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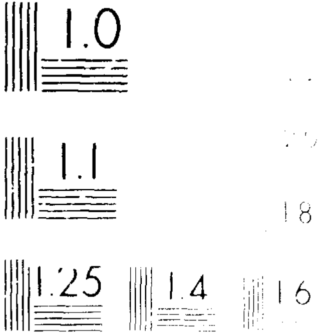

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CONSULTANCY SERVICES FOR THE PETROLEUM REFINING INDUSTRY

DP/IND/80/015

INDIA

Terminal report *

Prepared for the Government of India
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Lavalin International
UNIDO Contract No.82/65

United Nations Industrial Development Organization

Vienna

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1.0 ABSTRACT

This report summarizes the work carried out by Lavalin International Inc. under: -

UNIDO contract number 82/62
Project number DP/IND/89/015
"Provision of Consulting Services for the Petroleum Refining Industry in the Republic of India".

Lavalin International carried out this assignment in the Refining and Pipeline divisions of Indian Oil Corporation Ltd. during April and May 1983.

Indian Oil Corporation Ltd. selected two refineries as typical of their operations. A combined team of Lavalin International consultants and seconded Indian Oil staff studied

- Safety
- Pollution Control
- Inspection
- Maintenance

at Barauni and Haldia Refineries.

Lavalin International consultants and Indian Oil staff studied pipeline

- Safety
- Operations
- Pipeline failures

at the subsea pipeline and oil terminal at Salaya on the Gulf of Kutch, the main feed pipeline from Salaya to Mathura refinery, and product lines from Barauni to Karnpur.

The report defines the scope of work, and describes the work carried out by the combined Lavalin International and Indian Oil Corporation teams. It contains conclusions and recommendations together with suggestions for further work.

The contents of the report were discussed in detail at both refineries and Indian Oil Corporation head offices in Delhi by the team members before they left India. Draft copies of the team's conclusions and recommendations were left with Refinery and Head Office Staff at this time.

In addition to the work summarized in this report a training seminar was held at Gujerat Refinery in the use of AGA Thermovision Infra Red Scanning equipment. This seminar was funded by UNIDO contract no. 82/62 and was subcontracted to AGA Thermovision UK, who supplied the original Infra Red Scanning equipment to Indian Oil Corporation.

2.0 INTRODUCTION

This report covers consulting work carried out by Lavalin International Inc. staff under UNIDO contract 82/65 Project No. DP/IND/80/15. The work was carried out during the period April, May 1983.

The scope of work for the contract is defined in Annex A of Ammendment No. 1 to Contract 82/65 contained in Appendix I to this report. The final scope of work was adjusted at the various sites by agreement between Indian Oil and Lavalin team members. This enabled the maximum coverage of specific problem areas, within the cost restraints of the contract.

The report covers work carried out in conjunction with the staff of both the Refinery and Pipeline Divisions of Indian Oil Corporation.

The refineries studied were:

- Barauni Bihar State
- Haldia West Bengal

Pipe Line Division areas included:

- Subsea pipeline and oil terminal at Salaya on the Gulf of Kutch
- Large diameter oil pipeline from Salaya to Mathura Refinery
- Product lines from Barauni to Karnpur.

The subcontracted AGA Thermovision training course held at Gujerat Refinery is not covered in the report.

The report submitted is written to provide a management overview of the work completed for both UNIDO and Indian Oil Corporation Senior Management. Lavalin is currently preparing a separte technical annex to the report. This annex will contain: -

- The final printed version of the draft technical reports which were left with Indian Oil Corporation when the team left India.
- Additional technical data provided by Lavalin consultants since their return from India.

The report consists of four main elements.

3.0 Executive Discussion

Executive Discussion covers items such as corporate career structure which we feel should be addressed by Indian Oil Corporation Senior Management.

4.0 to 9.0 Technical Findings

These items summarise our findings on the technical scope of the work which we carried out in India.

9.0 Training

We have summarised our recommendations for training IOC staff, both inside and outside India, in one section for each of reference.

10.0 Future Work

We have suggested work which might be undertaken in future contracts. The suggestions cover

- Extensions of current work scope.
- Additional work flowing from current scope.
- New work.

3.0 EXECUTIVE DISCUSSION

Indian Oil Corporation faces severe challenges in operating its refineries and pipelines. We were impressed with the enthusiasm and dedication with which these challenges were being tackled, and in many instances overcome. We appreciated the assistance of all the staff we met, and the frank discussions which took place at all levels during the project.

There are unfortunately no quick and easy solutions to the problems which we discussed and certainly no technological "great leaps forward" which will enable long standing problems to be resolved instantaneously.

However none of IOCs many problems are insoluble, they can all be solved by a combination of: -

- Diligent and painstaking application of current knowledge, systems and procedures.
- Training and upgrading of IOC technical staff's knowledge and experience.
- Contact and open discussion with people who have experienced and resolved similar problems.

We have highlighted some of our major conclusions and recommendations for action in the balance of the report.

. CORPORATE ORGANISATION STRUCTURE

We were not asked to review IOC's corporate structure as part of our scope of work. However we feel that many of the problem areas which we reviewed can best be treated by a change in corporate philosophy.

Indian Oil Corporation is unique in our experience. It is the only major oil company which has neither

- Central engineering department

  nor

- Technical career ladder for specialist staff.

Most of the problems which we discussed can be traced to a lack of technical expertise, and a structure which would enable this expertise to be developed ans used on a Company wide basis.

The present IOC organisation structure offers no advantages, and presents some severe disadvantages in overcoming the problems which are inherent in operating a major oil company in India.

We recommend the establishment of a central engineering department, and a technical career ladder for the following reasons.

. CENTRAL ENGINEERING DEPARTMENT

There should be a single source of engineering standards and technical data. This should be made available across the company to all technical staff.

At present IOC has a limited number of standards and is dependant on individual staff members experience and judgement for day to day engineering decisions.

A central engineering department is an economical way of developing expertise and making it available Compagny wide. It avoids the problems of

- "Re-inventing the wheel" when dealing with recurring situations
- Duplicating staff at each refinery.

