OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

07973

Distr.
RESTRICTED

UNIDO/IOD. 153
16 January 1978

English

UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANIZATION

PILOT PLANT FOR CRUDE OIL PROCESSING,

TF/YUG/77/002
IS/YUG/74/018

YUGOSLAVIA .

Terminal report .

Prepared for the Government of Yugoslavia
by the
United Nations Industrial Development Organisation

Based on the work of Prof. Nazim M. Gusseinov,
expert in crude oil refining

id. 78-222

Explanatory notes

A comma (,) is used to distinguish thousands and millions.

A full stop (.) is used to indicate decimals.

The following abbreviations are used in this report:

NAFTAGAS	Government Petroleum Organization of Yugoslavia
Nm^3	Normal cubic metres
RDTC	Research, Development and Training Centre for Crude Oil Refining Processes
RNS	Novi Sad Refinery

The annexes have been reproduced without formal editing.

ABSTRACT

The project entitled "Pilot Plant for Crude Oil Processing" (TF/YUG/77/002, IS/YUG/74/018) arose from a request made by the Government of Yugoslavia in August 1974 for United Nations Development Programme (UNDP) assistance in the design and establishment of a pilot plant for crude oil and petroleum derivatives processing. The request was approved in March 1975, with the United Nations Industrial Development Organization (UNIDO) designated as the executing agency and the Novi Sad Refinery (RNS), a member of the NAFTAGAS petroleum organization of Yugoslavia, as the government co-operating agency. The expert began his four-month mission in September 1976, his assignment being subsequently extended a further 12 months to enable him to contribute to the solution of a number of outstanding problems relating to the project, the implementation of which was expected to take several years.

Among the conclusions of the report, the following should be noted:

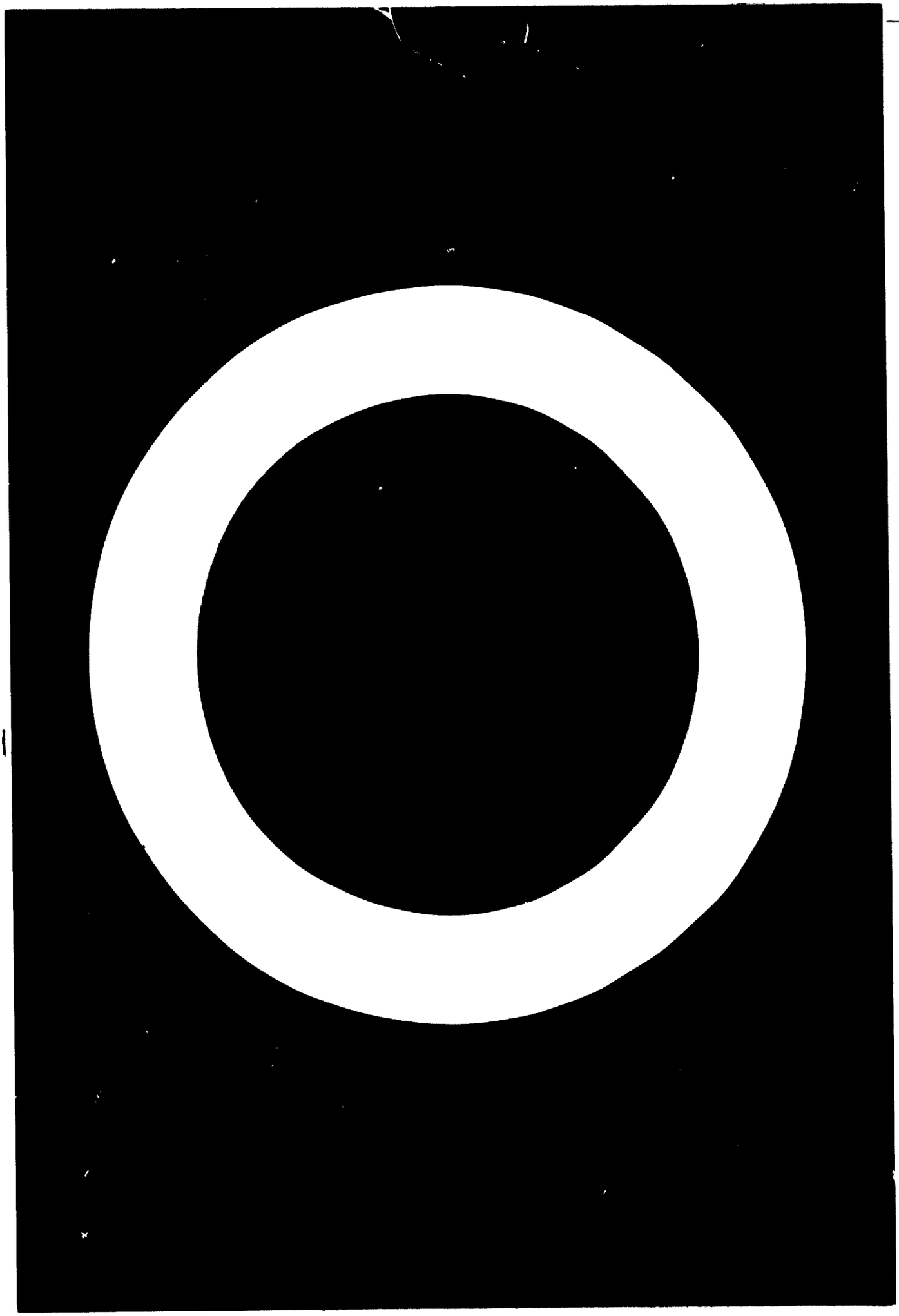
(a) The main task of the new research and development (R and D) pilot plant facility would be to ensure experimental confirmation of new licences, processes, instruments, fuels etc., in order to make recommendations for updating existing plants and constructing new commercial plants. Such a facility would make possible future development of RNS technology and products, considerably reduce the number of licences to be bought, and enlarge the knowledge and experience of RNS and NAFTAGAS experts;

(b) The equipment and materials required in the plant could be purchased locally, as local manufacturers have been found to be highly qualified and to meet international standards.

The following recommendations are also noteworthy:

(a) The proposed Research, Development and Training Centre (RDTC) should be used not only to meet the requirements of RNS and NAFTAGAS, but also to train scientific and technical staff, specialists and students from developing countries;

(b) NAFTAGAS, RNS and UNIDO should devise a programme under which RDTC would become a UNIDO international centre for research, development and training.



CONTENTS

I. INTRODUCTION

Yugoslavia plans to develop further its oil production, refining and petrochemical industries. At present 14 million tons of crude oil are processed at petroleum refineries in the country, and about 30 million tons are expected to be processed by 1990. To this end new large-scale refineries are to be built, and modern and efficient petroleum-refining processes and equipment introduced. Some of these modern plants have already been purchased abroad and will be constructed and put into operation with the assistance of experts from experienced foreign companies.

However, at this stage the Yugoslav petroleum refining industry needs to develop its own research and development (R and D) programme in order to examine and study new processes, technological systems, apparatus, equipment, catalysts and different types of crude oils so as to make recommendations for commercial plant production. Successful implementation of the task of establishing a R and D centre and solving the great number of problems which are likely to arise require extensive activities concerning scientific research and experimental work, designing, organization, construction and installation of suitable facilities.

Such an R and D Centre effectively operated could accelerate the development of national petroleum production and the processing industry, and improve conditions for training technical staff and students of petroleum chemical engineering.

NAFTAGAS is one of the biggest Yugoslav petroleum companies. It has several thousand employees. NAFTAGAS exploration, production and processing facilities are located in different parts of the country, i.e. Pančevo, Belgrade, Kikinda, Zrenjanin, Novi Sad, Elemir etc. Its major activities can be listed as follows:

Exploration, production, processing and transportation of crude oil, natural gas and their derivatives, including liquid natural gas and low-pressure gas

Commercialization and distribution of petroleum products

Preparation of investment and development programmes, including design and engineering services

Import of basic feedstocks and other petroleum products

Current development programmes have forseen construction of new projects and reconstruction and expansion of existing facilities. Especially important is the expansion of the Novi Sad Refinery (RNS).

All the above-mentioned factors underlay the decision by the Government of Yugoslavia in August 1974 to request UNDP assistance in the design and establishment of a pilot plant for crude oil and petroleum derivatives processing. The request was approved in March 1975, with the United Nations Industrial Development Organization (UNIDO) designated as the executing agency and the RNS, a member of the NAFTAGAS petroleum organization of Yugoslavia, as the government co-operating agency. The expert began his four-month mission in September 1976, his assignment being subsequently extended a further 12 months to enable him to contribute to the solution of a number of outstanding problems relating to the project, the implementation of which was expected to take several years.

In particular, the expert was assigned the following specific tasks:

(a) To assist in the design work of a pilot plant for the processing of crude oil and its derivatives. The pilot plant was to incorporate in the first stage of development two atmospheric distillation units, two vacuum distillation units, a catalytic hydrogenation unit, an absorbtion unit and a bitumen production unit. The pilot plant's activities would include collecting data and information regarding the various types of crude oil, gathering data for the design of commercial plants and training the technical personnel and students in oil refining;

(b) To co-operate in the preparation of the tender specification for contracting the basic engineering for the pilot plant and assist the installation work.

