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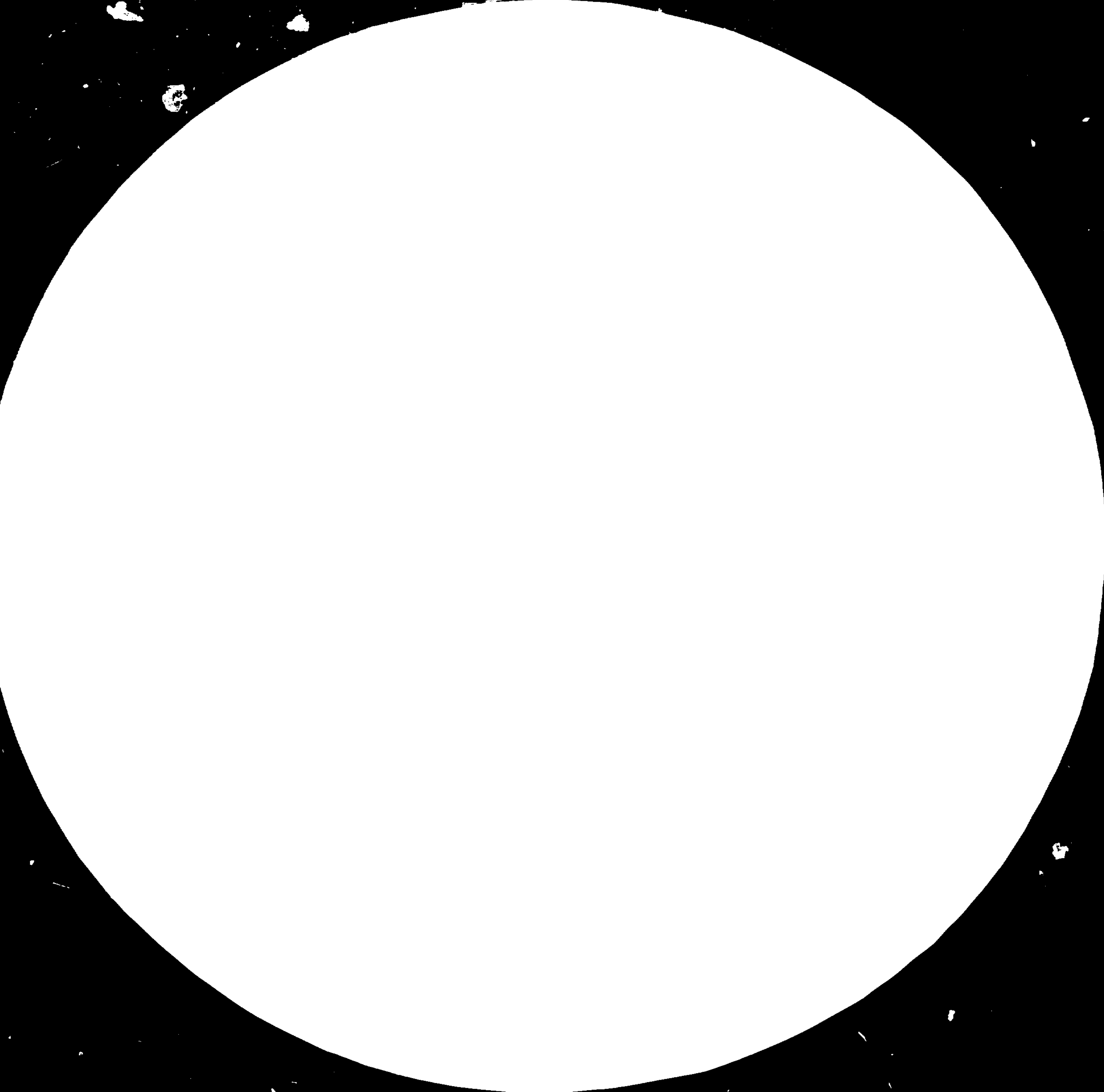

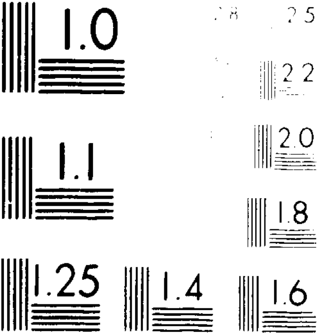
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RESEARCH AND DEVELOPMENT FACILITIES FOR TRINTOC

DP/TRI/81/003

TRINIDAD AND TOBAGO

Technical Report*

Prepared for the Government of Trinidad and Tobago by the United Nations Insutrial Development Organization, acting as executing agency for the United Nations Development Programme

Based on the work of F. Moser, Consultant in Petroleum Development and F. Pass, Consultant in Petroleum Engineering

United Nations Industrial Development Organization
Vienna

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Introduction / Assumptions

The purpose of the project was defined as follows: (Ref. 1)

> To assist the TRINIDAD AND TOBAGO OIL COMPANY LIMITED (TRINTOC) in setting up a research and development facility for petroleum engineering, petroleum refining and petrochemical development at the Point Fortin Refinery.
>
> In consultation with appropriate government and TRINTOC authorities the consultants were to carry out the following duties:

1) Review TRINTOC's ideas and objectives concerning the establishment of R&D facilities for oil and gas production, refining technologies and petrochemical development.

2) Assess the requirements in terms of technical manpower, foreign expertise, training facilities locally and abroad, laboratory and testing equipment, technical library, etc., for the proposed R&D programme.

3) Assist TRINTOC in preparing the R&D programme defining its objectives and giving justifications, time schedule and estimates of resources required.

4) Assist in identifying local and foreign organizations, which are potential collaborators or suppliers of expertise or other resources for the R&D programme.

5) Make recommendations regarding bilateral and international cooperation for implementation of the R&D programme.

-/-

On arrival at the location, the experts were informed that contrary to the information contained in Ref. 2 as regards refinery upgrading projects proposed to be completed by the end of 1984, involving a radical change in production from the Point Fortin Refinery, no decision to go ahead in this respect had been taken. There had, however, been an offer made by TEXACO to sell the existing TEXACO Refinery at Pointe-a-Pierre with a nominal capacity of 250,000 bsd to the Government of Trinidad and Tobago. Negotiations between TEXACO and the Government of Trinidad and Tobago have been in progress at the time. Similar negotiations for a take-over of the shares of an oil producing company, jointly owned by the Government and the US Company TRINIDAD-TESORO are also taking place at the time.

As the operational situation of TRINTOC is of paramount importance also for the setting up of future R&D facilities, certain assumptions had to be made by the experts in order to proceed with their assignment which are described below.

1) It is assumed that a positive decision will be made either to implement the projected refinery upgrading programme at Point Fortin or to take over the TEXACO refinery. In both cases there would be substantial activities of TRINTOC to be involved in the reorientation and restructuring of the petroleum industry in Trinidad/Tobago and sufficient feedstock and products would emerge from which to warrant R&D facilities.

2) Independent from the refinery situation there will also be substantial activities of TRINTOC in the fields of natural gas and petroleum exploration and production in the future. These activities as such would justify already the installation of R&D facilities at least for this field alone.

The experts based their considerations and recommendations also on memoranda which had been prepared by TRINTOC personnel prior to their arrival (Ref. 5, 6). These memoranda are contained in this report as Appendix I.

Summary and recommendations

At the request of the Trinidad and Tobago Oil Company (TRINTOC) the setting up of a research and development facility was studied by two experts provided by UNIDO. The results of their findings and recommendations can be summarized as follows:

1) The establishment of an R&D organization for TRINTOC should have the highest possible priority for the following reasons -

   a) to enable the company to support and expand its present and future activities with personnel trained and qualified to evaluate indigenous and foreign activities in the fields of petroleum production, petroleum processing and petrochemicals production

   b) to support the operating activities of the company in production and refining

So far the nation's attention has been drawn more to expand the utilization of natural gas than that of petroleum (comp. Ref. 1). This somewhat unbalanced development of the utilization of Trinidad and Tobago's natural resources engrosses the dangers of a higher vulnerability and dependance of its economy on influences from externally determined economic forces. The above mentioned pending decisions with regard to Trinidad and Tobago's refinery situation together with the considerations to establish R&D facilities for TRINTOC could remedy this unfavourable situation to some extent.

2) Therefore it is recommended to install an R&D organization in three phases which should -

a) support TRINTOC's operations regarding natural gas and petroleum exploration and production.

b) support TRINTOC's petroleum processing and petrochemicals operations

c) safeguard and guarantee TRINTOC's future expansibility and competitiveness.

3) To achieve the above, the installation of two to three R&D groups and laboratories is recommended involving in the final stage an employment of 200 people of which about 150 would be technical staff.

4) The time schedule for the establishment of such an organization would comprise three phases of three years each, starting with -

a) R&D facilities for exploration and production of natural gas and petroleum,

b) followed by R&D facilities for petroleum products and petrochemicals

c) and finally R&D facilities for exploratory research into new products.

5) The total capital involved for the establishment of the R&D organization over 10 years would amount to

6,875m US$
===============
(investment on request 3,570m US$)

The operating costs (without overheads) in the particular stages per annum would be (at 1982 money value) about

First stage	1,930m US$/a
Second stage	4,681m US$/a

6) Recommendations with regard to recruitment and training of personnel as well as for cooperation with the University of the West Indies are given and should be regarded as crucial factors for success or failure of this venture.

7) It is recommended that the main emphasis of the R&D programme for TRINTOC should be laid into the following activities -

a) Exploration of natural gas and petroleum resources of Trinidad and Tobago. Special emphasis in this field should be given to the exploration for natural gas, oil resources and enhanced recovery of light crude oils as well as to the exploration and production possibilities of heavy oil, which, although likely to be more expensive to produce than conventional crude, would expand the crude oil resources of Trinidad and Tobago beyond those presently existing.

b) Optimized utilization of natural gas and petroleum in processing petroleum and petrochemical products.
In this regard special attention should be given to the production possibilities of methanol for gasoline substitution and of aromatics as petrochemical feedstock by extraction from the respective petroleum fractions.

I. Basic considerations for R&D facilities

A. General considerations and priorities

The quality of research results obtained from research organizations are determined by the following factors -

* the quality of the research personnel
* the size and flexibility of the organization
* the intellectual environment, in which the organization is working

Research cannot and should not be carried out in isolation. As the success of research activities depends on the number and quality of ideas produced, it is essential to see it dependent on an information network. Therefore the best research is obtained where the information density is the highest. This should be a prime consideration as regards locating research facilities. Furthermore, there are several areas of work in R&D, which differ and therefore also require different human qualities. The following main areas of work can be expected to be salient under the circumstances -

* supporting research for company operations
* exploratory research into new applications
* basic research
* process and project evaluations

In all of these areas creativity of the individual as well as a certain methodology, stemming in the main from previous experience in research, will be required for the key personnel (comp. Ref. 3). Furthermore, a motivation of all people involved, coming from a flexible organization working under technically and intellectually stimulating conditions, is of primary importance for the success of such an undertaking (comp. Ref. 4).

Although the foregoing considerations may sound so general as to be obvious, it is the experience of the experts that these should be considered primarily as basic priorities in the establishment of R&D facilities for TRINTOC. Violating for whichever reasons these priorities would most likely result in disappointment and disillusion having spent the expenditure for such a venture in vain. It is therefore of utmost importance for all concerned with the decisions in this respect to know of these facts and consider that adjustments to an existing organization can hardly be made afterwards. Therefore, concern for the priorities in this case is most relevant, and the primary concern in any R&D organization is "people". It is also important not to allocate into R&D people who were not successful in other activities but to look for the best, i.e. the most suited for the purpose in question.

It should also be pointed out that although the primary aim of research for any company, and especially for TRINTOC, being a principal factor in the economy of Trinidad & Tobago, is to guarantee optimum operations of the company at present and safeguard its middle and long-term existance, there is also an important infra-structure oriented function. By setting up research facilities at certain locations, the entire scientific-technological environment will be activated and stimulated.

B. Specific considerations

Having studied the operations of TRINTOC to some extent, the experts considered an adequate R&D organization for TRINTOC, similar to other independent petroleum companies in industrialized countries, as an important instrument for management to restructure and reorientate the activities of TRINTOC's organization and to generate in permanent elaboration the basis for decisions making in all relevant fields and finally to support operations in -

* exploration and production
* optimization in refinery processing
* petroleum products marketing
* exploratory research into new products, e.g. petrochemicals development on the basis of locally prevailing situations as well as energy conservation and oil substitution activities
* process and project evaluation studies for such activities
* stimulate other activities and innovations

The objectives of these long-term activities should be to safeguard and extend the national income from natural gas and petroleum resources. This seems, as is generally agreed, one of the major factors of the T&T economic situation. Experience in various countries under similar situations has shown that oil operations without supporting R&D and project evaluation capacities are severely hampered as they are based on sometimes biased, sometimes unreflected or non-nationally minded opinion. For this reason the self-reliance and the self-respect for the decisions that must be made independently can only come from such capacities.

However, equally important as a decision with regard to the necessity of an R&D organization for TRINTOC, is the realization of its limitations and the description of its boundaries. This can best be done by defining the objectives for the respective fields of activities.

Exploration/production of natural gas and petroleum

In this field enhanced oil recovery (EOR) is of prime importance. Secondary and tertiary recovery methods are under active study in many countries. The optimum method for the specific field, however, can only be evaluated locally.

Petroleum processing

Assuming, as mentioned in the introduction, that a diversification of refinery operations is undertaken, it has again been shown by experience that optimum operation of the refinery requires definite information as regards crude compositions and yield structures for the several downstream operations. These can be obtained from small-scale laboratory pilot plants operated on the feedstocks in question.

Petroleum products/petrochemicals development

Exploratory research into new applications for natural gas and of existing petroleum products or adaptation of known processes to such feeds is another important activity. In this relation also petrochemical products as well as the entire field of energy conservation and oil substitution or extension of activities should be of interest to any oil company. Oil companies will, because of ther know-how in dealing with petroleum products and energy, play a vital role in this field on a national as well as on the international scene.

Product-process-project evaluation

Finally, the possibilities to judge the viability of new processes, products, plants or equipment that will be studied by the R&D organization must be at hand within the R&D organization to make it effective.

The objectives for product-process-project evaluation group can be described as follows. The group would have to deal with the evaluation of products, processes and projects.

- Product evaluation
  Study of production possibilities, in cooperation with the exploration and petroleum products department, for various products derived from natural gas or petroleum. Study and estimates of market potentials, price and sales volume developments.

- Process evaluation
  Study of various processes, routes for the production of oil, petroleum and petrochemical products.

- Project evaluation
  Feasibility studies and optimization of potential projects.

Depending on the accuracy of the required evaluations the work in this group will have to be based either on literature data for screening evaluations or on data supplied by contractors or the respective TRINTOC R&D and other departments for investment proposals to the management.

Furthermore, it should be pointed out that in order to carry out the R&D activities under optimum conditions for the company as well as for the personnel, all aspects as regards location in the vicinity to the exploration and production as well as refining operations, as well as the possible connections to other research and teaching facilities, especially the universities, will have to be taken into account.

II. Requirements for the proposed R&D facilities

A. The ultimate organization

In order to arrive at the desired goals as described above it seems necessary to define at the outset the ultimate R&D organization and its structure. However, although this seems necessary, it need not be understood that this proposal is rigid and that therefore no flexibility as regards size, structure, etc. depending on upcoming problems and on the type and quality of personnel is feasible.