IOC currently has no organised method of ensuring its operating experience and requirements are fed into specifications for new projects. A central engineering department would ensure that such items as:

- Process flexibility
- Equipment reliability
- Spare parts requirements
- Operating and maintenance considerations
- Balance between operating and capital costs

are collected and built into the specifications for a new project. At present there is no common format for the generation of refinery performance and operating statistical data. Analysis of data collected is difficult because there is no common base. Central engineering department could standardise data collection and analysis.

Central engineering department would provide the structure to enable a technical career ladder to be built.

Technical Career Ladder

Many of the IOC staff we met would prefer to develop their careers as specialists, rather than moving into general management positions. A technical career ladder permits the developemnt of specialists by establishing a hierarchy of titles and salaries parallel to the general management career structure.

During our discussions with IOC staff we noted that

- Trained specialists are routinely allocated to non-specialist posts at other refineries.

- Re-allocation often occurs in an arbitrary manner, and does not co-incide with either the work load or the arrival of replacement staff.

- There is little or no hand over period. Transfer of know how and experience is not practicable. The new staff member spends time learning the job from the beginning.

Given that

- India has a shortage of skilled engineering manpower

- IOC is competing against Indian and offshore companies to attract and retain scarce manpower

- IOC devotes considerable manpower, time, and money to training inside India and offshore.

We suggest that IOC should make every effort to retain manpower, and should make optimum use of this scarce and expensive resource.

We consider that this can best be done by establishing a technical career ladder within a central engineering group.

. APPLICATION OF CORPORATE TECHNICAL STANDARDS

Corporate technical standards are available for several of the areas studied. Application of these standards, and review of refinery technical operations, is not carried out by central management on a systematic basis.

We noted the following problems

- Existing standards and procedures are not distributed and are not used consistently.

- Each refinery specialist group sets its own level of performance. There is no uniformity across the Company.

- There is no practical follow up of the implementation of Company standards and procedures.

For example we found that: -

- Fire hoses from the fire trucks would not connect to the crude tank foam connections at Barauni.
  Despite a major crude tank fire earlier this year this elementary practical problem had not been discovered and corrected.

- Maintenance planning at both refineries ignored the IOC maintenance planning manual.

- Neither refinery could provide basic maintenance statistics. Our review of maintenance performance and problems was based on opinion, rather than factual analysis of the records.

LATEST TECHNOLOGY

IOC staff frequently requested advice on the acquisition of the "latest technology". There was an inbuilt assumption that most problems could be solved by the installation of sophisticated equipment.

We pointed out that in many cases this simply is not so. In fact high technology equipment can bring additional complications without necessarily solving the original problems.

We feel very strongly that most of the problems we met can be solved by a combination of

- Additional training and exposure to experienced staff

- Diligent application of current knowledge and equipment

We recommend that where a technological solution is worthwhile, IOC should look for "the most appropriate technology" which is applicable to the Indian context.

We have summarized our conclusions in the application of the latest technology to some of the major topics discussed.

Equipment design

The latest Western equipment is designed to produce small incremental reductions in capital and operating costs. The fundamental assumption inherent in the use of such equipement is that the equipment will operate in the context for which it was designed.

The assumptions are: -

- Complete local infrastructure is available for installation and maintenance

- Full inventory of spare parts is immediately available

- Trained skilled manpower is available, with all required special tools and equipment

- Immediate access to suppliers technical support staff

Many of these conditions cannot be met in India. Plants designed around the latest equipment, which is unsupported by the essential infrastructure, are likely to be less reliable than older unsophisticated designs.

We consider that all IOC installations are strategic resources. In our view they should be specified, designed, and maintained to provide the highest on stream factor attainable; rather than the lowest achievable capital and operating cost.

Computerisation of Maintenance and Inspection Records

A computer cannot generate information. It can only sort, collate and reproduce information which is fed into it. Any computerised system requires that consistent data is collected and input to the computer.

The quality of the computer output is directly linked to the quality of data provided as the data base.

Garbage in = Garbage out

Is an unfortunate basic fact of data management.

At present basic data is not collected and analysed manually. There is therefore no useful input available for computerisation.

In our experience computerisation of inspection records is not feasible in less than two years. Computerised maintenance records are ever further in the future.

We recommend that any thoughts of computerisation should be set aside for the present. We recommend instead that a concentrated effort should be made to produce regular, consistent reliable data by the manual systems which are available but not used consistently.

. Maintenance Tools and Instrumentation

As far as we could determine the majority of unscheduled and scheduled maintenance work is caused by bearing failures. Causes include

- Poor bearing storage
- Brutal bearing installation procedures
- Poor shaft alignment

These problems can be greatly reduced by a combination of rigorous training programmes at the craftsman level, coupled with the provision of better tools and supervision at the shop and field level.

We recommend that the problem should be reduced to manageable proportions by improving mill-wrighting skills, before purchasing additional sophisticated diagnostic equipment to better predict incipient bearing failure.

. PLANT SAFETY - REFINERIES

We divided plant safety into two categories.

- Invisible safety
- Visible safety

. Invisible Safety

This covers the design and layout aspects of the refinery and its safety systems. We reviewed both Haldia and Barauni Refineries against the appropriate Indian standards and International standards.

. Both refineries complied with the requirements covering

- Refinery layout and unit spacing
- Provision of adequate utilities and services
- Design of fire protection systems

We concluded that

. Both refineries were designed with the minimum of process alarms and trips.

. Emergency lighting in both refineries is inadequate and must be upgraded.

. Haldia Refinery has no fire alarm system and has inadequate fire sirens.

We consider it mandatory to install a complete fire alarm system and an additional siren.

. Visible Safety

Visible safety covers more traditional aspects of refinery safety

- Housekeeping
- Operational condition of fire protection and safety conditions
- Training of refinery and fire fighting staff
- First aid and medical care

We found that: -

. Housekeeping

Housekeeping at Haldia is good in the process units and maintenance areas, and poor in the offsites and tank farm areas.