In 1971 the management of RNS had decided to build a pilot plant with several units, the purpose of which would be to collect information on different types of crude oils to be later used for commercial plant designing and operation, and for training of technical staff and students.

The original pilot plant project was critically reviewed and revised with the assistance of the expert, and the decision was taken to establish the first Yugoslav Research, Development and Training Centre for Crude Oil Refining Processes (RDTC). The idea behind that decision was that the Centre would help solve problems of RNS and broader problems of the national petroleum industry and also accelerate development of its own processes and licences competitive with those from abroad, thus reducing the need to buy them

outside the country. Such a centre would also be an additional opportunity for the country to promote its technical co-operation with other developing countries in the field of petroleum research and training of technical staff, operators and students.

Since that time many efforts have been made to carry out the project, and the following units were designed, manufactured, installed, tested, started up and finally put into operation:

Bitumen blowing unit

Catalytic hydrodesulphurization unit

Acid treating unit

Vacuum distillation unit

Microhydrogenation unit (hydroisomerization, reforming and platforming processes)

Large size hydrogenation unit (industrial tests)

Carbamide dewaxing unit

Molecular sieve dewaxing unit

Liquid phase oxidation unit

Two more units listed below are at the stage of manufacture or installation:

Automatic atmospheric distillation unit

Furfural selective refining unit

The completion of the RDTC is thought to require installation of a separate analytical laboratory and a few additional units:

Fluidized bed catalytic cracking unit

Olefin direct catalytic oxidation unit

Pyrolysis unit

Lube-oil blending unit

Deasphaltizing unit

Cold dewaxing unit

Catalyst recovery unit

The following documents were also worked out:

Orders placed to Yugoslav manufacturers to produce certain specialized pilot plant items

Recommendations regarding the aesthetic aspect of RDTC

Instruotions for start-up, testing, operation and safety of all the units

Experimental work sohedule from 1978 to 1979

Reoommendations on the oo-operation of RNS with other refineries and university oentres in the field of researoh, development and training

Reoommendations regarding Yugoslav speoialists (engineers) to be sent to experimental oentres abroad for training.

Before working out a sohedule of RDTC aotivities, RNS antioipates having its staff trained abroad and establishing teohnioal oo-operation with institutes and organizations in developed and developing oountries.

Suooessful oompletion of the projeot is of interest not only to RNS, but also to the whole national petroleum industry and various petroleum and ohemioal institutes and organizations.

RNS and NAFTAGAS attaoh great importanoe to the RDTC and the possibility of oontinuing oo-operation with UNIDO on the projeot. UNDP assistanoe is viewed in terms of servioes of highly-qualified international experts, training of Yugoslav teohnioal staff, and the purohase of oertain pilot plant equipment in order to finalize the projeot and organize the first Yugoslav RDTC for orude oil refining processes.

II. PROJECT ACTIVITIES

One of the most important and complex problems in the practical application and development of the results of scientific research and investigation in industry is that of scaling up laboratory models to commercial plants. The solution of this problem is especially important today owing to the rapid growth of petroleum chemical engineering, which opens the way to substantial changes in the petroleum industry. Each year brings new improvements in product specifications, plant product slates and output, process philosophies, methods of manufacture, equipment and facilities. Unfortunately, however, the methods currently used to solve the problem cannot be regarded as the most effective.

At present, practically the only, though the most expensive, method of scaling up laboratory results to commercial plants is by empirical (physical) modelling, that is, the method of gradually magnifying the models of laboratory and micro facilities, pilot plant and small-size plant, and eventually commercial operations.

In spite of the fast development of mathematical models, which are no doubt very promising, they cannot yet successfully replace empirical models, as quite a few problems - simulation of chemical reactions, limit stages, speed of concurrent reactions, gradual reduction of catalyst activity, the effect of by-product reaction upon the speed of the main reaction, the problems of microkinetics etc. - have not yet been solved and will probably remain unsolved in the near future. For some time to come, therefore, empirical models will remain the basic method of practical application of scientific research results in the petroleum and petrochemical industries.

The first days of the expert's assignment in Yugoslavia were devoted to specifying the details of the mission's stated goals. It was found out that RNS intended to construct pilot plant units for vacuum distillation, acid treatment, furfural refining, hydrofinishing, bitumen blowing and hydroisomerization, that is, a total of six units. The units were meant for collecting experimental data and information about different crude oils which were required for designing commercial plants and also for training technical staff and students.

During the next stage of the mission, the design, technical documentation and data for project implementation were reviewed, analysed and checked. At

the same time, together with Yugoslav experts, a number of trips were made to various petroleum, petrochemical, chemical and engineering organizations, power plants, scientific centers, institutes and universities in order to gather information on the current situation, development plans and prospects of NAFTAGAS and the national petroleum industry.

On the basis of tests, analyses and studies of physical and chemical properties of domestic and imported crudes, and taking into account the technical capacilities of local facilities, the overall project was defined, and recommendations were made on the organization of the first modern R and D centre in Yugoslavia tailored to current requirements of R and D activities in the petroleum and petrochemical industries. The main task of the centre appeared to be experimental confirmation of new licences, patents, processes, apparatus, catalysts, fuels, lubricants, petrochemicals, instruments etc., in order to make recommendations for updating existing plants and constructing new commercial plants. Such a centre, with the most modern equipment and instruments, would make possible future development of RNS processes, apparatus, products and patents, considerably reduce the number of licences to be bought, and enlarge the knowledge and experience of RNS and NAFTAGAS experts.

The RNS management consented to the proposed recommendations and asked for prompt execution of the new project.

When the expert began his assignment, installation of the first unit (acid treatment) had already been started in a hall measuring 15 m x 11 m x 8 m.

The design provided for installation of only three units in a rather large hall with separate steel structures, utilities (water, gas, air, electric power etc.) and sewer lines, automatic measurement and control instruments for each unit. The separate automatic measurement and control systems would have considerably complicated synchronous operation of the units and increased operating costs as a result of the additional time and staff required. The inefficient arrangement of the equipment and utilization of available space (8%) prevented the installation of all the units. It was decided that at least two more units had to be located in the hall, which was therefore redesigned to make possible the installation of 10 to 12 units, in anticipation of additional space requirements created by the Centre's future expansion.

As soon as the project was revised and redefined the acid treatment unit was dismantled. The revised design provided for two four-storey steel structures with fully centralized utility and sewage systems, in addition to centralized automatic measurement, control and optimization systems. In December one of the steel structures was built and the installation of three units (acid treatment, furfural extraction and vacuum distillation) was started. The units occupied only 25% of the hall space and six additional units were also installed (including units for atmospheric distillation, heterogeneous adsorption processes and carbamide dewaxing).

The original design had provided for separate compressors, pumps, and steam heaters for air, water and steam supplies. All these items were deleted and replaced by lines to industrial plant supply systems. The replacement saved many equipment items and reduced the number of operating and maintenance personnel.

Thus, in spite of extensive organizational, scientific, technical and other activities, the work in 1976 was mainly concerned with preparations for the establishment of an optimum experimental centre. At the same time, a new research programme was worked out and confirmed by NAFTAGAS, RNS, UNDP and UNIDO (see annexes II and III). In the new programme the range of the Centre's activities was considerably expanded.

The completion of the first Yugoslav R and D Centre required the performance of the tasks listed below:

Review and correction of the existing designs and preparation of new designs

Updating technical and technological solutions provided for in the designs

Designing, updating, reconstructing and installing new optimum steel structures and interconnecting lines

Designing and installing new centralized electrical and automatic measurement and control systems

Reviewing, correcting, updating and installing feed storage and distribution systems

Designing and reconstructing a new N-2 hall for heterogeneous catalytic hydrogenation processes

Preparing and issuing an N-2 hall steel structure design data for the third (large) catalytic unit with all auxiliary systems

Designing, manufacturing and installing new special gas (H_2 and N_2) storage and distribution facilities

Developing specifications and placing orders with Yugoslav manufacturers for updated equipment, materials, structures and instruments, all in accordance with the revised designs

Building optimum steel structures and installing centralized utilities (water, steam, air, gas) and sewer lines

Manufacturing and installing the pilot plant units:

Acid treatment

Vacuum distillation

Selective (furfural) extraction

Catalytic hydrogenation, isomerization, platforming, hydrofinishing (two units) and hydrodesulphurization (one unit)

Starting up the plant and establishing unit operations

As already mentioned, an optimum R and D centre requires a certain number of units to make possible the examination of basi petroleum and petrochemical refining processes and systems. It was therefore decided to build five additional units for the following operations: carbamide dewaxing, adsorption, fluid bed oxidation, automatic atmospheric vacuum distillation, molecular sieve paraffin separation. The extension was to be carried out in 1977 by RNS and by a team of Yugoslav experts. It included development of design data and designs for the new units; preparation of specifications and placing orders for new unit equipment, materials, steel structures, automatic measurement and control instruments etc.; equipment arrangement plans and installation of the units on steel structures with full utilization of existing utility lines in halls N-1, N-2 and N-3.

