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FINAL REPORT

UNIDO CONTRACT NO. 74/42

PROJECT NO. IS/SYR/71/806

PROJECT	Assistance to the Oil Refinery at Homs - Syrian Arab Republic.
CONTRACTOR	Engineers India Limited 4 Parliament Street New Delhi - 110 001 India.
DATE OF COMMENCEMENT OF WORK IN PROJECT AREA	March 7, 1975
REPORT PREPARED BY	Central Services Organisation (EIL) (H.O. : (Dr) A.K. Lahiri Site : R. Shivakumar P.L. Santra)

C/F

DATED - AT NEW DELHI December 10, 1975.

PP. c. 80

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SYNOPSIS

The Homs Refinery plays a vital role in the national economy of Syrian Arab Republic and it is, therefore, essential that the Refinery achieves the longest sustained throughput run possible and shutdown, inspection and repairs are kept to a minimum. This objective can be achieved only through a well conceived system of equipment inspection, sound recording system optimum maintenance material inventory control and trained engineers to ensure that adequate and necessary repairs are done at proper time. The activities during the contract period were, therefore, directed towards introducing such a system after identifying the existing problems connected with mechanical inspection and preventive maintenance in the Refinery.

Homs Refinery Management has not been able to establish a sound mechanical inspection and preventive maintenance systems due to various constraints. Suitable systems were, therefore, developed tailored to the local needs and implemented with full cooperation of the Management.

Mechanical Inspection recording system has been introduced in two units and work on the third initiated. In the areas of PM 25% of rotating equipment in the Refinery have been covered by the new system. These will act as 'model cases' for covering the whole Refinery under the new system.

The counterpart engineers and other technicians and workmen have been trained and guided in the implementation of the system.

Additional equipment, testing facilities and changes in the organisational set-up have been recommended after discussion with the Homs Management. Schedules, code of practice and recommended procedure in the field of inspection and maintenance have also been developed/provided wherever necessary.

Advice on materials, inspection, maintenance and other problems was rendered during May '75 shutdown and also on problems arising out of day-to-day work.

The improvement in maximising production and in optimising maintenance cost can only be achieved if the new system is introduced for all the units and then sustained in future. In achieving this goal, a three step programme consisting of a) training of engineers, b) interaction with specialist group and c) maintenance and management training of Heads and Asst. Heads of concerned Departments has been recommended.

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1.0 INTRODUCTION

1.1 At present the Syrian Arab Republic has only one oil Refinery at Homs to meet the demands of its petroleum products. The capacity of the Refinery is 2.6MT/year crude oil throughput to which two more units will be added in the recent future thus increasing the throughput to 4.6 MT/year. This Refinery plays a vital role in the whole national economy and it is, therefore extremely important that the Refinery is run without interruptions to achieve the longest sustained throughput run possible.

To achieve this objective it is necessary to ensure that such services as mechanical inspection and preventive maintenance are adequate. Since local expertise in these fields is limited UNIDO assistance to advise and assist the Management of the Homs Refinery on the organisation and development of mechanical inspection and preventive maintenance services was sought by Syrian Arab Republic. In pursuance of the requirements for the services of an organisation with necessary backstopping and supervision, UNIDO awarded the contract to EIL(CSO), which has necessary expertise in this field, for providing the assistance.

1.2 The scope of services included:

a) identify existing problems regarding mechanical inspection and preventive maintenance at the Refinery;

b) prepare a programme for mechanical inspection and preventive maintenance in order to ensure that all the units of the Refinery are running at maximum efficiency; the programme shall be based on modern techniques adapted to local conditions;

c) prepare and provide "Codes of Practices", "Manuals" and "Standards" in the various fields of maintenance, planning, mechanical inspection, recording, corrosion control, welding, painting, refractories, etc. essential for the smooth and efficient running of the Refinery;

d) assist in the execution of the above programme for mechanical inspection and preventive maintenance;

e) assist in the organization of a Mechanical Inspection Unit and a Preventive Maintenance Unit at the Refinery;

f) train counterpart engineers until they are fully competent to take charge of the above units;

1.3 For the performance of the above scope of work EIL(CSO) provided two experts at Project Site, one on maintenance (Team Leader) for a period of 8 months and another on mechanical inspection for a period of 4 months. Back-stopping and supervision services during the period of

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assignment were provided by EIL(CSO) from the Home Office at New Delhi and also by two visits by experts from EIL(CSO) at the Project Site.

1.4 This report is the final report covering the work of the Contractor's personnel at Homs Refinery (Project Site) during the period of assignment. The report deals with the problems identified in the Mechanical Inspection and Preventive Maintenance, the steps taken to introduce a sound recording system in the above areas, progress and the training given to the refinery personnel in the implementation of the new system. The report deals with the future needs and recommends the steps needed for the Refinery to have an effective and economical maintenance system. The report also outlines the additional assistance given to the Refinery Management in the field of mechanical inspection and PM during the period of assignment.

2.0 PRELIMINARY SECTION

2.1 Physical facilities and organisation of Homs Petroleum Complex is given below:

2.1.1 The Homs Refinery Complex consists essentially of Refinery I of 1.6 million ton per year built in 1959 and Refinery II of 1.0 million ton per year, which was added on in 1968. A further two million ton per year capacity is being added and this is in the form of two topping units of 1 million ton per year each. The original two units were built by CHEPOS of Czechoslovakia and the two units currently being constructed are by INGECO of Italy and CHEPOS of Czechoslovakia.

2.1.2 Refinery I consists of a combination Topping and Vacuum Distillation Unit (10), an Unifiner Platformer (200) and a Treating Unit (12). All units in this Refinery are in operation except the Desalter and some parts of the Treating Section, which were damaged during the war.

2.1.3 Refinery II consists of a Crude Distillation Unit (100), Vacuum Distillation Unit (19), Vapor Recovery & Merox Treating, Kero HDS (14), Light Coker Gas Oil HDS, Heavy Coker Gas Oil HDS, Steam Reformer, H_2S Treating, Sulphur Unit and Delayed Coker (11). Of these only the Crude Distillation, Vacuum Distillation, LT Gas Oil HDS and Merox Treater are in operation. The rest of the units had been damaged during the war. Reconstruction has been entrusted to CHEPOS. The LT Gas Oil HDS Unit has been modified to process Kero since Kero requirements are more pressing.

2.1.4 The Refinery Complex has water treatment plants and power house for utilities production. The Refinery also has its own oxygen/nitrogen production unit.

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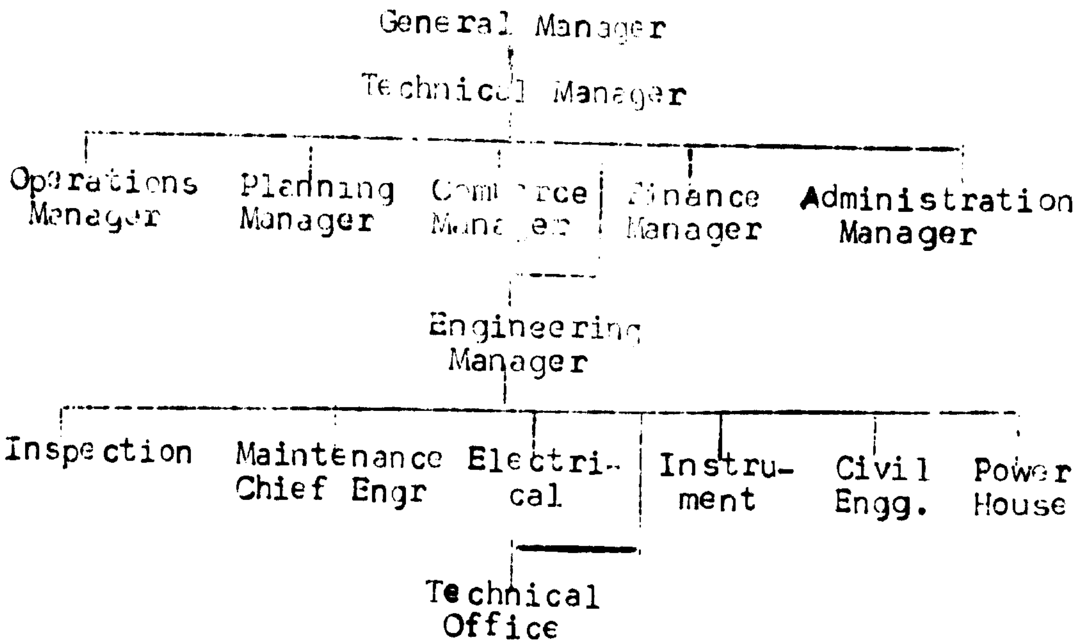
2.1.5 The organisational set-up of the Refinery administration is as follows:



2.2 Contractor's Personnel at Project Site

2.2.1 R. Shivakumar, PM Specialist arrived at Project Site on March 7 for a 8 months assignment at Project Site. (He is scheduled to complete his assignment on Nov. 6, 1975).

2.2.2 P.L. Santra, Mechanical Inspection Specialist arrived on April 24, 1975 and completed 4 months tour of duty on August 24, 1975.

2.2.3 The first of t.. short field visits by Head Office was made by Dr M.S.Mitra, Head of Central Services Organisation in EIL during the period April 6 to April 14. After study of the system by him and that made by the Team Leader, exhaustive discussions wer held with the top Management personnel of Homs Refinery and the objectives and outline of the programme were finalised.

2.2.4 The second of the field visits by Headquarters specialists was made by Dr A.K.Lahiri during the period Sept. 25 to Oct.4, 1975. Dr Lahiri reviewed progress of work, inspected systems established and its operation and also discussed with Manager of the Engineering Deptt. regarding Refinery's appraisal of the work done, and their future needs in training programmes.

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2.3 Homs Management Cooperation

2.3.1 Mr S.Drouby, Engineering Manager showed keen interest in the development of Mechanical Inspection and PM systems and provided necessary facilities for the services established.

2.3.2 Mr Z.Sibai and Mr G.Hayek took active interest in the implementation of Inspection Recording and PM systems and also other recommendations pertaining to Mechanical Inspection and PM.

2.3.3 Homs Management expressed their appreciation of the work done and felt that it has helped them by stimulating their interest in the new procedures, which they feel will assist in better operation. They realise that the success of the programme would depend on its continued application and development.

2.3.4 Services of one engineer and workman for Mechanical Inspection and two mechanics for PM were allocated to help in the programmes.

2.4 Mechanical Inspection & Preventive Maintenance

2.4.1 In the initial period problem areas were identified. Mechanical Inspection and PM systems were somewhat haphazard due to lack of a recording system with attendent procedures and standards for data interpretation. The problem has been compounded by a lack of continuity of engineers in-charge for supervision and the absence of a retrievable systematic recording system. Suitable systems were developed and implemented.

2.4.2 Mechanical Inspection

2.4.2.1 A modified and proven recording system tailored to the needs of the Homs Refinery was finalised and introduced. Two of the units, unit 10 and unit 11 were covered by the system. Inspection personnel were made fully conversant with the new system and are now competent to extend this system to the rest of the units. Work on unit 100 is now in progress and the Inspection Deptt. has agreed to enter the data collected during the May '75 shutdown in the cards.

2.4.2.2 Shutdown inspection procedures, plans and organisation have been discussed and recommendations given.

2.4.2.3 A suggestion has been made for a changed organisational structure and this has been accepted by Homs Management in principle.

2.4.3 Preventive Maintenance (PM)

2.4.3.1 In the area of PM for rotating equipment, a recording system was devised and introduced for five units, 10, 14, 1?, 100 and 200, covering about 130 pieces of equipment which is about 25% of the rotating equipment in the refinery (excluding the two units under construction).

2.4.3.2 A small group of mechanics have been trained in the operation of the PM system and additional equipment needs were formulated.

2.4.4 That the need for such systematic procedures of PM and inspection and a sound recording system is essential, has been recognized by the concerned personnel.

2.4.5 Throughout the project period emphasis has been placed on exchange of ideas, explanation of reasons for decisions and imparting procedures and techniques to local personnel. The May '75 shutdown was utilised for joint study.

2.4.6 Equipment needs laboratory facilities and library facilities were studied and recommendations made to bring these upto date to meet the needs of the Refinery.

2.4.7 Several codes of practice and recommended procedure have been prepared and handed over to the Homs Management.

2.5 During the period of assignment considerable progress has been made in implementing the Mechanical Inspection and PM systems which will work as a demonstration model for enlarging the system to the rest of the Refinery. Progress would have been still more but for the difficulties in communication with most of the staff in English and the difficulties of the Refinery Management to assign people on long term basis to the Contractor's team in the initial stages.

To get the full benefit of a sound Mechanical Inspection and PM systems, it is essential that the recommended systems are implemented in full and updated from time to time based on experiences of Homs Refinery and refineries in other countries where such systems exist. This will need (a) a change in philosophy of the Homs Management from 'fire fighting' maintenance to 'organised' maintenance (b) a change in the attitude of the engineers and workmen who are tuned to the present system (c) continuing contact with the systems as developed and modified in other refineries outside Syria by periodic visit/training and (d) interaction with outside specialists in these fields through periodic visits of the specialists to Homs Refinery and (e) maintaining a link with a developed organisation for complementing own efforts and introduction of new developments.

3.0 MECHANICAL INSPECTION

3.1 Recording System

3.1.1 In modern industries plant inspection, which was in early days associated mainly with safety, plays a vital role in maintenance and productivity. To prevent unscheduled breakdowns of plants and equipment, the practice of scheduled inspection and on-stream inspection is essential. The function of inspection does not end with taking measurements. It is essential that a proper easily retrievable recording system is maintained so that inspection is in a position to confidently advise on schedule, plan, forecast and analyse problems to take corrective measures in time to keep the refinery running at maximum efficiency.

3.1.2 The first major step identified in Mechanical Inspection was the recording system. Accordingly, a sound proven recording system modified to local needs was finalised and introduced in consultation with Homs Management.

