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UNITED NATIONS
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Workshop on Maintenance and Plant Inspection in Petroleum Refineries

Vienna, Austria, 5 - 23 November 1984*

REPORT**. (Maintenance in petroleum refineries).

* Organized by United Nations Industrial Development Organization (UNIDO) in co-operation with the Government of Austria, the OPEC Fund for International Development and OMV Aktiengesellschaft.

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## 1. Introduction

In previous years UNIDO, in co-operation with the Austrian Government, the state-owned petroleum enterprise Osterreichische Mineralöl Verwaltung (OMV), and the OPEC Fund for International Development, has organized three workshops on petroleum refining industries in Vienna, Austria:

(i) Workshop on Petroleum Processing, 21 - 30 April 1981
(ii) Workshop on Production Planning and Energy Management in Petroleum Refineries, 3 - 19 May 1982
(iii) Workshop on Maintenance and Plant Inspection in Petroleum Refineries, 5 - 23 September 1983

In continuation the fourth workshop of the series was organized on "Maintenance and Plant Inspection in Petroleum Refineries from 5 - 23 November 1984 in Vienna, Austria.

## 2. The Workshop

As on previous occasions, the technical programme of this year's workshop was conducted by OMV at their refinery in Schwechat/Vienna, and included lectures, discussions and plant visits.

The Workshop provided a good opportunity for refinery managers, engineers and technicians from developing countries to exchange experience and information on the above mentioned topics among themselves and with OMV. They were able to examine techniques and methods applied successfully by OMV and to identify possible co-operation in this field.

The topic of the workshop organized in 1983 was of particular importance to petroleum refiners in developing countries as many of them suffer from old plant installations and consequently from inefficient performance. It is in this area that refineries in developing countries need more assistance since not only good material but also skilled and experienced workmanship is required to raise the efficiency of a refinery.

For the above reasons, the theme of maintenance and plant inspection was repeated in this year's workshop. As part of this workshop a meeting of an experience exchange group was conducted dealing with practical problems related to maintenance and plant inspection in petroleum refineries.

The workshop, comprising the meeting of the experience exchange group, had the following purposes:

- to exchange experience and information in maintenance and plant inspection of petroleum refineries for the improvement of the capabilities of refinery personnel from developing countries and to establish means for co-operation among themselves and with OMV in that field;

- to review well proven and new methods in the field of maintenance/inspection of petroleum refineries and assess their applicability in developing countries;

- to discuss possible solutions for selected maintenance/inspection problems brought up by the participants.

## 2.1 Programme and Summary of Lectures

### 5 November

Opening Session at UNIDO

Monitoring Session at OMV Refinery, Schwechat

Visit of the refinery

### 6 and 7 November

**Maintenance in Refineries - An Overview (J. Maier)**

The rationalization measures taken in recent years within the processing industries have led to the construction of an increased number of units/plants in the production sector, resulting in a decrease of the production costs. At the same time, however, the cost of maintenance - a labour-intensive sector - has considerably increased. Therefore efforts are being directed towards minimizing the costs of maintenance to the lowest economically and technically acceptable level. This implies careful design of maintenance strategies and their implementation.

The management of a refinery has therefore to plan and establish appropriate maintenance policies. Modern maintenance requires interaction between many different working groups of a refinery and cannot be left with the maintenance department alone, which, together with the staff of the production plants, will carry out the required maintenance function as defined in an overall refinery maintenance policy.

Maintenance Functions, Policy and Strategies (J. Maier)

Maintenance as a whole comprises all personnel and activities involved in the maintenance of a refinery. Maintenance policy is geared towards minimizing maintenance costs and generally would allow expenditures only in cases where the output contributes to the safety of personnel and plant equipment, to the refinery profitability and to the implementation of Government, community or labour organizations regulations. As a general principle the following guidelines may be observed: refinery-wide awareness and responsibility for maintenance expenditures; reasonable approach in terms of safety, profitability, environmental control, energy conservation; improvement of the skills of maintenance and other staff.

The day-to-day maintenance decisions may be guided by the following considerations:

- Break-down maintenance: A given system breaks down due to a part which has become completely useless and therefore needs either repair or replacement. The latter requires spare parts stockage causing storage costs.

- Preventive maintenance: Based on the estimated lifetime of parts, a scheme for planned exchange of parts can be developed. With larger plant systems this requires special index card systems for control and, from a certain size of the refinery on, the assistance of a computerized part control, exchange and supply system.

- Predictive maintenance: Since today various test methods are available to check the status of plant parts on stream, failure of equipment can be predicted within a certain uncertainty range and repair programmes, production and procurement schedules can be set up accordingly. These measures are based on comparative analysis of cost of repair of defective part and production loss weighted against the consequences caused by total break-down envisaged for the defective part. Scientific methods combined with empirical data and practical experience will assist maintenance managers in the decision-making process.