Barauni housekeeping is universally poor. This refinery is unsafe by North American standards.

. Fire Fighting Equipment

Both refineries have adequate fire fighting equipment, foam tenders etc. All equipment is well maintained and in good condition. We recommend an increase of 50% in the foam inventory, which is currently maintained at minimum international standard levels.

. IOC Safety and Fire Rules

IOC Safety and Fire - Rules and Regulations is a very good basic document. However it is not implemented with sufficient vigour.

We recommend that Refinery Managers re-inforce the application of this document.

- Fire Water Systems

  Haldia refinery firewater system was incapable of fighting a simulated crude tank fire. Urgent repairs were undertaken to bring the system back to its design specification.

  Barauni refinery system is adequate. Some monitors require relocating. Hydrant and monitor maintenance requires improvement.

- Safety Showers

  The showers in both refineries were; inadequate in number, poorly located, and 100% inoperable.

  This situation is unacceptable and must be remedied.

- Product Shipment. LPG cylinder filling, cylinder handling

  There are major deficiencies in the design and operation of facilities at both refineries for

  - Product shipment by road and rail
  - Filling and handling LPG cylinders
  - Handling of chlorine and other gas cylinders

  A crash programme is essential to upgrade these areas. They are presently unsafe when reviewed against IOC's own standards and international practices.

. Training of Refinery Staff and Fire Crews

Theoretical training is excellent. Practical training is unimaginative and inadequate. We recommend that practical training should be improved, and regular large scale disaster simulations should be introduced.

. First Aid and Medical Care

First aid facilities were adequate and medical facilities at refinery hospitals excellent. Medical examinations and records for IOC staff followed industry standards.

. Working Conditions and Welfare of Non-IOC Staff

We noted that the majority of dirty jobs; exchanger cleaning, sludge disposal etc, were contracted to non-IOC subcontractors staff. These people are exposed to toxic, and carcinogenic materials with no protective equipment, and no provisions for washing and clean up. Their exposure is not measured and recorded and they have no medical supervision.

We consider this state of affairs to be totally unacceptable. We recommend that IOC takes appropriate measures to remedy this situation.

PLANT SAFETY - PIPELINES

Pipelines safety was restricted to visible safety aspects of the Oil Terminal at Salaya.

. Housekeeping

Housekeeping was excellent.

. Safety Procedures

Pipelines operate with the IOC safety and fire rules and regulations.

. Operational condition of fire protection and safety equipment

The equipment provided is in good condition.

Considerable extra equipment is required to bring the installation up to standard. Major requirements include

- Fire truck
- Hoses and fog nozzles
- Additional fire extinguishers

. Training in Fire Fighting

Basic training is adequate. More imaginative regular fire drills are recommended.

. First Aid and Medical Care

Facilities available are adequate and will be extended.

POLLUTION CONTROL

We reviewed the pollution control systems at Haldia and Barauni Refineries. Seconded staff from Digboi and Gauhate refineries joined the group and presented specific pollution control problems for discussion.

Detailed problem solving discussions took place the results are recorded in the appropriate sections of the report. The main points can be summarized: -

. Haldia Refinery

The current effluent treatment plant is undersized and overloaded. Space for expansion is severely restricted.

We reviewed the proposals submitted by the refinery for upgrading the plant, and suggested modifications. We consider the upgrading of Haldia facilities should be given high priority.

. Barauni Refinery

We calculated the capacity of the Baurauni Refinery effluent plant, and confirmed the refinery's opinion that the plant is generously oversized. We consider that there is considerable room for more efficient operation of the refinery, and that modifications to the installations will be required to meet proposed legislation.

We suggest that: -

- Effluent stream segregation should be practised. Existing facilities for segregating effluents should be re-commissioned and further segregation should be considered.

- Barauni should investigate alternates to the bio-treatment plant which is under study at the moment.

. Slop Oil recovery and oily sludge disposal at both Refineries

We discussed the segregation and recovery slop oil from various effluent streams, and concurred with IOC engineers proposals. These should reduce the amount of oily sludge for disposal.

We recommend that oily and chemical sludges residues should be disposed of by land farming rather than by incineration.

MAINTENANCE

The maintenance function in the refineries is critical to achieving planned production targets and extending on stream time.

The planned on stream time for the two refineries studied is 12 months; this objective is not achieved. North American refineries routinely achieve 36 to 60 months on stream. We feel that on stream time is presently governed by equipment reliability. This in turn is controlled by the maintenance operations at the refineries.

The maintenance performance overall is considerably better at Haldia and Barauni. The Haldia work force is more highly skilled, better equipped and better motivated. We feel that this may be due to the differences in design between the two refineries.

Barauni is extremely well provided with spare equipment, bypasses and interconnections, and is considerably over designed. It is easy to run Barauni at name plate capacity with major maintenance backlogs.

Haldia is extremely tightly designed with little spare equipment. Every piece of equipment must be serviceable for the refinery to stay onstream. Operation of Haldia at a name plate capacity requires a major effort for both operations and maintenance crews.

We were unable to obtain any reliable statistics on maintenance activities at either Haldia or Barauni refineries. The IOC maintenance planning manual contains a good basic section on the collection and analysis of statistical data. We recommend that IOC implement a programme of data collection in order to provide a factual basis for the analysis of maintenance operations.

We support IOC's long term objective of moving from planned maintenance to predictive maintenance. We agree that this will in the long term reduce maintenance costs and give longer onstream times. Planned maintenance requires that equipment is maintained on a strict schedule regardless of its actual condition. Predictive maintenance involves monitoring the equipment's condition and maintaining the equipment only when work is required.

The introduction of predictive maintenance assumes that:

- Equipment's service hours are recorded
- Equipment is running well at planned maintenance time
- Total amount of work specified at planned maintenance period may be unnecessary or excessive
- Equipment could remain in service for extended periods
- Deterioration in performance is progressive
- Performance is monitored to prevent catastrophic failure ocurring
- Equipment is withdrawn and overhauled on a planned basis as required

We discovered in our discussions at Barauni and Haldia that these conditions are not met at present.