3.1.3 The system (Annexure A) consists of a) Unit Index Inspection Scheme Card, b) History Card, c) Field Observations Sheet and d) Equipment Data Card. In devising the system, all equipments have been classified into heaters, columns and vessels, heat exchangers/coolers/condensers, piping, safety valves, tanks and lifting tools and tackles and individual cards, as above, prepared for each equipment. Indicative sketch of equipment along with critical points where measurements are to be taken, are included in data card.

Index Inspection Scheme Card indicates by means of a colour scheme, the dates of previous inspection as well as of the next inspection when due. Similarly, History Card gives at a glance, the start up, various periods of downtime including emergency breakdown, scheduled shutdowns and idle periods.

3.1.4 Detailed procedures for data recording and interpretation laid down and the system as a whole has been regularly discussed and explained to Inspection Engineers during implementation. Homs management desired maintenance of the system in English except the history cards where the entries will be in Arabic and the system has been implemented accordingly.

3.1.5 As desired by Homs Management, implementation in Unit 10 and Unit 11 were taken up and both the units have been fully covered by this system. Its importance and impact on efficient operation of the units have been understood by the concerned engineers and early enlargement of the system to cover the remaining units has been assured by the Homs Management. The specialist prior to departure from the Project Site initiated taking up the another unit (unit 100) independently by Inspection personnel. The progress of work was from time to time checked in the collection and posting of base data of columns, vessels and heat exchangers. The work of this unit had progressed considerably by the end of the contract period which demonstrates the understanding and capability of implementation of the new system by the Inspection at Homs Refinery.

3.2 On-Stream Inspection

3.2.1 On-stream inspection gives advance warning of any impending failures due to change of corrosivity of the process streams, changes in process conditions and critical areas where deterioration rates are known to be high for which Maintenance will have enough lead time for planning in procurement of materials and pre-fabrication of parts which in turn will reduce workload and downtime in the shutdown. With the above objective an on-stream inspection programme has been prepared in consultation with the Chief Inspection Engineer.

3.2.2 On-stream inspection has been categorised into a) thickness measurement by ultrasonic method, b) thickness measurement by radiography and c) full inspection. Thickness of overhead lines, reflux lines and storage tanks shall be measured by ultrasonic method. Cutting of windows on insulations at inspection points has been recommended. Thickness of heater and reactor transfer lines shall be measured using radiographic technique. Full inspection shall be made on heat exchanger equipment and vessels which can be isolated during the run. Inspection, as due, has been marked in three different columns on the programme for identification of type of inspection to be made. Critical areas in pipings have been covered by the programme.

3.2.3 The programme covering crude oil & M.S. storage tanks and critical pipings which are prone to corrosion in unit 10, 100 and 200, has already been given. It has been recommended to include the remaining units in the programme after these units are recommissioned. Preparation of isometrics of pipings and marking inspection points have also been initiated.

3.3 Organisation

In view of the increased physical capacity of the Refinery and consequent change in magnitude and complexity of inspection problems restructuring of the existing organisational set-up was considered essential. The organisation recommended here has been developed after discussion with the local management who have accepted this as desirable for efficient working. In the recommended structure the Inspection Department will be headed by the Chief Inspection Engineer and the whole Refinery

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has been divided into two geographical areas, each area under an Area Inspector who will be assisted by Inspection Assistants. Both these areas will draw the services of the metallurgist and the non-destructive testing group as and when required.

The recommended structure is given below:

Chief Inspection Engineer

Area Inspector Area I	Area Inspector Area II	Metallurgist	Non-destructive Testing Group
Inspection Assistants (2)	Inspection Assistants (2)	Assistant (1)	Inspection Assistants (8)

3.4 Inspection Equipment/Testing Facilities

3.4.1 Inspection Equipment

3.4.1.1 Inspection Department is fairly well-equipped. The following inspection equipments are available:

Metascope, ultrasonic instruments for thickness measurement and flaw detection, X-ray machine & gama radiography, vibrameter, portable Brinnel hardness testers, optical pyrometer, vacuum box, microscope and scissor callipers, dye-penetrant, magnaflux-magnetic crack detector.

3.4.2.2 Following additional inspection equipment are recommended necessary for more critical inspection:

a) Boroscope for inspection of internal surfaces of tubes/pipes.

b) Probolog for internal surface evaluation of non-ferrous heat exchanger tubes by eddy current.

c) Digital wall thickness gauge - D meter, Model DM-1, Krautkramer for accurate thickness measurement.

d) Corrosometer CK-2, Magna Corporation, USA with M.S. probes for on-stream corrosion measurement.

e) Dial end gauge - Flange callipers, MPJ for thickness measurement of flanged pipes, nozzles, heat exchanger shells and component.

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f) Small dial gauges - Jaw opening 0-12mm and 12-30mm for OD & thickness measurement of heat exchanger tubes.

g) 1 lb and 2 lbs. ball-peen hammers for hammer testing.

h) Chipping hammers.

i) Inspection mirror - Ullman Model K-2 - ULLMAN CO. U.K.

j) Horse shoe pocket magnets.

k) Pit depth gauge for measurement of Pit depths - Moorlane Supply Co., Oklahama, USA.

l) Elcometer - For paint thickness measurement - Elcometer Insts Ltd., Fair Field Road, Drylsden, Manchester, U.K.

m) Micrometer depth gauge - 0-25mm.

Detailed specifications of inspection equipment and testing facilities are given in Annexure B.

3.4.2 Testing Facilities

3.4.2.1 In the physical testing laboratory a tensile testing machine, Brinnel & Rockwell Hardness testers and an Izod impact testing machine are available.

3.4.2.2 A small metallurgical laboratory is required for investigation of day-to-day material failures. As no such testing facility is available in nearby areas, a metallurgical laboratory is required to be set up. The laboratory will be under the charge of the metallurgist who will investigate material failures and strive to prevent recurrences either by eliminating the cause or by specifying better materials. Inspection already has a microscope. The following accessories need to be procured to use the microscope:

a) Specimen mounting machine.

b) Surface grinder.

c) Variable speed metallographic sample polisher.

d) Necessary chemicals for etching commonly used metals and alloys in the Refinery.

3.5 Inspection Library

It is essential that Inspection Library is well equipped with necessary documents, books and standards for ready references. Books and standards existing in the Inspection library, were checked and its development was discussed with the Chief Inspection Engineer and it was agreed to include the followings:

a) Flow diagrams for all units.

b) Plot plans showing numbering and location of equipment.

c) Set of manufacturers test certificates for all equipment.

d) Complete set of equipment drawings.

e) Stores catalogue.

f) Books dealing with non-destructive testing, corrosion control, material handbooks, international pressure vessel codes etc.

g) Important international specifications for materials.

A list of books and standards (Annexure B) has been given to the Chief Inspection Engineer and procurement action has already been taken by him.

4.0 PREVENTIVE MAINTENANCE - PM

4.1 Principles of Maintenance Management

4.1.1 For minimum costs, maintenance must be managed in the broadest management sense. The basic objectives of maintenance are:

1. To manage the Maintenance Division so as to obtain total minimum operating costs.

2. To keep facilities and equipment in good operating condition.

3. To maximise equipment availability to operation. (94% is considered a desirable level).

4.1.2 Basic principles of optimum maintenance are:

1. Maintenance is an integral part of the organisation.

2. Maintenance is a service function.

3. Maintenance work is controlled at the source by proper authorisation procedure.

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4. Workload must be controlled. Backlog is measured periodically. Defer work intelligently.

5. Workload must be executed in an orderly manner.

6. There are seven basic functions:

   a) Request

   b) Plan - Job requirements, resources, sequence.

   c) Estimate

   d) Authorise - By careful control 15 to 20% of work can be dropped.

   e) Schedule - Centralised maximum utilisation of resources.

   f) Execute

   g) Review - By exception.

7. Work is planned before execution.

8. Work of every maintenance mechanic is scheduled.

9. Schedules are met a high % of the time - 85% is the goal.

10. Foremen have 3 basic responsibilities:

    a) Obtain high quality work.

    b) Obtain satisfactory labour productivity.

    c) Minimise material and transportation in line with above.

11. All maintenance jobs are reviewed.

12. Maintenance performance is compared to indexes - Ex. - overtime

    - labour/material ratio

    - maintenance cost as % of plant replacement.

13. Maintenance costs are reported so that they are meaningful.

14. Maintenance receives adequate technical support.

15. Maintenance receives adequate logistic support.

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16. There is a good craft training programme.

17. There is a centralised PM programme.

Above basic principles enable a programme of optimum maintenance contributing towards better refinery efficiency. A PM programme is one of the important steps in such a programme.

4.2 Definition of PM

We will state the philosophy of PM. PM is maintenance performed to retain an equipment in satisfactory operating condition through systematic inspection, fault detection and prevention of incipient failures. Equipment condition is monitored visually, by instruments and by onstream inspection. Components are repaired/replaced as they fail. Improvement areas are identified. Equipment is overhauled only when there is a clear indication of wearout accompanying degradation of performance.

PM can also be defined as performing necessary tasks to keep equipment operating with minimum production delays and at optimum costs. Hence any sound PM system must not only ensure that these tasks are performed but also set up a regular inspection schedule for all equipment so that we will know, well in advance, what work is to be done and be sure we are going to be able to get it done in time.

One measure of success of a PM programme is reduction in the number of breakdowns and production delays. These must be balanced against amount of money required to keep them low.

It is a well known fact that total maintenance cost is parabolic when plotted against "level of maintenance". Too little PM with attendant large breakdown results in high cost. On the other end, too much PM will also result in high cost. The ideal will be to operate in the valley of the parabola. Records on PM costs, breakdown costs, No. of breakdowns, production losses will help in highlighting this. However, adherence to the philosophy of PM as postulated earlier will help in maintaining an optimum level of maintenance.

4.3 Previous PM System and Problems

Homs Refinery has been handicapped by the lack of a planned PM programme. The recording system was inadequate. One of the reasons probably is lack of understanding, of all concerned, of the substantial gains which can be obtained from an organised PM programme. Lack of enough

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trained engineers, discontinuity in the organisation due to key engineers being transferred frequently were factors which have played a large part in inhibiting establishment of a PM system. The maintenance effort has been mainly towards "Repairing equipment and keeping units running for the moment". Obviously such a system of work would result in upsets in work plan, avoidable overtime, long equipment outages and some production loss.

4.4 The New PM Programme

The key element of a sound PM programme is the Recording System. The recording system devised (Annexure C) consists of:

a) Equipment data card

b) History card

c) Check lists for each category of equipment.

d) Unitwise equipment inspection scheme card.

4.4.1 In devising the system all equipment have been classified and placed in definite categories, so that we would need as few check lists as possible. Equipment has been classified as centrifugal, reciprocating and rotary. The centrifugal pumps have been further subdivided as pump with two external bearings, overhang type and vertical. Individual cards have been made for each equipment.

4.4.2 The equipment data cards list constructional details, size capacity etc.

4.4.3 The history card gives at a glance when major repairs have been done, parts changed, probable cause of failure. It also indicates dates when PM checks were done.

4.4.4 The check lists tabulate in detail the checks to be done for each family of equipment. The check lists are colour coded to distinguish, the various types of checks viz. monthly, 3 monthly and 6 monthly.

4.4.5 The equipment inspection scheme card for each unit lists the various equipment; inspection period, and type of inspection is indicated by a colour scheme.

4.4.6 Above system was finalised after discussions with the counterpart engineer, and has been introduced for units - 10, Topping; 14, Kero HDS; 100, Crude Vacuum Unit; 200, Reformer; and 19, Asphalt Unit.

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4.5 Assistance in Execution

4.5.1 The importance of PM checks has been generally explained to the engineer, foremen and workmen.

4.5.2 Contractor's specialist has made regular daily field visits and explained the contents of each typical check list, what is to be done, how it is to be done, and the importance of making recorded observations of equipment condition.

4.5.3 Necessary guidance was given in inspection methods

- Inspection of wear ring condition and recording clearance.
- Inspection of throat bush and record of clearance.
- Shaft condition and trueness.
- Coupling condition; if coupling shows signs of wear, investigation of alignment, coupling seal and condition of lubricant (if lubricated type of coupling).
- Bearing condition and its fit on shaft and bearing housing.
- Seal condition.
- Vibration monitoring.

4.6 Assistance in Organising a PM Unit

4.6.1 Equipment data cards and PM check lists were formulated after extensive discussions and references to equipment catalogues. An inspection scheme was formulated based on manufacturer's recommendations and local experience.

4.6.2 Two mechanics were deputed by Homs Management for setting up the programme. Both these mechanics have been trained in the routine paper work part of the PM programme.

- Reference to Inspection schemes.
- Issuance of weekly check-lists.
- Checking weekly check lists for completion.
- Filing of check lists.
- Updating inspection scheme card.
- Recording breakdown history by reference to daily logs of foremen.

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4.6.3 The entire system has been discussed with counterpart engineer and he is now in a position to extend this system to the rest of the units. He would, of course, need extra help.

4.7 Requirements of PM Unit

4.7.1 Office space - There should be a reasonable size office with necessary filing cabinets, and other furniture.

4.7.2 Workshop - There should be a centralised shop facility. Of course, this would serve not only the PM crew but also the breakdown crew. Present facilities are at 2 different places far apart. The shop should be large enough to accommodate about 20 work tables.

4.7.3 Equipment & Tools

1) The shop should have the following facilities:

a) Pillar drilling machine.

b) Hydraulic press.

c) Overhead crane/hoist.

d) Two or three jib cranes.

e) Parts cleaning and washing facility.

f) Hydraulic puller sets.

g) Torque wrenches.

h) Medium size dynamic balancing machine.

i) Impact wrenches and sockets.

j) Better quality slogging wrenches.

k) Vibration monitoring equipment.

2) Additional set of inside/outside micrometers and depth gages.

4.7.4 Reference Catalogues

Catalogues for equipment should be available in the PM office. Presently one has to go to the library which is in a different building.