- Corrective maintenance: In cases of high frequency of damages which may reveal a defect in the construction, a solution for the improvement of such a construction must be found.

Maintenance through External Contractors (J.Maier)

Many refineries have maintenance work done through outside contractors. The extent to which external contractors are assigned for this work depends largely on local conditions, the maintenance policy of the refinery and technical security regulations. The decision for an engagement of an outside contractor is usually guided by the following considerations: provision of know-how not available within the refinery; repair/overhaul of plants; periodic requests for maintenance works to be contracted and establishment of a contract on a permanent basis; high work peak loads within the refinery and lack of own personnel; requirement of very special technical devices and skills for certain maintenance works. Maintenance management must decide at an early stage whether work should be done through contractors or whether additional investment and recruitment of personnel is more appropriate for satisfying maintenance needs.

Shut-down Planning and Scheduling (J. Maier)

Very special methods are necessary for shut-down operations of a plant, which must be carried out at the shortest time possible. This is efficaciously done through network planning and network analysis (critical path planning method). This implies the preparation of a detailed work programme involving the plant manager, field technician, plant technician, the inspection department and the stop planner. Network plans are established and analyzed. Personnel is usually recruited through contracting firms. The shut-down programme is supervised and monitored preferably by the stop planner. A very important phase is the evaluation of data after work has been completed. These data represent a good basis for future planning.

8 November

Maintenance of Equipment - Compressors, Turbines (H. Miglitsch)

Plant equipment such as turbines and compressors need special attention in maintenance and service, whereby one has to distinguish between reciprocating compressors and turbine compressors and turbines. Organization of the responsibility for staff concerned with service and maintenance depends on the size of the refinery. Engineers and workers have to be trained almost on a continuous basis. OMV has made the experience that for turbines and compressors periodic service is not necessary but recommends regular protocols for controls of machine performance data. Through the variation of these data malfunctions can be identified. Reciprocating compressors, however, will require maintenance work at regular intervals as recommended by the manufacturer, mainly due to the higher wear rate of many parts of this type of compressor system. Several examples for maintenance work during a planned plant shut-down are given.

The degree of vibration of rotary machinery is a very strong indicator for imperfect alignment, instable bearings, unbalanced rotors, etc. These causes for malfunctions must be destroyed. Therefore the many different types of bearings must be checked as well as the rotors (pumps, fans, electric motor rotors, compressors, turbines), and the influence of the settling of the foundation and of temperature difference.

Some special instruments exist such as alignment calculator, bolt extensiometer, pressure test/repair facilities for compressor valves. Particularly the extensiometer appears to be very useful as it is a means to determine the precise length of a bolt (ultrasonic) and therefore provides the basis for accurate calculation of the bolt preload. It also can be used for checking relaxation and helps to prevent thermal cycling, vibration, gasket creep, load cycles and joint failures.

9, 12 and 13 November

Plant Inspection in Petroleum Refineries (O.P. Hornasek)

Plant inspection in general addresses the following issues: corrosion, lifetime of equipment and scheduling of inspection, inspection methods, deterioration/failure of equipment and its prevention, detailed equipment inspection, on-stream inspection and special test methods.

Corrosion problems: In oil refineries mild steel is the material most commonly used and it suffers from corrosion at various degrees caused by a variety of sources. It is necessary to determine the nature and mechanism of corrosion so that suitable and economical methods may be applied for its prevention. Various remedial actions are discussed such as coating/linings, addition of inhibitors, cathodic protection, and some causes for corrosion such as chloride stress corrosion cracking, polythionic acid stress corrosion cracking, sulfide stress cracking, uniform corrosion, acid corrosion, caustic corrosion, high temperature corrosion, are described.

Schedules for equipment inspection: Government regulation (e.g. Austrian pressure vessel law) determines the frequency required for inspection, in general not less than every three years, and for hydrotesting every six years. Only under very special circumstances can this schedule be modified, if Government authorities agree. Inspection work to be carried out is listed and recorded at the beginning of the calendar year by the inspection department, covering the work for vessels, piping, safety valves and leaking glands. Examples for inspection schedules are demonstrated.

Inspection methods: This part describes the methods to be applied for the preparation and execution of inspection work. The following points have to be borne in mind: local Government regulations, construction code requirements, inspection service for corrosive and non-corrosive equipment. General inspection may be carried out through visual inspection, hammer testing, gagings, followed by very special inspection methods as required. To determine the remaining lifetime of a given piece of equipment requires considerable experience. The decision on whether or whether not to withdraw equipment from service may be guided by two considerations: (i) the minimal allowable wall thickness, and (ii) lack of justification for economically acceptable repair.