There are major differences between theory and real life operations. We have summarized the main points in the following table.

The inescapable conclusion is that the planned work schedule is rarely achieved. Unplanned maintenance work routinely disrupts the planned schedule. This ensures that planned maintenance work is not completed, and is postponed or abandoned. The planned work which is not achieved eventually results in further unplanned breakdowns and disruption of the maintenance efforts. The maintenance operations can easily spiral out of control.

IOC MAINTENANCE OPERATIONS

THEORY	REAL LIFE OPERATIONS
• Service time is recorded	• Service time is not usually recorded
• Maintenance history is available	• Consistent records not available
• Problem equipment identified and monitored	• Little monitoring of problem equipment
• Planned maintenance periods are achieved	• Frequently not achieved
• Random equipment failures are rare	• Random failures are common place
• Maintenance staff can accomodate infrequent random failures and emergencies	• Maintenance scheduling cannot accomodate present frequency of random failures
• Planned maintenance work loads are regularly achieved	• Planned work load is not achieved due to emergency work dominating maintenance efforts. • The total maintenance work load is increased – Planned maintenance work load is not achieved – Further random failures occur. Last week's unachieved planned maintenance becomes this weeks random failure
• Maintenance work load can be reduced by moving to predictive maintenance	• Predictive maintenance is premature at present

We recommend that IOC should concentrate their maintenance efforts on reducing on the high proportion of unplanned work. This will enable IOC to bring the maintenance work under control and then to plan the future course of maintenance work.

As a first step IOC should give high priority to determining a list of critical equipment which will be the focus of maintenance operations. Critical equipment is either: -

- Major equipment which is essential to operations
- Equipment with a history of random failure

The performance of this equipment should be logged and analysed. Its maintenance should be planned to increase on stream time. This work will require close co-operation between operating and maintenance staff, and should provide a useful basis for eventually increasing the on stream time for all equipment.

We also feel that some of the equipment may be operating close to or beyond its design limits. We recommend an engineering evaluation of equipment design specifications and duty conditions for equipment with a history of persistent failures.

Although we have no firm data we suspect that a major cause of unscheduled maintenance is sudden bearing failure.

During our refinery visits we noted the following causes of bearing failure

- Poor shaft alignment
- Poor bearing replacement practices
- Poor coupling specification or maintenance
- Inadequate bearings
- Inadequate monitoring of bearing condition
- Inadequate lubrication

From our observations we concluded that the main problems are

- Poor shaft alignment
- Poor bearing fitting practices

These can be readily corrected by practical, hands on training at the craftsman and supervisor level; together with the provision of better tools, instrumentation, and facilities.

The planning of maintenance work loads can be improved by: -

- Improved record keeping
- Designation of critical and problem equipment as priority items
- Comprehensive monitoring or priority items to prevent catastrophic failure

We recommend that refinery management should become involved in improving maintenance performance.

INSPECTION

The inspection work covered a review of personnel, procedures, equipment, and the discussion of many specific problem areas. The personnel, procedures, and equipment conclusions, and recommendations are summarized here for convenience.

Personnel

We found the Inspection staff at both Haldia and Barauni to be well qualified theoretically and highly motivated. By international standards they had inadequate practical experience, and lacked exposure to the latest inspection techniques and practices. The average experience at Barauni was 3.65 years and Haldia 2.52 years. We consider these figures to be unacceptably low. They are a result of the lack of technical career structure and frequent transfers of specialists to non specialist staff functions.

We recommend that IOC should add two new specialist inspection categories to its staff. These are corrosion engineer, and civil engineering inspectors.

- Corrosion Engineers

  Two corrosion engineers are required, one for Refineries and the other for Pipelines. The position should be a career function. In other companies the corrosion engineer occupies a senior engineering position in the central engineering group.

The corrosion engineers main duties include

- Selection of materials for new construction and repairs work.
- Consultation on unusual corrosion problems.
- Preparation of corporate corrosion monitoring and control manual.
- Leading the implementation of corrosion monitoring and control programme.
- Development of a chemical cleaning manual.

. Civil Engineering Inspector

We recommend that each refinery should have a Civil Inspector who would be responsible for

- Steel and wooden structures
- Concrete, brickwork and refractories
- Roads and earthworks
- Painting and insulation

Equipment

IOC staff were well trained and experienced in the use of the inspection equipment provided. Additional equipment, and training in its use, is required to bring the inspection capability into line with international standards.

. Radiography Equipment

Radiography capability is limited by the weak source available; 8 curies of Iridium 192.
The industry standard worldwide is 100 curies of Iridium 192.

We recommend that the facilities should be uprated to this standard, to enable a wider range of radiographic examination. We anticipate the useage would be at least 20 radiographs/day at each refinery.

We understand that increased radiography source strength may require a special dispensation from the Indian Atomic Energy authorities.

- Ultra Sonic Inspection Equipment

  Additional Kraut Kramer Ultra Sonic Test Equipment is required at both r- -neries to enable high temperature thickness measurements to be carried out.

- Magnetic Particle Crack Detection Equipment

  This equipment is required at both refineries.

- Metallurgical Analysis

  Texas Nuclear or equivalent metallurgical analysis equipment is recommended for both refineries.

- Temperature recorder

  Required for Barauni stress relieving furnace.

- Codes and Standards

  Both refineries codes and standards libraries require updating. Current copies of all relevant documents should be available in the inspection departments.

PIPELINES

. TANKER UNLOADING AND TANK FARM-GULF OF KUTCH

This installation is the only method of unloading crude oil from the Middle East and Bombay High Fields for use ac Gujerat and Mathura refineries. The facilities include a single bouy mooring (SBM) subsea pipeline, on shore pipeline, tank farm and pumps.

. SBM and Subsea Pie Pipeline

We found that the resistivity of the outer concrete jacket of the pipeline is poor, and that it offers negligible protection against external corrosion.

