purification
37. Pilot plant phase
38. Ind.plant ordering
39. Ind.plant construct.
40. Ind.plant transport
41. Ind.plant assembly
42. Ind.plant start-up
43. Ind.plant running-in
44. Regular production
45. Exports of concentrate
46. Exports of catalyst

76. 01. 21