Cleaning for inspection: Various methods exist for this purpose ranging from water/steam washing, manual cleaning, sand blasting, brushing, reaming, chipping, to chemical and thermal methods.

Metal loss measurements and calculations: The parameters which govern the lifetime of equipment are: minimum allowable thickness, remaining corrosion allowance, corrosion rate, remaining life. An example for estimation of actual lifetime is presented. The various methods for corrosion rate measurements are described and their application explained.

In addition, the means for pressure testing are presented and procedures and safety considerations are explained. A very important work within inspection is welding, which requires very skilled personnel. Different types of welding necessary for inspection in petroleum refineries are listed and briefly described.

Deterioration/failure of equipment: The major cause for equipment failure is due to mechanical failure and corrosive attack. A review is presented on effects on various material and equipment, caused by mechanical stress and corrosion and oxidation. In addition, material exposed to a very special environment, such as high sub-critical temperature, overheating and others, may change its surface characteristics which may lead to dangerous conditions. Furthermore, the basic principles of cathodic protection are described and the different applications are outlined.

Lifetime of equipment: Very careful thought must be given to the judgement of lifetime to be expected for equipment. Premature retirement of equipment can waste money, while overdue utilization may cause failure with fatal consequences. Establishing the lifetime to be expected for a platforming heater is presented in detail as an example. Furthermore, an example for calculating remaining lifetime based on original and actual wall thickness is carried out (determination of remaining corrosion allowance and remaining life).

Detailed equipment inspection: Guidelines to be observed when a full inspection for any piece of equipment is called for, are laid down. Importance is attached to safety precaution and to the general safe limits of equipment. This is followed by a detailed description of a complete inspection, including nomenclature, design and retirement criteria, construction materials and repair and testing of the following equipment pieces: columns, pressure vessels, storage tanks, heat exchanger and cooling towers, process furnaces and boilers, pumps, turbines, compressors and machinery, instruments, piping and fittings, joints, bulk transmission lines, structures, fire proofing, insulations and foundations, and services.

On-stream inspection and special testing methods: The inspection of equipment in operation requires non-destructive testing methods (NDT-methods). However, many details cannot be detected while the unit is on-stream. The types and basic requirements of methods for on-stream inspection are described, which include visual inspection, ultrasonic, radiation tracer and infrared techniques as well as thermometric methods, radiation pyrometer method and acoustic emission methods. Examples are given on NDT acoustic inspection on pressure vessels and storage tanks and results are discussed.

10 and 11 November 1984 Saturday/Sunday

14 November

Material Management (G. Brantner, V. Klima)

Material management comprises the management of the warehouse, material handling and administration. An efficient material management can greatly reduce the shut-down time of a plant. Therefore security for material supply has high priority.

At OMV, 50% of the stored spare parts are permanently on stock, also for cases of unforeseen events. This long range planning requires capital cost. Efforts are therefore directed towards reducing these costs through improving warehouse administration. Storage of materials classified into material groups helps to locate material (sequential system) easily but requires a considerable amount of space. A new storage system was developed following the findings that 80% of stored parts are smaller than 950 x 200 x 350 mm. A computer-aided storage information system was created for locating parts. The new storage system needs only half the space of the old one. In addition, a computer programme is being developed to support material administration taking into account catalogue and technical information, purchasing, warehousing and accounting.

Material Supply - Spare Parts Information Flow and Purchase (H. Kreisler)

Being a relatively large refinery and involved in exploration, pipeline transport, engineering and construction, OMV has decided on a centralized purchase department. The material catalogue comprises 60,000 items. The material administrator revises this catalogue and the warehouse stocks according to actual requirements from the refinery. A selective control system has been developed which takes into account spare parts needed with higher frequency than others. Most of the materials are ordered from Austrian companies, USA and European companies with an average delivery time of 10 weeks, whereby four weeks are needed to comply with administrative regulations within the organization.

Maintenance of Process Pumps (H. Sieb)

An important cost factor represents the maintenance of process pumps. Pumps repair costs are approximately 7% of the total maintenance expenditures of a refinery. Most of the pump failures originate from defects in the mechanical seals (70%), bearings and oil seals, corrosion, erosion, cavitation, etc. OMV has developed a number of proceedings to reduce these cost factors.

Maintenance of Instrumentation - Pneumatic, Electronic Instruments (H. Kloyber)

For the control of approximately 6000 process variables, 3200 alarms and others, OMV refinery attaches importance to proper functioning of the respective control instruments. The types of instruments used - pneumatic, analog and digital electronic, microprocessor-based electronic - are all maintained by specially skilled technicians. Work is scheduled and organized for shut-down periods and for operation periods. There exists an experience exchange group on instrumentation which meets annually for two days presenting a catalogue of questions/problems for discussions.