. Pipe to soil and pipe to sea potential readings should be taken at regular intervals to check the efficiency of the cathodic protection systems.

. Internal corrosion control can be improved by a series of measures

- Minimising sea water flow from ballasting operations.
- Ensuring line is purged of sea water when not in use.
- Maintaining design oil velocities.
- Maintaing a waxy coating in the line by pigging the line with Bombay High Crude in situ.
- Use of inhibitors.

- Additional protection is required to guard against oil spills. We recommend a combination of floating booms, oil skimmer boat, and barge mounted oil/water separator should be purchased.

- Crude Tank Farm at Salaya

  We recommend that

  - The design of the firewalls and dikes should be reviewed to ensure that there is adequate capacity to contain a burst tank.

  - Bottom three metres of tanks and pontoon wall beneath seals should be coated to extend their life span.

  - Steps should be taken to eliminate the build up of wax from Bombay High crude in the tanks.

  - The automatic switch over system for tank farm standby power generator should be upgraded.

  - Fire and safety systems should be upgraded as outlined in the relevant sections of this report.

  - The Vareg tank gauging system should be rebuilt.

CRUDE PIPELINES AND PUMPING STATIONS

We recommend that

- All new pumping stations should be designed with a fire wall between the pumps and diesel drivers. Where practicable firewalls should be installed in existing pumping stations. Where firewalls are not practicable the exhaust manifolds and exhaust pipes should be insulated.

- Full contingency plans should be prepared to cater for a major line failure.

- Emergency drills and simulated line failures should be incorporated in maintenance training.

- Custody transfer should be changed from manual tank dipping to automatic metering.

- Continuous cathodic protection of pipelines must be ensured.

PRODUCT PIPELINES. BARAUNI - KAMPUR

- External Corrosion

  The product pipeline system is old. Problems due to external corrosion are endemic. They are due to a combination of

  - Coating degradation
  - Lack of continuous power supply for cathodic protection.

The actual number of failures to date is low and reflects credit on the operations and maintenance staff. We consider that an exponential rate of increase in failures with time is inevitable in this system. A major increase in cathodic protection reliability is essential if the rate of increase of leakage is to be contained.

. Internal Corrosion and Erosion

There is little evidence of wide spread internal corrosion. It appears that the inhibitor injection programme has been satisfactory. We recommend that this programme should be confirmed.

Erosion of the expansion bends at KP 12.5 indicates the presence of solids in the products pumped. We recommend upgrading of the filtration systems, and continuation of the tank cleaning programmes initiated prior to our visit.

. Pressure Testing

We recommend that the lines should be pressure tested at a maximum interval of 5 years.

. <u>Personnel</u>

We recommend that a corrosion engineer is appointed to the Pipelines Division. This should be a senior engineering career appointment.

TRAINING

During our work we noted that the vast majority of IOC staff are extremely competent theoretically and are well motivated. They lack practical experience and exposure to the latest methods and equipment.

This can be overcome by training. We recommend training should take place both offshore, outside India, and within India.

- Offshore Training

  Offshore training is both expensive and disruptive of work schedules. Offshore training should be carefully organised to ensure that

  - Only staff who will benefit directly from the training are selected.
  - Training highlights the latest methods and equipment in current use.

- Training Within India

  Training within India is more cost effective and less disruptive than training outside India. We recommend that training inside India should be used wherever practicable.

  Course instruction could be provided by: -

  - The use of expert assistance from outside India to provide training in the refineries and the pipeline division.
  - Combined training schemes using the resources of both IOC and the other Indian state oil companies

We suggest that IOC should develop "Centres of Excellence" within the company and use these centres for in house training.

This concept requires that each refinery and operating department is audited. The audit group selects the best department in each speciality. This department becomes the focus for a major upgrading and development effort and is designated IOC's Centre for Excellence, in that speciality.

If for example Haldia is designated the Centre for Excellence in maintenance, it would serve both as a bench mark for all other refineries maintenance groups; and as an in house training centre for maintenance staff.

SPECIFIC TRAINING RECOMMENDATIONS

- Safety and Fire Protection

We recommend that Safety and Fire Protection staff should be given training both offshore and inside India.

Offshore training would give exposure to current practices in firefighting equipment and training and also safe working practices.

Training within India would concentrate on more imaginative and practical firefighting emergency drills and training.

- Pollution Control

Senior Pollution Control Engineers should visit refineries offshore to see at first hand.

- The impact of current and projected legislation on refinery design, operation and pollution control facilities.

- Latest trends in effluent treatment facilities.

- Maintenance and Inspection

Both maintenance and inspection staff should be given training inside and outside India.

Offshore training will highlight the methods used to achieve 36 to 60 months on stream periods, which are routinely achieved. It will also highlight the evolutionary nature of this achievement.

Training in India must emphasise the necessity for regular monitoring, good record keeping, and a programme to improve both facilities and workers' skills.

- Pipelines

Pipelines staff would benefit from training both outside India, and additional training inside India.

They should visit a major crude oil terminal, tank farm storage and crude pipeline complex to discuss long term operating experience, corrosion problems; and the latest thinking on pipeline design, corrosion, monitoring, and custody transfer etc.

Training in India should concentrate on upgrading existing facilities, and solution of specific design, corrosion and operating problems.

. Corrosion Engineers

Both the refinery and pipeline corrosion engineers will require training outside India. Basic theoretical training should follow the US National Association of Corrosion Engineers guidelines. This should be reinforced by a period of practical training with the engineering division of a major operating oil company, and a pipeline company.

FUTURE WORK

Future work which should be carried out can be subdivided: -

- Extension of current work scope
- Additional work which logically follows from current work scope
- New work which is not directly related to current work scope.

. Extension of Current Work Scope

- Training of IOC staff as recommended.
- Follow up of implementations of recommendations contained in this report by an audit in early 1984.
- Carry out a similar review of the balance of IOC's refinery activities.
- Provide additional consulting services to IOC pipelines division.