For the optimum size of an R&D organization, the following principal considerations are valid:

Depending on the area of work as described above, one could, with some simplification, say:

- there is a critical size and there are overcritical sizes of R&D organizations

- for basic and applied research activities, experience has shown the optimum size of the organization to be between 25 and 50 people, service organizations, e.g. analytical and maintenance groups not included

- for development activities the size of the organization depends on the project size and can go up to several hundreds

Based on these considerations the following ultimate medium term R&D organization is proposed for TRINTOC:

<u>Exploration and production of natural gas and petroleum</u>
consisting of

* Pressure-Volume-Temperature (PVT) working group
* Reservoir engineering
* Enhanced oil recovery, etc.

<u>Petroleum processing and petrochemicals group</u>
consisting of

* Crude oil evaluation
* Unit operations and distillation processes
* Conversion processes
* Petroleum products development and products application

<u>Exploratory research</u>

* Petrochemicals
* New products
* Energy conservation, etc.

<u>Plant and process evaluation group</u>

* No subdivision necessary

All groups working on an experimental basis must be supported by service groups containing instrumental analysis and maintenance groups.

B. Implementation and recommendations as regards location

The setting-up of R&D organizations is a most delicate matter. Therefore, as pointed out in the introduction, not only locations and operations, but also infrastructural considerations implying information network and similar situations must be taken into account.

For tnis reason the experts recommend the implementation of R&D facilities for TRINTOC in stages. It should again be understood that this proposal is not to be considered to be too rigid, although the ultimate situation probably consisting of several locally separated facilities in one organisational structure is considered to be essential. The programme extending over a period of ten years can be considered to involve three phases of development.

First phase

The most important and most easy to be advanced operations concern oil exploration and production. Therefore R&D into supporting these operation should be started first. A possible site at Penal, or wherever the future center of the oil exploration and production activities might be, seems suitable especially because of the vicinity to the exploration and production operating functions.

At the same time in addition to the oil exploration and production activities some R&D working groups should also be started involving the following activities:

* crude oil evaluation and petroluem products development
* product and process evaluation

The build-up of the necessary information services including library services and literature facilities should be undertaken. The location for these latter activities could be at any of the locations considered, preferably at Port of Spain.

Second phase

As soon as a decision as regards the refinery situation is taken and possibly, as far as recruiting is concerned even earlier, the build-up of the refinery operations supporting and petrochemical working groups should be undertaken. As soon as facilities are provided at the selected site, the activities with respect to petroleum processing and products developments should be transferred to this new laboratory. The refinery operations supporting group is best located at the site where the future main activity in refinery operations will occur because of the essential contact with operations. The same is true for the petrochemical exploratory working group at the beginning. However, at a latter stage, called phase 3, it is considered advantageous to relocate these latter activities as described below.

Third phase

For reasons of optimum information density and the value of cross-fertilization of ideas between universities and industry, in this case the University of the West Indies, at St. Augustine, Trinidad and TRINTOC, it is recommended to consider installation of R&D facilities for TRINTOC at or in the vicinity of Port of Spain. The experts consider this part for their recommendations as most essential long term. The R&D facilities of TRINTOC at Port of Spain should contain the following activities:

* exploratory research into oil processing and petrochemical processes and products
* product and process evaluation studies
* general services including technical information, services and instrumental analysis

It is realized that such a proposal consisting of a three phase implementation and installation of facilities at possibly three different locations is a major decision involving large capital expenditure. However, the importance of R&D activities as such and their relation to and for the company orientated as well as intellectual infra-structure orientated activities is of such a value to both that such expenditure seems safely justifiable. Of course, considerations as to possible incorporations or cooperations of this third facility with other R&D activities of Trinidad and Tobago should also be considered by TRINTOC.

As regards the process and projects evaluation group it is considered very important by the experts that such a group should be established at an early date in order to gear from the beginning the respective research activities with regard to their economic value. In this respect research and company development activities need to be followed at any level of sophistication by economic analysis even on basis of scarce data available. The research personnel should be made aware of the fact that any of their successful efforts will only become viable on an economic analysis for various degrees of project sophistication as described in detail in the literature (comp. Ref. 7).

C. Technical manpower requirements

The following outline is based on the assumption that about ten years will be required to build up an efficient R&D organization, consisting in the main of different types of engineers:

*	For exploration and production of natural gas and petroleum	- petroleum engineers - physicists
*	For petroleum processing/petroleum products and petrochemicals	- chemists - chemical engineers
*	For exploratory research	- chemists
*	For process & plant evaluation	- chemical engin - economists

Estimated manpower requirements are given in Tab. 1. In this table the different figures apply to operations of the R&D facilities in the first, second and third phase.

Details on qualifications for the technical personnel as listed in Tab. 1 are given in Appendix II.

The proposed organization is - within a framework of activities in the main fields - a project orientated organization in matrix form composed of project teams for specific tasks and service groups.

Fig. 1 - R&D ORGANISATIONAL SCHEME

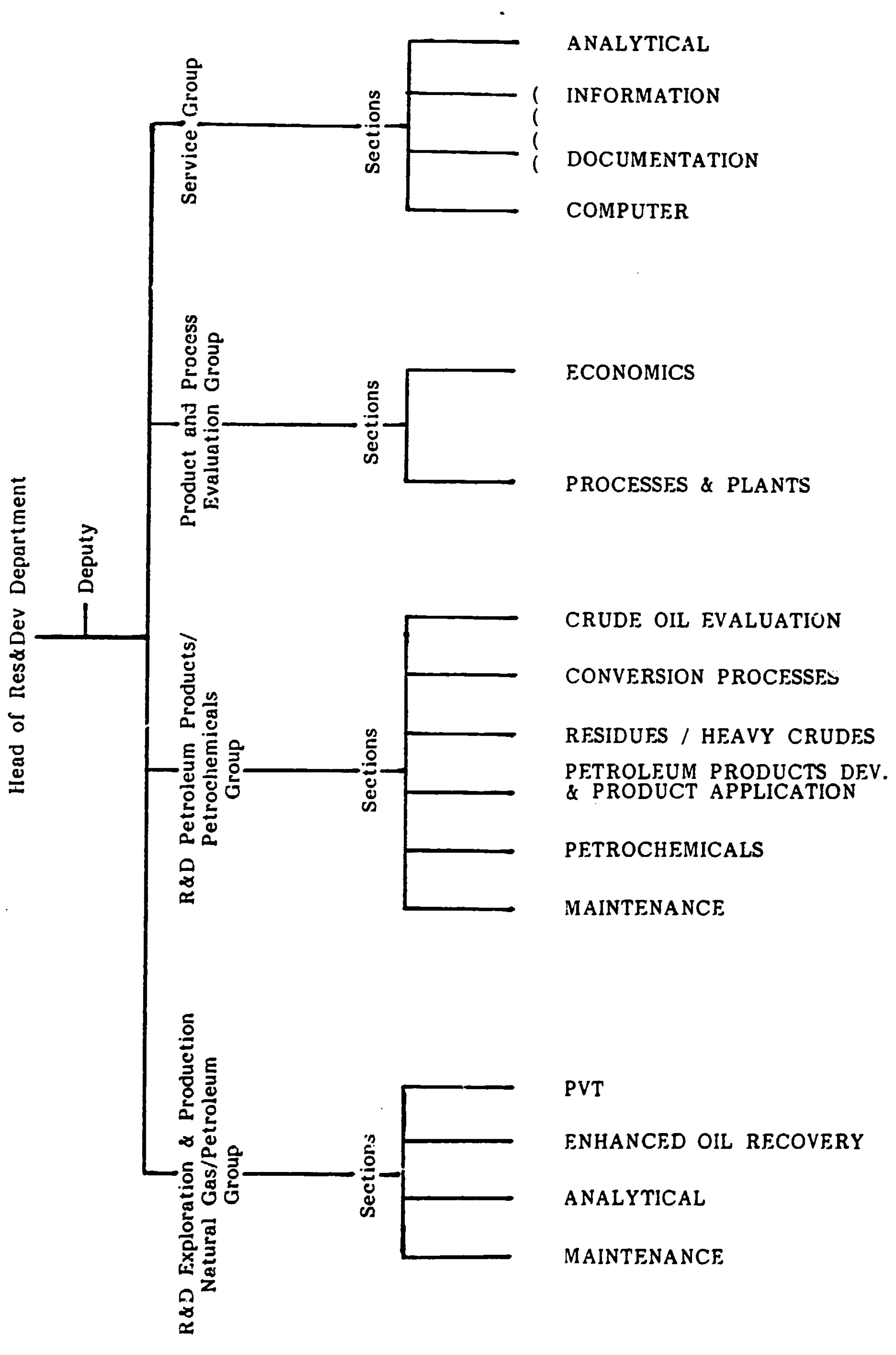

Table 1 - R&D MANPOWER REQUIREMENTS

	R&D Exploration and Production				R&D Petroleum processing/ Petrochemicals							Process Evaluation		Services						
																	Manager Head of Groups	2 4	2 6	
	PVT-Laboratory	Reservoir Engineering /EOR	Instrumental Analysis	Maintenance	Crude Oil Evaluation	Petroleum Development	Conversion Processes/ Residues Heavy Oils	Petrochemicals	Energy Conservation/ New Products	Instrumental Analysis	Maintenance	Economics	Process Evaluation	Instrumental Analysis	Information/Documentation	Computer and Maintenance		1st	2nd	3rd
1st phase	3	6	4	2	4	6	-	-	-	4	2	2*	2*	-	2*	1*	Research-Scientists and Technicians	38		
2nd phase	3	18	8	3	8	10	5	10	-	10	4	2*	6*	-	3**	2*			92	
3rd phase	3	21	12	4	8	10	10	20*	10*	10	6	2*	10*	10**	4**	8**				148
				10							26					16*	Non-technical staff	10	36	52
Totals				50							100 (30*)		12*			38 (32*)	Total	54	128	200

* to be located preferable at Port-of-Spain
** to be located preferable at Port-of-Spain and Refining Location

D. Facilities and Equipment

The following facilities and equipment are recommended to be installed as a basic outlay for the several R&D groups.

1) Exploration/Production - Enhanced Oil Recovery (EOR)

PVT laboratory - This includes equipment for high pressure experimental work in this field.

Reservoir engineering - including computer based simulation model for evaluation of field data.

Enhanced Oil Recovery - several pilot plants for heat injection, Alkali treatment, CO_2 miscible flood and chemical treatment.

Analytical equipment - including tracer analysis of hydrocarbons and other impurities.

2) Petroleum processing/Products application

Crude oil evaluation - including True Boiling Point (TBP) distillation and other distillation equipment.

Petroleum products - including testing equipment for automative fuels and lubricants, bitumen and residues.

Conversion processes - including equipment for platforming/isomerization; hydrogenation, hydro-treatment; visbreaking and thermal residue conversion.
Hydrocracking - hydroconversion of residues and heavy crude oils.
Instrumental analysis - including elemental analysis, trace metals, Gas-Liquid Chromatography (GLC) and High Pressure Liquid Chromatography (HPLC), spectroscopy (infrared/UV) and atomic absorption.

A more detailed description of this equipment is given in Appendix III.

3) Petrochemical products

As the scope of such investigations is very wide, no special indications need to be given here except for standard laboratory glass equipment.

It is to be understood that the above list is geared to the first and second stage of implementation and that the third stage would develop from these stages in a logical manner.

In the first and second stage of implementation facilities to accomodate the respective laboratories as well as a pilot plant building would be required. More details on those facilities are given in Annex IV.

E. Information/Documentation

A basic requisite for any research organization is a well equipped library including scientific journals. A list of recommended subscriptions for journals as well as books is given in Tab. 2.

The information and documentation services should include access to:

- data banks on physical and chemical data*
- literature research services*

Both are of great importance. A computer terminal is required for this purpose which enables direct contact with such data banks. More details on these services are given as recommendation in Table 2a.

Duplication of books and journals can and should be avoided by allotting special fields and areas to different locations (departmental libraries) if necessary and installing lending services between them.

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* The services of the SDC SEARCH SERVICE, System Development Corporation (2500 Colorado Avenue, Santa Monica, California 90406; tel 213/829-9436 or 213/829-7511; telex 65-2358-TWX: 910/343-6443) using several most important data banks for petroleum industry can be recommended as subscription in this respect.

PROPOSED JOURNALS FOR SUBSCRIPTION

* CHEMICAL ABSTRACTS / Columbus, Ohio
Sect.: Applied Chemistry and Chemical Engineering

* CHEMICAL ABSTRACTS / Columbus, Ohio
Sect.: Organic Chemistry

* CHEMICAL ABSTRACTS / Columbus, Ohio
Sect.: Physical and Analytical Chemistry
edited by: American Chemical Society (ACS)
1155 Sixteenth Street, N.W.
Washington, D.C. 20036

* CHEMICAL ENGINEERING / New York
edited by: McGraw - Hill
1221 Av. of the Americas
New York, NY 10020

* HYDROCARBON PROCESSING/Houston
edited by: Gulf Publishing Co.
P.O.Box 2608
Houston, Texas 77001

* INDUSTRIAL AND ENGINEERING CHEMISTRY
Fundamentals / Washington

* INDUSTRIAL AND ENGINEERING CHEMISTRY
Process, Design and Development / Washington

* INDUSTRIAL AND ENGINEERING CHEMISTRY
Product, Research and Development
edited by: American Chemical Society (ACS)
1155 Sixteenth Street, N.W.
Washington, D.C. 20036

* JOURNAL OF THE CANADIAN PETROLEUM TECHNOLOGY / Montreal

* PETROLEUM REVIEW / London
edited by: Institute of Petroleum
61 New Cavendish Street
London, W1M 8AR

* PIPELINE AND GAS JOURNAL / Dallas
edited by: Harcourt Brace Jovanovich Public.
P.O.Box [illegible]89
Dallas [illegible]

* WORLD OIL / Houston
edited by: Gulf [illegible]
P.O. [illegible]
Houst[illegible]

* CORROSION / Houston
edited by: National [illegible]ation of Corrosion Engineers,
144[illegible] South Creek
Houston, Texas 77084

RECOMMENDED HANDBOOKS AND SCIENTIFIC LITERATURE

* API - American Petroleum Institute
  Technical data book - Petroleum Ref.ning (1970), Vol 1 and 2

  American Petroleum Institute, Washington

* PERRY, J.H.
  Chemical Engineers' Handbook (1950) - Metric Edition
  McGraw - Hill Kogakusha Ltd / Tokyo

* CRC Handbook of Chemistry & Physics
  CRC-Press, Boca Raton, Florida

* NELSON, W.L.
  Petroleum Refinery Engineering (1958)
  Petroleum Publishing Co, Tulsa, Oklahoma

* NELSON W.L.
  Guide to Refinery Operating Costs (1976)
  Petroleum Publishing Co, Tulsa, Oklahoma

* BROWNSTEIN A.M.
  Trends in Petrochemical Technology (1976)
  Petroleum Publishing Co, Tulsa, Oklahoma

* PAUL, J.K.
  Methanol Technology and Application in Motor Fuels (1978)
  Noyes Data Corp.