The tasks listed below also had to be performed:

Developing instruction manuals, flow-sheets, and other documents required for safe operation of the units

Preparing documents required for the approval of local authorities

Undertaking the start-up and test runs, ensuring operation of the units and issuing experimental data

Developing scientific and research programmes for 1978 through 1980 in acoordance with the RNS general development programme

Preparing a programme of co-operation and joint research activities with Novi Sad University, petroleum, petrochemical and chemical institutes, scientific centers, petroleum refineries, chemical plants etc.

Developing RDTC and RNS training programme for young engineers, scientists and other technical staff

Developing a programme of reports, papers, lectures, seminars, consulting sessions and discussions with petroleum and petrochemical companies, scientific centers etc.

Preparing a final report upon completion of the first Yugoslav R and D Centre

Drawing up conclusions, summary and recommendations

The above lists show that the work required to complete the project in 1977 consisted of a variety of activities very different in their nature.

It has already been mentioned that almost all designs, equipment, apparatus, instruments and structures had been provided for by foreign companies (Austria, France, Switzerland, United States etc.) in the period from 1971 through 1976. Most of the items were therefore out of date, some were corroded and some even lost. Naturally, it was not possible to ask the suppliers to replace the out-of-date items or update their designs. The possibilities of local manufacture had to be examined (modern equipment, apparatus, pumps, compressors, structures, instruments, pipes, materials etc.),and this was done together with a team of Yugoslav experts. Visits were made to various commercial and experimental plants located throughout the country. The results of the investigation showed that 90% to 95% of the equipment and materials required could be purchased locally. All manufacturers were highly qualified and conformed to international standards.

Frequent contacts and exchange of information make possible the production of a series of different products not only for the pilot plant but also for some commercial plants. As a result, the project was completely revised and updated and orders were placed with local manufacturers. In 1977 no item was purchased abroad.

The construction of six very different units had been anticipated as part of the project activities, but the arrangement plan did not take into account their specific characteristics. A new arrangment plan was therefore worked out. It was based on the unit classification concept and provided for the three separate rooms indicated below:

N-1: Primary processes of petroleum refining and distillation

N-2: Catalytic and hydrogenation processes

N-3: Oxidation processes

Such an arrangement made it possible not only to avoid extra investment (H_2 is used only in N-2, oxygen only in N-3 etc.), but also to classify the processes and select suitable operators and specialists to ensure smoother operation of the whole plant in future and to improve the quality of work and training of technical staff. The heads of the units would soon become very experienced and capable experts ready to make important contributions to the new petroleum industry of Yugoslavia.

As already stated, under the original design each unit was to be installed on a separate structure with individual utilities, sewer, measurement and control systems to make possible independent operation of the units, but such an approach implied high investment and operating costs.

The new arrangment of the units and their classification into three sections, the centralized utility supply and the installation of the units in one common structure save a large amount of money, equipment, materials, instruments and operators, and at the same time simplify the operation. The main project revisions are described below.

Hydrogenation processes are performed under high pressure (P) and temperature (T) in the presence of hydrogen (H_2) and a catalyst. They are rather complex and require great care and attention, and the safety measures applicable to these processes - their exploitation, start-up, completion, gas storage and distribution, and feed and utilities storage and distribution - are more stringent than with other processes. The operators have to be specially trained and instructed on how to run the units. The original design provided for installation of three different units on the same platform, which could not be allowed from the standpoint of equipment and personnel safety and maintenance of operating conditions under the norms and standards applicable in developed countries. Another breach of safety regulations was the installation of the units in a laboratory, i.e. installation of a process with certain parameters (P=500 bar, T=600^{o}C, H_2 and light hydrocarbons) in the presence of a considerable number of people who are not familiar with a process which can seriously endanger their lives. So a new design was worked out in order to provide a separate room (N-2) for the process in question and similar processes. The design provided for the construction of a room with light plastic and glass material walls for the three units designed and a spare space for two additional units.

One of the basic feedstocks used in that room was H_2, which required specific methods of handling and knowledge of its physical and chemical properties. Thus a separate design was worked out including H_2 storage, use, consumption and distribution from a special, insulated box in N-2. In addition to the H_2 container, there was in the box an N_2 container for system washing to remove traces of H_2 and CH. Nitrogen tail-gas removal and utilization facilities were also designed.

By the end of June the low-molecule hydrocarbon hydrogenation unit was put into operation. The unit was fully tested for operation up to 100 bar and 400°C. Naphta circulation was performed under operating conditions, pumps and coolers were checked, and material balance was made. The pilot plant unit was ready for experimental work and catalytic hydrogenation of naphthenic (light) hydrocarbons. But at that stage the work was temporarily interrupted because of the reconstruction of N-2 and two other units.

The Ball Reid (United States) microlaboratory was completely redesigned by Yugoslav specialists and installed in N-2 in August.

In order to obtain a large number of test patterns for petroleum fraction hydrofinishing and hydrogenation the team started work on a large 15-litre unit purchased several years ago from Lurgy (Federal Republic of Germany). The column was completely modified, a process flow sheet developed, and a new steel structure designed, since owing to its dimensions the column could not be placed into the hall. In October the column was completely installed and in November instrument and electrical system installation started.

All instruments (start-up, operation, shut-down, exploitation and safety) were designed subject to approval by the respective authorities. Unfortunately, the approval to operate the units required a rather complex procedure, since in Yugoslavia there are no pilot plant regulations, and the regulations applicable to commercial plants are not suitable. A request for prompt solution of that problem was written by the expert, since pilot plant centres will be developing very fast in Yugoslavia. Yugoslav specialists will have to work out instructions exclusively applicable to pilot plants, similar to those existing in almost all developed countries.

In the middle of October construction of all pilot plant units assigned to the expert (vacuum distillation, acid treatment, bitumen blowing and two hydrogenation units) was completed. The bitumen unit was also started in October, upon which commercial operation recommendations were issued.

It should be noted that certain faults occured in the bitumen unit design and construction. Such faults could have disturbed the smooth operation of the unit. Namely, oxidation of heavy naphthenic residues is performed by exothermal reactions, which require precise reaction temperature control devices in the reactor. Such a device was not provided for in the design, and the temperature rise could not be controlled. That had a bad effect upon the process regime, which in turn caused unstable bitumen properties.

The design was defective in a few other respects. Corrections were made together with the team of Yugoslav specialists. Before that time the unit practically did not operate at all. First a laboratory-size two-litre oxidizer with a temperature reducing device was designed and put into operation. The first experiments gave good results, the parameters were unchanged during operation. Based on those experiments, the pilot plant unit was reconstructed and started up in August. The operation parameters were also stable, and data were obtained with a view to issuing recommendations for the commercial plant.

The original design provided for large feed tankage (seven tanks with a total volume of 100 Nm^3) at the investment cost of 3 million Yugoslav dinars. For example, the 70-litre vacuum unit-still had a storage capacity of 1,750 l, i.e. a three to five-year feed reserve. By no means would such a large quantity of one kind of feedstock be suitable for a small-size pilot unit, with which, by contrast with a commercial plant, the type and composition of feed frequently change depending on the information to be supplied for commercial operation.

In addition, the tankage was connected to a complex steam-traced distribution system a few kilometres long. About 10,000 l of feed was required to fill the distribution system, and the amount of light fraction (naphta, kerosene, diesel fuel) required to wash the system before every exchange of feed was three times that quantity. That would have wasted large quantities of naphta or some other light fraction used for washing, raised the operating cost, and reduced the operating efficiency of the unit. Corrective measures included omission of most of the pipelines, reduction of the tankage to 15 m^3, and preparation of bottle (100 mm) storage facilities for feed and samples.

Steady operation of most processes usually requires heavy high-viscous components. They are difficult to handle and require pre-heating, especially in winter. For that purpose a heating box was installed in October. The box had a temperature of 60° to 70°C and it provided storage for the pilot plant and central laboratory samples. Similar and analogous technical solutions and updatings were made at all other units and the pilot plant as a whole.

As already mentioned, five additional units, not contemplated in the original project, were designed, manufactured and installed. That was done in accordance with the overall NAFTAGAS development programme, shown to the expert for review and comment. The realization of the programme required construction of not less than ten additional units that would have had to be built in future. It was agreed with the management to build first the priority units, including those listed below:

(a) Automatic atmospheric and vacuum distillation unit for light naphthenic hydrocarbons, chemical compounds, monomers and other petrochemical products. The unit will be manufactured by a local glass manufacturer, Boris Kidrič, Pula. It will be fully automatic with a capacity of 250 l. It will be the first time this manufacturer is to produce such a facility, although they have been working successfully for years;

(b) Unit for carbamide dewaxing of petroleum fractions manufactured by RNS;

(c) Heterogenous adsorption process unit. The unit will be manufactured and installed by RNS. It will be used for catalytic and adsorption processes with stationary contact section;

(d) Unit for molecular sieve distillation and dewaxing of gasoline and other light fractions to improve their properties;

(e) Unit for fluid bed oxidation and production of naphtenic acids. The unit will be manufactured and installed by RNS.