. Additional Work Flowing From Current Scope

- Provide assistance in establishing IOC Central Engineering Division.
  - Establish organisation structure.
  - Select and train staff.
  - Prepare consistent engineering standards and procedures.
- Assist in establishing technical career ladder structure for IOC specialists.

- Review engineering aspects of critical equipment failures.
- Participate in refinery audits to determine location of centres of excellence for each speciality.
- Provide technical assistance in developing centres of excellence concept to the point where IOC training can take place in house.

NEW WORK

Investigation of performance of existing refinery.

Objectives are to: -

- Maximise saleable products from existing investment.
- Determine bottlenecks and outline steps to debottleneck refinery operations.
- Complete an energy audit for refinery operations.
- Determine steps necessary to minimise energy consumption.
- Optimise refinery operation to balance yields and energy consumption.
- Use the investigation as a training exercise for IOC staff.

APPENDIX I

February 18, 1983

Mr. Krasiakov
UNIDO
55, Lodi Gardens
New Delhi

UNIDO Contract DP/IND/80/015

Consultancy Services for the Refining Industry in the Republic of India

Project Execution Phase Work Plan

Definition of Services to be provided

Dear Mr. Krasiakov,

I enclose copies of the proposed Work Plan and Definition of Services to be provided for the Project Execution stage of this contract.
Following approval by UNDP Delhi and UNIDO Vienna. This will supersede the Project Execution Section of Annex F - Detailed work plan for implementation of the Project which is currently part of the contract document.

Indian Oil Corporation have decided to restrict bulk of the study to two typical refineries, Haldia and Barauni. This will minimise the time spent in travelling and will enable our consultants to concentrate on specific problems. Indian Oil staff from other refineries will be seconded to Haldia and Barauni for training sessions. A separate AGA Thermovision course is planned for Gujarat refinery.

The above document have been drawn up with this philosophy in mind. Indian Oil staff at both Head Office and Barauni and Haldia refineries have contributed to the final version of the Definition of Services and Work Plan.

Both documents have been signed by Mr. Lakhanpal - General Manager Maintenance and Inspection, Indian Oil Corporation and myself, on behalf of Lavalin.

As was forseen at the meetings in Delhi in December 1982 the final scope of work requires a larger number of consultants. Since the contract price is fixed the increased number of consultants will require modification of the number of mandays on site to accommodate the increased travel costs and travel time. UNIDO Vienna have accepted this principle.

Final Number of Consultants

. Team Leader

The execution phase work plan includes a minimum amount of the team leaders time, in order to maximise the input of the team. We feel it is essential that the team leader is in India at the start of the project and should be in India for the final summing up at Haldia refinery and Delhi.

The one month allowed under 2.03a of the contract has been used in the Project Planning phase of the work.
The team leader's time for de briefing in Vienna is shown in the schedule but not included in the calculations of mandays in the project.

. Fire and Safety Consultants

Indian Oil Corporation have requested that we investigate two aspects of safety.

- Invisible Safety
- Active Safety

Invisible Safety relates to Refinery layout, specification, process trip and shutdown philosophy etc. These decisions are taken early in the design phase of the refinery.

This work will require an additional consultant, a Mechanical Process Engineer, who has been involved in the translation of the basic process flow diagrams into P and I.D.'s and definitive unit layouts. He will be familiar with North American standards and practices.

Active Safety is the traditional review of existing equipment and systems envisaged when we prepared our proposal. This will be carried out by a Fire and Safety specialist.

. Pollution Control

Indian Oil Corporation have asked us to focus on two aspects of pollution control.

- Minimising pollution from process units.
- Treating unavoidable effluents.

Minimising of pollution requires a review of the process and an appreciation of the mechanical limitations of the installed equipment. Severe flare problems exist at Barauni, and Haldia. Haldia is currently flaring H_2S gas. This and similar work will require the addition of a Process Engineer to our team.

Treating unavoidable effluents will be studied by an effluent treatment specialist.

. Inspection and Maintenance

The scope of inspection and maintenance has increased and the requirements have become more detailed. We therefore propose to divide the work amongst three consultants.

- Pipelines
- Inspection
- Maintenance

<u>AGA Thermovision Training</u>

During the discussions it has become apparent that the need for detailed specialist training with AGA Thermovision 782 Infra Red Equipment, Annex E1(A) of the Contract, is acute.

Lavalin and Indian Oil Corporation agree that this specialised requirement can best be met by a two week seminar in Gujarat refinery given by a senior specialist from AGA U.K.

We have obtained a cost for this work from AGA and in accordance with Article 7 of Annex A of the Contract will be requesting permission to subcontract this work to AGA U.K.

AGA U.K. daily costs are approximately $ 700 US per day, this is well above Lavalin's quoted daily rates for the project. However the total subcontract price will be approximately $ 14,000, or 7% of the total contract price, we recommend that the work be subcontracted and the cost deducted from the balance of costs available for Lavalin consulting work.

Schedule for next stage

I plan to spend the week of 20th February :-

21st - 22nd	:	UNIDO Vienna
23rd - 24th - 25th	:	London

- AGA Thermovision Subcontract
- Data Collection from Institute of Petroleum and International Labour Office.
- Sources of replacement drive for Barauni Coking Plant.

I shall return to Montreal on 28th February, 1983.

Team Selection

I have already telexed outline requirements for additional specialists to Montreal. I will send C.V.s of additional team members to UNIDO Delhi and UNDP simultaneously. Mr. Lakhanpal of Indian Oil Corporation is anxious to obtain copies of these C.V.s and comment on the suitability of the final team. I trust that you will keep Mr. Lakhanpal informed of developments.

Team arrival in India

Assuming no problems in UNIDO and UNDP approval of the final team, I plan to return to India with the Lavalin team as early as possible in April. I am aiming for an April 11, 1983 start date. The AGA Thermovision subcontract can operate independently of the main Lavalin team and can be planned for any two week period up to the end of the Lavalin teams time in India.

UNIDO Supplied Facilities and Services

Section 3.01 of the Contract specifies that UNIDO will provide certain services and facilities. Indian Oil Corporation have agreed to provide most of these, including office space and ground transport between remote airfields and the refineries.