Maintenance of Process Analysis Instruments (H. Kloyber)

Due to the relatively large number of analyzers (625) to be controlled, the process analyzer department of OMV has been divided into four groups: pH group (conductivity, pH, oil in water); $O_2$ group ($O_2$, viscosity, CO, $CO_2$, CPA, sulfur, pour point, IR, $H_2S$, boiling point, opacity); gas detection group (hydrocarbons, $H_2S$, portable gas detectors); process chromatograph group (GC, moisture analyzer). These instruments must be controlled exactly according to their maintenance manuals. Calibration of these instruments is an important task and must follow standardized sampling and analysis methods.

15 November

On-stream inspection and special testing methods: The inspection of equipment in operation requires non-destructive testing methods (NDT-methods). However, many details cannot be detected while the unit is on-stream. The types and basic requirements of methods for on-stream inspection are described, which include visual inspection, ultrasonic, radiation tracer and infrared techniques as well as thermometric methods, radiation pyrometer method and acoustic emission methods. Examples are given on NDT acoustic inspection on pressure vessels and storage tanks and results are discussed.

Material Standards (Raaber, B. Wischin from TUV, Austria)

In general various types of materials are used as construction material for the equipment in a refinery depending on the type and the strength of stress to which it is exposed: for temperatures up to 400oC carbon and low alloy steel, for high temperatures chromium steel, austenitic steel, for high pressure in presence of hydrogen chromium steel, and others. The Austrian legislation on pressure vessels defines the standards under which quality systems certificates can be granted for certain products operating under pressure. In addition, inspection of these units must be done in the presence of TUV (Technical Inspection and Control Authority). Only with their certificate the tested unit can be put into operation.

Trouble Shooting (H. Miglitsch)

Trouble shooting and predictive maintenance are closely linked. Today's machinery, e.g., turbo-machinery is technically getting more and more sophisticated and better trouble shooting techniques have become essential. Some recommendations are given to avoid malfunctioning of turbo-compressors, turbines, reciprocating compressors and other rotating equipment, such as pumps, fans, gears units. For compressor and turbine units, permanent monitoring of the vibration is necessary since vibration is one of the most frequent causes of failure of such units.

Analytical Trouble Shooting (H. Huber)

Methods and techniques are presented for supporting decision making and prediction of critical situations. The four models of reasoning in daily routine work - namely to determine the reason for troubles, to choose the best measure, to recognize problems ahead of time, to split a complex situation into parts - can be optimized by rational techniques. Although the approach to decision making and problem solving as described is of general nature, its practical application to maintenance within a refinery will have an impact on the efficiency of such a refinery.

Recuperation of Flare Gas

Even at thorough, normal operation of refineries and petrochemical plants, combustible gases (flare gases and tail gases) are developed, which represent a considerable waste of energy. OMV has therefore developed an economic flare gas utilization process, whereby the flare gas is fed into the fuel gas system of the plant. Care must be taken to avoid air in the recuperation unit for well-known reasons. The operation of this plant is automatic to the greatest possible extent to keep the whole system economic. The plant presently installed at OMV has a nominal capacity of 5000 $m^3$/hour. The process has been patented.

Planning a Repair Shop (P. Kielhauser)

A detailed analysis shows that maintenance costs can be reduced by careful planning of repair shops for the refinery. The main questions to be answered are: What is the maintenance demand? How can this demand be met? Where should the repair shops be located? Will repair shops need extension? How to plan the internal organization? How to plan equipment storage? All planning steps have to undergo critical evaluation with a view to their impacts on economics.

Training of Maintenance Personnel (J. Schweng)

Maintenance work may be done by contractors or by own personnel. Most refineries follow a mixed system whereby services like cleaning, welding, etc. are done through contractor and long/short-term repair/ turnarounds by refinery personnel. Skilled personnel is usually provided through recruitment of specialists from other refineries or by on-the-job training of experienced workers from other industries. A very important source for skilled workers is established through an apprenticeship programme in Austria. Nearly 60,000 students start every year such an apprenticeship in various fields/trades, whereby the apprentice receives practical on-the-job training according to a well established and approved training schedule and theoretical training in a vocational school (dual system). After 3.5 years a certificate as a qualified worker is awarded. At OMV 60 new apprendiceships were started in 1983.

A large part of training of maintenance personnel is done during installation and start-up of new units when experienced workers from contractors, manufacturers, engineering companies work together with the own workshop personnel. This is the moment for acquiring know-how in trouble shooting and repair work.

New training methods such as audio-visual and video programmes are now available. In addition, interactive training systems and simulator systems can be applied which represent very powerful training techniques, especially for training in the operation and maintenance of highly sophisticated machinery and instrumentation.