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4.7.5 Manpower

The Refinery has about 600 pieces of rotating equipment. All these equipment can be covered by the PM programme with a staffing of 8 men.

It is our opinion that the required men can be released from the present breakdown crew. PM checks will eventually on a longer time scale reduce the number of breakdown repairs.

The crew should be headed by a full time engineer to administer the programme. Present set up of pump and compressor repair group is one engineer, three foremen and 50 workmen. This engineer has also to guide the PM programme.

5.0 TRAINING

5.1 Mechanical Inspection

5.1.1 One Inspection Engineer and one workman were trained in administrative part of the recording system.

5.1.2 Inspection engineers have good knowledge of modern inspection techniques. As regards practical work, necessary assistance and guidance, wherever necessary, have been given to Inspection engineers in day-to-day inspection work.

5.1.3 Degree of competence and skill of inspection workmen on radiography and use of most of the inspection equipment are of adequate level but they lack experience in ultrasonic flaw detection. This was demonstrated.

5.1.4 International codes and standards, modern inspection techniques, materials and welding technology have been regularly discussed with Inspection Engineers.

5.2 Preventive Maintenance

5.2.1 Two mechanics have been trained in the administrative part of the system.

5.2.2 Since the programme was finalised only after discussions, the Engineer is conversant with all aspects.

5.2.3 The PM check lists have been explained to the 3 foremen and a small group of 7-8 workmen. On the job training of PM checks for various types of equipment was given.

5.2.4 Training was also given in:

- Seal face reconditioning
- Bearing fits and tolerances
- Shaft trueness check
- Impeller wear ring and throat bush clearance
- Shaft sleeve condition check
- Check of coupling condition
- Lube oil condition check
- Shaft sleeve reconditioning by metal spray
- Fundamentals of vibration measurement and analysis.

5.3 Contractor's specialists daily routine included discussions with the counterpart engineers on daily problems and their solutions. This covered the entire range of trouble shooting, equipment inspection, repair techniques, and control of essential parameters.

5.4 Training was also given in preparation of shutdown worklist, formation of a plan, and a schedule for pump repair and mechanical inspection during the May '75 shutdown.

6.0 CORROSION PROBLEMS

6.1 It was reported by Inspection and Operation that there is not much corrosion problem in the Refinery at present, Interruptions due to equipment failure are rare.

Corrosion problems were studied in general and in particular for some process units during the May '75 shutdown. Study was based on available records, laboratory analysis of process streams and data collected during the shutdown. Corrosion rates in general indicated the adequacy of corrosion control measures being practised at present. However, conclusion was tentative as past records were not available in many cases. Recording system introduced will provide necessary data for corrosion investigation and control in future.

6.2 It was reported that no significant corrosion is encountered in the water side of coolers, condensers and boilers. The cooling water treatment was reviewed and from specifications of treated water treatment seems adequate. Data on corrosion of cooling water mains and water side of coolers and condensers were, however, not sufficient to establish reliable corrosion rates.

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The present capacity of cooling water treatment facility is not sufficient to meet the demand and in Unit 100 raw water after chlorination is used for the cooling system. The capacity of the cooling water treatment facility is being increased and expected to be ready by next year.

Fouling in water sides of coolers and condensers is of considerable seriousness specially where raw water is used. Need for measurement of corrosivity and fouling of cooling water remains and this was agreed upon by Homs Management. Corrosion coupons installed in cooling water line at present fail to represent the actual corrosion rate and fouling prevailing in coolers and condensers. Installation of coupons and a test exchanger as per CSO/COP-10 (Annexure D) in the cooling water system was recommended to Homs Management who have assured their early installation. The coupons will be exposed at the outlet of the cooling tower and the outlet of heat exchangers.

7.0 ASSISTANCE AND GUIDANCE GIVEN IN DAILY WORK AND DURING SHUTDOWN

7.1 Organisation

The Refinery complex was shutdown in May '75 for turnaround inspection and maintenance. The recommended procedure for shutdown planning and execution of work (Annexure E) was discussed with Homs Refinery and accordingly, a shutdown inspection team was organised to the extent practicable within the existing system at Homs. The Management has assured its full implementation in future shutdown.

Shutdown worklists were also prepared for rotating equipment.

7.2 Participation

Contractor's specialists were fully associated with the Inspection and Maintenance team in the shutdown. The specialists demonstrated inspection techniques as required, inspected critical areas and advised on necessary repair and replacement. Contractor's specialists have also worked closely, when requested, with the counterpart engineers for day-to-day work in respective fields. The highlights of the service rendered have been given for Mechanical Inspection in Annexure F and for PM in Annexure G and some important observations and recommendations made are given below:

a) An important inspection technique i.e. hammer testing of pipelines was not carried out because of lack of experience in this technique. A demonstration was given.

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b) Inspection of equipment which can be isolated during the run was recommended. This will reduce both inspection and maintenance workload in the shutdown.

c) The present practice is to open all the equipment for inspection during scheduled shutdown. Recording system introduced will help in phasing out inspection and maintenance on the basis of inspection interval, set up, and review of past records. This will reduce the workload and downtime in the shutdown. More critical inspection has been stressed.

d) Inspection check lists for columns, vessels and heaters have been prepared (Annexure H).

e) A work plan for unit 10 shutdown consisting of work on heat exchangers, columns, and drums, and heaters has been prepared as requested by Homs Management. Work includes listing of work, estimation, a work plan and schedule.

f) Assistance was given in metal spray techniques for part rebuilding using eutectic 'Rototec' equipment.

g) Suggestions have been given on organisation of a central tool room service for issue of tools and equipment. Also some suggestions on shop lay-out, issue of daily consumables were tendered.

8.0 <u>SCHEDULES, CODES OF PRACTICE, STANDARDS ETC.</u>

8.1 A schedule of requirement for seal welding of threaded connections has been provided (Annexure I).

8.2 Homs Refinery desired installation of skin thermocouples in their Catalytic Reformer Heaters to control operational severity. CSO manual CSO/COP-6 (Annexure J) for the above has been given to the Chief Inspection Engineer.

8.3 Homs Management requested for a code of practice for Gas Cylinder Testing. This has been developed (CSO/COP-17 - Annexure K) on the basis of existing Indian and British codes tailored to local requirement.

8.4 On the request of the Homs Refinery, a procedure for maximum utilisation of the potential life of 5Cr-½Mo catalytic reformer heater tubes was recommended based on the reliable long time creep rupture data available at present (Annexure L).

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8.5 A table of Arbitrary minimum wall thickness of Process pipelines has been handed over to the Chief Inspection Engineer. Material specifications for centrifugal pumps and a procedure for investigation of unusual material failures have also been provided (Annexure M).

8.6 A procedure for vibration monitoring (CSO/RP-15) has been prepared (Annexure N).

9.0 FUTURE NEEDS AND TRAINING PROGRAMMES

9.1 Homs is the only oil Refinery in Syria. The Refinery is staffed with qualified engineers educated in Syria and abroad. These engineers, almost immediately after graduation, have taken over duties in the Refinery. Several severe constraints peculiar to the local conditions have imposed a heavy burden on Homs Management. The original staffing and maintenance facilities meant for the initial 1.6 million ton per year Refinery have not been sufficiently expanded following the later expansion to 2.6 million ton per year capacity. The Refinery is in the process of further expansion to 4.6 million ton per year and this is giving rise to additional workload. Some of the existing units have suffered damage during the war. An enormous amount of effort has to be put in by the Engineering Department in the reconstruction even though reconstruction has been entrusted to CHEPOS. There is also an almost continuous request for material, craftsmen, workshop facilities and engineering help from the Refinery by other Govt. agencies since Homs Refinery is about the only organisation in this area capable of giving quick and requisite services. Besides, compulsory military service requirements, trained engineers have often been repositioned by the Govt. for other assignments. Homs Refinery thus has a rather high turnover of engineers as well as some burden of activities outside its scope. This has placed an unusual burden on the Management resources, and necessarily the Engineering Department has to willy-nilly restrict itself to a 'fire fighting' role in maintenance work.

The engineers have not, generally speaking, had the opportunity to work in a modern, well organised Refinery elsewhere, observe their systems and methods. Advances in Maintenance and Inspection is continuous and dynamic process and only with exposure and cross-fertilisation it is possible to maintain a continuous improvement in these fields. To fulfil the above objective, the following programme is recommended:

(a) In the areas of PM & Mechanical Inspection covered in this contract, it is recommended that a minimum of two engineers in each discipline should be sent

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to work in a Refinery abroad for minimum period of 6 to 8 months. Training should be on the job and should include organisation, report system, records, work techniques and usage of latest monitoring equipment.

(b) This should be followed by periodic short term visits of experts in these two areas for a further development of the systems established in this contract and also to advise on any other problems related with maintenance. EIL(CSO) which provides such a service to number of refineries in India and abroad can extend such services to Homs Refineries by a separate contract either through UNIDO or directly with the Syrian Govt.

(c) Rapid technological changes in material maintenance and material management have imposed new demands and responsibilities on plant managerial cadres. To keep pace with these changes it is essential that Departmental and Asst. Departmental Heads at Homs Refinery also attend Maintenance and Material Management courses. Such courses are available in many countries and one of the leading organisations of this type in India is the Administrative Staff College of India, Bella Vista, P.B.No.4, Hyderabad-500004.

Above recommended three step programme would go a long way in strengthening and expanding the basic systems established during this contract.

9.2 Craft skills are average or above average in some cases. But there is a sizeable minority of workmen who need craft training. Training should be oriented to ability to refer to catalogues, drawings and practical on the job training. Such a training can be provided by the engineers at Homs Refinery.

9.3 Warehouse storage and inventory control needs large assistance. Some work was done by an Egyptian expert; but he has since left and the work is not yet complete. Work needs to be done in organisation, proper storage, identification and retrieval systems, cataloguing, rationalisation, inter-changeability index, and inventory control.

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10.0 **TERMINAL SECTION**

10.1 Basic elements of a sound PM system and mechanical inspection programme have been established.

10.2 Mechanical Inspection

10.2.1 Inspection Recording System for unit 10 and 11 is operational. Progress on unit 100 is found satisfactory.

10.2.2 Inspection personnel have been trained in the implementation of the new system and they have demonstrated their capabilities by starting covering other units by this system. Wherever necessary, inspection techniques have been demonstrated.

10.2.3 Restructuring of existing organisational set up, additional equipment, books and standards have been recommended.

10.2.4 Problem of scaling and corrosion pittings on water sides of coolers and condensers has been identified and recommendation for evaluation of corrosive and scaling characteristics of water as per CSD manual has been made.

10.2.5 An on-stream inspection programme has been evolved.

10.2.6 A Code of Practice for gas cylinder testing and Recommended Procedure for maximum utilisation of the potential life of 5Cr-$\frac{1}{2}$Mo reformer heater tubes have been developed.

10.3 Preventive Maintenance

10.3.1 The key is the recording system which:

- Tabulates equipment unitwise;
- clearly defines what parameters are to be checked;
- how often it is to be checked;
- when it is to be checked;
- guidelines on acceptance levels;
- permits review of equipment history at one glance;

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- highlights repetitive problems;

- gives advance warning of equipment condition;

- affords the possibility of planned purchases and spares replacement.

10.3.2 The system established is based on the above. 25% of equipment have been covered during period of assignment. Even in the short time PM has been in operation, at least six breakdowns have been averted.

10.3.3 Technical personnel have the basic background and they have been guided and instructed in the implementation of the system. Training has also been given in preparation of shutdown worklist, formulation of a plan and a schedule for pump repair.

10.3.4 Requirements of PM Unit, as regards manpower, workshop facilities, equipment and tools and office space have been recommended.

10.3.5 A Recommended Procedure for vibration monitoring of equipment has been prepared.

10.4 Full benefits of any system can only be achieved by dedicated implementation and continued modification based on experience. If the introduction of the systems developed is sustained on the basis of three step programme recommended, it is bound to produce tangible results in the long run.

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ACKNOWLEDGEMENTS

EIL(CSO) would like to record its appreciation of the help, assistance and courtesies extended by the Homs Refinery Management without which successful completion of the assignment would not have been possible. EIL(CSO) would also like to thank UNIDO for awarding this contract and giving an opportunity to share the experience of this consulting organisation with the Homs Refinery at Syria.

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ANNEXURE A

CSO/COP-4
MANUAL FOR
INSPECTION RECORDING SYSTEM

CENTRAL SERVICES ORGANISATION

ENGINEERS INDIA LIMITED

NEW DELHI

OCTOBER 1972

REVISED FOR HOME REFINERY

MAY 1975

INSPECTION RECORDING SYSTEM

1.0 INTRODUCTION

One of the most important aspects of Refinery Inspection is the Inspection Recording System. This is so because one should get from it at a glance the state of every equipment right from its commissioning and its history in a chronological order, types of repairs it has required, its reliability in service, and, over and above, its life expectancy.

A sound Inspection Recording System gives to Inspection Wing comprehensible and yet concise data for each equipment under their purview which immensely help at the time of taking decisions on major repairs. A constant use of it by Inspection Wing by making innumerable references leads to a highly useful intimacy with the entire plant.

With a good recording system, Inspection Wing can make a unique contribution to the total maintenance activity and its daily, monthly, yearly planning of work in various operating units thus helping in better manpower utilisation leading ultimately to overall economy which is the management goal.

A good recording system highlights the problem areas and their dimensions so that corrective actions regarding materials, process, operation etc. can be considered and instituted as found economically necessary.

A well-recorded history makes it easy to advise the procurement wing to locate a possible supplier with enough lead time for its manufacture and delivery.

2.0 WHAT IT CONSISTS OF

2.1 Inspection Recording System should consist of the following:-

2.1.1 Unit Index Inspection Scheme Card (Form No.1) listing each equipment of the Unit like Heaters, Columns & Vessels, Heat Exchangers, Safety Valves, etc. indicating therein by means of the colour scheme shown on Master Card, the dates of previous inspections as well as of next inspection when due.