I would appreciate if you could arrange for UNIDO to provide ground transportation for the time spent in Delhi. The team size in Delhi will be 8 including the team leader. Indian Oil are unable to provide cars or a minibus for this number.

Official UNIDO transport would greatly facilitate our work in Delhi and would be particularly welcome on arrival in the early hours after a non-stop flight from Montreal.

Yours truly,

P.G. HIRON, Eng.
Lavalin Team Leader

Encl. As above

Copy to: Mr. Lakhanpal, Indian Oil Corporation

Mr. Tomkins, UNIDO Vienna

UNIDO Contract DP/ IND/80/015

Definition of services to be provided

A. CONSULTANCY SERVICES PLANT SAFETY

A1. Review of invisible safety aspects of refinery design and layout

* Review Indian standards -"Indian Petroleum Rules" against current North American parties standards.
* Take two bench mark refineries
  - Barauni - 1964 - older refinery
  - Haldia - 1975 - new refinery

  Review plant layout of units and equipment within units against current N.American practices.

A2. Review of emergency systems at both bench mark refineries

* Emergency power supply and distribution.
* Firewater system and back up.
* Power and air to critical instruments.
* Training of fire fighters and refinery staff in response to an emergency.

A3. Overall review of LPG storage & shipping facilities at both bench mark refineries

* Bulk storage of LPG.
* Bulk shipment of LPG by road and rail tanker.
* Cylinder reception filling and despatch.
* Cylinder inspection.
* Fire protection.
* Electrical grounding etc.

A4. <u>Review of alarms, shut down trips, etc. on selected process units</u>

* Review of alarm and trip philosophy adopted during design stage.
* Review of actual performance of systems.

A5. <u>Visible safety review of both bench mark refineries</u>

* Review will concentrate on major aspects of active safety. Detailed check lists will be prepared by refinery staff safety team.
  - Plant layout and accessibility in emergency.
  - Emergency lighting.
  - Overall layout of equipment, cable trays, instrument raceways etc.
  - Access for maintenance equipment.

<u>INFORMATION REQUIRED FROM IOC</u>

* Indian Petroleum Rules.
* Indian Electricity Rules.
* IOC Safety Manual.
* Plot Plan for Barauni Refinery.

B MODERNISATION OF FIRE FIGHTING SCHEME

B1. Review of current Indian standards

- Regulations of Indian Fire Insurance.
- Tarif Advisory Committee.

B2. Comparision with North America Practices

B3. Review of current installations at Barauni & Haldia

* Comparision with above standards and practices.
* Review of actual installations.
  - Condition of installation.
  - Training and capabilities of staff.
  - Response of all refinery staff to a major emergency.

B4. Review of the various systems installed for

- Fighting unit fires.
- Tank farm fires.
- Lightening arrestors on tankage.

B5. Comments on the different foam systems installed

- Fixed foam injection.
- Foam monitors.
- Mobile foam generators.

B6. Comment on suitability of latest technology and design practices for Indian conditions

- Automatic halogen equipment on crude tanks.
- Automatic start up of firewater pumps and emergency firewater pumps.

INFORMATION REQUIRED FROM IOC

* IOC Fire Manual.

C CONSULTANCY SERVICES PARAMEDICAL AND INDUSTRIAL HYGIENE

C1. Review medical and paramedical facilities available at Barauni and Haldia refineries

C2. Review protective health care of refinery staff

- Frequency of checks.
- Scope of checks.
- Record keeping etc.
- Follow up of staff in hazardous areas.

C3. Review particular health hazards present

- H_2S - SO_2.
- Benzene, toluene , phenol.
- MEK.
- Bitumen pitch, and coke units.
- Use of solvents in work shops.
  Benzene.
  Carbon tetra-chloride.
  Methanol.
  Diesel.

C4. Other health and safety problems

* Safe access to tanks etc.
* Review IOC, International Labour Office (ILO) and N.America practices on noise pollution and worker protection.
* Review of interchange of statistics between IOC and ILO.

D CONSULTANCY SERVICES PIPELINES

D1. Subsea Pipelines

* Review scope of current subsea pipeline subcontract.
  - Operation.
  - Inspection.
  - Maintenance.
* Review the actual performance of the subcontractor on site.
* Review cathodic protection of subsea pipeline and its onshore extension to tank farm.
* Methods of checking integrity of outside concrete sheath.

D2. Product Pipeline Haldia - Barauni - Kanpur
Haldia - Maurigram - Rajbandh

* Review specifications of
  - Pipeline - coating system.
  - Cathodic protection system.
* Review history of current failures of system.
* Review experience in use of inhibitors (IOC use Du Pont DMA4).
* Review inspection procedures and inspection frequency.
* Recommend additional precautions and testing which could be used to
  - Improve reliability.
  - Predict likely location of failure.

D3. Review feasibility of detecting problems in Haldia concrete lined and coated raw water pipe

INFORMATION REQUIRED FROM IOC

* Copy of contract with Under Water Maintenance Services.
* Copies of pipeline specifications.
* Copies of reports on failures to date and remedial action taken.

E. CONSULTANCY SERVICES POLLUTION CONTROL FIELD

E1. Water pollution objectives

* Maximise effectiveness of API separators.
* Feasibility of increasing API separator capacity at Haldia.
* Eliminate present intermediate floculation treatment downstream of separators.
* Review and suggest improvements for treatment and disposal of oil sludges from
  - API separators.
  - Tank bottoms.
  - Floculation system.
* Comment on availability of proven systems for waste sludge disposal
  - Packaged plant.
  - Scientific land fill and cultivation of waste sludge.
* Minimise production of noxious waste streams by combined process / water treatment review
  - Minimise production of waste streams.
  - Recycle of waste streams.
  - Controlled release of bulk wastes.
  - Disposal of high sulphide waste streams.
  - Disposal of phenol / caustic wash at Barauni.
  - Alternate scheme to clean phenol towers before maintenance.