16 November

Meeting at the Federal Economic Chamber of Austria and with various Austrian suppliers of refinery equipment.

17 and 18 November Saturday/Sunday

19 November

Visits to Austrian companies/plants

20 to 22 November

Experience Exchange Group

23 November

Visit to OPEC Fund for International Development.

Closing Session at UNIDO.

## 2.2 Opening Session (5 November 1984)

Opening speeches were delivered by:

- Mr. L.F. Biritz, Deputy Director
  Division of Industrial Operations, UNIDO

- Mr. H. Miltner, Counsellor
  Adviser to the Permanent Representative of Austria

- Dr. A. Ezzati, Director
  Project Appraisal, The OPEC Fund for International Development

- Dr. F. Cech, Director of Refinery
  OMV Aktiengesellschaft

- Dr. H. Lederleitner
  Austrian Federal Economic Chamber

## 2.3 Closing Session (23 November 1984)

The session was introduced by Mr. Maung, Senior Industrial Development Officer, UNIDO, followed by Mr. J. Maier of OMV who thanked the workshop organizers and participants. During the ensuing Mr. B. Holloway, a consultant financed by The OPEC Fund for International Development, pointed out the need for more preparation and selectivity for the experience exchange group.

## 2.4 The Experience Exchange Group

In addition to the programme organized by OMV a three-and-one-half-day programme was organized for the Experience Exchange Group in which discussions were led by the OPEC Fund consultant Mr. B. Holloway. Topics discussed included:

- maintenance and planning control;
- corrosion problems;
- energy conservation;
- future activities of the Experience Exchange Group.

Presentations were also made by technical personnel of Fluor Plant Services International, UK, Gesellschaft für Industrieanlagen-Planung (GIP), FRG, and OMV, Austria. Participants from developing countries also made presentations on their problems and experiences.

The proceedings of the Experience Exchange Group are attached as Annex II.

## 3. Resolution of the Participants

The participants to the Experience Exchange Group have unanimously agreed to the following resolution - namely that:

(i) The Experience Exchange Group should be continued as a permanent mechanism.

(ii) UNIDO should provide permanent technical and administrative support.

(iii) There should be a continuous exchange of information by participants through UNIDO.

(iv) There should be an annual meeting to discuss problems and exchange information. This should be in conjunction with a series of technical lectures at the refinery.

(v) Before the meeting UNIDO would call for proposals for topics to be discussed and for offers of papers, particularly case studies, to be presented by the participants at the meeting.

(vi) In addition to these papers there should be a contribution on the topic from a highly developed refinery.

(vii) Some visits to plant of special interest should be included.

(viii) UNIDO should provide the Chairman for the meeting.

(ix) It is considered desirable that there be continuity of representation.

(x) The meeting should take place in September each year unless to be held in a country in which this was not the most suitable time of the year.

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## Proceedings of the Experience Exchange Group

Tuesday, 20 November

1. Topic: Maintenance Planning and Control

2. Introduction: The following participants had stated a special interest in this subject in the questionnaire:

- Mr. R.A.C. Perez (Cuba)
- Mr. T. Mulu (Ethiopia)
- Mr. H. Al-Shaban (Kuwait)
- Mr. K.I.R. Fernando (Sri Lanka)
- Mr. O.H. Allawandi (Sudan)
- Mr. A. Intiyanaravut (Thailand)
- Mr. A. Ertem (Turkey)
- Mr. S.R. Saeed (Yemen)

The participants from Turkey and Kuwait also included this subject in their technical report. Whilst OMV included this subject in their programme it was considered so important that further specialized outside presentations were included and the participants discussed the implementation of modern techniques appropriate to their situations.

3. Proceedings:

3.1. Following introductory remarks by Dr. D. Runca welcoming the participants to this phase of the experience exchange the session started with the first of the outside presentations.

3.2. Presentation by Fluor Plant Services International (UK)
Speakers - Mr. B.H. Dorman - Vice President, Marketing
Mr. J. Morris - Senior Maintenance Engineer

3.2.1. Mr. Dorman stated that Fluor Plant Services International had some 8,000 staff from engineer to trademan and over 200 clients. He said they could offer a range of services including total maintenance, maintenance management, etc..

3.2.2. Mr. Morris said that Fluor had three systems to cater for differing sized requirements:

1. MTS which used Basic and a microcomputer
2. CMMS 1 which used RGP2 and an IBM 34/36 minicomputer
3. CMMS 11 which used Cobol and an IBM Series 4300/30XX

MTS could handle 1,000 files, CMMS 1 could handle 5,000 files whilst CMMS 11 was unlimited. He went on to explain how the system worked in some detail.