Since most heat exchangers, coolers/condensers which can be planned for inspection during normal operation will have their next inspection dates shown on this card, it will be of considerable help to advise quarterly the Maintenance Planning Wing for the purpose of their planning the job. Other equipments like safety valves, P & V valves of tanks as well as lifting tools and tackles in the particular Unit will also be shown on this card with the previous inspection dates as well as future inspection when due.

2.1.2 <u>Unit History Card</u> (Form No.2) giving its start-up, various periods of down-times including emergency breakdown, scheduled shutdown and idle periods, if any. Reason of each downtime will be briefly recorded here.

Alongwith this card, a simplified process flow scheme of the unit, will be kept. The scheme should show quantities, temperatures, pressures, relief valves and important controls A small table of special materials other than mild steel used in various equipments should also be included.

2.1.3 <u>Data Card</u> of each equipment, giving its salient design and operation details as well as test requirements. This card will naturally vary from equipment to equipment.

2.1.4 <u>History Card</u> giving in chronological order the dates of inspections, brief observations made in each inspection, mentioning repairs and any special steps like action for replacement etc.

2.1.5 <u>Data Record Sheet</u> giving inspection measurements against various inspection points taken from the development drawing.

2.2 In order to make it possible for the above-mentioned data cards to have all the relevant information from any inspection, the following will be required:-

2.2.1 Sketch of the equipment alongwith its development so that the inspector is able to take prints of this to site in order to record his observations on the print itself. (Copies of the same sketches are also used to illustrate instructions to maintenance, for repairs etc. as well as in the final inspection report as necessary).

2.2.2 Measurement sheets as in the case of heater tubes (Form No.6) which can be taken to site to note down various measurements made.

2.2.3 Field observations sheet (Form No.3) where the Inspector can record his observations in the plant on any equipment during onstream or shutdown.

2.2.4 All field measurements sheets as in 2.2.2 and 2.2.3 above are to be kept till the next shutdown is over so that it is possible to compare the previous readings wherever required.

3.0 CLASSIFICATION OF EQUIPMENT

Since one equipment is different from the other, each type of equipment has to be dealt with separately so that the Inspection Recording System should be fully versatile by including various types of information on the cards in order to meet the specific inspection requirements of each type.

The refinery equipment can, therefore, be sub-divided as:-

1. Heaters
2. Columns and Vessels
3. Heat Exchangers/Coolers/Condensers
4. Piping
5. Rotating Equipment (Normally records in this case are maintained by the Maintenance Planning Section)
6. Safety Valves
7. Tanks
8. Lifting tools and tackles

4.0 DETAILED METHOD OF RECORDING FOR EACH TYPE OF EQUIPMENT

All cards of the recording system will be maintained unit-wise since it provides considerable ease of referencing.

4.1 Heaters

Each Heater in the Unit will have the following:-

4.1.1 Data Card giving important details pertaining to design, construction, materials and operation as shown on Form No.4. Materials like tubes and return bends whose replacement is at times called for are also given stores Code Nos. in order to make the material assessment easier.

4.1.2 History Card (Form No.2)

Here the date of inspection will be given in the first column and the inspection observations will be recorded in the 2nd column. Any repairs on refractory etc. as well as other work done on the heater will be chronologically recorded on this card.

4.1.3 Tube Data Record Card (Form No.5)

In order to be able to fill data in this record Card, it is necessary to have a sketch of the heater indicating the number of tubes with their serial numbers marked. A sketch of the Heater H-1 of Homs Refinery is shown here to illustrate the manner in which the sketch has to be made. The tubes are circled and numbered serial-wise along the direction of the flow in each of the two passes which make interpretation of inspection observations more convenient. The view of convection shown is of "South" which means that this end is towards the Unit while the other end of the tube called the "North" is away from the Unit. (Variations as East, West, Top, Bottom can also be used). The tube connections by means of headers or Return Bends on the "South End" are also shown in full whereas those on the "North End" are shown dotted. Only one view like this is considered adequate and its size being that of the card makes it very convenient for the Inspector to take a print of the sketch along with Form No.6 and Form No.7 for actual measurements during the shutdown.

4.1.4 Measurement Sheets (Form Nos.6 & 7)

Form No.6 has various columns, the first column being for the tube number followed by two main columns, one each for "North End" Top and "South End" Bottom.

Below the main column "North End" Top, there are two columns, one for "Beyond Roll" and the second for "In Roll". Below "Beyond Roll" and "In Roll" there are two columns eac . In the first column for "Beyond Roll" figures and the first column of "In Roll" figures, the Inspector can note down the previous inspection measurements before going to the Plant and in the second column of the "Beyond Roll" and "In Roll" the measurements of the present inspection can be noted. Also, in case the Inspector feels interested in recording the wall thickness of a certain Return Bend where he suspects corrosion/erosion, he can take down the various measurements on the Return Bend and include against the particular tubes where the Return Bend is located its minimum wall thickness. The provision for recording this wall thickness is given on both "North End" Top and "South End" Bottom. It may be mentioned that "Beyond Roll" figure is the internal diameter of the tube away from the roll, whereas "In Roll" means the internal diameter of the tube at the rolled portion.

On Form No.7, provision is made for measuring ultrasonic thickness along the entire tube length starting from the "North End" Top, the first column is for the tube number while the entire space on its right is sub-divided in 13 columns, the width of each representing one meter. This is to include the maximum tube length of our heaters, generally 12 metres whereas few tubes which are extended by means of weld-joints, on the inlets/outlets happen to be around 13 metres.

From the readings obtained on Form No.6 and Form No.7, the Inspector is in a position to fill the permanent tube data record sheet (Form No.5). Here the first column represents the tube number, second column is for its location, i.e., "North/Top End" denoted by "N/T" and "South/Bottom End" by "S/B". The next column is meant for recording the original measurement of "Beyond Roll" denoted by "BEY" and "In Roll" denoted by "IN" followed with a column where minimum wall thickness of the tube is recorded.

Subsequent columns provided in the record sheet are meant for various inspections by giving the inspection date in the first row and below this in the three columns measurements of "Beyond Roll"

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"In Roll" and minimum wall thickness on the tube with the help of Form No.6 and 7 and 15 are recorded. In case it is desired to record on this card minimum wall thickness of the Return Bend as noted on Form No.6, the same can be put against the particular tubes where the Return Bend is located in Form No.5 itself but in a different colour. When more detailed recording of header measurements is considered necessary, separate Form No.5 can be used as well for headers.

4.2 Columns & Vessels

Each column and vessel of the Unit will have the following in Inspection Recording System:-

4.2.1 Data Card (Form No.8) showing information on design, manufacture, drawing no., materials, dimensions, and operating conditions. This data card is to be filled for column and vessel in the Unit and kept Unit-wise.

4.2.2 History Card (Form No.2)

On every inspection this has to be filled in by recording the inspection date and salient inspection observations made.

4.2.3 Sketch

A sketch for a column and a vessel comprising of the development sketch of the same is enclosed to illustrate and the same has to be drawn for each column and vessel in the Unit. The Inspector will take a print of this and note down various observations/measurements against various inspection points of his choice on the print itself including therein various highlights of the inspection.

4.2.4 Data Record Card (Form No.9)

From the observations including measurements made on the sketch during actual inspection, thicknesses at various inspection points are to be recorded on this card. The first column is meant for inspection point, the second column for description followed with data on original dimensions. Beyond the "Disc. Limit" i.e. discarding limit column, inspection dates can be put and against the inspection point the actual measured thickness is recorded.

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4.2.5 Based on first inspection on each column and vessel, the important locations deserving a close look on future inspections can be ascertained and the inspection points then decided depending on how corrosion/erosion prone the column/vessel is. Thus the Inspector will lay more stress on such areas making a good use of the development sketch and the small observation sheets so that for the record sheet he will have adequate information for recording which will be of great help at the time of next inspection.

4.3 Heat Exchangers

All heat exchange equipment, i.e., exchangers, coolers and condensers will have the following cards in the recording system:-

4.3.1 Data Card (Form No.10) giving all information about the manufacture, construction including various components of the equipment as well as operating conditions. This has to be filled in for each exchanger/cooler/condenser of every Unit.

4.3.2 History Card (Form No.2)

There should be two separate cards for shell and bundle. These will indicate in the chronological order brief comments on each inspection and will also invariably record any anticipated action like replacement of any component so that it can be of help towards material planning and formulating the time of the next inspection.

4.3.3 Development sketch is not generally required for tubulars but this can be made for equipment which are prone to corrosion/erosion. Once such cases are established, more importance is to be given and sketches made. All measurements taken are then recorded on Data Record Card (Form No.9).

Tubulars in which tubes are regularly plugged during the life time of the bundle a sketch showing the tube-plan from the tube side inlet end should be prepared for showing progressive tube plugging.

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4.4 Piping

Inspection Recording System will include the following in each Unit:-

1. Transfer Lines

2. Reflux lines in circuits prone to corrosion/erosion

3. High temperature process lines (above 300°C).

In case any other circuit is found prone to corrosion/erosion by experience, the same has to be inspected and recorded like the above mentioned three categories in the following manner:-

4.4.1 History Card (Form No.2) giving brief comments of inspection in the chronological manner including any anticipated replacements and assessing the actual time of future replacements by evaluating rates of corrosion.

4.4.2 Data Record Card (Form No.9)

To be able to fill this, make isometric sketch for each piping system and to illustrate sketch for a transfer line is shown having various inspection points from 1 to 23 marked on this sketch. The Inspector will take a print of the same and take measurements in the plant and then fill in the various columns of Data Record Card, the actual minimum wall thickness measurements taken against each inspection point.

4.4.3 By this type of critical inspection, various important points of consideration will naturally emerge from each inspection and thus be of considerable help in making recommendations for future action.

4.5 Rotating Equipment

The data and history card for this type of equipment are normally maintained by Maintenance Planning Section. It is considered highly desirable that Maintenance Section should intimate Inspection about equipments which have been found by them prone to corrosion/erosion and Inspection then will separately maintain records for such equipment in the following manner:

4.5.1 Data Card giving salient features about the particular equipment.

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4.5.2 History Card (Form No.2) indicating inspection observations made against each inspection.

4.5.3 Data Record Card (Form No.9)

For filling this, a sketch showing sectional view of the equipment may be made where various inspection points can be marked and actual measurements against these can be recorded on the data record sheet. This will yield a systematic evaluation and timely action for replacements can be taken.

4.6 Safety Valves

Following cards are to be maintained for each safety valve location in various Units:-

4.6.1 Data-cum-History Card (Form No.11)

The card gives for each safety valve location salient details of construction, spring no., as well as operating conditions on which it has to be set. Any repairs done while revisioning and resetting are to be recorded against the inspection date column.

4.6.2 Inspection Scheme - Relief Valves (Form No.12)

Against particular R.V. No. state here the interval at which inspection is required and then fill in the "due" column and state in the next column when the inspection is actually held. This will help inspection to bring to the notice of Production Department that a certain safety valve is due for inspection and that it should be done within a reasonable period of the due date.

4.6.3 These cards are also to be used for all pressure and vacuum valves mounted on the tanks in the same manner as mentioned above.

4.7 Tanks

The following cards are to be maintained for tanks for Inspection Recording System:-

4.7.1 Tank data and Inspection Card (Form No.13)

Fill in for every tank the required information on the card giving details about manufacture, capacity and dimensions, including original thickness of various courses of the tank.

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Underneath, in the first column record the date of inspection and on its right side mention briefly highlights of the inspection.

4.7.2 Data Record Car (Form No.9)

This can be maintained for tanks which are corrosion prone as established by actual inspection and such tanks can be inspected on priority at close intervals. All thickness measurements against various inspection points are to be recorded in this sheet.

4.7.3 History Card (Form No.2) This will record observation of periodic external inspection.

4.8 Lifting Tools and Tackles

Following cards will be maintained for lifting tools and tackles which are to be inspected as per rules laid down by Factories Inspectorate as these are in their purview:-

4.8.1 Data-cum-History Card (Form No.14)

Record all information on this card pertaining to the manufacturer, serial number of the equipment, its capacity, and location where it is installed. A brief history has to be recorded against the date of inspection.

4.8.2 Inspection Scheme - Lifting Tools & Tackles

Form No.12 itself can be used for recording frequency of inspection of lifting tools and tackles.

Maintain this card by including all the lifting tools of the refinery Unit-wise, serially numbered with their location, inspection interval as per requirements of Factories Inspectorate. State below the "Due" column when the inspection is due and record the date of actual inspection in the next column.

This card will serve as a great help for planning the inspection of all lifting tools and tackles in the Refinery.

Form No.2 can be used as a continuation sheet of the particular lifting tool for recording further history of inspections.

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LIST OF CARDS

Following is the list of cards/sheets reference to which has been made in the Manual

Form No. 1 - Inspection Scheme Card

2 - History Card

3 - Field Observations Sheet

4 - Heater Data Card

5 - Tube Data Record Card

6 - Tube Measurements Sheets

7 - Ultrasonic Thickness Measurements Sheet

8 - Vessel Data Card

9 - Data Record Card

10 - Heat Exchanger Data Card

11 - Safety Valve Inspection & Service Record Card

12 - Inspection Scheme for Relief Valves

13 - Tank Data & Inspection Card

14 - Lifting Tools & Tackles Data & Inspection Card.

15 - Tube/Header Gauging Sheet

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INSPECTION–SCHEME

.... UNIT

NAME	INSPECTION INTERVAL	YEAR:												YEAR:												YEAR:												YEAR:											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12

HOMS REFINERY

FORM No. 1

HOMS REFINERY

FORM No. 2

UNIT ____________ DATE ________

INSPECTION FINDINGS	MEASUREMENT PREV.	MEASUREMENT PRESENT	CORR. RATE MMPY

HOMS REFINERY

FORM No. 3

HEATER DATA CARD

HEATER ________ UNIT ....