* BECKMANN H.
  Geological Prospecting of Petroleum (1976)
  Pitman

* CHAPMAN, R.E.
  Petroleum Geology (1976)
  Elsevier / Amsterdam - Oxford - New York

* DAKE, L.P.
  Fundamentals of Reservoir Engineering (1979)
  Elsevier / Amsterdam - Oxford - New York

* MAYER - GURR, A.
  Petroleum Engineering (1976)
  Pitman

* MEGILL, R.E.
  An Introduction to Exploration Economics
  Petroleum Publishing Co. 1979

* ANDERSON, G.
  Coring and Cor Analysis Handbook
  Petroleum Publishing Co. 1975

* CHILINGARIAN, G.V.
  Drilling and Drilling Fluids (1980)
  Elsevier / Amsterdam - Oxford - New York

* ANSELL, M.F.
  Rodd's Chemistry of Carbon Compounds
  Elsevier / Amsterdam - Oxford - New York

YEARBOOKS IN SERIES

* WORLD PETROLEUM CONGRESSES - Proceedings
  1975 (Tokyo) - 1979 (Bucharest) - 1983 (London)
* AMERICAN PETROLEUM INSTITUTE (API)
  Division of Refining: Midyear meeting, Proceedings (API/Washington)
* INTERNATIONAL PETROLEUM ENCYCLOPEDIA (1981, ...)
* AMERICAN CHEMICAL SOCIETY (ACS)
  Division of Petroleum Chemistry: Symposia Preprints
  (for members only - included in yearly dues).

SUBSCRIPTIONS FOR INFORMATION SOCIETIES AND SEARCH SERVICES

API AMERICAN PETROLEUM INSTITUTE
156, William Street, New York 138

Subscription dues are calculated from the yearly refinery capacity plus sales of petroleum products and natural gas of the respective member.

Example:
The Austrian National Petroleum Company (ÖMV) was charged with $ 39.000.- for the year 1982. Since ÖMV is a comparatively small-sized company, it is expected that TRINTOC would have to pay a similar amount.

ISA INSTRUMENT SOCIETY OF AMERICA
67, Alexander Drive, P.O.Box 12277, Research Triangle Parc, N.C., 27709, USA

Instructions about instrumentation: books, films, videotapes
Membership dues: $ 35.00

PERP PROCESS EVALUATION / RESEARCH PLANNING
ChemSystems Inc., 747 Third Avenue, New York, N.Y. 10017

Reports about petrochemicals

Membership dues: $ 20.000,—

Comment:
seen to be at hand of TRINTOC staff!

SDC Search Service
2500 Colorado Ave., Santa Monica, California 90406

Searching costs appr. $75/hr without telephone charges. One search problem on a few data bases would last appr. half an hour.

F. Training and recruiting

In order to obtain the required staff for the proposed R&D organization the following measures are proposed:

1) The Head of the R&D Department should have practical experience in the field of explorations and production and/or petroleum processing. He must be well acquainted with the TRINTOC organization as a whole in order to ensure the necessary connections to all other divisions and the implementation of R&D results within the operational departments.

2) Senior members of the new organization should have experience in research or in operations. The latter would need to show interest for research. They would have to be recruited from outside TRINTOC or even outside of T & T. Such personnel should be given the opportunity to acquaint themselves with other research organizations in the USA and/or Europe.

3) Junior members for the new organization should be recruited from the University of T & T or the Caribbian Area and given a training of about one year. During this time they should get acquainted to practical operations of TRINTOC, i.e. work at an exploration field or in refinery operations, preferably in petroleum processing. Good experience was obtained by putting such trainees on shift work. Of course the training programme should be laid out in detail and also include other areas of the company. A good understanding of the operations of TRINTOC, however, is considered essential as it will further the identification of the personnel with the company and the problems at hand.

   In order to obtain the required junior staff from the universities it is essential to keep in close contact with university staff and hire junior members preferably at the recommendation of university members. This is common practice especially in Europe and has proven useful.

G. Estimate of required resources

The estimate will be separated into capital cost estimates for facilities and operating costs and given for the first and second phase only, as estimates too far into the future are difficult to justify.

1) Capital costs for facilities (based on assumptions as laid down in Appendix IV)

First phase - both laboratories at same site in one facility.

(a) Petroleum/Natural gas exploration and production laboratory

buildings	1,600m US $
equipment	0,960m US $

(b) Petroleum processing/Petroleum products and petrochemicals

equipment	0,370m US $

Second phase - installation of petroleum/petrochemical products laboratory

(a) Oil exploration and production laboratory

pilot station	1,600m US $ (on request)
equipment	0,575m US $

(b) Petroleum processing/Petroleum products and petrochemical laboratory

laboratory building and pilot station	3,200m US $
equipment	0,170m US $

Note: In the figures above, a comma signifies a decimal point.

III. Recommendations with regard to R&D programme

In considering an R&D programme for TRINTOC, a clear differentiation of the objectives for the various activities should be made. Basically, we have experimentally oriented R&D activities and design oriented R&D activities, operation supporting and products development R&D activities. The basic principle in starting a new R&D organization should be to begin with a limited number of clearly defined projects in areas of vital importance to the company. A few of such projects will be discussed below, based on proposals of TRINTOC (Ref. 5 and 6).

1) R&D exploration and production

1.1 PVT studies

Such studies are absolutely necessary as a basis for characterizing reservoirs in operation and should therefore obtain the highest priority.

1.2 Reservoir simulation by mathematical modelling

For such work, a sizeable computer is required. The respective models must be established preferably in cooperation with experienced institutions.

1.3 Enhanced oil recovery

Further to work already at hand by TRINTOC. it is recommended to carry out preliminary screening tests on laboratory scale with model packings to support the basic data for the mathematical modelling of reservoirs.

Besides steam injection, it is also recommended to start work on:

- alkaline flooding for naphthenic crudes,
- CO_2 miscible flooding studies as well as
- simple water flooding

Also in these cases laboratory screening studies to establish the required parameter for mathematical modelling to serve as basis for field tests should be made.

At a latter stage also the polymer/surfactants flooding methods can be envisaged for study.

1.4 Characterization of surface and formation waters

Such studies form a necessary part of water flooding studies.

1.5 Control of emulsions from oil production

seems necessary for production purposes.

1.6 Additional fields of work

Core laboratory, paleontology and microscopy of minerals, instrumental analysis (including elemental analysis and gas-chromatography).

1.7 Heavy oil production

A special major R&D project should be envisaged for the exploration and production of heavy oil. It is recommended that this project, because of its size, should be carried out in cooperation with the university.

2) Petroleum/Petrochemical products

2.1 Crude oil characterization and evaluation

Starting with crude oil manuals for every crude oil type including True Boiling Point (TBP) distillation, evaluating yield structure on standard fractions for production planning preferably by computerized refinery simulation models, including conversion units, lube-oil and bitumen production.

2.2 Corrosion control of crudes in production and refining

Corrosivity and measures to prevent corrosion are recommended for study.

2.3 Dewaxing of petroleum fractions

In case high paraffinic crudes are under consideration, dewaxing of some fractions would be required, especially middle distillates and lube-oil fractions.

2.4 Naphthenic acids

Recovery from kerosene, light gasoil, heavy gas oil fractions by extraction should be studied by process evaluation and possibly experimentally. Sales of naphthenic acids as such or processing to dehydrated naphthenic acids or respective salts from different metals seem a project to which a high degree of priority should be given.

2.5 Bitumen evaluation

Deep vacuum distillation versus bitumen oxidation should be studied. A combination of both processes will probably be optimal. Evaluation of products for several end uses to be carried.

2.6 Heavy crude oil conversion

Study into several possible ways of processing should be undertaken. Being a major and very important project, it could be considered to bring this into the first phase of the R&D implementation programme.

The production and possible conversion of this heavy crude to lighter products seems to present a favourable project for TRINTOC as the availability of natural gas, required for the production of hydrogen needed for a possible conversion of the heavy crude, is given. It is therefore recommended to start with such a project at an early date, beginning with screening evaluations, and give it a high priority.

2.7 Gasoline/Diesel type fuels

Studies for the improvement by additives could be undertaken.

2.8 Hydrocarbon solvents

Production by extraction or other separation techniques could be studied as a base material for the paint and lacquer industry.

2.9 Lubricating oils

for automotive and industrial use.

3) Long term projects

Long term projects in this case are considered to be projects of a longer duration not necessarily to be stacked at a latter date, although this is also possible in some cases.

3.1 Synthesis Gas/methanol

Production from natural gas for methanol, addition or conversion to gasoline could be studied by the process evaluation group. Especially the possibility to produce methanol for the addition to gasoline seems very interesting and such studies should be given a high priority.

3.2 Aromatics production

As indigenous crude oils are high in their naphthenes and aromatics content the possibility for production of aromatics in large quantities should be studied.

3.3 Agricultural wastes

In Europe considerations are being given to production of ethanol, mixed alcohols for addition to automotive fuels. Such studies could be undertaken by the process evaluation group. Furfural is another very interesting by-product of such productions.

3.4 Hexamethylentetramin (comp. Ref 5, 6)

Unless there is access to the primary raw materials, ammonia and methanol, this production seems rather unattractive.

3.5 Rubber recycling (comp. Ref. 5, 6)

For road and building compositions seems rather out of scope of the work for an oil company. These projects should be given different priorities according to local circumstances, and the decisions pending with regard to the refinery situation.

It should be stressed that the above list of possible R&D projects should not be considered to have resulted from a systematic or detailed study but rather are based on the discussions with TRINTOC personnel and the experts' experience.

The recommendations with regard to an R&D programme should be viewed in the light of certain priorities, some considerations of which are given below.

Top priority should be given to all projects in the field of exploration and production in order to increase the production. Special emphasis should also be given to heavy oils.

The research projects pertaining to supporting the petroleum refining activities also are to be given high priorities in order to obtain optimized operations at minimum costs.

Petroleum products research is necessary to support the marketing of these products and is also of great importance.

The same is true for the process and project evaluation studies in order to be able to establish the refinery upgrading and expansion programme as well as the value of middle and long-term development projects.

These activities will consume much of the R&D allocated capital expenditure and personnel resources of TRINTOC in the first years.

It is therefore considered of minor importance and less attractive to establish R&D activities into petrochemical commodities such as ethylene and polymers etc., as there presently are sizeable overcapacities in the USA and in Europe.

Some considerations with regard to the future developments of the petrochemical industry based on European experience are summarized in Appendix V. A project of special interest could, however, be the production of aromatics from indigenous crudes as their content of naphthenes and aromatics is high. The production possibilities for some special petrochemical products in which the local situation with regard to feedstock and transportation is extremely favourable should always be given careful considerations. It is generally agreed within the chemical industry that future expansions within the industry and especially for commodity chemicals should only be considered for local circumstances where the feedstock and transportation cost situation is extremely favourable as e.g. for cases where large amounts of ethane are available for the production of ethylene.

IV. Recommendations with regard to cooperation

A. International cooperation

1. Exploration and production

   In the opinion of the experts, cooperation in this field is difficult to obtain. If cooperation is wanted, bilateral exchange of information should be sought for.

2. Petroleum products

   For automotive fuels testing (Octane rating) cooperation in the corresponding working group of COORDINATING RESEARCH COUNCIL (CRC) in the USA or COOPERATIVE OCTANE REQUIREMENT COMMITTEE (CORC) in Europe should be sought.

It is recommended also to establish cooperation with specific national oil companies in order to obtain information for the following projects:

- Reservoir simulation models
- Crude characterization and evaluation, application of refinery production planning models
- Design for special pilot plants, e.g. petroleum conversion processes
    * Visbreaker
    * Fluid Catalytic Cracking (FCC)
    * Hydrogenation - hydrotreating, etc.
    * Residue oxidation

3. Petrochemical products

   No special form of cooperation in this field can be recommended as such does not normally exist among the various companies active in this field.

   Any activity in this field should consider the special situation vis à vis the National Energy Council (NEC).

It should also be mentioned that UNIDO has a Special Industrial Service (SIS) programme to provide short-term consultants upon request. UNIDO can furthermore provide technical advisory and training services in establishing R&D facilities for natural gas and petroleum processing industries in developing countries.

B. National Cooperation

The experts consider cooperation with the Universities the most important factor on the national level for two reasons:

a) recruitment and training of personnel
b) possibilities to carry out special well defined research projects.

The contracts with the University of the West Indies should be made at an early date to ensure from the start a close cooperation in the various fields of activities. Especially recommended is a cooperation in the following fields:

OIL EXPLORATION AND PRODUCTION

The Chemical Engineering Department has available some equipment for research in oil exploration and production, especially PVT apparatus. Such equipment, available for some time, had not been used for lack of trained personnel and funds to carter for operating costs. It is therefore recommended to start cooperation here in order to put the University in a position to activate this field. Thereby it can be expected that interesting research projects for TRINTOC can be taken up and students working with this equipment be recruited, which then can implement the envisaged research facilities at Penal.

It should be pointed out, however that although cooperation with the University is recommended, this should and must not mean that some of the proposed R&D activities for TRINTOC could be entirely disposed to the University for the following reasons:

- to safeguard TRINTOC's interests with regard to secrecy in certain cases
- to ensure the continuity and follow-up possibilities for the specific projects.

In both cases an University cannot provide the necessary guarantees for obvious reasons.

PETROLEUM PRODUCTS/PETROCHEMICALS

It is recommended to seek cooperation with the University in these fields, although at the moment no specific recommendations can be given because of lack of information on the interest of the University. It seems that in this field no special activity in research is conducted at the University at present. However, one should seek to encourage any University activities which might develop in the future.

During a short visit to CARIRI (Caribbean Institute of Industrial Research) it emerged from a discussion with CARIRI members that the interest of the two companies in R&D in the field of petroleum and petrochemicals were geared to different goals, while CARIRI is acting more as a technical service laboratory in petroleum for small and medium size companies, TRINTOC would be in an entirely different field, which is described in detail in the foregoing. It is also considered advisable by the experts that this situation of separated areas for the respective activities of the two organizations should continue to prevail in future.

Nevertheless in all scientific fields concerning petroleum industries of Trinidad & Tobago cooperation with certain institutes of the University of the West Indies should be initiated, as also to relevant departments of CARIRI and NIHERST (National Institute for Higher Education of Research - Science - Technology).

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LIST OF APPENDICES

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I	Reports of TRINTOC on R&D organization
II	Qualifications for manpower for R&D department
III	List of equipment recommended by the experts
IV	Provisional proposal on capital and operating costs prepared by the experts
V	Reasons for expected non-growth situations of industry, especially the petrochemical industry in Europe and in the USA

APPENDIX I (REF. 4)

TECHNOLOGY DEVELOPMENT DIVISION

BASIC ASSUMPTIONS

LAST QUARTER 1981 AND 1982

1. Preamble:

1.1 The quality of any research programme is determined in the main by the quality of the researcher. For this reason the personnel to be looked for by the Trintoc Technology Development Division should be experienced Ph.D's in Petroleum Engineering, Chemical Engineering and Chemistry, initially. It is proposed that they be called "Research Scientists" and that the Applied Research facility be organized around them. To this end, decisions to be made for their recruitment should be based on the realisation that such personnel are not easy to come by. Salary levels, housing and transportation arrangements should therefore be attractively packaged to enable recruitment of the best material available. For this reason also, consideration should be given to siting the facility in an area which is least likely to hinder the recruitment of such researchers.

1.2 From a budgetary point of view, a review of research expenditures by American Oil Companies (See Appendix A) shows that 19 of them spent an average of US$1590 per total company employee in 1979. This represents an average of 0.4% of sales and 6.2% of net profit. The range was from a low of US$259/employee (Charter Oil) to US$2,700/employee (Socal), but included such small oil companies as Tosco (US$2.8 million to total annual R & D expenditure) spending US$1,038/employee.

Bearing in mind the initial capital requirements for building construction and purchase of equipment (circa TT$4 x 10^6) the future operating budgets can be expected to be of the order of TT$2.5 x 10^6 per annum, or TT$2,272/employee.