Thus the RDTC today has 12 pilot plant units that will enable RNS to start implementing a short-term development programme. Unfortunately, Yugoslav experts had no design data for these units, and their performance was exclusively based upon information taken from literature, i.e. reports and summaries. Obviously that could not be an optimum method for designing the unit, and it is expected that the first information obtained will not fully correspond to that derived from the design. Data will inevitably have to be adjusted and new commercial coefficients calculated, on the basis of which the units will be amended and updated.

The foregoing refers especially to oxidation of naphthenic hydrocarbons into synthetic naphthenic acids. This highly exothermal reaction requires very accurate temperature control. The design, manufacture and construction of the unit was handicapped by the lack of information on process kinetics, speed of reaction, speed constant, energy of reaction, material balance and other data. However, the specialists in charge of the unit for many years have been working in the field of naphthenic acid synthesis which encouraged the hope that in spite of the difficulties the work will be progressing quickly, and that a suitable pilot unit will enable them to solve many of the complex problems involved in the process. Good results in this area would also require co-operation with foreign experts, for example from the Union of Soviet Socialist Republics, who have made considerable progress in synthetic naphthenic acid manufacture.

To promote the activities of the Centre the team prepared a programme of co-operation of NAFTAGAS, RNS and Novi Sad University according to which the University team would prepare new synthetic catalysts to be used for the development of new hydrogenation processes in RNS pilot plant facilities. A training schedule was also worked out. It included the training of young scientific workers, and the results obtained would be applied to the commercial plant, since the main purpose of the Centre was to issue recommendations for the commercial plant, improve product specifications and outputs.

In accordance with the management's decision and instructions, individual programmes for each unit were prepared for 1977-1978 showing the activities concerning start-up, test runs and normal operation. A list of prospective research work was also drawn up in accordance with the programmes of NAFTAGAS, RNS and other petroleum companies. Start-up, test runs, shut-down, operation, safety and maintenance instructions were made for each unit.

By the end of December 1977 seven units were tested: hydrodesulphurization, hydroisomerization and hydroreforming (micro facility), bitumen blowing, acid treatment, vacuum distillation, carbamide dewaxing and heterogeneous adsorption processes. The tests showed that the units were ready for normal operation, but the insufficient number of operators did not allow starting them up simultaneously. At the meeting with the RNS management it was decided to prepare a general pilot plant schedule determining normal operation of the units after they are tested. The only unit that was delayed was the furfural

extraction unit, as Kühni (Switzerland) did not send missing structure and piping items in time. The unit will be started early in 1978. With respect to its technical level, effectiveness, economics and aestetics, upon the completion of the overall project, the RNS experimental centre will be one of the best R and D centres in the world.

During the project, in agreement with NAFTAGAS and RNS, the expert prepared a number of lectures, consulting sessions, reports, studies and colloquys at the Universities of Novi Sad, Belgrade, Zagreb, Sarajevo and Ljubljana, chemical institutes and centres, refineries, petroleum companies, plants and enterprises (at Novi Sad, Belgrade, Zagreb, Sarajevo, Skoplje, Kikinda, Zrenjanin, Elemir, Pančevo Niš, Slavonski Brod, Slavonska Požega, Kraljevo, Kula, Pula, Sisak, Osjek, Kelebija etc.), about 150 in total, with more than 3,000 listeners and participants. The titles of the major lectures are listed below:

The importance of crude oil and its rational processing

Theoretical principles of chemical engineering

Chemical kinetics and selection of optimum reaction system

Gaseous hydrocarbons and their place in petrochemical and chemical industries

Principles of heterogeneous catalytic processes

Dewaxing and effective wax processing

Catalytic cracking and manufacture of super gasoline

Heterogeneous and catalytic hydrogenation in petroleum processing

Solid catalysts

Pyrolysis of naphthenic crude

Olephine and aromatic hydrocarbons and their place in petroleum industry

Straight catalytic oxidation of low-molecule olephines

Principles of exothermal oxidation processes technology

Pilot plants and their place in petroleum, petrochemical and chemical industries

Empirical and mathematical models in chemical engineering

Scaling up pilot plant data to industrial plants

Optimum refinery in future

On 29 June 1977 the UNDP Resident Representative and a Yugoslav government official visited RNS to ascertain the status of the project. The ..

Resident Representative expressed his high opinion of the work performed and congratulated NAFTAGAS on the creation of the first Yugoslav R and D Centre. From 14 to 25 November 1977 an official representative of UNIDO visited Yugoslavia in order to acquaint himself with the further development of the project and his appraisal of the work executed was also very favourable. During the meeting the parties prepared draft project documents stipulating project development until 1980 and signed a protocol (see annex IV) which was sent to Yugosláv, UNDP and UNIDO authorities for review and approval. At the beginning of December 1977 the documents were given a preliminary review and approved in principle by UNIDO, but the final decision is expected only in early 1978.

III. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

1. The main task of the new R and D Centre would be to ensure experimental confirmation of new licences, patents, processes, apparatus, catalysts, fuels, lubricants, petrochemicals, instruments etc., in order to make recommendations for updating existing plants and constructing new commercial plants. Such a Centre would make possible future development of RNS processes, apparatus, products and patents, considerably reduce the number of licenses to be bought, and enlarge the knowledge and experience of RNS and NAFTAGAS experts.

2. The original design of the Centre was considerably revised in accordance with the overall NAFTAGAS development programme to ensure efficient arrangement of equipment and utilization of available space, to avoid extra investment, to ensure smoother operation of the whole plant in future, and to improve the quality of work and training of technical staff.

3. A study of local manufacturing potential and visits made to various commercial and experimental plants located throughout the country showed that 90% to 95% of the equipment and materials required in the Centre could be purchased locally, and that local suppliers were highly qualified and met international standards.

4. The RDTC currently has 12 pilot plant units that will enable RNS to start implementing a short-term development programme. However, Yugoslav experts had no design data for these units, and their performance was exclusively based upon information taken from technical literature, i.e. reports and summaries. It is therefore expected that the first information obtained will not fully correspond to that derived from the design. Data will inevitably have to be adjusted and new commercial coefficients calculated, on the basis of which the units will be amended and updated.

B. Recommendations

The centre should be entitled "Research, Development and Training Centre for Crude Oil Refining Processes", Novi Sad Petroleum Refinery, NAFTAGAS, Novi Sad, Yugoslavia.

One of the main problems to be faced by RDTC is the rational and effective exploitation of the Centre for the benefit of RNS, NAFTAGAS and the Yugoslav petroleum industry. For this purpose a few measures have to be

carried out both today and in future. Some of them are indicated below.

1. The organization of RDTC should be worked out to show the following:

(a) The authority under which RDTC operates, preferably one of the officials from the technical management of RNS;

(b) The number of specialists permanently employed with RDTC, such as engineers, scientific workers, instrument operators, technicians, maintenance workers;

(c) The primary processes and distillation division;

(d) The heterogeneous and catalytic hydrogenation division;

(e) The oxidation processes (liquid phase) division;

(f) The heads of each division;

(g) The organization of RDTC in the first phase (during start-up activities);

(h) The organization of RDTC in the second phase (during stable operation);

(i) The organization of RDTC upon completion of the extension (1978 to 1980).

2. Regulations on pilot plant commissioning and exploitation should be worked out and established through the respective Yugoslav authorities.

3. At the beginning of 1978 Yugoslav specialists should be sent to the Union of Soviet Socialist Republics and other countries for several months to familiarize themselves with pilot plant exploitation. Chemical engineers would study methods of digesting and preparing information to be used in pilot plant designing, construction and operation. Chemical engineers, engineering specialists and mathematicians would study methods of selection of pilot plant experimental data and scaling up such information to commercial units. A study would also be made of methods of developing patents and licences on pilot plants and that experience would be used later in the operation of RDTC.

4. Programmes of activities for 1978 and thereafter should be drawn up. This would involve the preparation of the following:

(a) A schedule of activities of RDTC and each of its units, all in accordance with the NAFTAGAS and RNS development programme;

(b) A schedule of training of specialists, scientific workers, engineers, technicians, operators, students etc.;

(c) A programme of co-operation of RNS and NAFTAGAS with other refineries, petroleum organizations, institutes and universities;

(d) A long-term programme of co-operation with some firms and organizations in foreign countries, for example the Union of Soviet Socialist Republics, in oil and gas processing, minimizing wastes, patent development etc.

5. In co-operation with UNIDO, a document should be prepared stipulating the conditions under which RDTC can be used as an international centre for training specialists from developing countries. A programme of such training activities should also be developed in co-operation with UNIDO.

6. The manufacture of highly purified products (oils, waxes, stabilizing components, monomers etc.) should be organized on a commercial basis for the chemical industry, cosmetics, pharmacies, the textile industry, research and other areas.