INFORMATION

DESIGN : ________
MANUFACTURER : ________
MANUFACTURER'S DRG. : ________

ORDER NO. : ________
JOB NO. : ________
REQUISITION : ________
BILL OF MATERIAL : ________
IN USE : ________

OPERATION DATA

FLUID HANDLED : ________
AV. HEAT FLUX : ________
INLET CONDITIONS :
DESIGN PRESSURE (Kg/cm^2) ________
OPTG. PRESSURE (Kg/cm^2) ________
DESIGN TEMP. (°C) ________
OPTG. TEMP. (°C) ________
OUTLET CONDITIONS :
DESIGN PRESSURE (Kg/cm^2) ________
OPERATING PRESSURE (Kg/cm^2) ________
DESIGN TEMP. (°C) ________
OPTG. TEMP. (°C) ________
HYD TEST PRESSURE :
(Kg/cm^2) AS NEW : ________
PERIODIC : ________

DETAILS

TUBES :
NOS. INSTALLED : ________
SIZE : ________
MATERIAL : ________
UNIT WT. (Kg) : ________
STORES CODE NO. : ________

180° RETURN BENDS :
NOS. INSTALLED : ________
SIZE : ________
MATERIAL : ________
UNIT WT. (Kg) : ________
STORES CODE NO. : ________

90° RETURN BENDS :
NOS. INSTALLED : ________
SIZE : ________
MATERIAL : ________
UNIT WT. (Kg) : ________
STORES CODE NO. : ________

TUBE SUPPORTS :
TYPES : ________
DRG. NOS. : ________
MATERIAL : ________

BURNERS :
NOS. INSTALLED : ________
TYPE OF BURNER : ________
DRG. NO. : ________
STORES CODE NO. : ________
REFRACTORY :
TYPES USED : ________
BRIDGEWALLS : ________
BURNER THROAT : ________
PASSES : NOS. USED : ________
NO. 1- CONV. TUBES : ________
RADN. TUBES : ________
NO. 2- CONV. TUBES : ________
RADN. TUBES : ________
NO. 3- CONV. TUBES : ________
RADN. TUBES : ________
JUMPOVERS :
PASS NO. 1:- BETWEEN TUBES : ________
PASS NO. 2:- BETWEEN TUBES : ________
PASS NO. 3:- BETWEEN TUBES : ________

WELD JOINTS ON TUBES : ________

NOM'S REFINERY

FORM No. 4

TUBE HEADER DATA RECORD CARD HEATER ______ UNIT ____

TUBE No.	N/T / S/B	ORIGINAL			BEY.			IN			W.T. (ULTRASONIC)			BEY.			IN			W.T. (ULTRASONIC)		
		BEY.	IN	MIN. W.T.	Pres. I.D.	Corro. Rate	Life	Pres. I.D.	Corro. Rate	Life	Pres. W.T.	Corro. Rate	Life	Pres. I.D.	Corro. Rate	Life	Pres. I.D.	Corro. Rate	Life	Pres. W.T.	Corro. Rate	Life

DATE ....   **TUBE MEASUREMENTS**   HEATER .... UNIT

TUBE NO.	NORTH END / TOP			SOUTH END / BOT.			TUBE NO.	NORTH END / TOP			SOUTH END / BOT.		
	BEYOND ROLL	IN ROLL	MIN. W.T. (MM)	BEYOND ROLL	IN ROLL	MIN. W.T. (MM)		BEYOND ROLL	IN ROLL	MIN. W.T. (MM)	BEYOND ROLL	IN ROLL	MIN. W.T. (MM)

HOMS REFINERY

FORM No.

DATE__________ ULTRASONIC THICKNESS MEASUREMENTS HEATER__________ __________UNIT

TUBE NO.	DISTANCE FROM NORTH / TOP END (FEET)													
	0	1	2	3	4	5	6	7	8	9	10	11	12	13

PRESSURE VESSEL DATA CRAD

EQPT ________ UNIT ________

INFORMATION

DESIGN : ____________________
MANUFACTURER : ____________________
MANUFACTURER'S DRG. : ____________________
____
ORDER NO. : ____________________
JOB NO. : ____________________
REQUISITION : ____________________
BILL OF MATERIAL : ____________________
IN USE : ____________________

WEIGHTS

CARBON STEEL : ____________________
INTERNALS : ____________________
INSULATION : ____________________
EMPTY VESSEL : ____________________
OPERATING : ____________________
FULL OF WATER : ____________________
CAPACITY : ____________________

DIMENSIONS

TOTAL HEIGHT : ____________________
HEIGHT BETWEEN TANGENTS : ____________________
DIAMETER : ____________________
WALL THICKNESS : ____________________
____
TYPE OF HEADS : ____________________
CORR. BENCH MARKS : ____________________

MATERIALS

SHELL : ____________________
HEADS : ____________________
SKIRT : ____________________
BASE PLATES : ____________________
NOZZLE MANWAY ____________________
NOZZLES : ____________________
REINF. PADS : ____________________
____
____
____
____
LININGS : ____________________
____
____
____
____
INTERNALS : ____________________
____
____
____
____
____

CONDITIONS

DESIGN TEMP °C : ____________________
OPERATING TEMP °C : ____________________
DESIGN PRESSURE Kg/cm² : ____________________
OPERATING PRESSURE Kg/cm² : ____________________
HYDR. TEST PRESSURE Kg/cm² : ____________________
CORROSION ALLOWANCE : ____________________
STRESS RELIEVED : ____________________
RADIOGRAPHED : ____________________
LONG. JOINT EFF. : ____________________
HEAD EFF. : ____________________
CODE : ____________________

DATA RECORD CARD __________ __________ UNIT

Inspn. Point	Description	Size	Sched.	Material	Org. Thickn.	Disc. Limit	Pres. Thick	Corro. Rate	Life	Pres. Thick	Corro. Rate	Life	Pres. Thick	Corro. Rate	Life	Pres. Thick	Corro. Rate	Life

HEAT EXCHANGER DATA CARD

DEPT. ________ UNIT. ________

INFORMATION

MANUFACTURER : ________
DRAWING : ________
ORDER NO. : ________
JOB NO. : ________
REQUISITION : ________
BILL OF MATERIAL : ________
SURFACE SQ. M. : ________
TYPE : ________
SIZE : ________
TEST RING : ________
IN USE : ________

CONDITIONS

	SHELL SIDE	TUBE SIDE
FLUID CIRCULATED :		
TOTAL LIQUID ENTERING Kg/Hr. :		
TOTAL VAPOUR ENTERING Kg/Hr. :		
FLUID VAPORIZED OR COND Kg/Hr. :		
TEMPERATURE INLET °C :		
TEMPERATURE OUTLET °C :		
DESIGN TEMPERATURE °C :		
OPERATING PRESSURE Kg/cm^2 :		
DESIGN PRESSURE Kg/cm^2 :		
PRESSURE DROP Kg/cm^2 :		
HYDR. TEST PRESSURE Kg/cm^2 AS NEW :		
PERIODIC :		
NUMBER OF PASSES :		
HEAT EXCHANGED Cal/Day :		

CONSTRUCTION

TUBES ________ PCS ________ PITCH ________
SHELL ________ I. D. ________ O. D. ________ THICKNESS ________
SHELL - COVER ________ FL. HEAD-COVER ________
CHANNEL ________ CHANNEL-COVER ________
TUBE SHEET ________ TUBE SHEET FL. ________
BAFFLES ________ TYPE ________ PCS ________
GASKETS SHELL ________ SIZE ________ MATERIAL ________
GASKET FLTG. HD. COVER ________ SIZE ________ MATERIAL ________
GASKET CHANNEL ________ SIZE ________ MATERIAL ________
CONNECTIONS SHELL ________ IN ________ OUT ________ SERIES ________
CONNECTIONS CHANNEL ________ IN ________ OUT ________ SERIES ________
CORROSION ALLOWANCE ________ SHELL SIDE ________ TUBE SIDE ________
BOLTING SHELL-COVER TO SHELL ________
BOLTING CHANNEL TO SHELL ________
BOLTING CHANNEL TO COVER ________
BOLTING FLOATING HEAD-COVER ________
CATHODIC PROTECTION-CHANNEL ________ FLOATING HEAD-COVER ________

WEIGHT

BUNDLE : ________ Kg
SHELL AND BUNDLE : ________ Kg
FULL OF WATER ________ Kg

(S.R.) INDICATES STRESS RELIEVING
(X.R.) INDICATES RADIOGRAPHING

HOMS REFINERY

FORM No. 10

INSPECTION DATE	[illegible] IN [illegible]		REPAIRS AND REMARKS
	BEFORE CLEANING	AFTER CLEANING	

SAFETY - VALVE INSPECTION & SERVICE RECORD

INFORMATION

LOCATION : ____________
MANUFACTURER : ____________
SERIAL NO. : ____________
STYLE : ____________
ORDER NO. : ____________
REQUISITION : ____________
CATALOGUE REF. : ____________
DRG. NO. : ____________
SPRING NO. : ____________
IN USE : ____________

CONDITIONS

RELIEF PRESS(KG/CM²) : ____________
COLD SET PRESS(KG/CM²) : ____________
BACK PRESS(KG/CM²) : ____________
OPERATING PRESS(KG/CM²) : ____________
PRESS LIMIT(KG/CM²) : ____________
OPERATING TEMP°C : ____________
TEMP. LIMIT°C : ____________
MATERIAL FLOWING : ____________

DIMENSIONS

INLET : ____________
OUTLET : ____________
ORIFICE : ____________

MATERIALS

BODY : ____________
BONNET : ____________
DISC : ____________
NOZZLE : ____________
SPRING : ____________

PERIOD OF INSPECTION : ____________

INSPECTION DATE	COLD POP PRESS IN KG/CM²		REPAIRS AND REMARKS
	BEFORE CLEANING	AFTER CLEANING	

HOMS REFINERY

FORM No. 11

INSPECTION SCHEME - RELIEF VALVES

________ UNIT

CARD NO.	R. V. NO.	LOCATION	[illegible]	DUE	HELD	DUE	HELD	DUE	HELD	DUE	HELD	DUE	HELD	DUE	HELD	DUE	HELD	DUE	HELD

HOMS REFINERY

FORM No. [illegible]

TANK DATA & INSPECTION CARD

INFORMATION		CONDITIONS		DIMENSIONS	
LOCATION	:	CAPACITY (M3)		DIAMETER	
MANUFACTURER	:			HEIGHT	
SERIAL NO.	:	CONTENTS		NO. OF COURSES	
TYPE	:				
ORDER NO.	:	STEAM COILS PARTICULARS			
REQUISITION	:				
DRG. NO.	:	WATER DRAINING SYSTEM			
IN USE		P & V VALVES			

WALL THICKNESS (MM) COURSE		CORROSION ALLOWANCE (MM)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

DATE INSPECTED	

INSPECTION REPORT OF LIFTING EQUIPMENT ____________ UNIT

[illegible] : ______________________ CAPACITY : ______________________

MANUFACTURER : ______________________ TYPE : ______________________

SERIAL NO. : ______________________ LOCATION : ______________________

DATE	PARTICULARS OF DEFECT AND ANY REPAIR CARRIED OUT	INSPECTION MARK	SIGNATURE

FORM No. 18

HOMS REFINERY

DATE	PARTICULARS OF DEFECT AND ANY REPAIR CARRIED OUT	INSPECTION MARK	SIGNATURE

[illegible] FORM No. [illegible]

LOCATINO ....
M. A. T. ....
MATERIAL ....
SIZE ....

TUBE / HEADER GAUGING SHEET

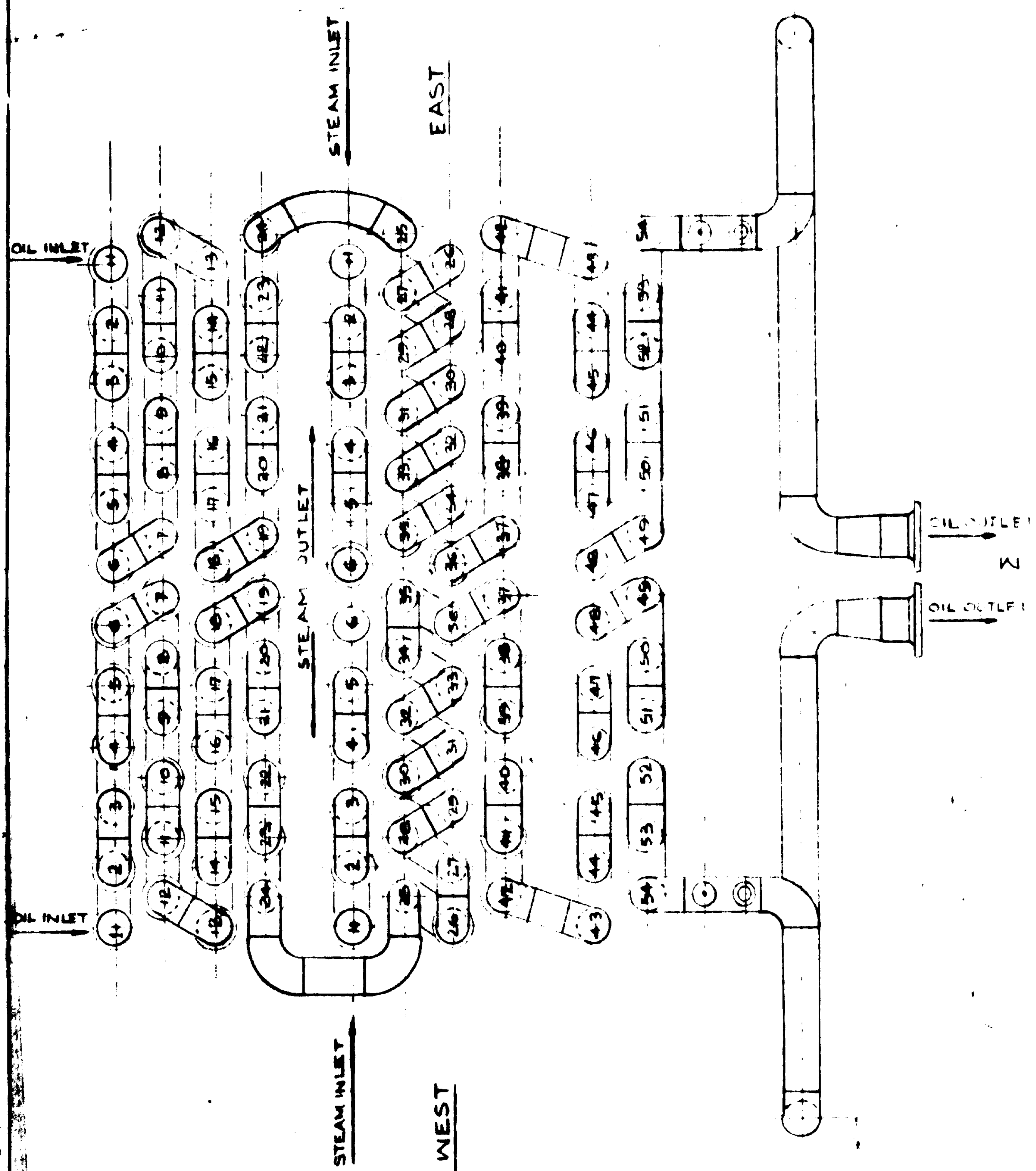
UNIT ....
HEATER ....
DATE ....