2. Consultants

2.1 Preliminary discussions with UNIDO have already been held with a view to their offering the services of a Petroleum Engineer and Chemical Engineer with a background in Petro-chemicals. The main purpose of these advisors would be to recommend the layout design, staffing requirements and organisational arrangements for the Research Facility. Actual project proposals will also be discussed. Action is now awaited from UNIDO to recommend various people for these consultancies from which Trintoc may select.

2.2 Meanwhile, because of the complex nature of Petroleum Engineering Research and the difficulty in hiring such people, it is proposed that Trintoc undertake a short term contract with Energy Inc. of Boston to develop a detailed program of work, and possibly to assist in identifying a suitable recruit for the position of Research Scientist (Pet. Eng.). Specific approval to investigate this foreign contract is therefore requested.

3. Establishment of Office and Laboratory Facilities

The following action plan indicating the approximate time schedules indicates what is required.

	Action	1981	1982	1983
(i)	Land Selection and Purchase (if necessary)	x		
(ii)	Land Survey	x		
(iii)	Temporary Structure Layout	x		
(iv)	Temporary Structure Construction		x	
(v)	Permanent Structure Layout & Design*		x	
(vi)	Permanent Structure Construction		x	x
(vii)	Selection and Purchase of Furniture/ furnishings		x	x
(viii)	Selection and Purchase of Laboratory equipment*	x	x	x

* Dependent on advice of Consultants.

4. Personnel Requirements

4.1 Pending the advice of Consultants, the following list of employees is proposed as adequate to operate three on-going projects simultaneously within the budgetary framework outlined in 1.2 above.

Manager	1
Manager's Secretary	1
Research Scientists	3
Assistant Research Scientists	3
Secretarial	2
Technologists (Chem. Eng.)	2
Business Analyst	1
Technologist (Pet. Eng.)	1

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Librarian	1
Chief Technician	1
Technicians:	
Laboratory	3
Mechanical	1
Electrical	1
Instrument	1
Glassblower	1
Draftsman	1
Messenger/Clean-up	1
Total	25

An Organogram of the Division is attached as Appendix 'B'.

4.2 The rate of hiring of personnel will be highly dependent on the rate of attraction of research scientists and to a lesser extent their assistants. The anticipated recruitment is indicated below.

	1981	1982	1983
Research Scientist (Chemistry)	1		
Research Scientist (Chem. Eng.)		1	
Research Scientist (Pet. Eng.)		1	
Asst. Research Scientist (Chemistry)	1		
Asst. Research Scientist (Chem. Eng.)		1	
Asst. Research Scientist (Pet. Eng.)		1	
Chief Technician	1		
Technician (Mech. Fitter/Machinist)		1	
" (Elec. Fitter)	1		
" (Instr. Fitter)	1		
" (Lab. Operators)	1	2	
" (Glassblower)		1	
Process Engineers	1	1	1
Business Analyst		1	
Librarian		1	
Draftsman		1	
Messenger		1	
Research Scientists' Secretaries		3	
Manager	1		
Manager's Secretary	1		
TOTAL	9	16	1
Total to be recruited	6	16	1

5. Housing

5.1 Housing should be provided for:

(a) Researchers

(b) Overseas recruits (other than researchers) for periods of up to 2 years to enable them to settle into Trinidad before having to purchase their own homes.

5.2 Housing loans should be made available to:

Asst. Researchers
Process Engineers
Business Analyst
Chief Technician
Librarian

These are to be based on Senior Staff loan provisions.

6. Transportation

Rented company cars should be provided for the Researchers.

7. Training

Provision is to be made for at least one (1) Researcher and one Asst. Researcher to attend courses in their fields of study.

Researchers should also attend relevant professional association meetings to keep abreast of state-of-the-art technology.

Technician training, especially in the early years, in the use of small scale high pressure equipment and other non-routine techniques, is also to be undertaken.

8. Travel

Provision is to be made for the activity in 7 above.

9. Work Programme

Prior to discussion with Consultants, a preliminary work programme has been drawn up for budgetary purposes. The projects and their approximate timing are indicated below:-

		1981	1982		1983
			1st half	2nd half	
(i)	Steam Stimulation			X	
(ii)	Control of Water-in-Oil Emulsions	X	X		
(iii)	Recovery of NOR prior to hydro-treating oils		X	X	

		1981	1982		1983
			1st half	2nd half	
(iv)	PVT and Core Analyses				X
(v)	Determination of Crude Prospectus (from each producing field)	X	X		
(vi)	Bitumen technology evaluation	X	X		
(vii)	Recycle Rubber Studies		X	X	

Divisional model procedure and detailed job descriptions are currently in preparation and will be forwarded shortly.

2nd September 1981

APPENDIX 1 (REF.5)

TECHNOLOGY DEVELOPMENT DEPARTMENT

STRATEGIES 1982-1985

The extent of trade in technology between developing and developed countries (principally the U.S.A.) has risen from around $ 2,700 million in 1965 to $ 14,000 million in 1978, with direct costs alone estimated to reach over $ 6,000 million by 1985.

This arises from the high concentration and dependence of the economies of developing countries on modern industrial and manufacturing technology, which has resulted in an ever increasing technology gap.

To arrest this trend adequate growth of technological infrastructure and capability is essential and concomitant with self-reliance. Our department has therefore adopted an evolutionary strategy throughout the 1980's to facilitate objectives, which are accordingly formulated.

(i) Utilization of such technology that is required to maintain quality control in crude production and refining.

(ii) Improving process yields by better utilization of available raw materials and technology.

(iii) Changing systems where applicable and advantageous to accommodate local raw materials and so develop indigenous processes and products.

Pursuant to these objectives, the development of an adequate technological information system either internally or externally, which can monitor changes in technology is deemed necessary.

By such an approach, initiated in strength on the firm footing of petroleum, we hope to establish our thrust at the meridian of TRINTOC self-improvement and so contribute towards the development of Trinidad and Tobago.

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LABORATORY FACILITIES

A temporary research facility is due to be completed sometime in November 1982. This location will serve as the precursor to a permanent site, (probably in Point Fortin), which is proposed for completion towards the beginning of 1984. A parcel of land comprising approximately twenty-five (25) acres in the vicinity of Techier Village has been identified for this purpose. The temporary site (c.f. work schedule), will therefore reflect preliminary evaluation, whereas deeper project definition and scope undertaken at the permanent facility.

The following is our proposal with time schedules indicated:

ACTION	1982		1983		1984	
	1st half	2nd half	1st half	2nd half	1st half	2nd half
1. Approval of proposed permanent site		x				
2. Purchase of suitable site contingent on (1)		x				
3. Land Survey		x				
4. Completion of temporary facility		x				
5. Layout and design of permanent facility		x				
6. Construction of permanent facility			x	x	x	
7. Selection and purchase of laboratory equipment*		x	x	x		
8. Purchase of furtniture and furnishings				x		
9. Completion of permanent site					x	

* Purchase of laboratory equipment is an on-going exercise, which will be contingent on the stage of development of the project.

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WORK PROGRAMME

PROJECT	82	83	84	85	86
Characterization of surface and formation waters	x	x			
Control of emulsions from petroleum production	x	x	x	x	x
Reagents and procedures for dewaxing parallinic crudes		x	x		
Corrosion control in crude production and refining	x	x	x		
PVT studies and core analyses			x	x	x
Bitumen technology evaluation		x	x	x	
Recycle rubber in road and building compositions			x	x	x
Hexamethylenetetramine (from ammonia and formaldehyde) synthesis for extensive local applications			x	x	
Naphthenic acid recovery prior to hydrotreating oils		x	x		
Naphtenic acid salts as wood preservatives and in paint manufacture			x	x	x
Reservoir simulation by mathematical modeling			x	x	x
Determination of crude properties from each producing field		x	x	x	
Enhanced Oil Recovery	x	x	x	x	x

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PERSONNEL

Staffing is based on the simultaneous operation of projects related to the production and manufacturing divisions and to utilize current process developments in natural gas to national advantage. Thus, guided by corporate objectives within the framework of research expenditure by American Oil Companies, our ultimate goals necessitate the personnel as indicated. Our strengths at the moment, rest mainly at the micro levels of research which supports the early choice of projects. Nevertheless, a positive derive should be made to attract research personnel in process and petroleum engineering if we are to maximize our indigenous research and development strategy.

S T A F F I N G	1982	1983		1984		1985	
	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
Research Scientist (Chemistry)	1						
Research Scientist (Chem. Eng.)	1						
Research Scientist (Pet. Eng.)	1						
Research Assistant (Chemistry)	1						
Research Assistant (Chem. Eng.)		1					
Research Assistant (Pet. Eng.)		1					
Technologists		1	1				
Business Analyst			1				
Information Scientist				1			
Chief Technician	1						
Technician (Mechanical)				1			
" (Electrical)		1					
" (Instrument)		1					
" (Laboratory)	2	1					
" (Glassblower)		1					
Draughtsman				1			
Messenger				1			
Research Scientist Secretaries				3			
Manager's Secretary	1						
Manager	1						
TOTAL	10	7	2	7			
TOTAL TO BE RECRUITED	5	7	2	7			

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TRAINING

A potential problem for our proposed development is the required growth of specialized skills, particularly at the lower levels. Whereas money is sometimes present to accommodate new technology, knowledge on the other hand cannot always be available to assist in such transfers. Our progress will thus be determined by the quality and quantity of training particularly at the base.

Training of personnel is commensurate with increasing mobility. However, it is envisaged that with careful selection of staff under the guidelines of corporate objectives, mobility would be internal and separations minimized.

Three areas are suggested viz.:

(i) Academic or course study in technical fields to graduates and later in management-oriented sciences to employees, who further demonstrate leadership capabilities.

(ii) Part-time technical courses at local institutions for suitable technicians.

(iii) In-house training. This is particularly useful in stimulating cross-fertilization, which is imperative for the success of any research team.

Project leaders would be expected to keep abreast of the state of the art by attending conferences, or any other relevant symposia and to develop subordinates accordingly.

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GOALS

Drs. Fred T. Pass and Franz Moser, consultants in petroleum engineering and petrochemical development, respectively, are due to arrive in Trinidad on 20th September 1982, for one month, during which time, their advice on TRINTOC's proposals will be solicited.

Ultimately, we aim at the evaluation of technologies which accord with local needs, development of more valuable downstream products from petroleum, and synthesis of locally used petrochemicals and agrochemicals, (or development of suitable alternatives).

Thus, by observation, exploration and synthesis, we hope to facilitate technology transfers, its attendent employment increasing opportunities, and improvement in the socio-economic benefits to Trinidad by TRINTOC's operations.

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Appendix II

Qualification for Technical Manpower

This appendix is based on the manpower considerations as given in Tab. I and the organisational scheme as given in Fig. 1.

Exploration and Production Department - Group leader

Preferably PhD in petroleum engineering with several years of practical experience in the field. Also experience in an R&D organization would be equivalent to practical experience although less important.

Petroleum Products/Petrochemical Department - Group leader

Preferably PhD in chemistry or chemical engineer with some practical experience in refinery operations if possible or at least R&D projects in the field.

Process Evaluation - Group leader

Preferably MSc in chemical engineering with practical experience with a contracting firm in oil and/or petrochemical processes.

Head of Services - Group leader

Preferably PhD in analytical or physical chemistry with experience in instrumental analysis or spectroscopy.

Exploration and Production Group

PVT laboratory - Section leader

Preferably MSc in petroleum engineering or petrophysics with some experience in high pressure experimental work.

Reservoir engineering - Seaction leader

Preferably MSc in petroleum engineering or reservoir engineering with experience in mathematical modelling and computer application in reservoir engineering.

Instrumental analysis - Section leader

BSc or MSc in analytical or physical chemistry. Some experience in analytical work.

Technicians

High school graduates with professional training as technical assistants.

Maintenance personnel

Technicians with experience in welding, fitting and machining.

Petroleum products/Petrochemicals group

Crude oil evaluation - Section leader

BSc or MSc in chemistry or physical chemistry.

Petroleum products - Section leader

BSc or MSc in chemistry

Conversion processes - Section leader

BSc or MSc in chemistry

Petrochemical products - Section leaders

BSc or MSc in chemistry or chemical engineering.

Energy/New products - Section leader

BSc or MSc in physics, chemistry, physical chemistry or chemical engineering.

Instrumental analysis - Section leader

BSc in analytical chemistry.

Process evaluation group

Economics

Business economist with experience in project analysis and operational research.

Process evaluation

BSc or MSc in chemical engineering.

Services group

Instrumental analysis

Same as above

Information/Documentation

BSc or MSc in chemistry or information services.

Computer and Maintenance

BSc or MSc in electronics and computer science.

Technicians (in all cases)

High school graduates with professional training as mechanics, chemists or technical assistents.

Maintenance (in all cases)

Technicians with experience in welding, fitting and machining.

Appendix III

List of equipment recommended by the experts

This stage of laboratory equipment

should be reached

after all three stages of development

about ten years after opening activities

* See additional list "SUPPLIERS OF TEST EQUIPMENT"

EXPLORATION & PRODUCTION NATURAL GAS/PETROLEUM

No of pieces	Apparatus	Source of supply*
Experimental reservoir engineering		
- Petrophysics		
1	Core extraction apparatus (for 18 samples, sample diameter 3 and 5 cm)	
4	Core extraction units as pretreatment for purification of core samples, diameter 10 cm	
18	Core extraction units for determination of oil or water content (sample diameter 5 cm)	
4	Core extraction units for 10 cm diameter cores	
2	Apparatus for porosity determination by liquid saturation method	
2	Heliumporosimeter	
2	Cabinet dryer (volume 140 l each)	
1	Vacuum shelf dryer	
1	Conditioning cabinet	
2	Equipment for determination of gas permeability for different core diameters	
2	Apparatus for measuring capillary pressure, method Purcell	
1	Apparatus for measuring capillary pressure, disc method (18 core samples at the same time)	
1	Centrifuge to measure capillary pressure	
1	Equipment to measure permeability (Klinkenberg)	
2	Deoiling device	
2	Equipment for measuring relative permeability unsteady - state	

No of pieces	Apparatus	Source of supply*
2	Equipment for measuring relative permeability steady - state	
1	Triaxial overburden pressure apparatus to measure permeability and porosity	
2	Equipment for resistivity measurement on cores and brines, evaluation of "m" and "n"-factors	
4	Calculator, such as HP 41	23
1	Data processing, such as HP 85	23
4	Thermostat circulating bath	
3	Vacuum pumps	
2	Electronic balances	40
2-3	Automatic sampler	
1 (each)	Calibration standards for manometer and electronic balances	
4-12	Metering pumps electronic pressure gauge (min 2x6 chanel) with digital or analogous registration	
	Table centrifuges, 20 precision manometers (better than 0,6) needle valves, multiway valves, microvalves, ball valves, 2-, 3- and 4-manifolds, gas meters, gas measurement devices, gas separators, gas burettes, desiccators, calibrated flashs and centrifuge tubes, calibrated measurement cylinders, titration device as well as all kinds of general laboratory glassware.	