3.2.3. Mr. Morris then presented a short description of a development of a sister company, Loveland Controls Company, in which a computer programme has been prepared to assist in the checking and calibration of instruments.

3.2.4. In discussion it was confirmed that the system could provide for maintenance by hours run. It did not cater at present for number of starts. It could be integrated with existing stores systems. There was no fixed price as Fluor wished to provide an ongoing service. The first effect of the programme was to reduce stock inventory. Then the programme reduced manhours and increased up-time.

3.3. Presentation by Gesellschaft für Industrieanlagen-Planung (GIP)

Speaker: Mr. J. Kiehl – Marketing Director

3.3.1. Mr. Kiehl's presentation was on the use of consultants for the planning of work which did not involve licenced processes. Under these circumstances an experienced team could be provided on site which had immediate access by facsimile transfer to the programmes and back-up staff in the head office. This meant that, where licenced processes were not involved, it was not necessary to go back to the original contractor. The refinery plus consultant with his back-up support could carry out the work more economically.

3.3.2. In discussion Mr. Kiehl stated that GIP had about 100 engineers. About 50 of these were on site and 50 in head office.

3.4. Presentation by Mr. B.P. Holloway, OPEC Fund Consultant

Mr. Holloway stated that in any maintenance system the effect was only as good as the detail of the maintenance to be carried out. He drew attention to the "Guide for the Inspection of Refinery Equipment" published by the American Petroleum Institute, and the "Refining Safety Code" of the British Institute of Petroleum.

3.5. Presentation by Mr. Al-Shaban (Kuwait)

3.5.1. Mr. Al-Shaban spoke on the need to involve the maintenance engineer in the design phase of a project.

3.5.2. In discussion it was agreed that the maintenance engineer should be a member of the project control team. It was felt that the job description for a project engineer should include a requirement to have served for a time in the maintenance department of the same refinery. The maintenance engineer should be involved in inspecting the plant and equipment during manufacture.

3.5.3. Conclusion:

It was agreed that the attention of management should be drawn to the desirability of involving the maintenance engineer during the design phase as a means of improving the operational efficiency of the completed plant.

3.6. Presentation by Mr. A. Ertem (Turkey)

3.6.1. Mr. Ertem spoke about the human effects of introducing computerized maintenance. He considered that such systems were involved in reducing labour costs but in LDC's labour costs were much lower and the system would not produce the same savings. In Turkey they were involving the labour force in the management role. They had allocated pairs of pipefitters to each area. They had set up local stores. The teams were responsible for steam leaks and had achieved a significant reduction in steam consumption. Due to the reduced labour costs the pay back time would be much greater in LDC's. He considered that UNIDO should make available data on comparative costs.

3.6.2. In discussion it was stated that all refineries should start by conducting an Energy Audit. This was of greater value than comparing statistics. In Turkey they were using local material of lower quality as they found this more economical even if they had to maintain on a six month basis rather than annually.

3.6.3. Conclusion:

It was concluded that it was necessary to take full account of the human factors in any maintenance system. Tradesmen were the eyes of the maintenance manager and must be encouraged to look for and report all malfunctions.

3.7. Presentation by Dr. P. Strauss, OMV AG

3.7.1. Dr. Strauss presented a talk on the computerized system for Warehouse Management and saving storage space in use at OMV AG. This paper is attached as Annex 8. This system had achieved savings of about 50% of the storage space required for the holdings of the OMV stock. This was achieved by binning parts according to their space requirement. This meant that a store location had no other significance than the spatial one. In order to find the space it was necessary to have a very efficient management system. This was provided by the computer. When the computer was not available parts could be located by means of microfiche and viewers available in all 85 storehouses. The microfiches were produced monthly from the current computer printout.

3.7.2. Questions:

1. In answer to question Dr. Strauss stated that OMV AG had 65,000 catalogue items. Due to the multiple storage locations this meant 120,000 storage items. The warehousing programme required a computer capacity of 20 M bytes. The total stored programme required 200 M bytes.

2. Mr. Al-Shaban (Kuwait) said that in some cases the supplier would only provide a complete set of parts. How could the system cope when only one item of the set was required.
Answer: Each case must be examined on its own merits. It might be possible to break a set down into components and replace used items such as O rings from another source. On the other hand the cost of trying to account for a subdivided set may be greater than the cost of the complete set.

Wednesday, 21 November

1. The session was opened by Mr. M. Maung, Chief, Fertilizers, Pesticides and Organic Chemicals Unit, who spoke on the financial resources of UNIDO and the ways in which UNIDO is able to assist developing countries. In particular he talked about the programme of technical co-operation and special industrial services. He explained how proposals for such assistance could be initiated by the participants through their own Government channels.