7. A small control laboratory for continuous control of pilot plant operations should be organized.

8. In close co-operation with NAFTAGAS, a centre for the computerization of experimental data obtained in RDTC and the preparation of recommendations for commercial units should be planned and developed.

9. The future expansions of RDTC should include the units listed below:

Modern catalytic cracking facility

Universal facility for exothermal catalytic processes of direct oxidation, chlorination, ammoniation, polymerization etc.

Thermocontact pyrolysis facility

Catalyst synthesizing unit

Fuel and lube-oil blending facility

Deasphalting

Cold dewaxing

Dehydration

10. Research and development activities in the fields listed below should be accelerated:

Petrochemical synthesis

Production of monomers for organic synthesis

Production of straight-run, 95-98 octane gasoline with no tetraethyl lead injection

Annex I

HOST COUNTRY PERSONNEL

Mr. Bojan Kosić, Chemical Engineer
Manager Processing Division.

Mr. Slobodan Repić, M.S. of Chemistry
Head Pilot Plant.

Mr. Djordjo Maletić, Chemical Engineer
previous Manager Development Department.

Mrs. Bogdanka Mamuzić, Chemical Engineer
Chief Pilot Plant Catalytic Unit

Mr. Slobodan Mihalački, Chemical Engineer
Chief Pilot Plant Oxidation Unit

Mr. Dragiša Vasiljević, Chemical Engineer
Pilot Plant Engineer

Mrs. Dušanka Antonijević, Chemical Engineer
Pilot Plant Engineer.

Annex II

WORK PROGRAMME

PROJECT: TF/YUG/77/001/11-02 to design and set-up a pilot plant processing the crude oil and its derivaties.

DATE: January 1977

COUNTRY: Jugoslavia, "NAFTAGAS" Companies, RNS

DURATION: One year, until 31st december 1977.

Expert in crude oil processing prof. Gusseinov N.M.

In accordance with JOB Description and the PROGRAMME 1976 and 77 which was handed over to you previously, the mission of UNIDO expert, prof. N. Gusseinov will be continually executed in co-operation with a team of Jugoslav experts in rafineries, crude oil processing facilities, scientific centers, engeneering bureaus, universities, enterprices, companies manufacturing crude oil processing equipment, facilities, and instruments in Belgrade, Zagreb, Novi Sad, Kikinda, Rijeka, Pančevo, Ljubljana, Skople, Sarajevo, Pula, Kula, Velebit, Velebija, Sisak, Nish, Sambor Subotica, Zadar, Kraljevo, Slavonski Brod, Slavonska Požega, Elemir, Zrenjanin etc. in accordance with the enclosure. Prof. Gusseinov N. will be a consultant and should assist the Jugoslav counterpart with completion and organization of the Experimental centre with several pilot plants in RNS "NAFTAGAS" Yugoslavia.

The Experimental centre's activities will include research, testing, collecting data and information regarding the various types of crude oils, gathering data for the design of commercial

plants ant training technical personnel and students in oil refining.

The expert should prepare in cooperation with his counterpart the tender specification for contracting the basic engeneering for the pilot plants and assist during the correction work.

In accordance with the above description the work presupposes, practically for the first time in Yugoslavia, organization of experimental production in pilot plant units in order to examine and study new processes, technological systems, apparatus, equipment catalysts, different types of crude oils, and to make recommendations for commercial plant production.

It has already been made known that not only Novi Sad Refinery is interested in the Experimental centre with pilot plants, but also other scientific institutions, NOVI SAD Technological Faculty, as well as the whole community, having in mind that the pilot plants should also be used for experiments and tests to be performed for the new Petroleum and Petrochemical Institute.

Yugoslav specialists are at the begining of a large and rather complex and serious problem the successiful solution of which would require numerous scientific technical, esperimental, design organisation, construction, installation, and other activities.

The work would spread over several years, and only the scope of work described above would take at least 12-18 months under the most favourite conditions and the most active perfomance.

The activities listed are to be performed within twelve months of the current year. Expert, prof. Gusseinov N.M. would be engaged as consultant and would render scientific, technical and organizational assistance to Yugoslav specialists during performance of the work.

PROGRAMME OF ACTIVITIES IN 1977.
FOR COMPLETION AND ORGANIZATION OF THE
EXPERIMENTAL CENTRE WITH SEVERAL PILOT
PLANTS IN "NAFTAGAS", RNS, YUGOSLAVIA

No.	A C T I V I T Y	PERIOD OF REALIZ.
1.	Completion of reconstruction of the pilot plant hall	may
	1.1. Design and construction of central pilot-plant safety system plants for furfurol extraction, acid trating, and vacuum distillation - with possibility of extending supply lines in future.	january april
	1.2. Design and construction of centralized system of automatization, optimization and control of regime of examined processes with spare capacities for future expansions.	
	1.3. Completion of construction of metal structure for standing equipment.	april
	1.4. Design and instalation of ventilation system of the hall.	february june
	1.5. Construction of the second gallery (metal contruction).	Next year
2.	Acid trating pilot-plant	
	2.1. Completion of installation of the equipment, apparatus, electrical insulation, automatization system, discharge lines and connection to the centralized system.	januaru may
	2.2. Start-up and test-run activities, becoming aquainted with the new apparatus and system	june
	2.3. Composition of instructions, starting of pilot-plant on continuous working and distribution of data for commercial plants.	June September

No.	A C T I V I T Y	PERIOD OF REALISATION
3.	Vacuum distillation pilot-plant	
	3.1. Completion of construction and installation of the equipment, apparatus, electrical insulation, automatization system, discharge lines and connection to the centralised system.	February
	3.2. Start-up and test-run activities, becoming aquainted with the new appartus and system, composition of instructions, continuous working of pilot-plant and istribution of data for commercial plants.	June September
4.	Pilot-plant for treating of heavy oil hydrocarbons with furfurol.	
	4.1. Completion of construction and installation of the equipment, apparatus, electrical insulation, automatization system, discharge lines and connection to the centralised system.	September
	4.2. Start-up and test-run activities, becoming aquainted with the new apparatus and system, composition of instructions, continuous working of pilot-plant and distribution of date for commercial plants.	October December
5.	Pilot-plant of hydrogenization of lights oil Hydrocarbons.	
	A) 30-35 atm. B) 100-200 atm.	
	5.1. A) Start-up and test-run activities, becoming aquainted with the new apparatus and system, composition of instructions, continuaus working of pilot-plant and distribution of date for commercial plants.	March September
	5.2. B) Reconstraction, start-up and test-run activities, becoming aquainted with the new appartus and system, composition of instructions, continuous working of pilot-plant and distribution of date for commercial plants.	April Octobar

No.	A C T I V I TY	PERIOD OF REALISATION
6.	Pilot-plant for hydrogenization, izomerization and platforming.	
	6.1. Projection, completion ofconstruction and installation of the equipment, apparatus, electrical insulation, automatization system, discharge lines and connection to the centralised system	Jule Avgust
	6.2. Start-up and test-run activities, becoming aquainted with the new apparatus and system, composition of instructions, continuous working of pilot-plant and distribution of date for commercial plants.	September December
7.	Pilot-plant for hydrogenization and treating of lubrycations.	
	7.1. Completion of construction and installation of the equipment, apparatus, electrical insulation, automatization system, discharge lines and connection to the centralised system.	Maj June
	7.2. Start-up and test-run activities, becoming aquainted with the new appartus and system, composition of instructions, continuous working of pilot-plant and distribution of date for commercial plants.	August December

Pilot plants who it is necessary to have in the Experimental Centre in RNS NAFTAGAS.

1. Atmospheric distillation plant - 2
2. Deparafinization unit
3. Adsorbtion unit
4. Heterogen-catalitic proccesing's unit.