Cost estimation for "Petrophysics" (Austrian prices at the end of 1982)

AS 7 to 10 Mio = 410.000-590.000 US $

No of pieces	Apparatus		Source of supply*
-	Pressure-Volume-Temperature (PVT) analysis		
1	Windowed pressure cell with liquid heating bath, temperature controlled (800 bar, appr. 350°F)		3a
1	Blind pressure cell with liquid heating bath, temperature controlled (800 bar, appr. 350°F)		3a
1	Condensate pressure cell)	in addition 1 or 2 air bath units, thermostatically controlled	
1	Volatile pressure cell)		
1	Recombination pressure cell)		
1	Recombination pressure cell with liquid heating bath, temperature controlled		
4	Automatic mercury press (500 cc)		
4	Piston manometer		
2	Air hydraulic oil pumps		
4	Depth sampling unit		
10 (each)	Container, 0.5 and 1 l		
1	GOV-(Gas oil volume ratio-)determination apparatus		
1	Precision gas meter		
2	Gas meter		
1	Flash separator		
1	Electronic balance; up to 2000 gr		40
1	Electronic balance, up to 50.000 gr		40
1	Gas chromatograph		
1	Digital density measurement apparatus, standard conditions		45a
1	Digital density measurement apparatus, under pressure and temperature		45a

No of pieces	Apparatus	Source of supply*
40	Gas sampling device	
1	Table centrifuge	
20	Precision manometer, quality grade 0.2 or better	
1	High-pressure viscometer for viscosity measurements under reservoir conditions	52a
3	Vacuum pumps	
1	Air conditioning and room ventilation	
4	Mercuri pressure container (appr. 3 l)	
2	Cabinet dryer	
2	Cryostat for temperature control of Mercuri presses	
1	Hand piston pump for field service	
4	Differential pressure gauge	
1	Inert gas compressor	
4	Recorder for analogous evaluation of differential pressure measurements	
2	Calculator Hewlett Packard 41 CV (or equivalent model)	23
	Laboratory materials and additional instrumentation similar to core analysis equipment, such as valves, distributors, cross pieces, etc.	

All equipment mentioned is available from specialized laboratory equipment suppliers in USA, UK and Europe (Federal Republic of Germany, France). Specialized petroleum production equipment is available at Core Lab., Dallas, or Ruska Corp., Houston, USA.

Cost estimation for 'PVT-analysis' (at 1982 prices in Austria)

AS 10 to 12 Mio = 600.000-700.000 US $
=====================================

List of equipment similar to that of Prof. Bruce, University of the West Indies, but more complete; adequate the reported activities of Trintoc in exploration and production.

No of pieces	Apparatus	Source of supply*
Chemical well treatment		
4	High-pressure mercuri press (250 ml) with motor drive and infinitely variable gear costs: AS 250.000 a piece	52a
6	Low pressure core holder (Standard Hassler cells)	
4	High pressure core holder costs: à 100.000 AS	10b
1	Cenco-DuNoüy-tensiometer costs: AS 200.000	
2	Pressure cells (500 - 1000 ml) with rotating stirrer for corrosion tests costs: à 150.000 AS	3a
1	Cement thickening time tester costs: AS 750.000	9a
4	Cabinet dryer (up to 300°C	
4	Thermostats	
4	Standard filter press (Fann or Baroid)	
2	High-pressure filter press	
4	Stirring units	
2	Vacuum pumps	
3	Millipore- or Nuclepore-filter equipment	
2	Brookfield viscometer	8
2	Brinkman-photometer	
6	Automatic titration euqipment	
1	pH-unit	
1	Analytical balance	40
1	Technical balance	40

Cost estimation for Chemical well treatment laboratory (at 1982 prices)

AS 3,5 Mio = 205.000 US $

No of pieces	Apparatus	Source of supply*
	Sedimentology/Paleontology	
	- <u>Sampling pretreatment (general)</u>	
2	Roc saw (cutting of drill cores, shaping single core samples) price: à 50.000 AS	
1	Core plug drilling machine (for drilling of plugs) price: 150.000 AS	
1	Jaw crusher) for coarse granulation	
1	Hydraulic press) for coarse granulation	
	Extraction apparatus (15 Soxhlet-units)	
1	Disc mill or similar equipment price: 150.000 AS	
2	Agate mortar pestle	
1	Sample splitter	
1	Ultra-sonic unit (surface swing for purification of samples)	
1	Cabinet dryer (140 l)	
2	Deep freezer (for core conservation)	
2	Set of gradation sieves (6 pieces), 2mm-0,063 mm)	
	- <u>Sedimentology</u>	
1	Polarization microscope with point counter and counting unit	
2	Binocular microscope (1 reflected light; 1 reflected light and transmitted light with polarization equipment)	
1	Ground machine with polishing equipment for preparation of thin cuts and polished surfaces price: 500.000 AS	
1	Sieving machine	
5	Set of sieves (0,03 mm)	
10	Attenberg-cylinder	

No of pieces	Apparatus	Source of supply*
5	Pressure filtration units	
3	Stirrer	
1	Magnetic separator	
1	Titration equipment respectively 5 Scheibler-units	
1	Mortar mill	
2	Cabinet dryer	
2	Analytical balance	40
On request in later period of establishing research laboratories		
1	X-ray diffractometer with autosampler (for investigations in detail a scanning electron microscope in combination with an energy-dispersive X-ray system is recommended) costs: AS 2,000.000 and more	
- Paleontology		
1	Polarization microscope with fluorescent unit and photometric evaluation (reflected and transmitted light) costs: AS 700.000	
2	Binocular microscope (reflected light)	
1	Binocular microscope (reflected light and transmitted light with polarization equipment)	
	Elutriation laboratory with facilities for hydrofluorid acid preparation:	
3	Cabinet dryer, one for samples pretreated with hydrofluorid acid)	
1	Ultra sonic unit for purification of samples	

Cost estimation for "Sedimentology/Paleontology" (at 1982 prices in Austria)

AS 8 Mio = 470.000 US $

No of pieces	Apparatus	Source of supply*
Instrumental analysis		
1	Gas chromatograph with two detectors (FiD and TC) for natural gases, range C1 to C6 and inert gases costs: AS 200.000	23,46,61, 56,12,55,44,16
1	Gas chromatograph with process computer, results through printer/plotter; for natural gases, identification in higher range of carbon numbers (c6 to C15), for crude oils and fractions. "Simulated distillation". Applicable up to molecular weight of $C_{45}H_{92}$. costs: AS 450.000	23,46,61,56,12,55,44,16
1	Gas chromatograph with microprocessor controlled integrator, autosampler, printer/plotter for organic-geochemic analysis of mineral extracts costs: AS 600.000	23,46,61,56,12,55,44,16
1	Atomic absorption spectrophotometer with automatic sample changing, graphite tube unit, microprocessor controlled, printer, graphic evaluation on screen For analysis of trace elements in water and mineral samples. Corrosion problems costs: AS 750.000	46,61,49,26
1	Infrared spectrophotometer for analytical investigations of oil traces in drilling cores, oil contamination in soils as well as surface and ground waters costs: AS 250.000	
	Additional equipment such as data documentation, literature and search programmes, reproduction on projection screen costs: AS 1.300.000	46,61,55,29,48
1	Kerogen investigation unit for organic-geochemic problems: hydrocarbon potential in sediments, type of Kerogen, maturity degree of organic substances costs: AS 750.000	10, 58
1	Carbon determination apparatus for organic bonded carbon to register total organic substances contained in sediment samples costs: 650.000 AS	33

No of pieces	Apparatus	Source of supply*
1	High pressure liquid chromatograph (HPLC) for investigations on crude oils, extracts of sediments in hydrocarbon groups and hetero compounds costs: AS 150.000	
	Complete with autosampler, on-screen reproduction of chromatograms in production costs: AS 800.000	23,46,61,55,29,62,31,35,48
1	Ultra sonic extractor for pretreatment of sediment samples for analysis of organic substances therin. costs: AS 70.000	60
—	Equipment for analysis of crude petroleum viscometry, sulfur determination, molecular weight, standard vacuum distillation costs: AS 50.000 to AS 250.000 s e e crude oil characterization of petroleum products	27,3,57

Activities should be coordinated with crude oil petroleum products as also equipment shared for the first period of establishing research laboratories.

-	Additional equipment for "Instrumental analysis" in general costs: AS 750.000	

On request, recommended for a later period of activities

1	Mass spectrometer coupled with evaluating gas chromatograph for investigations of correlation crude/crude, crude/mother sediment, recording of chemo fossiles. costs: AS 1,800.000	46, 61,29,48

Cost estimation for total "Instrumental analysis" plus "Geochemistry" (at 1982 prices in Austria)

AS 8 Mio = 470.000 US $
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O n r e q u e s t

Enhanced Oil Recovery (EOR)

Activities for certain reservoirs and production fields has to be prepared by exploratory applied research projects in pilot test series. Alkaline, CO2-miscible or sufactants/polymer flooding may be envisaged depending on conditions in the selected reservoirs.

Pilot tests of this type would be an additional investment of about

US $ 500.000.
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For the next stage of development field tests have to be undertaken at costs depending on individual field situation and size of field experiment.

PETROLEUM PRODUCTS/PETROCHEMICALS GROUP

a) Recommendations for standard equipment

No	Test method	Source of supply*
Crude oil characterization/residues		
	Distillation equipment: Glassware, fractionating columns distillation apparatus, dividing still heads	41, 50
	Rotary vane pumps costs: AS 250.000	34
	"DISTAM", Automatic distillation apparatus (TBP-Distillation) costs: AS 1,600.000	19
	"DISTACT", Short pass distillation costs: AS 850.000	34
	Cost estimation (at 1982 prices in Austria) AS 2,700.000 = 160.000 US $ ==========================	
Evaluation of petroleum products and primary fractions		
ASTM D 1298 ASTM E 100	Specific gravity (Hydrometer)	13 57
ASTM D 86	Distillation	24, 18, 57
ASTM D 323	Reid vapor pressure	24, 18, 57
IP33, TP170	Flashpoint, Abel Pensky	57
ASTM D 156	Colour (Saybolt)	18
ASTM D 525	Oxidation stability (IP)	47, 57
ASTM D 381	Existent gum	24, 57
ASTM D 873	Potential gum	18
ASTM D 130	Copper corrosion	18, 57
ASTM D 526	Lead in gasoline (gravimetric method)	18
ASTM D 1322	Smoke point	57
ASTM D 1319	Aromatics (FIA)	18
ASTM D 3241	Thermal oxidation stability	1

No	Test method	Source of supply*
ASTM D 2550	Water separometer	14, 57
ASTM D 2386	Freezing point	18, 57
ASTM D 2784	Sulfur in petroleum products	57, 22
ASTM D 2624 IP 274	Electrical conductivity	57
ASTM D 93	Flash point, Pensky Martens (Semi-automatic Flash point test)	57
ASTM D 97	Cloud point	57
ASTM D 97	Pour point	
ASTM D 86	Distillation	24, 18
ASTM D 1500	Colour	57, 18
ASTM D 611	Anilin point	57
DIN 51 428	CFPP (Filterability)	24
ASTM D 189	Carbon residue, Conradson	24, 57
ASTM D 1661	Thermal stability test of Navy special fuel oil	57
ASTM D 473	Crude and fuel oils sediment	57
IP 143	Asphaltenes (n-heptane)	18
ASTM D 240 D 2382	Heat of combustion	18
ASTM D 721	Oil content of petroleum wax	57
ASTM D 87	Melting point of petroleum wax	57
	Balances	40, 18
FIA ASTM D 1319	Silica gel	38
	Water baths	18, 32
	Oil baths	18, 32
	Furnaces	22, 18
	Thermostatic baths	18, 24, 32
	Ovens	22, 18
	Muffle furnaces	22, 18

Cost estimation (at 1982 prices in Austria)

AS 1,200.000 = 70.000 US $

No	Test method	Apparatus	Source of supply*
Residues / bitumen			
ASTM D 2398	Softening point	Ring and ball apparatus with accessoires	15, 57
ASTM D 5	Penetration	Universal penetrometer with controller	15, 57
ASTM D 113	Ductility	Ductilometer briquette moulds, base-plates and water bath	15
IP 80	Breaking point (Fraaß)	Bending apparatus, heating plate and stand, cooling app. thermometer and metal plaques	57
ASTM D 70	Specific gravity	Glass pycnometer, water bath, thermometer	57
ASTM D 92 IP 36	Flash and fire point Cleveland open cup	Cleveland apparatus for gas heating (coal gas or natural gas)thermometers	15, 57
ASTM D 189 IP 13	Carbon residue Conradson	Seta-Single test unit, porcelan crucible, iron crucible w.cover burner	57
ASTM D 482	Ash content	Ash apparatus, muffle furnace - 1200°C	15
IP 143	Insulubility in n-Heptan	Heating bank unit, Erlenmayer flasks and Liebig-coolers	25
IP 70	Kinematic visc.	Redwood I and II viscometer with all accessoires	57
ASTM D 2171	Dynamic viscosity	Modified Koppers vacuum viscometer	9
ASTM D 1754	Thin film oven test	Oven with rotating shelf	4
ASTM D 2872	Rolling thin film oven test	Oven with vertical circular carriage	11
		Column elution chromatography (length 1200 mm, diameter 20 mm, filled with silicagel, at the head of column - container (diameter 45 mm, content 150-200 ml), at end glass stopcock, Pyrex glass)	18

Cost estimation (at 1982 prices in Austria)

AS 850.000 = 50.000 US $

No	Test method	Apparatus	Source of supply*

Characterization of automotive and industrial lubricants

Lubricating oils (minimum)

ASTM D 1298	Specific gravity
ASTM D 97	Pour point
ASTM D 92	Flash point
ASTM D 445	Viscosity
ASTM D 2270	Viscosity index
ASTM D 974	Neutralization number
ASTM D 94	Saponification number
ASTM D 2896	Total base number
ASTM D 189	Conradson carbon residue
ASTM D 482	Ash content
ASTM D 1500	Colour
ASTM D 893	Benzene (Pentane-) insoluble matter content
	costs: AS 350.000

Lubricating oils (advanced level, on request)

ASTM D 943	Oxidation stability (TOST)
ASTM D 2272	Oxidation stability (RBOT)
ASTM D 130	Copper corrosion
ASTM D 665	Rust preventing characteristics
ASTM D 1401	Emulsion characteristics
ASTM D 892	Foaming properties
ASTM D 3427	Air release
ASTM D 1479	Emulsion stability
IP 125	Soluble cutting corrosion
ASTM D 95	Water content (Xylol)
ASTM D 1533	Water content (Karl Fischer)
ASTM D 877	Dielectric breakdown voltage
ASTM D 924	Power factor
ASTM D 2112	Oxidation stability (bomb test)
ASTM D 2440	"
ASTM D 2603	Shear stability
ASTM D 2783	Extreme pressure properties, 4-ball method
ASTM D 2782	Extreme pressure properties, Timken method

No	Test method	Apparatus	Source of supply*
	Elements:		
ASTM D 129	Sulfur content		
ASTM D 808	Chlorine content		
ASTM D 1091	Phosphorus content		
ASTM D 811	Calcium content		
ASTM D 811	Barium content		
ASTM D 811	Zinc content		
ASTM D 811	Silica content		
	Metals:		
	Iron content	Atom absorption spectrometry	
	Lead content		
	Copper content		
	and other metals		
	Infrared spectrometer for product identification, inhibitor determination, identification of additive systems		
	costs: AS 1,000.000		

Lubricating greases (on request, if necessary)

ASTM D 217	Penetration		
ASTM D 1264	Water resistance		
ASTM D 1831	Roll stability		
ASTM D 128	Analysis of lubricating grease		
ASTM D 1404	Estimation of deletorious particles		
ASTM D 1742	Oil separation		
ASTM D 942	Oxidation stability		
ASTM D 2265	Dropping point		
ASTM D 1261	Copper corrosion		
ASTM D 1743	Corrosion preventive properties		
ASTM D 2266	Wear preventive characteristics (4-ball method)		
	Wear preventive characteristics (Timken method)		
	costs: AS 650.000		

Total cost estimation (at 1982 prices in Austria)