E2. Air pollution objectives

* Minimise release of odours from tank farms.
* Necessity and feasibility of installing
  - Integrated flare systems.
  - H_2S recovery systems.

F. CONSULTANCY SERVICES INSPECTION TECHNIQUES

F1. AGA Thermovision 782 infra red scanner

* Investigate cost and timing of subcontract with AGA U.K. for 14 day seminar and tutorial at Gujrat refinery.

F2. Monitoring tube wall thickness

* Advise on techniques available for monitoring tube wall thickness when exchangers are cleaned.

F3. Use and limitations of corrosion monitoring techniques

* Experience and advice required in corrosion monitoring following services
  - Above 100°C.
  - High temperature systems, above 400°C, experience with Kraut Kramer probe reliability and service life.
  - High velocity systems particularly where pitting is a problem.

F4. Documentation system and information retrieval

* Review of current systems.
* Improvements to systems to improve.
  - Data retrieval.
  - Scheduling equipment for inspection.
  - Planning shutdown and inspection turnarounds.

F5. Development of computerisation of inspection records

INFORMATION REQUIRED FROM IOC

Details of type, capacity, location of available computers.

G. CONSULTANCY SERVICES MAINTENANCE

G1. Review of implementation of existing systems in the field

* Maintenance planning and follow up
  - Job planning and estimation.
  - Recording costs, time, manpower and materials usage.
  - Monitoring planned and actual performance.
  - Interpretation of results and feed back to planning.
* Availability of resources
  - Equipment data.
  - Spares.
  - Tools.
* Review of levels of skill available and training requirements.
* Spare parts
  - Inventory control.
  - Specification of spare parts.
  - Substitution of indigenous spare parts for imported items.

G2. Analysis of equipment failure

* Recording and analysis of repetitive failures
  - Diagnosis of recurring failures.
  - Trouble shooting recurring failures
    Design problems.
    Service conditions.
    Quality of spares.
    Quality of maintenance work.
  - Monitoring condition of critical inline pumps.
* Training in analysis of equipment failures with emphasis on rotating equipment
  - Mechanical seals.
  - Bearings.

G3. Skills improvement and staff motivation

G4. Predictive maintenance of rotating equipment

* Substitution of preventive maintenance by predictive maintenance.
* The use and limitations of
  - IRD 350 Mechanalysis equipment.
  - Shock pulse meter equipment.
* Recommendations for more advanced analytical equipment.

G5. Turbine governor calibration and maintenance

* Feasibility of calibrating governors at site rather than returning them to supplier
  - Haldia steam turbines.
* Training in servicing governors at site.

G6. Development of computerisation of shut down planning

INFORMATION REQUIRED FROM IOC

Details of type, capacity, and location of available computers.

H. CONSULTANCY SERVICES MULTI DISCIPLINARY PROBLEMS

H1. Process side heat exchanger fouling

* Improvement of onstream time of crude preheater trains
  - Commission Barauni desalter.
  - Addition of antifouling agents to crude.

H2. Cooling water side fouling of heat exchangers

* Cleaning of tubes with hard deposits.

H3. Improved methods of tube bundle cleaning on shell and tube side.

- Chemical cleaning.
- Ultra sonic cleaning.
- Other methods.
- Removal of carbonates and tubercules in cooling water service.

H4. Feasibility of cleaning of steam turbine blades without stripping turbine.

H5. Recommendations for overcoming corrosion in Barauni crude unit

* Crude unit experiences corrosion typical of naphthenic acid. Corrosion is evident in
  - Outlet heater tubes.
  - Transfer lines, especially bends.
* Comment on choice of metallurgy (316 ss) for solution of this problem.
* Comment on necessity for passivation of stainless steel during shut down.

H6. Current practices in operation of spared equipment.

H7. Corrosion problems in distillate tankage

- Leaded gasoline tanks.
- Naphtha tanks.
- Furnace oil tanks.

* Experience in use of epoxy paint systems.

H8. <u>Corrosion problems in reboiler of SO_2 drying column at Barauni kerosine treating unit</u>

* Kettle reboiler is lined with 316 ss strip. Severe corrosion caused by H_2SO_3 and disolved chlorides from upstream drying towers.

H9. <u>Replacement hydraulic drives for Barauni coker</u>

* Specification and source of 11 KW hydraulic pump and hydraulic motor for kelly turntable and winch.

H10. <u>Corrosion of naphtha reformer reactor effluent coolers</u>

* corrosion caused by carbon tetrachloride injection to improve catalyst activity.

<u>INFORMATION REQUIRED FROM IOC</u>

H4. Analysis of turbine deposits.

H9. Specification for hydraulic drive duty

- Minimum and maximum speed of motor output shafts.
- Maximum torque.
- Electric drive motor speed.

H10. Process conditions and exchanger specifications

- Records of tube failure.

INDIAN OIL CORPORATION ______________ DATE 15.2.83

U N D P DELHI ______________ DATE ______

LAVALIN ______________ DATE 15.2.83

Consultancy Services for the Petroleum Refining Industry
in the Republic of India

PROJECT EXECUTION WORK PLAN

Summary Consultants Manweeks/Calendar Weeks each location

	Week Number									
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10
TEAM LEADER	D B					H D				
SAFETY										
. Invisible Safety	D B	B	B	H	H	H D				
. Active Safety	D B	B	B	H	H	H D				
Fire and Health										
POLLUTION CONTROL										
. Process Aspects	D B	B	B	H	H	H D				
. Effluent Treatment	D B	B	B	H	H	H D				
INSPECTION/MAINTENANCE										
. AGA Thermovision	G	G								
. Pipelines	D B	B	B	H	K	K D				
. Maintenance	D B	B	B	H	H	H D				
. Inspection	D B	B	B	H	H	H D				

INDIAN OIL CO. RK Lakhay date 16.2.83

UNIDO Delhi ________ date ________

LAVALIN [signature] date 16.2.83

B. Barauni
D. Delhi
G. Gujarat
H. Haldia
K. Gulf of Kutch