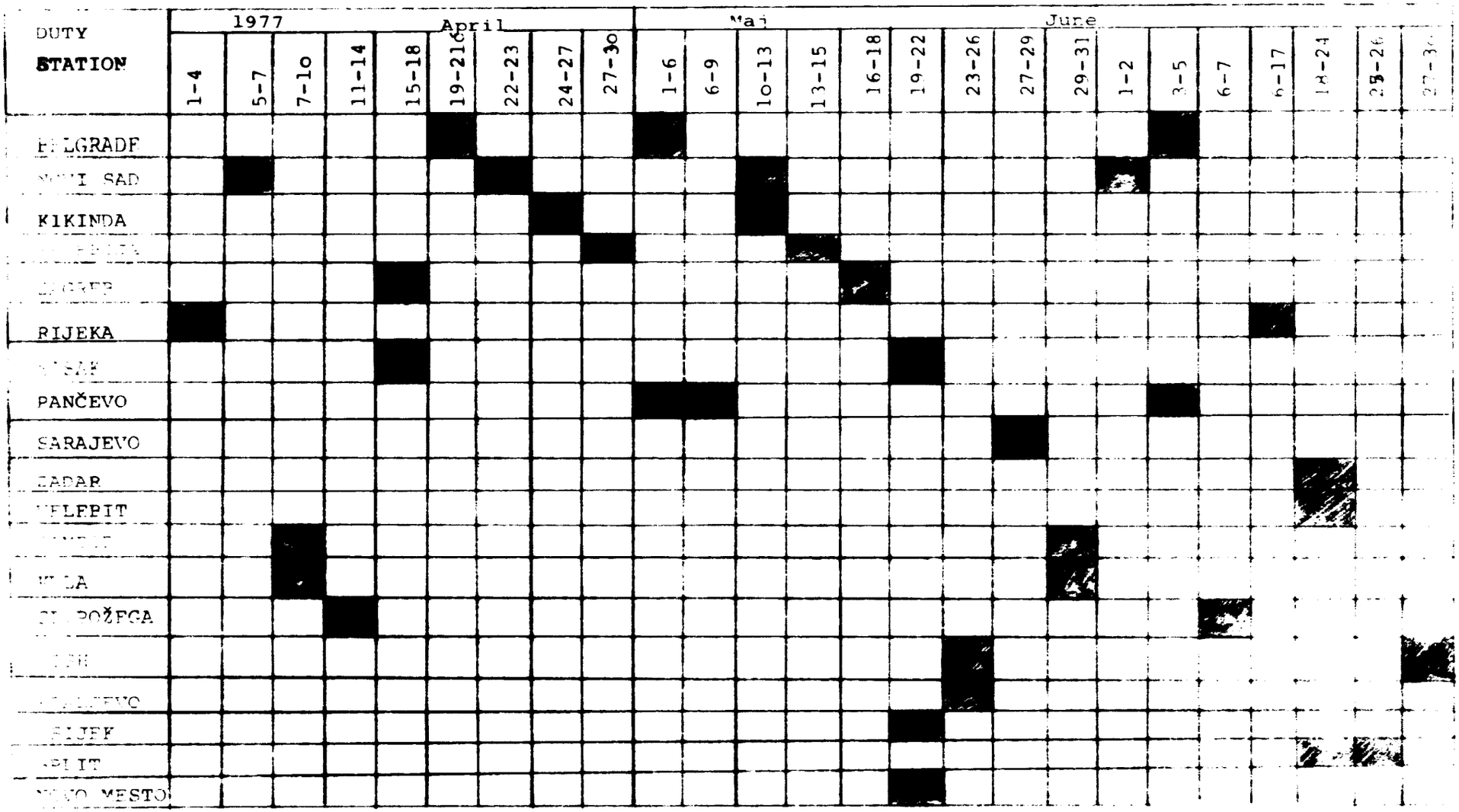
Training the technical personnel and students in oil refining may be after the completion and installation of pilot-plants in 1977

ENCLOSURE TO THE PROGRAMME

DUTY STATION	January					February									March								
	16-17	17-18	19-20	20-29	30-31	1-5	6-9	10-11	12-16	17-19	19-22	22-23	23-24	25-28	1-3	3-6	6-8	9-10	11-16	17-19	19-21	22-25	25-31
BELGRADE																							
PANČEVO																							
NOVI SAD																							
ZRENJANIN																							
KIKINDA																							
ELEMIR																							
KELEBIJA																							
ZAGREB																							
SISAK																							
NISH																							
KRALJEVO																							
SUBOTICA																							
KULA																							
SKOPLJE																							
SARAJEVO																							
ZADAR																							
LJUBLJANA																							
RIJEKA																							
KRK																							
SL.BROD																							
SL.POŽEGA																							

Note: Dates and places may be changed, as needed, to carry out the mission.

ENCLOSURE I TO [illegible] PROGRAMME



Note: Dates and places may be changed, as needed, to carry out the mission.

For successful and timely execution of the above described work, the following equipment, has to be purchased, prepared and installed by Yugoslav enterprices: apparatus, fittings, stealstructure, crude oil processing equipment and facilities, electrical and electronical equipment, automatic control instruments, pumps, compressors etc. The enterprices are located in above mentioned cities and towns of Yugoslavia.

Head of the Yugoslav team of Experts,

Dj. Maletić

January, 1977.

Expert of crude oil refining,

Prof. N. Gusseinov

January, 1977.

NAFTAGAS
RAFINERIJA NAFTE U NOVOM SADU
NOVI SAD

Annex III

RESEARCH PROGRAMME FOR THE PILOT PLANT

1.0 Process Description

1.1 Vacuum Distillation

The unit is discontinuous. It has a still of 150 l and four receivers of 12 l. The main purpose of the unit is to simulate commercial operation and to obtain oil fractions to be used as feed for other units of the plant and refined to finished products.

1.2 Bitumen Blowing Unit

The unit is discontinuous (batch blowing). It has a capacity of 100 l. The plant is designed to simulate commercial operation taking ito account all limitations laid down by the theory of similarity.

Bitumen blowing is a process in which vacuum residue comes in contact with air giving products with modified properties.

1.3 Acid Treating

The unit is discontinuous. It has a capacity of 70 l. The purpose of the unit is to produce oils of specified quality by minimizing the amount of components which reduce oxidation stability of oils. The unit also offers opportunity to investigate and establish optimum parameters for commercial operation. Vacuum distillates, used as feed stock for the unit, undergo "dry" and "wet" refination to obtain required raffinates.

1.4 Solvent Extraction

Solvent extraction, as a physical separation process, is applied to manufacture high grade lubricating oils in terms of oxidation stability and high viscosity index.
The undesirable components contained in the lubricating oil fractions can be removed by better selection and ratio of solvent (furfural, phenole) and feed (vacuum distillates) as well as by application of certain operation parameters.
The unit is discontinuous with solvent recovery. It has a capacity of 180 l/h.

1.5 Catalytic Unit

The unit is flexible enough to allow for alternate running of three processes depending upon feed, catalyst and operating conditions:

- platforming
- isomerization
- hydrogenation

Platforming is used to convert low octane number straight-run gasoline (93-171°C) to high octane number gasoline.
Isomerization is used to convert normal C_5/C_6 rings to iso-rings, high quality products, which are blended with gasoline to improve octane number.
Hydrogenation is a process in which low quality gasolines and oils are subjected to hydrogen treatment to obtain high quality products.

1.6 Hydrodesulphurization

The unit has a capacity of 0.4 l/h . The unit will be used for hydrodesulphurization and hydration of gasoline, benzene, in gaseous phase.

Hydrodesulphurization is a process applied to remove sulphur, nitrogen and oxygen which are components undesirable in the finished products.

1.7 Tankage

A tankage of seven tanks is provided to store feed stocks and finished products.

V = 25 m^3 ..... 2 pcs.

V = 4 m^3 ..... 2 pcs.

V = 1.7 m^3 ..... 1 pc.

V = 4 m^3 ..... 2 pcs.

Slop

2.0 Investment Cost Estimate

Estimate for 1977

2.1 Tankage and civil works	**1,500,000.-**
2.2 Utilities	**1,000,000.-**
2.3 Ventilation and heating	**150,000,-**
2.4 Hydrodesulphurization - reconstruction	**50,000.-**
2.5 Flexible catalytic unit - Ball Reid	**100,000.-**
2.6 Large unit for hydrogenation	**300,000.-**
2.7 Acid treating	**420,000.-**

2.8 Vacuum distillation	200,000.-
2.9 Solvent extraction	1,280,000.-
2.10 Bitumen blowing	300,000.-
TOTAL:	5,300,000.-

NOTE: The amount of funds estimated and approved for 1977 did not provide for 500,000.- Yugoslav dinars required to cover the catalytic unit.

3.0 General Time Schedule

Activity	Duration (days)	Completion
1. Ventilation and heating		
2. Utilities		
3. Electrical distr.		
- design	60	1st May, 77
- execution	30	1st June, 77
4. Tankage		
- design revision	30	15th April, 77
- civil works tender collection	15	15th April, 77
- civil works and tank erection	30	1st June, 77
5. Fire proofing		
- approval by local authorities	30	1st May, 77

3.1 Catalytic Unit

The activities related to this unit iclude:

- covering of the unit
- installation, interconnection, start up and operation of Ball Reid flexible catalytic unit
- installation. interconnection, start up and operation of hydrogenation unit.