AS 2,000.000 = 120.000 US $
==========================

No	Test method	Apparatus	Source of supply*
Instrumental analysis			
		Infrared spectrometer with pill press unit included costs: AS 800.000	46, 6
		Atomic absorption spectrometer costs: AS 800.000	46, 6
		Vapour pressure osmometer costs: AS 100.000	28, 20
ASTM D 240		Automatic adiabatic bomb calorimeter costs: AS 100.000	18
ASTM D 971		Interfacial tensiometer, model K 8600 costs: AS 80.000	30, 36
ASTM D 2624		Maihak transistorized conductivity indicator costs: AS 30.000	37, 2
ASTM D 2983		Brookfield viscometer, model LVT costs: AS 30.000	8
	X-ray fluorescence analysis (elemental analysis of several elements) costs: AS 1,200.000		43
		Rheomat (rotating viscometer, Couette cell) costs: 150.000	10a
	Rheology of vacuum residues and bitumen - low temperature flow characteristics	Shell sliding plate unit costs: AS 150.000	52

No	Test method	Apparatus	Source of supply*
		Capillary viscometer type Cannon Fenske (with thermostat) costs: AS 20.000	9
		Analytical balances of different kinds costs: AS 50.000	40, 54
		Gaschromatograph units with capillary and packed columns costs: AS 300.000	46, 23 44,16,61
	Total sulfur determination Total halogen determination	Wickbold combustion apparatus in hydrogen/oxygen flame costs: AS 100.000	22
	Elemental analysis CHNO costs: AS 600.000		22, 16, 46
		Photometer costs: AS 150.000	63, 5, 6
		pH-meter, AS 20.000 Potentiometer, AS 100.000 (Poiarograph, AS 150.000)	39, 40, 17, 45, 53
		Water determination apparatus (Karl FISCHER) costs: AS 80.000	39
		Several platin tools	42
		Electric heating devices	21
		Muffle oven	22

Total cost estimation (at 1982 prices in Austria)

AS 5,100.000 = 300.000 US $

b) Recommendations for special equipment on request

Pilot station - Distillation and conversion

- Pilot units for atmospheric frac... nation (200 l/h)
  costs: AS 1,200.000

- 2 hydrogenation units (max. 150 bar pressure)
  costs: AS 2,800.000

- 2 hydrodesulfurization units (max. 100 bar pressure)
  costs: AS 2,000.000

- Visbreaking / Thermal cracking
  costs: AS 1,800.000

- Bitumen Oxidation -
  BITUROX Process (ÖMV Vienna, Austria)
  under moderate pressure
  costs: AS 2,400.000

- Catalytic reforming or isomerization units
  costs: AS 2,600.000

- Furfurol extraction for lubricating oil fractions -
  Rotating disc contacter - pilot unit
  SHELL
  costs: AS 750.000

- Urea adduction of atmospheric and vacuum gasoil fractions
  TEXACO
  costs: AS 750.000

In cases of pilot units basic design and operating experiences would be available through ÖMV (Vienna, Austria) by sercive agreement, in some cases (like BITUROX) also through formal licensing.

Total costs Pilot station (at 1982 prices in Austria)

AS 14,300.000 = 840.000 US $

* For automotive fuels (in addition to CFR-Knocking engine) full range gasoline engines for road octane rating, improvement by detergents and alternative compounds

* Diesel engine - improvement of cetane number, other performance properties

* Liquid petroleum gases -
Standard methods of testing (ASTM) product properties, in addition performance characteristics for several applications like in automotive or industrial use.

* Equipment for water effluents treatment by flocculation, chemical pretreatment (oxidation) and final biochemical action

* Biological group
basic equipment in addition to general petroleum laboratory instrumentation

  - incubator up to 40°C, volume 50 l 22
  - sterilizer (pressure digester, vol 5 l)
  - dryer (up to 150°C, 50 l) 22
  - Petri dishes (/ 10 cm), one-use plastic discs, Drigalski spatula, Membrane filter (pore size o,2 um, / 47 mm) plus filtering apparatus (54), culture mediums and nutrient bottles (5oo and 1000 ml), microscope (up to 1600-fold, see 51)

  In case of fermentation activities a small pilot fermentor (Biostat S for example, see 7) would be extremely useful.

costs: AS 600.000

* Automotive lubricants
performance evaluation by sequences

1. GENERAL

This sequence under development is intended to define the minimum quality level of a product for presentation to CCMC members. Performance parameters other than those covered by the following tests may be indicated by the individual commercial vehicle manufacturers.

2. UNIGRADE/MULTIGRADE OIL PROPERTIES

		PROPERTIES		Unit of Measure	LIMITS Normal Aspirated Engines	LIMITS Supercharged Engines	TEST METHOD
HIGH TEMPERATURE PROBLEMS	MWM "B" or	Ring Sticking		Merit Points	NONE		CEC L-12-A-78
		Piston Skirt Varnish			55 min. (60 min. ?)	65 min. (70 min. ?)	
		Carbon Deposit					
		Oxidation					
	PETTER AVB						CEC L-13-T-74
WEAR	OM 616 and	Cylinder Liner	Average	µm	10 max.		CEC L-17-T-75
			Maximum		24 max.		
		Cam Wear	Average		30 max.		
			Maximum		60 max.		
	Cam + Tappet			mg	140 max.		CEC L-15-T-74
		Scuffing					
LOW TEMPERATURE SLUDGE	FIAT 600 D (MWM Cold)	Centrifugal Filter Sludge		g	55 max.		CEC L-04-A-70
				Merit Points	6.5 min.		
		Cylinder Head Top Sludge			9.5 min.		
		Rocker Cover Sludge			9.0 min.		
		Timing Gear Cover Siucce			9.5		
		Dispersancy Index					
	OM 616, Part A	Oil Pan Rocker Cover					CEC L-17-T-75
BEARING CORROSION	Petter W 1	Bearing Weight Lose		mg	25 max		CEC L-02-A-69
RUST							

NOTE
- Shear stability requirements for multigrade oils will be determined later
- Bore Polishing – currently being assensed by VOLVO TD 120 test for further consideration

1. GENERAL

This sequence defines the minimum quality level of a product for presentation to CCMC Members. Performance parameters other than those covered by the following tests may be indicated by individual car manufacturers.

2. UNIGRADE OIL PROPERTIES

PROPERTIES				Unit of Measure	VALUES SAE 10W	SAE 15W	SAE 20W	SAE 30	SAE 40	SAE 50	TEST METHOD
LOW TEMPERATURE SLUDGE	FIAT 600 D			g	55 max.						CEC L-04-A-70
		Centrifugal Filter Sludge		Merit Points	6.5 min.						
		Cylinder Head Top Sludge			9.5 min.						
		Rocker Cover Sludge			9.0 min.						
		Timing Gear Cover Sludge			9.5 min.						
		Dispersancy Index		–							
	or VC	Average Engine Sludge		Merit Points	8.5 min.						ASTM STP 315 F
		Average Piston Varnish			7.9 min.						
		Average Engine Varnish			8.0 min.						
		Oil Screen Clogging		%	5 max.						
		Oil Ring Clogging			5 max.						
		Compression Ring Sticking		–	NONE						
BEARING CORROSION	PETTER W 1 or	Bearing Weight Loss		mg	25 max.						CEC L-02-A-69
	CLR – L 38	Bearing Weight Loss			40 max.						Federal 791
HIGH TEMPERATURE OXIDATION	PETTER W 1 (1)	Viscosity Increase at 100° F		%	80 max.	75 max.	40 max.	40 max.	40 max.	40 max.	CEC L-02-A-69
	or III C	Viscosity Increase at 100° F after 40 hrs		%	400 max.						ASTM STP 315 F
		Piston Skirt Varnish		Merit Points	9.3 min.						
		Oil Ring Land Varnish			6.0 min.						
		Sludge Rating			9.0 min.						
		Ring Sticking		–	NONE						
		Lifter Sticking			NONE						
		Cam or Lifter Scuffing			NONE						
		Cam & Lifter Wear	Average	Inches	0.0010 max.						
			Maximum		0.0020 max.						
HIGH TEMPERATURE DEPOSITS	FORD CORTINA	Cold Ring Sticking		Merit Points	9.8 min. (2)						CEC L-03-A-70
		Piston Skirt Varnish			8.7 min.						
PREIGNITION	FIAT 124 AC	Hours to obtain preignition (with 2% by volume of oil in fuel)		Hrs	100 min.						CEC L-09-T-71
WEAR	OM 616	Cam Wear	Average		30 max.						CEC L-17-T-75
			Maximum	µm	60 max. (3)						
		Cylinder Wear (4)	Average		10 max.						
			Maximum	µm	24 max.						
RUST	II C	Average Engine Rust		Merit Points	7.9 min.						ASTM STP 315 F

For the future, CCMC propose the following tests:

HIGH TEMPERATURE OXIDATION – MORE SEVERE TEST			
CAM/TAPPETS WEAR – CEC RIG			

(1) Petter W 1 will be used until a more severe test procedure is available.
(2) No individual piston ring less than 9.0.
(3) One outlier above max. allowed.
(4) Cylinder wear only for oils intended also for passenger car diesel engines.

3. MULTIGRADE OIL PROPERTIES

PROPERTIES			Unit of Measure	VALUES SAE 10W30	SAE 10W40	SAE 10W50	SAE 15W40	SAE 15W50	SAE 20W40	SAE 20W50	TEST METHOD
LOW TEMPERATURE SLUDGE	FIAT 600 D or VC		g	55 max.							CEC L-04-A-70
		Centrifugal Filter Sludge	Merit Points	6.5 min							
		Cylinder Head Top Sludge	Merit Points	9.5 min.							
		Rocker Cover Sludge	Merit Points	9.0 min.							
		Timing Gear Cover Sludge	Merit Points	9.5 min.							
		Dispersency Index	-								
		Average Engine Sludge	Merit Points	8.5 min.							ASTM STP 315 F
		Average Piston Varnish	Merit Points	7.9 min.							
		Average Engine Varnish	Merit Points	8.0 min.							
		Oil Screen Clogging	%	5 max.							
		Oil Ring Clogging	%	5 max.							
		Compression Ring Sticking	-	NONE							
BEARING CORROSION	PETTER W 1 or CLR - L 38	Bearing Weight Loss	mg	25 max.							CEC L-02-A-69
		Bearing Weight Loss	mg	40 max.							Federal 791
HIGH TEMPERATURE OXIDATION	PETTER W 1 (1) or III C	Viscosity Increase at 100° F	%	80 max.	80 max	100 max.	75 max	75 max.	50 max.	50 max.	CEC L-02-A-69
		Viscosity Increase at 100° F after 40 hrs	%	400 max.							ASTM STP 315 F
		Piston Skirt Varnish	Merit Points	9.3 min.							
		Oil Ring Land Varnish	Merit Points	6.0 min.							
		Sludge Rating	Merit Points	9.0 min.							
		Ring Sticking	-	NONE							
		Lifter Sticking	-	NONE							
		Cam or Lifter Scuffing	-	NONE							
		Cam & Lifter Wear — Average	Inches	0.0010 max.							
		Cam & Lifter Wear — Maximum	Inches	0.0020 max.							
HIGH TEMPERATURE DEPOSITS	FORD CORTINA	Cold Ring Sticking	Merit Points	9.8 min. (2)							CEC L-03-A-70
		Piston Skirt Varnish	Merit Points	8.7 min.							
PREIGNITION	FIAT 124 AC	Hours to obtain preignition (with 2% by volume of oil in fuel)	Hrs	100 min.							CEC L-09-T-71
WEAR	OM 616	Cam Wear — Average	μm	30 max.							CEC L-17-T-75
		Cam Wear — Maximum	μm	60 max (3)							
		Cylinder Wear (4) — Average	μm	10 max.							
		Cylinder Wear (4) — Maximum	μm	24 max.							
SHEAR STABILITY	BOSCH Injector	Viscosity at 210° F after 30 Passes	cSt	≥ 9	≥ 12	≥ 14	≥ 12	≥ 14	≥ 12	≥ 14	CEC L-14-T-74
RUST	II C	Average Engine Rust	Merit Points	7.9 min.							ASTM STP 315 F
SHEAR STABILITY	Peugeot 204	Viscosity at 210° F	cSt	≥ 8.5	≥ 12	≥ 13	≥ 12.3	≥ 13.4	≥ 12	≥ 13	CEC L-16-T-74

For the future CCMC propose the following tests:

HIGH TEMPERATURE OXIDATION – MORE SEVERE TEST			
CAM/TAPPETS WEAR – CEC RIG			

(1) Petter W 1 will be used until a more severe test procedure is available.
(2) No individual piston ring less than 9.0.
(3) One outlier above max. allowed.
(4) Cylinder wear only for oils intended also for passenger car diesel engines.