2. Topic: Corrosion Problems

2.1. Introduction: Many of the participants have stated special interest in the corrosion problems they meet in their refineries. The particular aspects are as follows:

2.2. Tank corrosion: Mr. E.G. Danquah (Ghana)
Mr. E.M. Osman (Sudan)

2.3. Units and components: Mr. R.A.C. Perez (Cuba)
Mr. T. Mulu (Ethiopia)
Mr. E.G. Danquah (Ghana)
Mr. E. Ferreira (Mozambique)
Mr. N.N.I.R. Fernando (Sri Lanka)
Mr. S.R. Saeed (Yemen)

2.4. Sea water piping: Mr. T. Mulu (Ethiopia)
Mr. E.G. Danquah (Ghana)
Mr. A.S. Amaar (Libya)
Mr. Y.O. Mlungura (Tanzania)

Most of the above participants have included details of corrosion problems in their technical reports. The applicants from India, Mr. S.R. Kumar and Mr. E. Uddin also submitted technical reports on this topic.

3. Sea water intakes:

3.1. Mr. A.S.S. Amaar (Libya) presented his report on the novel way the accumulations of marine growth and silt had been cleared from their refinery sea water intakes. This was done on a self-help basis after receiving expensive proposals from contractors. In the discussion it was pointed out that in Ghana they had had a similar problem but the pipelines were 5 km long. They had cut manholes for access and put divers in to clear by hand. The pipes were concrete lined with one section of carbon steel which was the worst affected. This had been replaced by a section of Fibreglass which resisted marine growth. In Tanzania the pipes were about 1 km long and concrete lined. They had manholes for inspection but dosed with chlorine at the sea end. Due to the cost and hazard of using chlorine the desire was expressed for an alternative. It was agreed that there was probably no satisfactory alternative but that the hypochlorite could be produced by electrolysis of sea water which should prove more economical and avoided the hazard of handling chlorine gas. The use of thickwall,schedule 40 or 80 PVCC piping, was advocated for the hypochlorite line. The use of fibreglass piping was advocated and it was reported that it was being used for hot acid mixing tanks in Ghana so would stand elevated temperatures. Both Cuba and Kuwait reported that they were using concrete lined pipes successfully for sea water intakes.

3.2. Corrosion of heat exchanger:
It was reported that in Cuba sea water cooled heat exchangers were constructed of Admiralty Brass B 111 grade B but it had been found necessary to stress relieve the tubes and to temper the tube ends.

3.3. Fire fighting systems:
After discussing the problem of the use of sea water for fire fighting systems it was concluded that the systems could be charged with fresh water with the pumps only handling sea water in the event of a fire.

3.4. Tank corrosion
It was reported that in Ghana trouble was being experienced with the corrosion of the middle courses of a 6 course floating roof tank containing leaded gasoline. The Octel Co had stated that the corrosion was not attributable to TEL. The tank had been sandblasted and 600 mil epoxy paint coating had been applied consisting of a primer coat, 2 base coats and 2 top coats. There was no rubbing of the paint by the floating roof. It was considered that probably the sandblasting was inadequate. It was reported that in Kuwait they sandblasted to SAE 2 1/2 standard and had no trouble. It was agreed that more accurate description of the standard of sandblasting was desirable. There was some discussion of new painting systems coming on the market which would coat over rust and could be applied to wet surfaces. Not sufficient was yet known for an opinion to be formed.

3.5. Cathodic protection:
It was reported that trouble had been experienced in Ghana due to contaminated zinc anodes bought commercially. These had been replaced with locally cast anodes incorporating some aluminium. This had proved satisfactory. It was reported from Cuba that a satisfactory solution had been found by lining the water boxes with lead, with naval brass 171 tubes and plates and silicone bronze seats. Sacrificial anodes had been installed. Further discussion was posponed till the next day.

4. Topic: Energy Conservation

4.1. Introduction: Whilst only two delegates, Mr. A. Intiyanaravut (Thailand) and Mr. A. Ertem (Turkey) stated a special interest in energy conservation, Mr. Intiyanaravut submitted a well argued report based on his experience. It is considered that this is a subject of special importance to all refineries but especially in developing countries. It was not included in the OMV programme because of time restriction.

4.2. Mr. Intiyanaravut (Thailand) presented his paper on the reorganization of Military Oil Refinery in which major steps had been taken towards improving the energy balance. The major changes were in the improved operation of the plant and in the recovery of condensate from the steam system. Waste heat boilers were to be installed to recover flare gas. Non of the other refineries reported any attempt to recover flare gas. The impression had been gained that this could only be attempted by purchasing the system patented by OMV AG. Possibilities were discussed.