TUBE No.	N / T / S / B	DATE INSTALLED	DATE LAST GAUGED	DATE SINCE		ORIG. THICK.	LAST THICK.	PRESENT THICK.	LOSS		R.C.A.	* LAST RUN		OVERALL	
				INSTALLED	LAST GAUGED				O/A	* L.P.		CORRD. RATE	LIFE	CORRD. RATE	LIFE

* TO BE CALCULATED ONLY WHEN TUBE IS APPROACHING M. A. T.

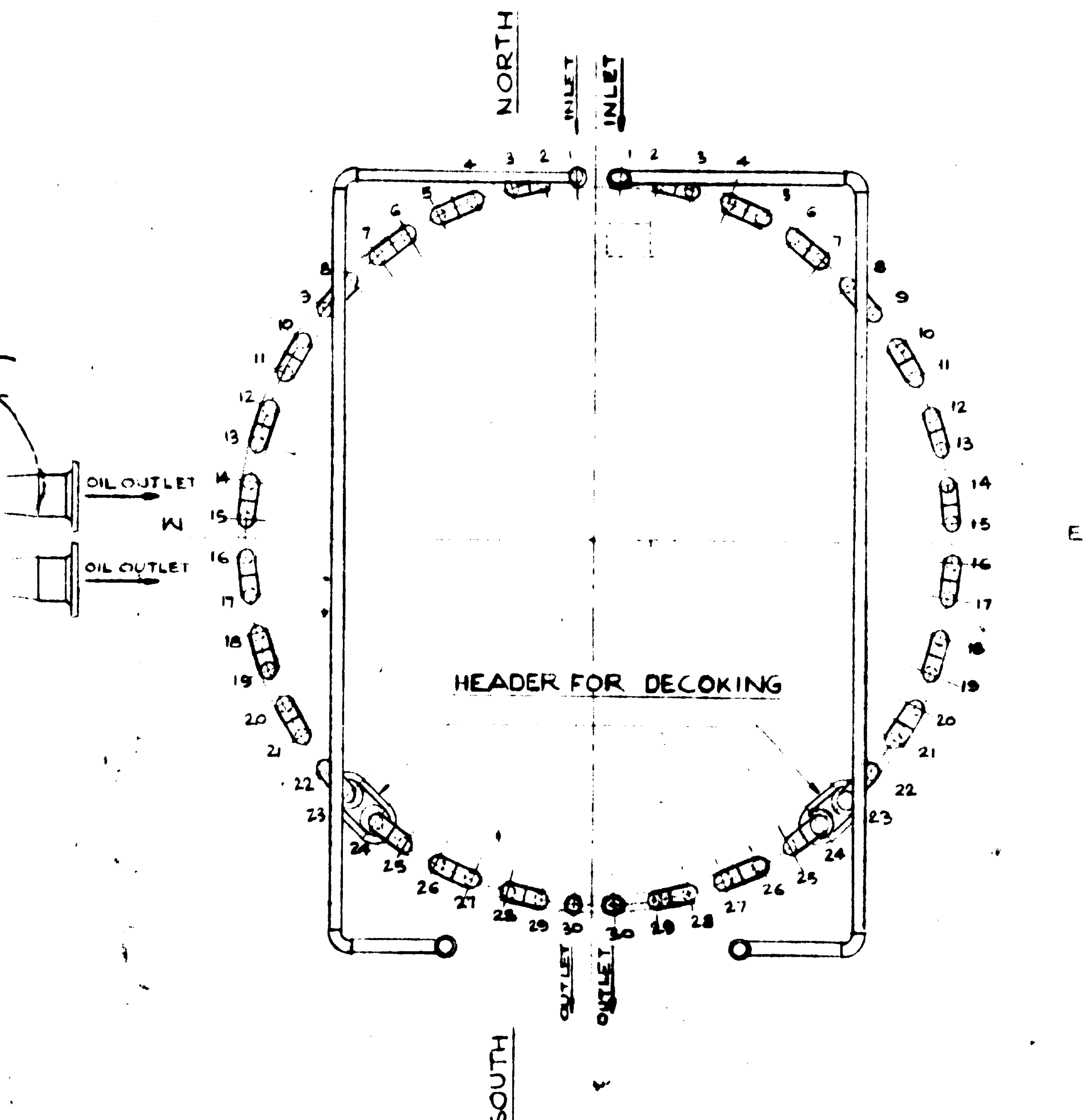
[illegible] REFINERY

FORM No. 15



SECTION 1

ENGINEERS INDIA LIMITED NEW DELHI	DWG. NO	REF DRAWING	HOMS REFINERY	NO. DATE



SECTION 2

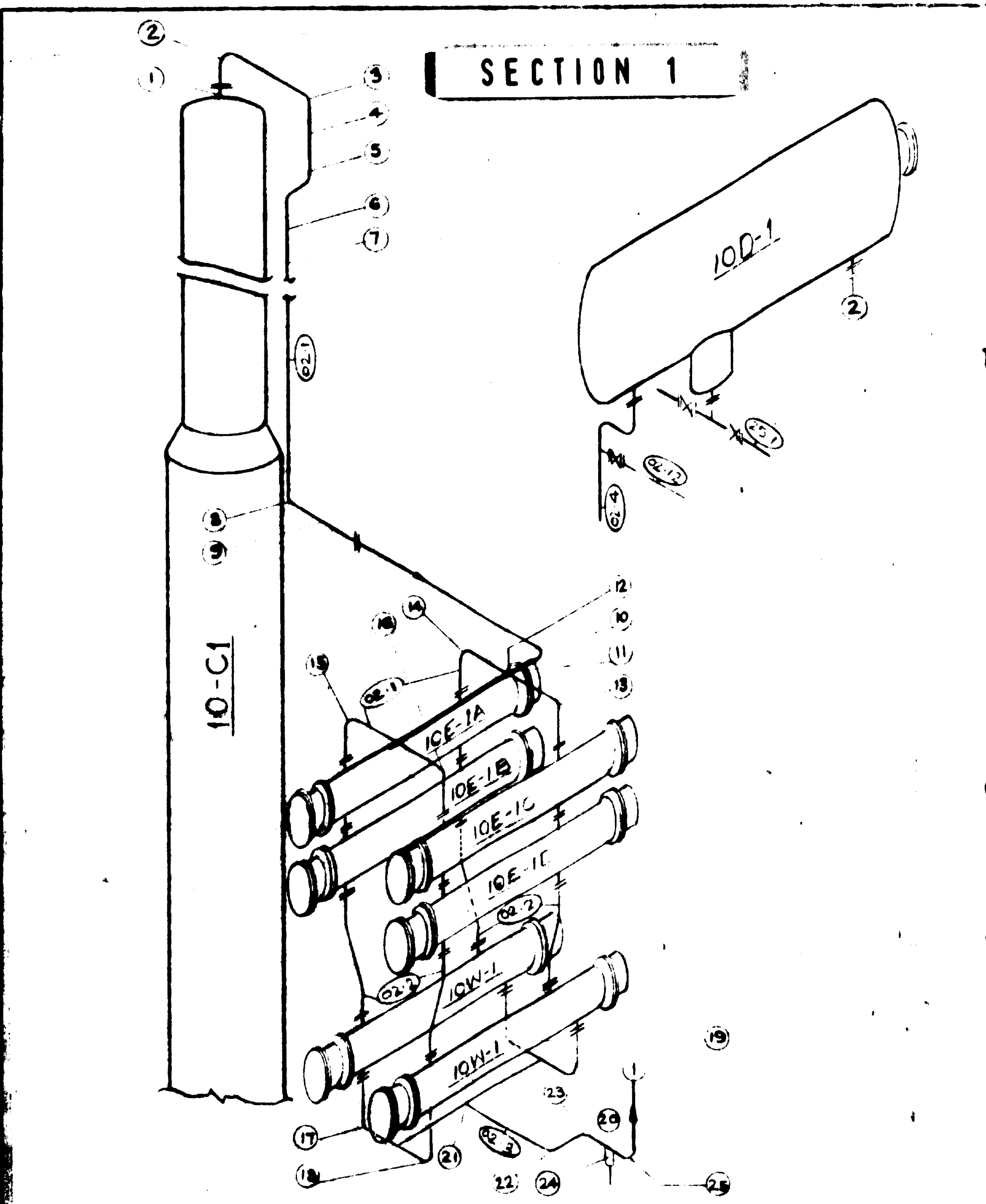
NERY	NO.	DATE	REVISION	BY	CK
APPD.					

TUBE SYSTEM
10-H1

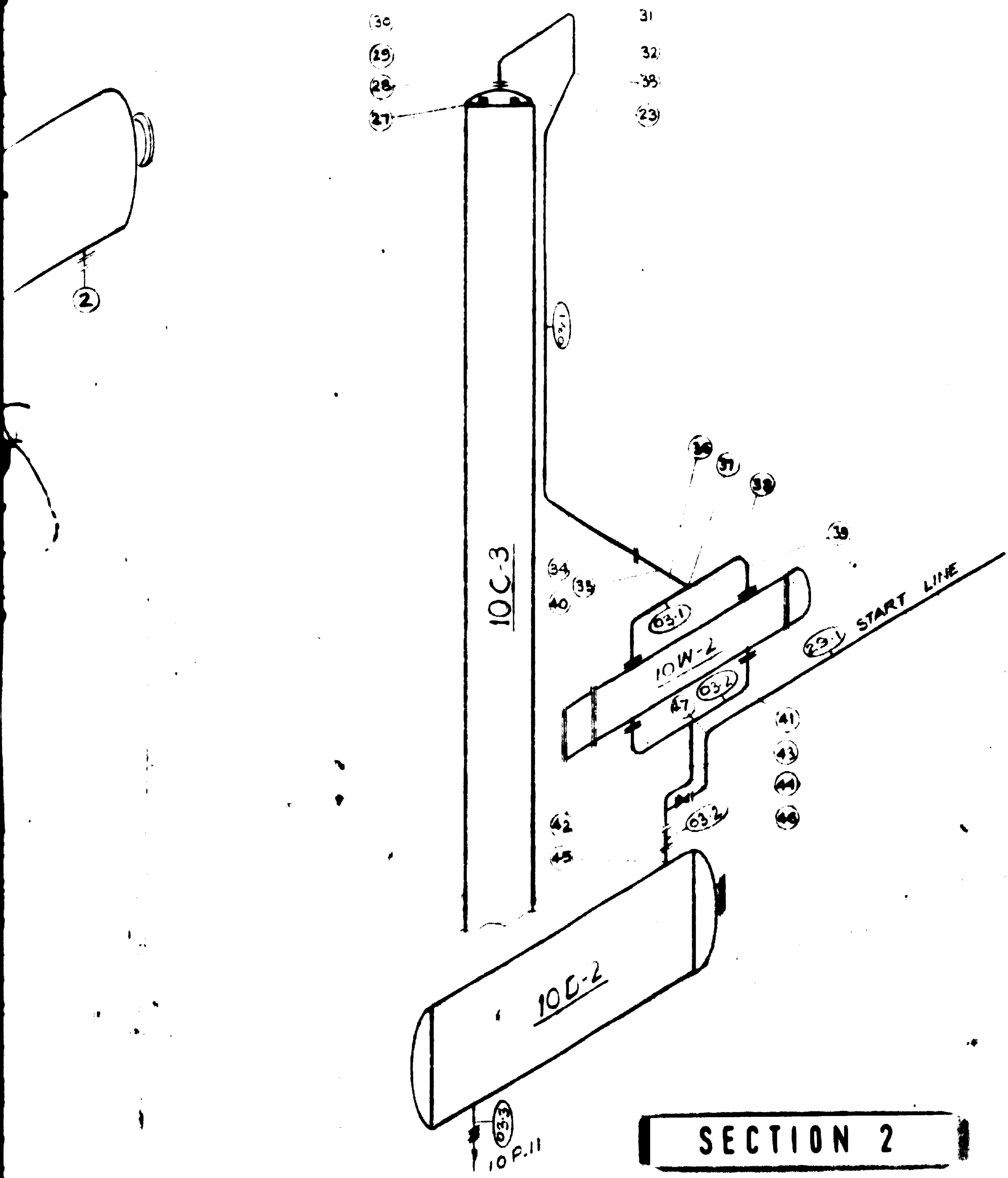
DRG. NO.
4.4005 / A-1
SHT OF

DISTRIBUTION CODE

SECTION 1



ENGINEERS INDIA LIMITED NEW DELHI	DWG. NO.	REF DRAWING	HOMS REFINERY	NO.	DATE



SECTION 2

FINERY	NO.	DATE	REVISION	BY	CH	APPD.	DEVELOPMENT SKETCH OF COLUMN AND VESSEL	4.4005 / A2 SHT OF

DISTRIBUTION CODE

ANNEXURE B

SPECIFICATIONS FOR INSPECTION EQUIPMENT/TESTING FACILITIES

	Name	Model/Specification	Manufacturer/Supplier
1.	Borescope	Industrial Type A - right angle system with integral lamp; sectionalised 3/4" dia, 18' length	American Cystoscope Makers Inc., 8, Pelham Parkway, Pelham Manor, N.Y.10803
2.	Probolog	Probolog 700	M/s. Krautkramer-Branson Inc. 76, Progress Dr. Stamford, CT USA 06904
3.	Digital wall thickness meter	D Meter DM-1	M/s. Krautkramer Gesellschaft Fur Electrophysik, 5, Koln, Luxemberger Stra BC-449, W.Germany Or M/s. Krautkramer-Branson Inc. 76, Progress Dr. Stamford, CT USA 06904
4.	Corrosometer	CK-2	M/s. Magna Corpn., 11808 S.Bloomfield Av., Santa Fe Springs, California, USA 90670
5.	Inspection Mirror	K-2	M/s. Ullman Co., UK
6.	Pit depth gauge	Range 0.2mm to 5mm with attachment to measure pit depth on flat and curved surfaces	M/s. Moorelane Supply Co., Oaklahama, USA