Activity	Duration (days)	Completion
1.1 Closing of the unit		
1.2 Designing and securing of financial resources		
1.3 Construction	60	20th April, 77
2. Ball Reid catalytic unit		
2.1 Installation	10	
2.2 Interconnection	20	
2.3 Automatics and control		
2.4 Start up		
3. Hydrogenation 2		
3.1 Mechanical and electrical design	60	
3.2 Steel structure	15	
3.3 Sewer	15	
3.4 Installation	30	

Activity	Duration (days)	Completion
3.5 Interconnection	15	
3.6 Automatic measurement and control	15	
3.7 Start up		

3.2 Acid Treating

Activity	Duration (days)	Completion
1. Mechanical completion	7	20th April, 77
2. Electrical - 13.5 KW	14	25th March, 77
3. Power supply - 140 KW	30	20th April, 77
8		

3.3 Vacuum Distillation

Activity	Duration (days)	Completion
1. Heater manufacture	30	
2. Still erection	3	
3. Pipeline construction	15	20th April, 77
4. Insulation	15	
5. Electrical	10 - 15	20th April, 77
6. Automatics	10 - 15	
7. Start up		1st May, 77

3.4 Solvent Extraction

Activity	Duration (days)	Completion
1. Main mechanical design	20	10th April, 77
2. Steel structure foundation	10	4th April, 77
3. Main equipment installation, anchoring, tank support columns	14	21st April, 77
4. Pipeline construction	30	1st Sep., 77
5. Heater erection and connection to pipelines	15	15th Sep., 77

NOTE: Pipeline and heater construction depends upon delivery time from abroad, and can be only indicatively estimated.

6. Installation of measuring and control instruments, panel erection, electrical and automatics	45	15th Sep., 77
7. Equipment and piping insulation	15	1st Oct., 77

4.0 Program approved for 1977

4.1 Experimental units'hall

a) Vacuum distillation pilot plant unit

b) Acid treating pilot plant unit

c) Furfural extraction pilot plant unit

d) Bitumen blowing pilot plant unit

4.2 Catalytic units' hall

a) Reforming and isomerization pilot plant units

b) Hydrodesulphurization pilot plant unit

c) Large (up to 20 l/h) hydrogenation pilot plant unit

The completion of the above plants requires the following activities to be carried out:

- Testing of the main equipment and apparatus and classifying and filing the documentation;
- Testing of all electrical and instrument lines and clasifying grounding documentation;
- Preparation of instruction manuals (operation, fire-fighting, safety);
- General pilot plant operation program and schedule;
- Organize and establish a laboratory and personnel responsible for analysis and control of respective products;
- Determine operators for continual operation of each unit

4.1.1 Vacuum Distillation Schedule

No.	Activity	Number of tests	Duration (days)	Number of operators
1.	Commissioning of the unit acc. to the flow sheet, starting of all utility lines	30 - 40*	30 - 40*	
2.	Prepare ethanol mixture of black oil, experimental distillation for outlet functions, determine effectiveness of the column	20	20 - 30	
3.	Distillation of black oils from commercial plant, analyses of the results, their correlation	20 - 25	20 -30	
4.	Determine the effect of temperature and vacuum conditions upon the products(under a special program with complete analysis)	40 - 50	30 - 40	
5.	Composition ofmixture of black oils from different crudes(Velebit, Kelebija), vacuum distillation, analysis of the flows (as planned)	60 - 70		
6.	Determine the effect of steam and natural gas on products obtained by vacuum distillation of black oil from different crudes (special program)	30 - 40		
7.	Determine optimum regime of operation for black oil vacuum distillation on basis of the previous tests	5 - 10		
8.	Prepare data for commercial operation to increase their effectiveness	5 - 10		

NOTE: * The numbers of tests and durations indicated can vary depening upon the results obtained from the first tests stable operation of the plant.

No.	Activity	Number of tests	Duration (days)	Number of operators
9.	Determine optimum regime of operation on basis of vacuum distillation of acid sludges from commercial plant and pilot plant unit	20	15-20	
10.	Experimental selection ofoptimum feed for sludge coal (under the program)	30	30	
11.	Purification of residual oils (vacuum and acid treating) - the amount depending upon the volume required	10	10	
12.	Blending of vacuum residues and sludge residues to obtain high quality machine, industrial and other oils	20	5	
13.	Determine optimum regime ofsludge vacuum distillation, blending and issue recommendations for commercial plant	10	10	
14.	Experimental obtaining of optimum samples of special ethalon oils	20	30	
15.	Motor laboratory testing of special oils obtained in the plant	continually		
16.	Develop operating conditions for special oils	continually		
17.	Prepare different experimental samples of special oils	20	20	

4.1.2 Selective (Furfural) Extraction

No.	Activity	Number of tests	Duration (days)	Number of operators
1.	Pressure and sealing testing of all equipment, apparatus and fittings under the flow sheet			
2.	Experimental testing of main equipment items and apparatus		10-15	
3.	El. proofing testing			
4.	Testing of automatic instruments, measurement and control systems			
5.	Experimentally determine the time required to heat up the unit and establish operating conditions			
6.	Test the column, establish the operation with ethalon mixture and determine the effectiveness of operation	10	5-5	
7.	Test the extraction column, establish the operation with ethalon mixtures, determine the effectiveness of operation	20	10-15	
8.	Test the mechanism, accuracy volume and productivity of feed, circulating and other pumps and meters			
9.	Test circulation and establish flow of feed from tankage to the aaparatus under the flow sheet			
10.	Prepare instruction manuals (operation, fire-fighting and safety)	100	40-60	
11.	Selective extraction of oil fractions obtained from commercial plant (special program)	100	40-60	

No.	Activity	Number of tests	Duration (days)	Number of operators
12.	Determine the effect of the degree of extraction upon raffinate properties varying: - temperature - furfural quality and quantity - feed/furfural ratio - flow rate and mixing rate - partial furfural injection	100	40-60	
13.	Determine the effect of previous feed deasphalting upon raffinate properties	20-40	10-20	
14.	Determine the effect of aromatic hydrocarbons upon raffinate and extract quantities and qualities	10-20	10	
15.	Select optimum conditions of extraction of oil fractions and issue recommendations for the commercial plant	/	5-10	
16.	Examine and select optimum furfural recovery conditions (special program)	20-30	15-20	
17.	Determine optimum conditions of solvent separation from extract solution (special program)	20-40	15-20	
18.	Carry out selective extraction of oil fractions obtained from pilot vacuum unit	20-40	15-20	
19.	Examine and select optimum conditions of extraction of oil fractions obtained from different crude mixtures	80-100	40-60	

No.	Activity	Number of tests	Duration (days)	Number of operators
20.	Analyse experimental data issue instructions for producing high quality oils from different crudes and their mixtures Simultaneously continually follow the properties of: - feed - solvent - raffinate - extract -products obtained	continually		
21.	Slightly modify the original program			

4.1.3 Acid Treating

No.	Activity	Number of tests	Duration (days)	Number of operators
1.	Establish sealing of the system			
2.	Determine electrical diagram of the unit		5-10	
3.	Determine the time required to heat the unit up and establish operating conditions			
4.	Establish automatic measurement and control systems		5-10	
5.	Start up establish the operatinn of the plant in accordance with the flow sheet			
6.	Determine the effect of the following factors upon the sludge from the commercial plant:			

No.	Activity	Number of tests	Duration (days)	Number of operators
	- temperature, quality and quantity of acid - feed/acid ratio - degree of washing - contact time (special program) - acid concentration	40-80	30-40	
8.	Sludge analyses and digestion of the obtained results	continually		
9.	Select optimum method of acid sludge treating (sludge from commercial plant) and issue recommendations (special program)	20-40	20-30	
10.	Determine optimum conditions of producing high concentration aromatic compaunds (special program)			
11.	Acid treating of sludge obtained in pilot vacuum unit	40-60		
12.	Examine and select optimum method of acid sludge treatment(special program)			

Upon selection of optimum mixture of black oil from crudes produced on different wells, and their treatment in the pilot vacuum column they will be treated in the commercial acid treating plant.

4.1.4 Light Fraction Catalytic Hydrogenation

No.	Activity	Number of tests	Duration (days)	Number of operators
1.	Determine electrical diagram			
2.	Check reactor heating system and determine the time required to heat it up			
3.	Grading of dosing pump at different pressures		10-15	
4.	Determine effectiveness of cooling			
5.	Calculate N_2, H_2 and feed losses and prepare respective table			
6.	N_2 testing of the system at different pressures		10-15	
7.	Establish operation of the unit acc. to the flow sheet with Rashing rings filled up			
8.	Carry out benzole hydration and determine dependance of cyclohexane upon: - temperature - pressure - H_2 amount - feed/hydrogen ratio - space velocity (special program)		40-60	
9.	Carry out laboratory analyses of products and waste gases (three times every day)	continually		
10.	Prepare process material balance and select optimum regime of operation		2-4	
11.	Continual operation at selected optimum conditions (10 days)		10-15	

No.	Activity	Number of tests	Duration (days)	Number of operators
12.	Hydrofinishing of low octane gasolines from commercial plant and analysis of the obtained results (under the program)	30-100	20-30	
13.	Determine dependance of reforming output upon: - temperature - pressure - H_2 quantity - H_2/feed ratio - space velocity (special program)	35-40		
14.	Continual operation at selected optimum conditions (10 days)		10-12	
15.	Obtain experimental samples of high octane gasolines and test them at CIF motor	10		
16.	Check catalysts activity and determine dependance of the product upon contact time (at least 1000 hours)	40-60		
17.	Analyse catalyst properties (after every 250 hours of operation) and determine catalyst activity dependance upon active component content (special program)	continually		
18.	Graphically determine the effect of time factor	10-15		
19.	Determine optimum conditions for reforming catalyst	5-10		
20.	Correlation of obtained results and issue recommendations for commercial plant			
21.	Examine other hydrogenation processes (like desulphurization) with suitable catalysts			