4.3. Mr. Ertem (Turkey) presented his paper on the measures they were taking to improve their steam consumption. This was through an energetic attack on leaking steam traps. It was hoped to manufacture replaceable steam traps in Turkey. Insulation to pipes was being improved. It was reported that difficulty was experienced in measuring results due to inadequate instrumentation As the improvements were only likely to be of the order of 0.5% to 1%, a high degree of accuracy was required in the measurements or else the changes would be lost in the instrumentation error.

4.4. Conclusion:
It was agreed that a high priority should be given to improving instrumentation required to measure the results of measures to improve energy conservation.

Thursday, 22 November

1. Experience Exchange Group

1.1. The group discussed the future of the concept of an Experience Exchange Group and came to a unanimous decision that they wished the group to continue on a permanent basis.

1.2. Discussion:
It was agreed that now that the technological level of the group had been established it would be possible for participants to prepare papers, especially case studies, for presentation at the meeting. This had not been understood before this meeting and so participants had not been fully prepared for the discussions. It was generally considered that the period at OMV AG had been too intense. The level of subjects was generally beyond the normal experience in LDC's and much could not be directly related to the work of the participants. The amount of instruction had been too concentrated especially as for most of the participants English was not their first language. Some topics such as Energy Conservation were very broad and attention should be directed to specific points.

2. Oil Loss Control

Copies of a summary of the papers read at the conference held by the Institute of Petroleum in London during October 1984 were presented to the delegates. Attention was drawn to the remarks made by Mr. H.L. Fenner of Esso Europe Inc. about the need to improve the accuracy of measurement in the industry. Esso had now set guidelines seeking an accuracy wit' a 95% confidence level of plus/minus 0.2%. He stated that most refineries had an energy conservation programme which had a close correlation to oil loss so that the two elements should be monitored together.

3. Discussion continued on the topic of corrosion.

3.1. Mr. Fang Jian Zao (China) described the problems they had been experiencing with pressure vessels for hydrocracking, with operating temperature of 450-500°C and pressure of 150 bar. They have two types of reactor - cold wall with refractory lining and hot wall. The cold wall reactor is of carbon steel with an inner liner of E 347. After a long period of use hot spots appear. To continue operating it is sometimes necessary to direct a blast of cooling air from a fan on the hot spot. Eventually, however, it is necessary to shut down and repair the leak in the liner and replace the defective refractory. The newer reactors were designed as hot wall vessels of 2 1/4 Cr 1Mo steel or 1 Cr 1/2Mo clad with 3 to 6 mm E 347. This, however, has produced a problem of the cracking of the base material under the cladding. This is difficult to detect but is probably due to differential expansion of the base metal and cladding. Answers are required to the following: Between cold and hot wall reactors which is more free from failure and which is simpler in maintenance inspection and repair? Which is cheaper? How do you solve the problems described above? What is the best material to choose for a platforming reactor exposed to high temperature (540°C) and hydrogen? If you use 1 Cr 1/2Mo or 2 1/4 Cr 1Mo what will happen after long service? Can you weld pressure vessel or pipes of CrMo steel using austenitic stainless steel electrodes? How can you prevent hydrogen attack in practice?

3.2. It was stated that in Cuba they have both types of reactor. They had a failure on a cold wall reactor and it was decided to remove the inner liner as being unnecessary. After a short while they had had to replace it. They used E 347-15 or 16 electrodes. It is necessary to dry out the electrodes very carefully before use. They apply a low pressure test, about 30 psi, between the shell and liner to test for leaks. It is a floating liner and they have had no more trouble. The operating temperature is 430°C and 430 psig (about 30 bar).

3.3. It was pointed out that the cost of a new reactor was very high, about US$20,000/ton. The cost of the liner is US$60,000/ton. A reactor under construction in Japan weights 4,000 tons.

3.4. It was reported that in Ghana they had had a small crack in one reformer reactor. Although they had repaired one previously it was recommended that they replace all four reactors. Although they were 18 years old this was considered wasteful.

3.5. Sri Lanka reported that they had a lamination problem in the cap of a naphta reforming reactor after 13 years in service. It was found by ultra-sonic investigations and the technique had not been used before on this cap. The laminations were extensive but there was no indication yet why they had occurred nor how long they had been in existence. The pressure was 700 psig and the temperature 340°C. It was considered that this was probably a material defect which had always been present but not previously identified. This indicated the need for the maintenance engineer being present during the manufacturing stage.

3.6. Mr. Ertem (Turkey) gave a talk on developments in Operational Research. Although he had not had the opportunity to use the techniques in Turkey he considered that engineers should study them as they could be of great assistance in problem solving.

Friday, 23 November

The morning session was devoted to a visit to the Computer Centre of OMV AG where participants were able to experience at first hand the retrieval of information on Warehousing and Stores Control.