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7.	Elcometer	Model 101/32	M/s. Elcometer Instrument Ltd., Fair Field Rd, Drylsden, Manchester, U.K.
8.	Metallographic specimen mounting machine	Simplimet II along with mounting	Buehler Ltd., 2120, Greenwood Street, Evanston, Ill, USA 60204
9.	Surface grinder	Motor driven suitable for belt sizes of 4 x 36 inches or 4 x 54 inches	- do -
10.	Metallographic sample polisher	Circular motor driven multi speed disc polisher Disc diameter - 8 or 10".	- do -

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ANNEXURE B

LIST OF BOOKS AND STANDARDS

ASME Boiler and Pressure Vessel Code

I. Power Boilers
II. Material Specifications
    Part A - Ferrous
    Part B - Non-ferrous
    Part C - Welding Electrodes
V. Non-destructive Examination
VII. Recommended Rules for Care of Power Boilers
VIII. Pressure Vessels - Division 1
IX. Welding Qualifications

TEMA Standard for Heat Exchangers — Published by Tubular Exchangers Manufacturers' Association of USA

ASA B 31.3: Petroleum Refinery Piping Standard

ASTM Standard Part 1 - Steel Piping, Tubing and Fittings (April 1971)

ASTM Standard Part 2 - Ferrous Castings; Ferro-Alloys (April 1971)

ASTM Standard Part 4 - Steel - Pressure Vessel, Forgings, Railway, Reinforcing, Structural (April 1971)

ASTM Standard Part 31- Metals-Physical, Mechanical, Non-destructive and Corrosion Tests, Metallography, Fatigue, Effect of Temperature (July 1971)

B.S. 1856:1964 — Specification of General Requirements for the Metal Arc Welding of Mild Steel.

B.S. 2645 — Tests for use in the Approval of Welders.

Part 1:1955 — Manual Metal-arc and oxyacetylene welding of mild steel and low alloy steel sheets, plates and sections.

Part 2:1956 — Manual metal-arc and oxyacetylene welding of mild steel & low alloy steel pipelines & pipe assemblies.

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B.S. 499	Welding Terms & Symbols
Part 1: 1965 Part 2: 1965 Part 3: 1965	
B.S. 709:1964	Methods of Testing Fusion Welded Joints & Weld Metal in Steel
B.S. 2600:1962	Radiographic Examination of Fusion Welded Butt Joints in Steel
B.S. 2910:1965	Radiographic Examination of Fusion Welded Circumferential Butt Joints in Steel Pipes
B.S. 4080:1965	Methods for Non-destructive Testing for Steel Castings
B.S. 3889:1965	Methods for Non-destructive Testing of Pipes & Tubes
	Part 2 A Part 3 A
B.S. 4336: Part 1A 1968	Methods for Non-destructive Testing of Plate Material
B.S. 2654:1965	Vertical Steel Welded Storage Tanks for Petroleum Industry
Part 1:	Design & Fabrication
Part 2:	Site Erection, Inspection & Testing
B.S. 4360:1968	Specifications for Weldable Structural Steels
B.S. 1515	Specification for Fusion Welded Pressure Vessels for use in Chemical & Petroleum Industries.
Part 1 - 1965	Carbon & Ferritic Alloy Steel
Part 2 - 1968	Austenitic Stainless Steel
B.S. 3274:1960	Specification for Tubular Heat Exchangers
B.S. 1560:1958	Steel Pipe Flanges & Flanged Fittings for Petroleum Industry

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B.S. 1640	Steel Butt-Welding Pipe Fittings for Petroleum Industry
Part 3:1968	Carbon & Ferritic Alloy Steel Fittings-Metric Units
Part 4:1968	Wrought & Cast Austenitic Chromium-Nickel Steel Fittings-Metric Units
B.S. 1873:1960	Specification for Flanged Steel Globe Valves for Petroleum Industry
B.S. 1414:1960	Specification for Gate Valves for Petroleum Industry
B.S. 1868:1960	Specification for Flanged Steel Check Valves for Petroleum Industry
B.S. 1750:1961	Specification for Bolting for Petroleum Industry
B.S. 3179	Comparison of British & Overseas Standards for Steel
Part 1 - 1967	Chemical Composition of Wrought Carbon Steels
Part 2 - 1962	Chemical Composition of Wrought Alloy Steels
B.S. 970	Wrought Steels
B.S. 3740:1964	Specification for Steel Plate Clad with Corrosion Resisting Steel
B.S. 3100:1967	Specification for Steel Castings for General Engineering Purposes
B.S. 1452:1961	Specification for Grey Iron Castings
B.S. 1832:1958	Oil Resistant Compressed Fibre Jointing
B.S. 2815:1957	Compressed Asbestos Fibre Jointing
B.S. 1902	Methods of Testing Refractory Materials
Part 1A:1966	Sampling & Physical Tests
Part 1B:1967	Basic Refractory Materials
Part 1C:1967	Mouldable & Castable Refractories

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B.S. 78 Cast Iron Pipes & Fittings

Part 1:1961 Cast Iron Pipes

Part 2:1965 Cast Iron Fittings

State Factories Rules (Latest Edition)

A.P.I. Standards/Publications

Std 5L, Specifications for Line Pipe, Twenty-sixth Edition, April, 1971

Std 5LS, Specification for Sprial-Weld Line Pipe, Sixth Edition, April 1971

Std 5LX, Specification for High-Test Line Pipe, Eighteenth Edition, April 1971

Bull. 5T1, Bulletin on Non-destructive Testing Terminology Third Edition, April 1972

RP 510, Inspection, Rating, and Repair of Pressure Vessels in Petroleum Refinery Service, Second Edition, 1970

RP 520, Recommended Practice for the Design and Installation of Pressure-Relieving Systems in Refineries, Parts I and II

Part I - Design, Third Edition, 1967

Part II- Installation, Second Edition, 1963

RP-521, Guide for Pressure Relief and Depressuring Systems, 1969

RP 525, Testing Procedure for Pressure-Relieving Devices Discharging Against Variable Back Pressure, 1960

Std 526, Flanged Steel Safety Valves, Second Edition, 1969

Std 527, Commercial Seat Tightness of Safety Relief Valves with Metal-to-Metal Seats, 1964

RP 530, Recommended Practice for Calculation of Heater Tube Thickness in Petroleum Refineries, 1958

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Std 598, Valve Inspection and Test, Second Edition, 1970

Std 599, Steel Plug Valves (Flanged for Buttwelding Ends), Sixth Edition, 1969

Std 600, Steel Gate Valves (Flanged or Buttwelding Ends), Sixth Edition, 1969

Std 601, Metallic Gaskets for Refinery Piping (Double- Jacketed Corrugated and Spiral Wound), Second Edition, 1962

Std 602, Compact Design Carbon Steel Gate Valves for Refinery Use, Second Edition, 1971

Std 603, 150-Lb, Light Wall Corrosion-Resistant Gate Valve for Refinery Use ½ In. to 12 In., Inclusive, 1962

Std 604, Flanged Nodular Iron Gate and Plug Valves for Refinery Use, Second Edition, 1966

Std 605, Large-Diameter Carbon Steel Flanges, 1967

Std 620, Recommended Rules for Design and Construction of Large, Welded, Low-Pressure Storage Tanks, Fourth Edition, 1970

Std 661, Air-Cooled Heat Exchangers for General Refinery Services, 1968

Std 2510, Design and Construction of Liquified Petroleum Gas Installations at Marine and Pipeline Terminals Natural Gas Processing Plants, Refineries, and Tank Farms, Third Edition, 1970

Steels for Hydrogen Serv ce at Elevated Temperatures and Pressures in Petroleum Refineries and Petro-Chemical Plants, 1970

Recommended Practice for Welded, Plain Carbon Steel Refinery Equipment for Environmental Cracking Service, 1971

Glossary of Terms Used in Petroleum Refining, Second Edition, 1962

Std 1104, Standard for Welding Pipeline and Related Facilities, Twelfth Edition, 1971

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RP 1107, Recommended Pipeline Maintenance Welding Practices, 1966

RP 1110, Recommended Practice for the Pressure Testing of Liquid Petroleum Pipelines, First Edition, 1972

Publ 1151, Guide for Follow-up Inspection of Interior Tank Coatings, 1970

RP 2001, Fire Protection in Refineries, Fourth Edition, 1959

Bull. 2007, Safe Maintenance Practices in Refineries, 1962

RP 2009, Safe Practices in Gas and Electric Cutting and Welding, Third Edition, 1967

RP 2015, Cleaning Petroleum Storage Tanks, 1968

PSD 2200, Repairs to Crude Oil, Liquified Petroleum Gas, and Products Pipelines, 1964

PSD 2201, Welding or Hot Tapping on Equipment Containing Flammables, 1963

PSD 2207, Prepairing Tank Bottoms for Hot Work, 1967

PSD 2210, Flame Arresters for Tank Vents, 1971

PSD 2211, Precautions while working in Reactors Having an Inert Atmosphere, 1971

API Guide for Inspection of Refinery Equipment

Chap. 1, Introduction, 1961

Chap. II, Conditions, ca sing Deterioration or Failures, 1957

Chap. III, General Preliminary and Preparatory work, 1960

Chap. IV, Inspection Tools, Second Edition, 1972

Chap. V, Preparation of Equipment for Safe Entry and Work, Second Edition, 1972

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Chap. VI, Unfired Pressure Vessels,
Second Edition, 1966

Chap. VII, Heat Exchangers, Condensers, and Cooler Boxes, Second Edition, 1967

Chapter VIII, Direct- Fired Boilers and Auxiliary Equipment, 1960

Chap. IX, Fired Heaters and Stacks, Second Edition, 1967

Chap. X, Pumps, Compressors, and Blowers, and their Drivers, 1961

Chap. XI, Pipe, Valves, and Fittings, 1963

Chap. XII, Foundations Structures, and Buildings, 1969

Chap. XIII, Atmospheric and Low-Pressure Storage Tanks, Second Edition, 1964

Chap. XIV, Electrical Systems, 1961

Chap. XV, Instruments and Control Equipment, 1962

Chap. XVI, Pressure-Relieving Devices, 1961

Chap. XVII, Auxiliary and Miscellaneous Equipment, 1962

Chap. XVIII, Protection of Idle Equipment, 1959

Chap. XIX, Inspection for Accident Prevention, Second Edition, 1971

Chap. XX, Inspection for Fire Protection, Second Edition, 1971

Appendix, Inspection of Welding, Second Edition, 1971

<u>Books</u>

1.	Mechanical Engineers' Hand Book	L.S.Marks and T.B.Baumlister (Published by McGraw Hill)
2.	Maintenance Engineering Hand Book	L.Morrow (Published by McGraw Hill)
3.	Engineering Materials Hand Book	C.L. Mantell (Published by McGraw Hill)

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4.	Metals Hand Book, 8th Edition	Published by American Society of Metals
	Vol. 1 - Properties & Selection of Metals	
	Vol. 6 - Welding & Brazing	
5.	The Petroleum Refininery Engineers' Book	by J.F. Strachan (Published by E & F.N.Spon Ltd., London)
6.	Chemical Engineers' Hand Book	by Robert H. Perry (Published by McGraw Hill)
7.	Corrosion Hand Book	by H.H.Uhlig (Published by John Willey & Sons)
8.	Piping Hand Book	by S.Crocker & J.R.King (Published by McGraw Hill)
9.	Petroleum Refinery Engineering	by W.L.Nelson (Published by McGraw Hill - Kogakushu)
10.	Corrosion & Its Prevention in Water System	by M.A.Butler & H.C.K.Ison (Published by Leonord Hill)
11.	Petroleum Processing	by R.J.Hengstbeek (Published by McGraw Hill)
12.	Refractories	by F.H.Norton (Published by McGraw Hill)
13.	Unfired Pressure Vessels	by Robert Chuse (Published by F.W.Dodge Corporation, New York
14.	Pump Operation & Maintenance	by Hicks (Published by McGraw Hill)
15.	Non-destructive Testing Hand Book, Vol. I & II	by R.C.McMaster (Published by Ronald)

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ANNEXURE C

CSO/COP-16
MANUAL FOR
PM RECORDING SYSTEM OF
ROTATING EQUIPMENT

CENTRAL SERVICES ORGANISATION

ENGINEERS INDIA LIMITED

NEW DELHI

APRIL 1975

PM RECORDING SYSTEM OF ROTATING EQUIPMENT

1.0 INTRODUCTION

The hard core of any PM programme for rotating equipment is the recording system. This record tells us at a glance the chronological history of an equipment and its maintaineability.