SUPPLIERS OF TEST EQUIPMENT

1 ALCOR, Inc.
5420 Bandera Road
(Area Code 512), 684-0210
P.O.Box 28299
San Antonio, Texas 78228
USA

2 AMPOWER Corp.
NY
USA

3 ANALIS Laboratory Equipment and Apparatus
rue Dewez 14
B-5000 Namur
Belgium

3a AUTOCLAVE ENGINEERING
USA

4 BAIRD & TATLOCK Ltd.
Chadwell Heath
Essex
Great Britain

5 BAUSCH & LOMB
FRG (=Federal Republic of Germany)

6 BECKMAN Instruments Inc.
FRG

7 BRAUN-MELSUNGEN
FRG

8 BROOKFIELD Engng. Lab.
Massachusetts
USA

9 CANNON Instruments Co.
B.O.Box 16
State College
P.A. 16801
USA

9a CHANDLER ENGINEERING
Tulsa, Oklahoma
USA

10 CHEMICAL DATA SYSTEMS, Inc.
Oxford
Pennsylvania 19363
USA

10a CONTRAVES GOERZ Corp.
610 Epsilon Drive
Pittsburgh
Pennsylvania 15338
USA

11 James COX & Sons Inc.
P.O.Box 674
Colfax
California 95713
USA

12 DANI S.p.A.
Via Rovani 10
I-20052 MONZA (MI)
Italy

13 H.J. ELLIOTT Ltd.
"E-MIL"-Works
Treforest Industrial Estate
Pontybridd, Glam.,
Great Britain

14 EMCEE Electronics, Inc.
Claymont, Delaware
Postbox 3
USA

15 Engineering Laboratory Equipment Ltd. (ELE)
Eastman Way
Hemel Hampstead
Hertfordshire HP2 7HB
England

16 CARLO ERBA Strumentazione
P.O.Box 4342
I-20100 MILANO
Italy

17 ESA
USA

18 GALLENKAMP & Co Ltd.
Christopher Street
P.O.Box 290
Technic House
London EC 2 P 2ER
England

19 GECIL
Electronique-Informatique
LYON
France

20 HALLIKAINEN
Berkeley
California, USA

21 HAAKE BUCHLER Instruments Inc.
244 Saddle River Rd.
P.O.Box 549
Saddle Brug
New York 07662
USA

22 W.C. HERAEUS GmbH
Heraeus-Straße 12-14
D-6450 HANAU
FRG

23 HEWLETT-PACKARD Co.
Mail Stop 20
20B3, 3000 Hannover St.,
Palo Alto, California 94304
USA

HEWLETT-PACKARD Co.,
16399 W. Bernardo Dr.,
San Diego
California 92127
USA

24 Walter HERZOG
Fabrik für Laboratoriumsapparate
Postfach 320
D-697 LAUDA/Baden
FRG

25 ISOPAD Ltd.
Oldmixon Industrial Estate
Weston-super-Mare
GB

26 Instrumentation Laboratory Inc.,
Jonspin Rd.
Wilmington, Massachusetts
USA

27 JENAer GLASWERK Schott&Gen.,
Hattenbergstraße 10
Postfach 2480
MAINZ
FRG

28 KNAUER
Oberursel/Taunus
FRG

29 KONTRON ANALYTICAL
630 Price Avenue
Redwood City
CA 94063
USA

30 KRÜSS
Hamburg
FRG

31 LABORATORY DATA CONTROL
Interstate Industrial Park
P.O.Box 10234
Riviera Beach
Fla. 33404
USA

32 LAUDA-Meßgeräte GmbH
D-6970 LAUDA-Königshofen
FRG

33 LECO CORPORATION
3000 Lakeview Ave.
St. Joseph
MI 49085-2396
USA

34 LEYBOLD-HERAEUS
Bonnerstraße 504
D-5000 KÖLN 51
FRG

35 LKB-Produkter AB
Box 305
S-16126 BROMMA
Sweden

36 LUX Scientific Instr. Corp.
NY
USA

37 MAIHAK
Hamburg
FRG

38 E. MERCK
Postfach 4119
D-6100 DARMSTADT 1
FRG

39 METROHM
CH-9100 HERISAU
Switzerland

40 METTLER-Waagen GmbH
Postfach 110840
D-6300 GIESSEN
FRG

41 NORMAG
Otto Fritz GmbH
D-6238 HOFHEIM/Taunus
FRG

42 ÖGUSSA
Gumpendorferstraße 85
A-1060 Wien
Austria

43 ORTEC Incorporation
Oakridge
Tennessee
USA

44 PACKARD INSTRUMENT COMPANY, Inc.
2200 Warrenville Rd,
Downers Grove,
ILL. 60515
USA

45 PAR, USA

45a PAAR
Graz
Austria

46 PERKIN ELMER
Main Av., (MS-12)
Norwalk
CT 06856
USA

47 Julius PETERS
Stromstraße 39
D-1 Berlin 21
FRG

48 PHILIPS AG
Allmendstraße 140
CH-8027 Switzerland

PHILIPS GmbH
Miramstraße 87
D-3500 KASSEL
FRG

49 PYE UNICAM Ltd.
York Street
Cambridge CB12PX
England

50 PYREX
James A. Jobling & Co, Ltd.
Wear glass works
Sunderland
GB

51 REICHERT

52 ROFA
Reisnerstraße 41
A-1030 Vienna
Austria

52a RUSKA Corp.
Houston, USA

53 SARGENT-WELCH
USA

54 SARTORIUS
FRG

55 SIEMENS AG
Postfach 21 1262
D-7500 KARLSRUHE 21
FRG

56 SHIMADZU Scientific Instruments, Inc.
9147-H Red Branch Road
Columbia
Md 21045
USA

57 STANHOPE Seta Ltd.
London Street
Chertsey
Surrey, KT16 8AP
GB

58 TECHNIP Geoproduction Division Geochéchanique
212, Avenue Paul Doumer
F-92508 RUEIL-MALMAISON
France

59 TELSEC

60 ULTRASCHALL-Gesellschaft KLN
Freiwillige Schützenstr. 6
A-4810 GMUNDEN/Traunsee
Austria

61 VARIAN
Florham Park
NJ
USA

62 WATERS
34 Maple St.,
Milford, Massachusetts 01757
USA

63 ZEISS
D-7082 OBERKOCHEN
FRG

Appendix IV

Provisional proposal
for capital cost estimate only

First stage - R&D Laboratory at PENAL

Manpower -	Exploration/Production	15
	Petroleum products/Petrochemicals	16
	Non-technical	10
	Management	6
	(2 manager, 4 heads of groups)	
	Total	47

Space -	PVT laboratory	150 m^2
	Reservoir engineering/	
	Enhanced Oil Recovery (EOR)	150 m^2
	Processing/Products	150 m^2
	Total laboratory space	450 m^2
	Off-sites	100 m^2
	Corridors, etc.	100 m^2
	Total	650 m^2

*   **Laboratory building**

one-storied, size approximately 16 x 40 m

Typical draft of such a laboratory bulding see "first draft" on separate sheet.

- Width of axis - appr. 3,40 m
- Hoods outside installation wall
- Corridor not symmetric, with power and utilities supply along length axis, interchangeable system of lab benches and hoods (recommendation regarding supply - Gallenkamp, UK)
- No cellar - basic ground plate 2 to 3 metres above ground
- Air conditioning with fresh air intake and exchange above hoods
- Supply of - natural gas
  electricity 110/220/440 V
  pressurized air (5 bar)
  pressure gases
  evacuation (vaccum)
  steam 5/20 bar (low/high pressure)

Project should be designed by TRINTOC Engineering Department and may be reviewed in detail by the experts later.

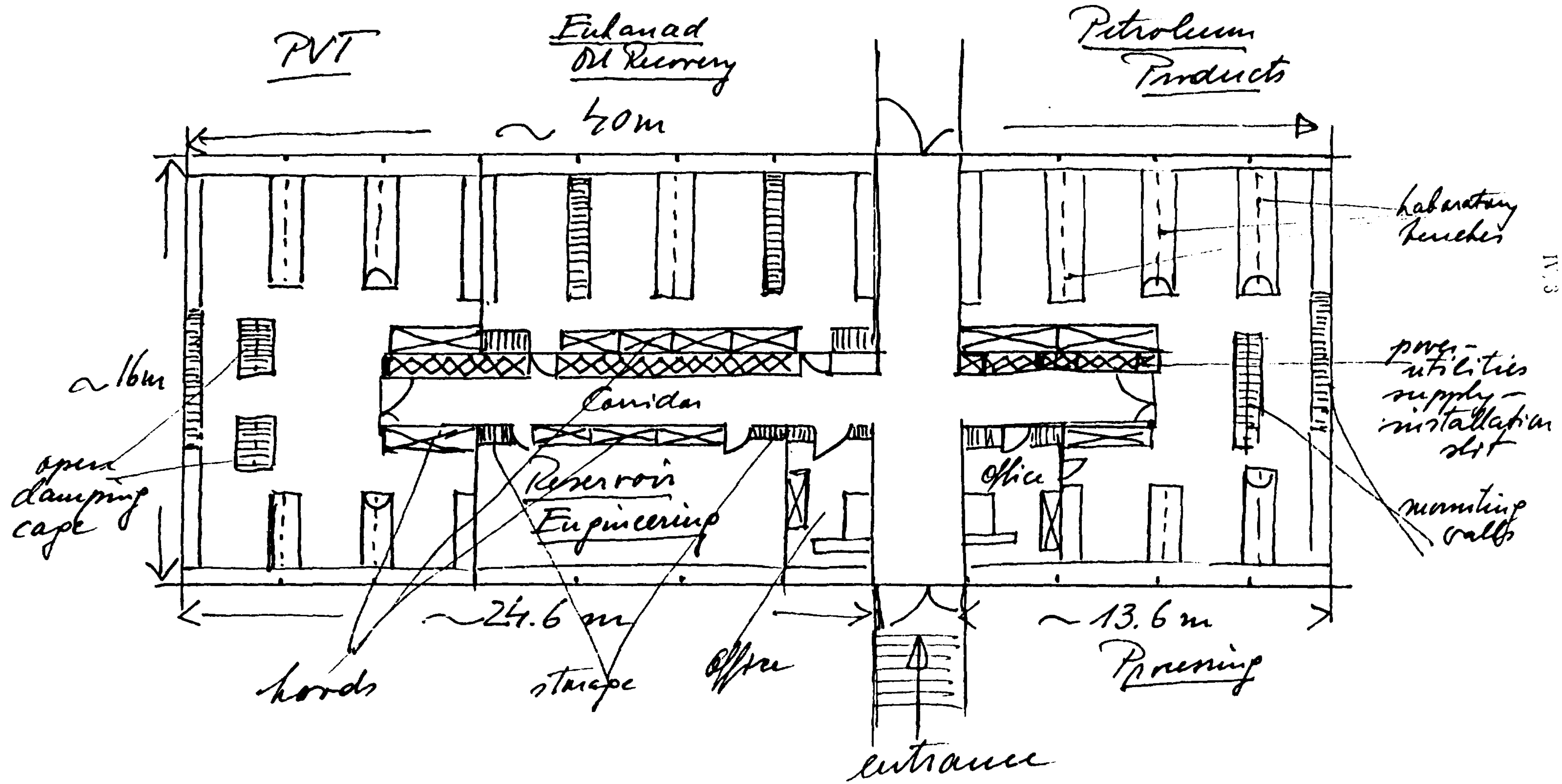
Cost estimation for laboratory building

Investment for 650 m^2 basis area with power supply, utilities, all benches and hoods, but without instrumental equipment -

AS 41.275/m^2 = 2,700.000 AS
= 3,600.000 TT$
= 1.600.000 US$

In our opinion these costs may be reduced through lighter construction - as normally used by TRINTOC under Caribbean climate conditions - for a one-storied building without heating facilities, but air-conditioning, by about 25%.

R&D laboratory – Penal (first draft)



Jan 83 Ivan

Second stage - TRINTOC R&D Laboratories

M a n p o w e r

Penal

o **Exploration & Production natural gas/petroleum**

	1st stage Penal	2nd stage Penal
Technical	15	32
Non-technical	5	10
Manager	1	1
Head of group	2	2
Total	20 + 3*	42 + 3*

o **Petroleum products/Processes/Petrochemicals**
(to be moved from Penal to selected refinery location after first stage)

	1st stage Penal	2nd stage Refin.locat.
Technical	16	47
Non-technical	5	18
Manager	1	1
Head of group	2	4
Total	21 + 3*	65 + 5*

Both together - 107 + 8*

* Manager / head of groups

<u>Port of Spain</u> (start at TRINTOC headquaters)

	1st stage Pt. of Spain	2nd stage Ref. loc. or Pt. of Spain
Economists	2	2
Process evaluation	2	6
Information/Document.	2	3
Computer	1	2
Non-technical	-	8
Total	7	21

S p a c e

Penal site

Same laboratory as in first stage but Petroleum products/Processes/Petrochemicals group moved out to selected refinery location with all instrumental equipment. Existing space is used for increasing staff and instrumentation of R&D Exploration/Production group only.

O n r e q u e s t

Pilot plant for EP use

Reservoir engineering - Enhanced Oil Recovery - size about similar to Product/Processes/Petrochemicals pilot station, full power supply and utilities - two floors working space above ground or alternatively one floor larger sized hall.

costs: ~US $ 1,6 Mio

Selected refinery location

Similar laboratory building as it will exist in Penal

Total laboratory working area	450 m^2
Offices	100 m^2
Corridors, off-sites	100 m^2
Total	650 m^2

- Ground size about 16 x 40 m
- Width of axis appr. 3,40 m
- About 2 to 3 metres above ground
  Main level equipped with all necessary utilities, power supply arranged at mid length area slit.
- Air conditioned with fresh air intake and exchange above hocds
- Supply of - natural gas
  electricity 110/220/440 V
  pressurized air (5 bar)
  pressure gases
  evacuation (vaccum)
  steam 5/20 bar (low/high pressure)

In addition -

Pilot plant building

- Ground size about 15 x 30 x 10,35 m = 900 m^2 (in two floors)

A two storied hall with all necessary installation, power supply and utilities - if necessary combined with engine test station for automotive fuels and lubricants.

Scetch of useful design see first draft.

<u>Investment</u>

Laboratory (basis area 650 m^2)

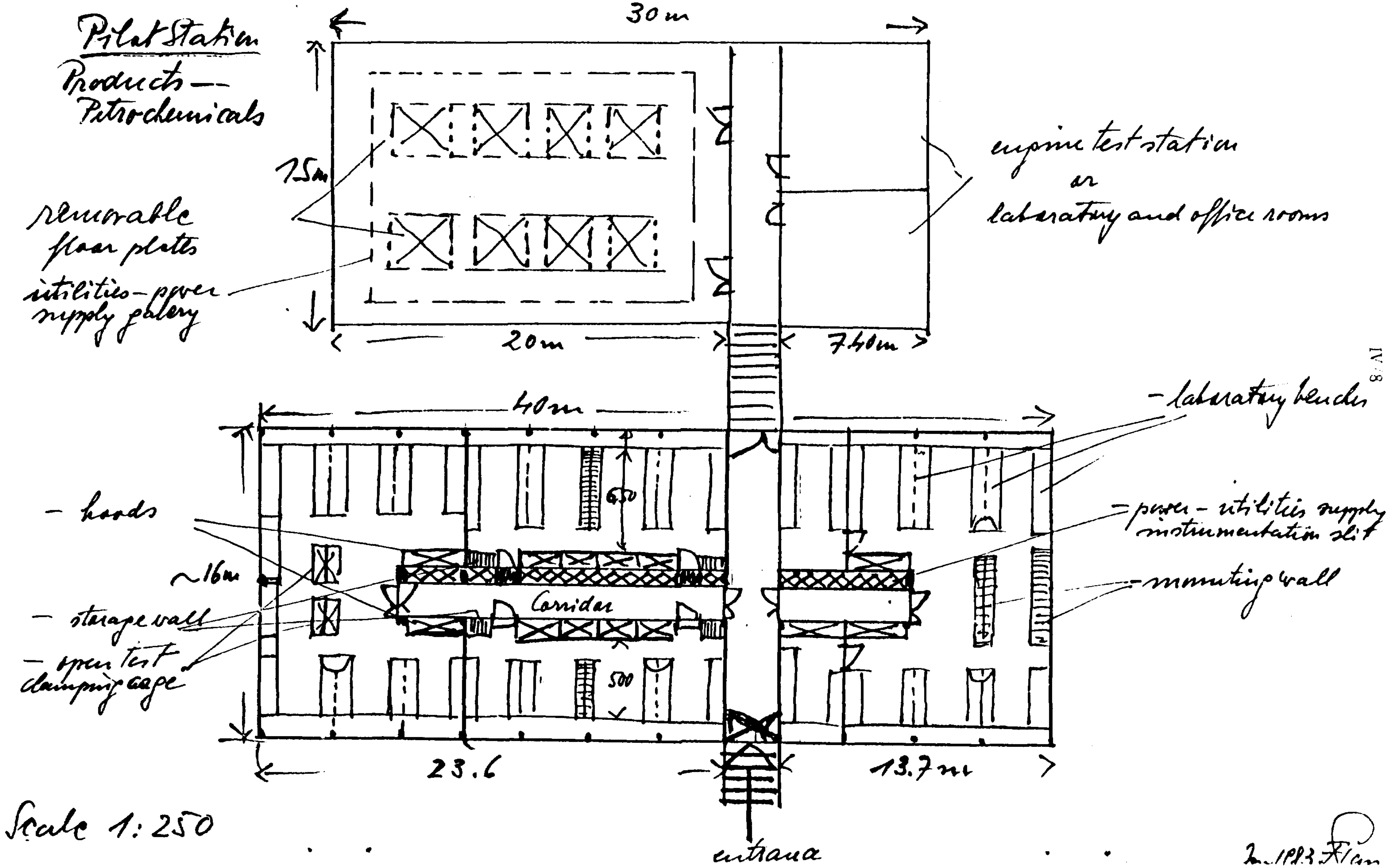
AS 41.275/m^2 = 27 Mio AS
= 3,6 Mio TT$
= 1,6 Mio US$
========================

Pilot Plant station (2 x 450 m^2)

AS 30.107/m^2 = 27 Mio AS
= 3,6 Mio TT$
= 1,6 Mio US$
=========================

Similar investment for pilot plant facilities at Penal.