Situation on the 31st of December, 1976

Category	Tuitition	No. of exxcutors	Experience (years)	Note
1. Head of Pilot Plant	Chem. eng.	1	5	empty
2. Diffuse oper. eng.	Engineer	1	3	
3. Tecnical doc. file		1	3 or	
	High school		5	
4. Cat. process eng.	Engineer	1	5	
5. Bitumen unit eng.	Engineer	1	5	
6. Pilot plant eng.	Engineer	2	5	
7. Pilot plant operat.	High scool or			
	Highly skilled worker	2	3	
8. Operator	High school or			
	Highly skilled worker	3	3	empty

Recommended Expansion

Category	Tuitition	No. of executors	Experience	Note
1. Pilot plant engineer	Engineer (el./mech.)	1	3	
2. Pilot plant engineer	Engineer (instr.)	1	3	
3. Operator	Sec. school (mech./chem.)	3	3	
4. Locksmith/ Welder	Highly skilled/ Skille worker	3	5	
5. Instr./el. operat.	Highly skilled worker or Secon. school	3	5	

The extension of the pilot plant organizational structure was suggested in view of the extensive activities of the centre in the next few years (installation, start up, operation and maintenance). The plant will also be working in three shifts.

It is,however, thought that the schedule of employing the new labour should be developed only after all the plants are put in operation.

The following analyses have to be daily performed for the normal operation of extraction, acid treating and vacuum units:

- inlet oil fractions
- raffinates, extracts, aromatic concentrate
- outlet products
- recovered furfural
- acid and acid sludge
- physical and chemical properties of all fractions from the vacuum unit as well as short residue.

These analyses are indispensable for effective operation of the pilot plant units, determination of process parameters and issuing recommendations for the commercial plant. The above laborytory activities require at least three operators.

Catalytic hydrogenation units require the following analyses to be performed:

- inlet feed
- gaseous chromatography of hydrogen and outlet gases
- physical and chemical properties of the product
- octane number of the hydrogenate
- physical and chemical properties of the catalysts (under a special program)
- gaseous chromatography of outlet gases after catalyst recovery.

The above laboratory activities require at least three operators. The results obtained in the pilot plant need to be mathematically correlated and compared with the data from the commercial plant.

UNIDO Expert

Prof. N. M. Guseinov

for "NAFTAGAS" RNS

Đ. Maletić

Mrs. B. Mamuzić

Mrs. N. Nakarada

Mrs. D. Antonijević

D. Vasiljević

S. Mihalački

Annex IV

P R O T O C O L

Minutes of the meeting held in Novi Sad from 17 th to 25 th November 1977 between the representatives of UNIDO - Vienna and representatives of NAFTAGAS - Refinery Novi Sad related to the cooperation with respect to the expansion and operation of the Research and Development Centre for Crude Oil Refining Processes NAFTAGAS RNS in Novi Sad.

Present at the meeting were:

UNIDO: Dr.Victor Kalitin, Industrial Development OFFICER UNIDO
Prof.Nazim Gusseinov, Special Expert UNIDO

NAFTAGAS - Kombinat naftne industrije Novi Sad
Ing.Djordje Burić, Assistant General Director for Development

RAFINERIJA NAFTE NOVI SAD
Ing.Miraš Obradović, Director RNS
Ing.Veselin Stanković, Assistant Director RNS
Ing.Bojan Kosić, Director Production Sector
Mr.Ing.Slobodan Repić, Head of the Pilot Plant
Ing.Djordje Maletić, Director Development Sector RNS.

I

By end of 1977 NAFTAGAS - Radna organizacija Rafinerija nafte (RNS) in Novi Sad will start up its Research and Development Centr for Crude Oil Refining Processes NAFTAGAS RNS. RNS also intends to proceed with further activities for the expansion of this center and develope pilot plant methods for crude oil and product processing.

RNS has expressed a wish to continue cooperation with and have further assistance of UNIDO in this respect.

II

Discussion included project definition, estimate of investment cost for the implementation of the project as well as the type of cooperation and the time schedule.

A draft programme for UNIDO - NAFTAGAS RNS cooperation (first draft) has been prepared and has been attached hereto.

III

It was mutually agreed that actions toward further improvement of this programme should be taken between December 1977 and April 1978 and toward obtaning approvals from competent authoritie of UNIDO, NAFTAGAS and competent Yugoslav authorities. Should parties come to an agreement within that period of time, an agreement for cooperation would be made in April 1978.

IV

Parties agreed the final version, if prepared, is to be adopted at a joint meeting of UNIDO/UNDP and the representatives of Yugoslavia.

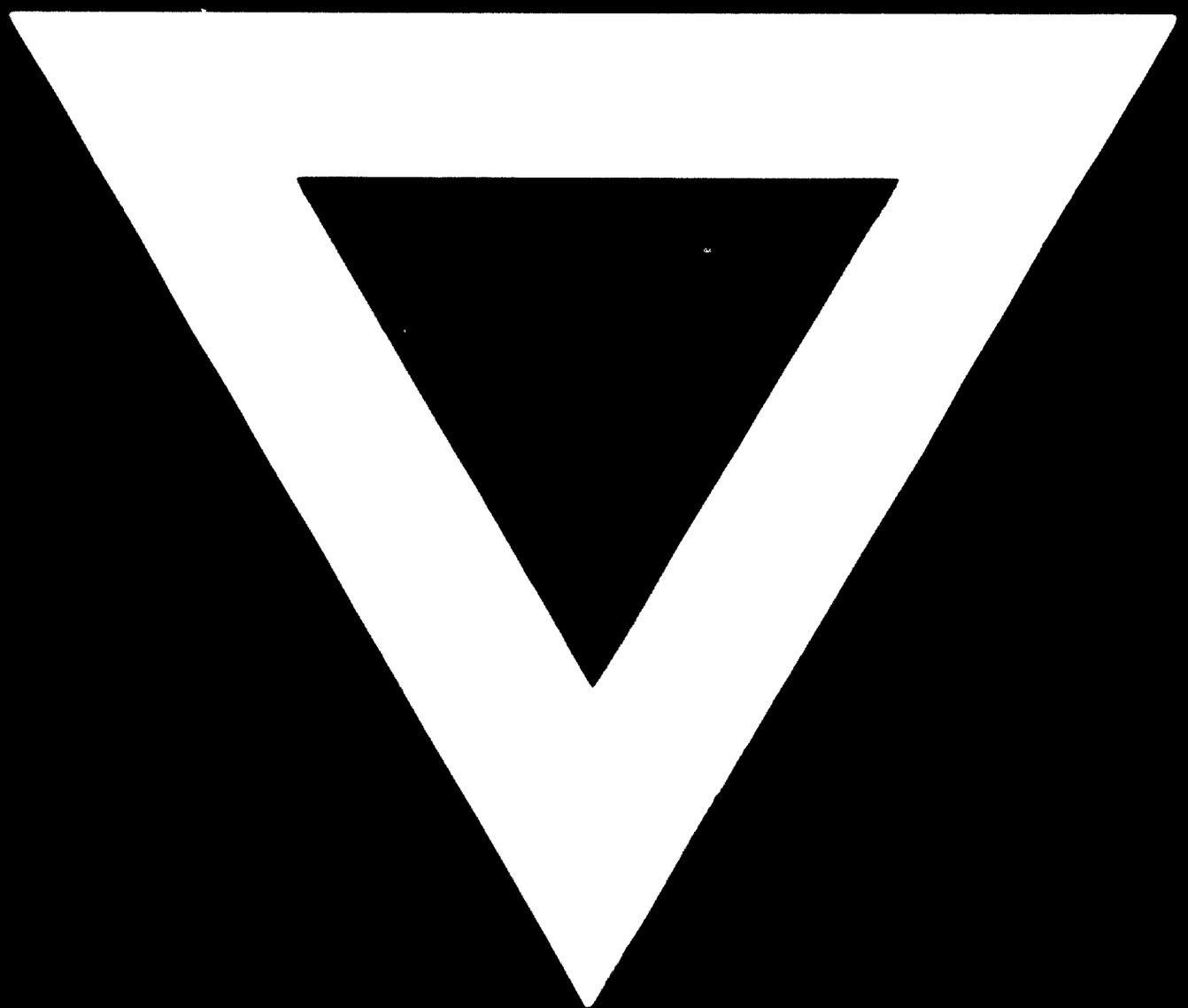
V

RNS representatives and Dr.V.Kalitin have reviewed the up-to-now cooperation between RNS and UNIDO, as well as the job done by Prof.N.Gusseinov who has been working in RNS under TF project (JUG/77/003/11-01) for 15 moths, and agreed that Prof.N.Gusseinov has performed his job in the best possible way thus contributing to the success of this task.

NAFTAGAS-RNS

UNIDO

B-14



79.11.15