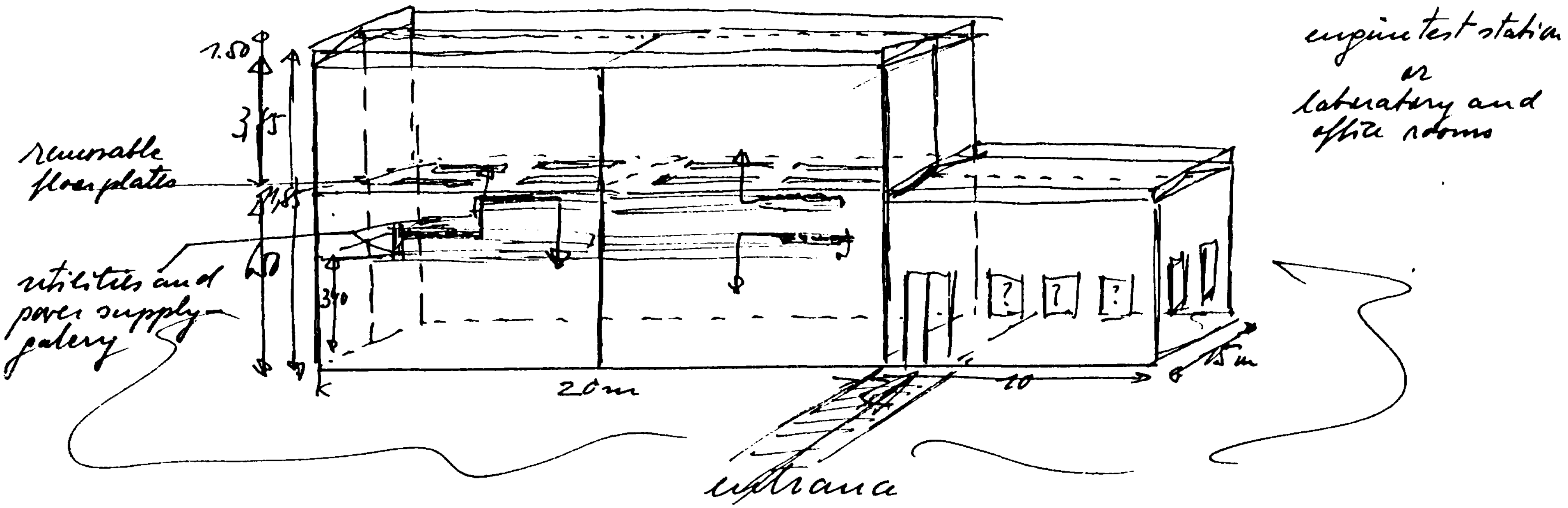
R&D Laboratory — selected refinery location (First draft)



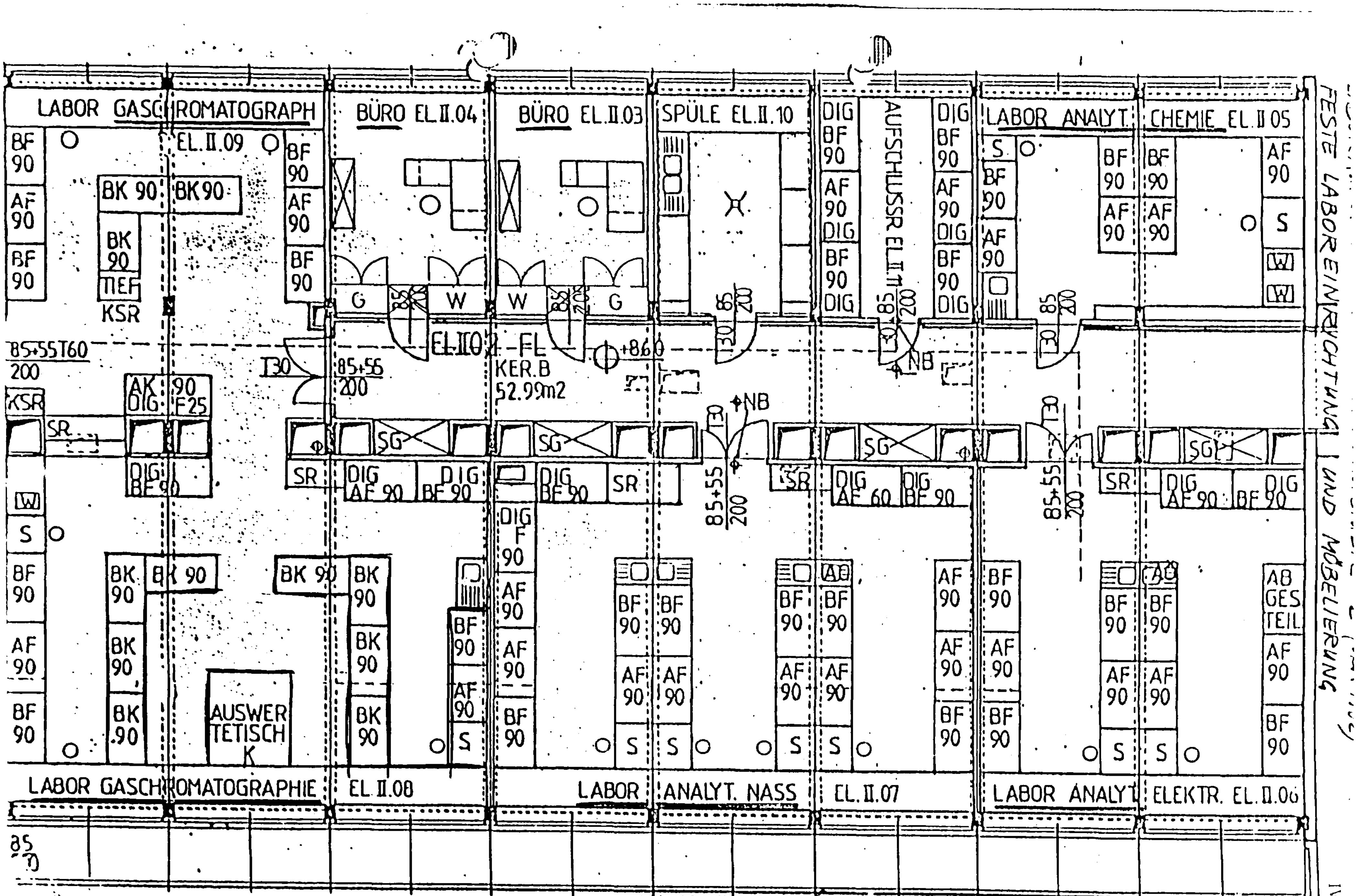
2.1983 Klam

Pilot station – petroleum products/petrochemicals (first draft)

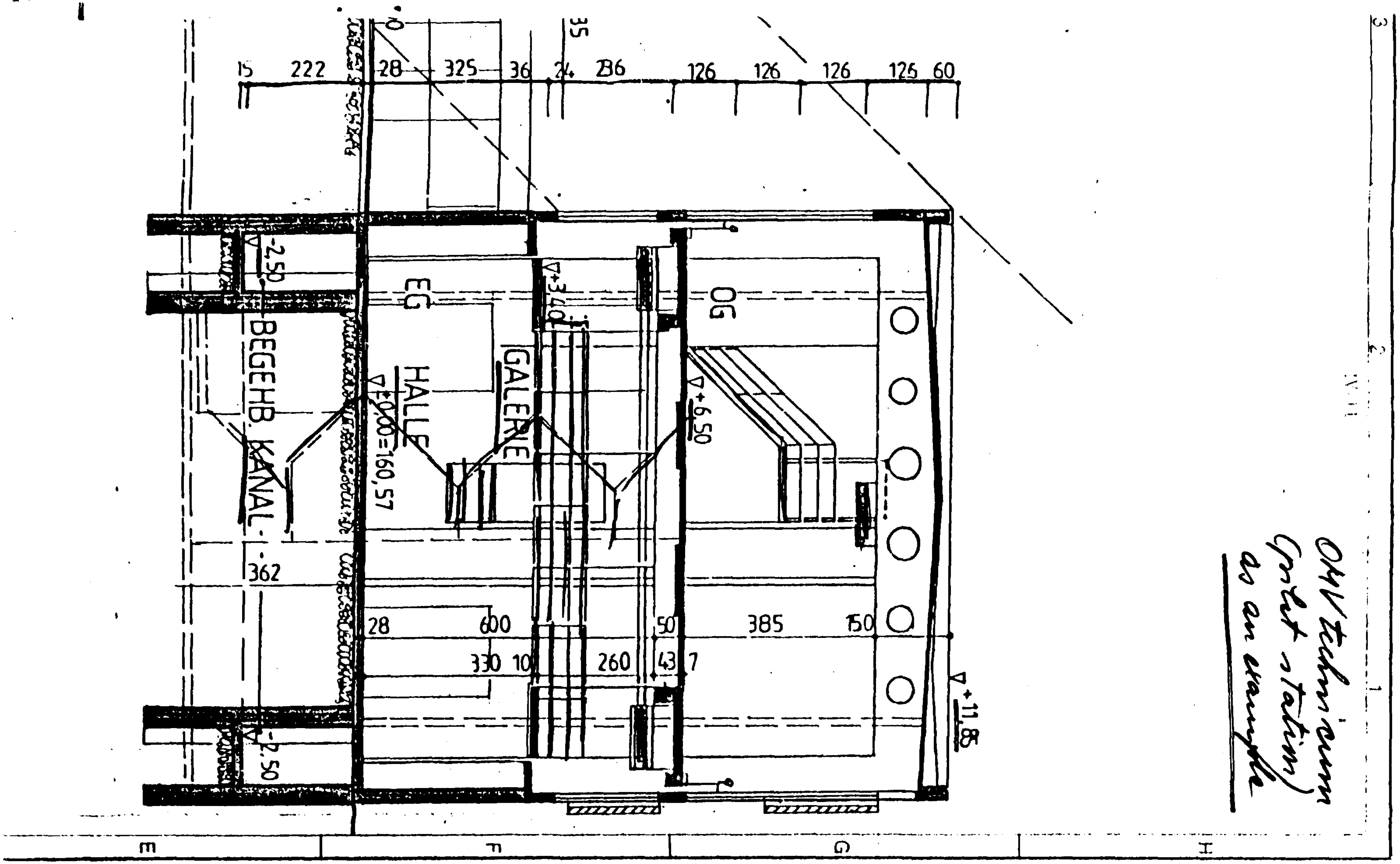
similar design – larger unit in operation at ÖMV Schwechat – R&D laboratories



Jan 83 – Pam



Example — OMV R&D enlargement project. Scale 1:100



OMV technicum (pilot station) as an example

E Q U I P M E N T

Cost estimation (in 1000 US$)

Stage (% of total)	1 (50%)	2 (30%)	rest on total	on request	TOTAL
Exploration&Production natural gas/petroleum					
Sedimentology/Paleontology	175	105	70	120	470
Geochemistry/Instrumental analysis	180	110	70	110	470
Experimental reservoir engineering	500	300	200	300	1.300
Chemical well treatment	105	60	40	-	205
Enhanced Oil Recovery (EOR)				500	500
	960	575	380	1.030	2.945
Petroleum products/Processes/Petrochemicals					
Crude oil characterization	100	60	-	-	160
Petroleum products	50	20	-	-	70
Residues/Bitumen	50	-	-	-	50
Lubricants	20	-	-	100	120
Instrumental analysis	150	90	60	-	300
Pilot plant station	-	-	-	840	840
	370	170	60	940	1.540
GRAND TOTAL	1.330	745	440	1.970	4.485

OPERATING COSTS

First stage

	Million TT$/a	Million US$/a
Exploration&Production natural gas/petroleum + Petroleum products/Processes/Petrochemicals		
Personnel	2,792	1,240
Materials and various costs[1]	0,931	0,413
Overheads[2]		
Port of Spain		
Personnel	0,469	0,208
Materials and various costs[1]	0,156	0,069
Overheads[2]		

Second stage

	Million TT$/a	Million US$/a
Exploration&Production natural gas/petroleum		
Personnel	2,590	1,150
Materials and various costs[1]	0,863	0,383
Overheads[2]		
Petroleum products/Processes/Petrochemicals		
Personnel	3,970	1,764
Materials and various costs[1]	1,323	0,588
Overheads[2]		
Port of Spain		
Personnel	1,343	0,597
Materials and various costs[1]	0,448	o,199
Overheads[2]		

1) based on experienced factor of 75% personnel costs in R&D laboratories.

2) as agreed with TRINTOC management this will not be given by the experts but estimated by TRINTOC.

Appendix V

Reasons for Expected Non-growth Situations in Industry, especially the Petrochemical Industry in Europe and USA

There are several factors which seem to justify a rather critical outlook on the future development of the petrochemical industry, especially with regard to the production of plastics and fibres. Some of them are discussed in short below.

1) Changes in the state of the societies

Already several years ago DANIEL BELL, an American sociologist, proposed a change in the emphasis of economic activities from manufacturing to services for the industrialized world (Ref. A). Based on a theory that all societies would move from a pre-industrialized to an industrialized and from that to a post-industrialized situation, Bell foresaw that in the latter the value of services including banking, hospitals and especially research activities would increase. Therefore, if the technician were typical for the industrialized situation of the social development, the scientist, i.e. the scientifically trained expert, would be so for the post-industrial times.

Such a development must depress the demand for products of the petrochemical industry as we obviously use less plastics when running an insurance company or a bank than we do when making a motor car. This steady shift of economic activity from the manufacturing sector to the service sector is making itself felt now in Europe and in the USA (Ref. B).

2) Saturation effect

Another effect tying in to some extent with the first is a saturation and end of substitution possibilities effect. At least in Europe it seems that opportunities for further substitution of traditional materials as glass, wood, etc. by plastics and fibres is close to complete for commodity grades of polymer even at today's depressed prices. Further substitution can only be expected with higher performance products in small volume markets (Ref. C).

3) Dissatisfaction effect

In Europe a growing dissatisfaction with industry and its social performance may definitely be felt especially among the younger generation (age 14 to 24 years). SHELL conducted a social study of the attitudes of young people towards the future and towards industry, which gave devasting results. Some of them were (Ref. D):

76 %	feel that chemistry and technology will destroy the environment
80 %	fear that raw materials will be scarce and economic crisis and famine will come
20 %	will vote for "green" (environmental) parties.

This dissatisfaction effect brings people to refuse plastics, e.g. in one-way throw-away flasks in Austria and the social pressure is high on the political powers to remedy this situation. Similar effects and tendencies prevail in many other areas.

4) Productivity drops

Anti-profit mindedness, over-socialization and "green" attitudes cause productivity stagnation or drops in spite of efforts to further mechanise industry.

Summing up, one could say that the expectations that economy will recover on the basis of further growth are close to illusions. Neither can it be expected that technology will do so by supplying new processes or new materials. For the large scale existing products we are in a mature phase and new processes are unlikely to be forthcoming. Also the prospect of a big scale new product to set growth off again as did the three main fibre polymers in the 1960's is remote. Ideas, new objectives and strategies related to world markets will shape the future, not new processes or products.

Ref. A DANIEL BELL
The Coming of Post-industrial Society
A Venture in Social Forecasting
Basic Books Inc. 1973, New York

Ref. B M.J. BENNETT
Vice President Chem Systems Intern. Ltd.
Paper presented at Management Center Europe Conference, Brussels, April 1982

Ref. C N.M. MIMS
CBE
Paper presented at Management Center Europe Conference, Brussels, April 1982

Ref. D A. FISCHER et.al.
"Jugend '81"
Study prepared for Deutsche Shell, edited by Jugendwerk der Deutschen Shell, Hamburg, 1981