The recording system furnishes a complete and concise data on equipment. This is of immeasurable help to the engineer during repairs. The system furnishes information on equipment condition by periodic inspections, warns of impending trouble spots, enables planned and programmed repair and makes it possible to order spares in time. Repetitive problems are highlighted, which would otherwise be 'lost' and suitable investigation and corrective action can be taken.

2.0 CONTENTS OF THE SYSTEM

2.1 The PM recording system consists of the following:

2.1.1 Data card for each equipment (Form 1).

This furnishes operating conditions, materials of construction, dimensions of major parts and lubrication details, and seal details.

2.1.2 History card (Form 2) for each equipment.

This gives in chronological sequence the dates of PM inspection, dates of breakdown repairs, probable cause, parts replaced/repaired, and present condition of parts.

2.1.3 PM check lists for each type of equipment (Form 3)

Equipment have been divided into the main categories - centrifugal, reciprocating, gear type and rotary. The centrifugal group has been subdivided into -

- Horozontal with two external bearings.
- Horizontal overhang.
- Vertical.

2.1.4 Unit Index Equipment Inspection Scheme Card(Form 4)

This lists all rotating equipment in a unit. The card is made for a period of 12 months, with each

.../...

month divided into 4 weeks, for convenience. Equipment inspection periods are indicated by a block. Colour schemes are used to indicate type of check.

2.1.5 Stores Spare Part. Listing with Stores Code No.

3.0 HOW THE SYSTEM WORKS

3.1 Data Cards are filled after reference to equipment catalogs. These are then put in individual file folders and located in a filing cabinet.

3.2 History cards for each equipment are also filed in respective file folders, alongwith data card. Foremen maintain daily logs listing work assignments, name and no. of equipment under repair, parts replaced/repaired, conditions of the parts, measurements of clearances and tolerances and alignment readings.

Personnel administering the PM program will scan the logs everyday and pertinent information in concise fashion will be transferred to the history card.

3.3 Unit Index Inspection scheme card is reviewed every week and blank copies of check lists for the weeks checks is filled with unit No. and equipment No. and also lube quality & quantity.

3.4 PM Check Lists

These are colour coded, blue for monthly, green for 3 monthly and yellow for 6 monthly. These colour codes are the same as used in the inspection scheme.

Differing check lists have been made for the broad categories of equipment. These again differ according to whether they are monthly, 3 monthly or 6 monthly. These check lists have been formulated based on information from equipment, catalogs, manufacturer's recommendations, local experience & specialists own experience.

Every week, the lists for the weeks scheduled inspection are handed over to the foremen. Foremen ensure that these checks done during the week. These check lists are then reviewed on a weekly basis before being filed in the individual equipment file. These lists are preserved for one year and then destroyed.

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3.5 Review of Completed PM Checks

The engineer reviews completed checks, notes any unusual conditions. He particularly notes the operating parameters of pressure and flow and vibration readings (see CSO/RP-15 'Monitoring on Vibrations'). For example, if coupling condition is bad, he orders that alignment be checked and coupling seal and lubricant if it is a lubricated type. A complete overhaul is scheduled only if warranted by unusual condition such as high, vibration readings or lower than normal operating parameters.

3.6 Review of Equipment History

Whenever an equipment file is taken out for entry of repair history, this is left in a separate tray for review and analysis by engineer before return to the cabinet. The engineer notes equipment condition and spares are ordered if required on the basis of this review.

3.7 The Stores Equipment Catalog

Spares list with code Nos. are also filed in the equipment folder. This helps in expediting daily work and also in furnishing correct description when reordering.

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LIST OF CARDS/CHECK LISTS FOR PM

Attach	Form 1	Data Card Pumps
		Data Card Compressors
	Form 2	History Card
	Form 3	PM Check Lists
	Form 4	Inspection Scheme Card
		- Typical for Unit 14 at Homs Refinery

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شركة مصفاة النفط بحمص

قسم الضواغط

بطاقة ضاغط

الوحدة :	رقم الوحدة : / رقم الضاغط

نوع الضاغط	رأسي	
	أفقي	
	زيت	
	بدون زيت	
	ترددي	
	حلزوني دوراني	
	طرادة مركزية	
الصانع		
الطراز		
رقم الصنع		
الوظيفة		

ظروف التشغيل

نوع الغاز	
الكثافة	
حرارة السحب م°	
حرارة الطراد م°	
ضغط المرحلة الاولى كغ / سم٢	
ضغط المرحلة الثانية كغ / سم٢	
ضغط المرحلة الثالثة كغ / سم٢	
ضغط المرحلة الرابعة كغ / سم٢	
السرعة	
الكمية م٣ ساعة	

المحرك

نوع المحرك	
الطراز	
لفة / دقيقة	
الاستطاعة / حصان	
أمبير التحميل	

منظومة التزييت

النظام	الزيت	الضغط كغ/سم٢	الحرارة م°	الكمية
الكروتير / الكرنك				
القميص والبستون				
علبة السرعة				
وصلة الكبلنج				

علبة السرعة

الطراز	
السرعة الداخلية	
السرعة الخارجية	

منظومة التبريد

الحرارة الداخلية م°	الحرارة الخارجية م°	الضغط كغ / سم٢	الكمية

المواصفات الميكانيكية

الجزء	رقم المخطط	القياسات	المعدن	ملاحظات
الجسم				
المكبس				
السكمانات				
ذراع البستون				
طرالة المكبس				
القميص				
الزلاقة				
طب الثلاث				
المناجع				
عمود الكرنك				
ذراع البيال				
أكس الزلاقة				
صمامات السحب				
صمامات الطرد				
الجلبات				
مسننات طب السرع				
مناجع طب السرع				
وصلة الكبالع				
فلتر الزيت				

شركة مصفاة النفط بحمص – قسم المضخات

بطاقة مضخة

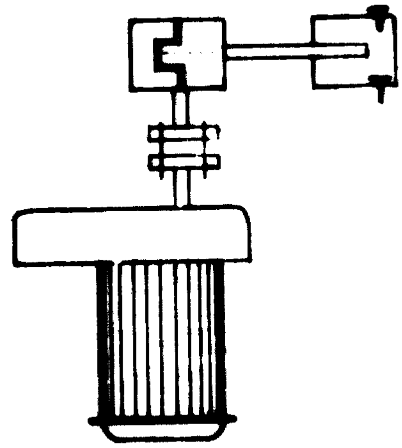
وحدة :	رقم الوحدة :	رقم المضخة :
نوع المضخة	**المواصفات الفنية**	**مواصفات المحرك**
الشركة الصانعة	المـــادة	طراز
الطراز	اللزوجـــة	عدد الدورات لفه / دقيقة
رقم المتسلسل	الوزن النوعي (sp.gr)	الاستطاعة ـ حصان
الوظيفة	درجة الحرارة °م	أمبير التحميل
منظومة التزييت	ضغط السحب كغ / سم²	**علبة المشاق**
نوع الزيت :	ضغط الطرد كغ / سم²	النوع / القياس
نوع التزييت: ضغط تناقلي	الكمية م³ / ساعة	حشوة
		جهاز ميكانيك سيل

المواصفات المكانيكية

الجزء	رقم المخطط	المعدن	القياس	الكمية	ملاحظات
الجسم					
الدوارة					
المحور					
باصكة محور					
باك تآكل الدوارة					
بلك تآكل الجسم					
المكبس					
حلقات الاحكام					
المسننات					
مروحة					
المدارج والمضاجع					
علبة السرعة					
رولمان علبة السرعة					
موانع التفرد					
جوانات					

سجل الاصلاحات

التاريخ	الاصلاحات التي أجريت للمضخة (وصف العمل)	اسم العامل	الوقت	ملاحظــــــــات



الجمهورية العربية السورية
شركة مصفاة حمص

الصيانة الوقائية

الكشف كل [redacted] ثلاثة اشهر

المضخات

اسم الفني : ١ ـ   رقم الوحدة :

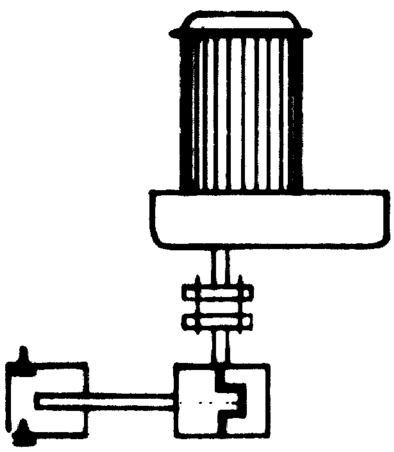
: ٢ ـ   رقم الآلة :

التاريخ   /   /   ١٩   النوع : زدية

غير مستخدم . . . غ . م	اجري	× لم يجري	ملاحظات م
١ ـ افحص زيت الكرنك ، بسكب كية قليلة واذا كان وسخاً ابدله			
٢ ـ افحص زيت علبة السرعة ، بسكب كية قليلة ، واذا كان وسخاً ابدله			
٣ ـ بدل زيت مضخة التزييت من التنظيف			
٤ ـ اكسح انابيب الزيت			
٥ ـ اكشف على وصلات الزنود			
٦ ـ اكشف من طنجه السلسرة وشد البراغي اذا لزم			
٧ ـ سجل ضغط المضخة والكية			

النوع   الكيه

التزيت : زيت الكرنك
علبة السرعة
مضخة الزيت



ملاحظات :

الوقت   عدد الفنيين

توقيع الفني   توقيع رئيس الورشة   توقيع المهندس

حـــص
شركة مصفاة البترول

الصيانة الوقائية
الكشف النصف سنوي
المضخات

اسم الفني : ١ ....
٢ ....
التاريخ : ....

رقم الوحدة : ....
رقم الالة : ....
النـــوع : ترددية

غير مستخدم ع.م   ✓ أجري   ✗ لم يجري   ملاحظات

١- أسكب زيت الكرنك ، أغسل الكراتير بالبنزين او زيت خفيف أملأ زيتاً جديداً ☐

٢- أسكب زيت علبة السرعة ، أغسل علبة السرعة بالبنزين أو زيت خفيف ، أملأ زيتاً جديداً ☐

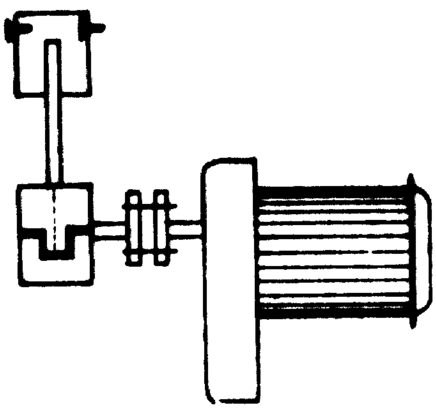
٣- بدل زيت مضخة التزييت بعد التنظيف ☐

٤- اكدح أنابيب الزيت ☐

٥- أكشف على فلنجة السدادة وشد البراغي اذا لزم ☐

٦- أكشف على وصلات الزند ☐

٧- سجل ضغط المضخة والكمية ☐



التزييت	النـــوع	الكمية
جسم الكرنك		
علبة السرعة		
مضخة الزيت		

ملاحظـــات

توقيـــع الفني   توقيـــع رئيس الورشة   توقيـــع المهندس

الجمهورية العربية السورية
شركة مصفاة حمص

الصيانة الوقائية
الكشف الشهري
المضخات

اسم الفني : ١ -	رقم الوحدة :
: ٢ -	رقم الآلة :
التاريخ / / ١٩	النوع : افقية بنهايتين

غير مستخدم . . . غ . م   اجري   X لم يجري   ملاحظات م

١ - زيت المضاجع . اسكب كمية قليلة من الزيت ؛ افحصه ، اذا كان وسخاً ابدله

٢ - افحص زجاجة تبيان الزيت للتأكد من عدم وجود تهريب .

٣ - افحص حرارة المضاجع وتأكد من عدم وجود صوت .
حرارة المضاجع العادية من (٤٠ - ٧٠ مْ) .

٤ - تأكد من وصول ماء التبريد الى جسم المضاجع وعلب الشاق .

٥ - تأكد من عدم وجود تهريب سائل ؛ شد براغي طنجة السلسرة اذا لزم
اذا كان جهاز الميكانيكل سيل يهرب ؛ اكتب ذلك .

٦ - سجل امبير التحميل .

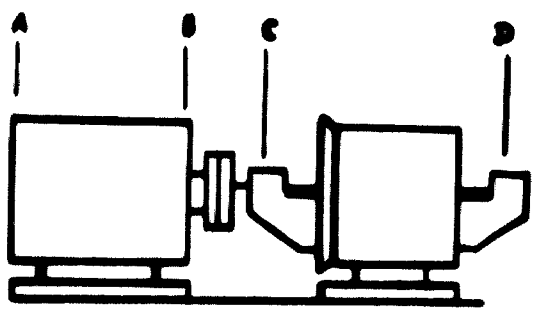
٧ - سجل الاهتزازات .

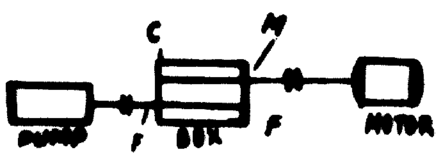
٨ - علبة السرعة : نظف الفلتر بالبنزين ، تأكد من ضغط الزيت
بين (٥ر٠ - ٢ كغ سم٢)

٩ - دون حرارة المضاجع لعلبة السرعة .
المحور القائد مضجع ١ ________ مضجع ٢ ________
المحور التابع مضجع ١ ________ مضجع ٢ ________

١٠ - سجل الضغط والكمية للمضخة .

موضع القراءة	الازاحة ميكرون			السرعة مم / ثانية		
	H	V	A	H	V	A
A						
B						
C						
D						
E						
F						
G						
H						





التزييت النوع الكمية

النتائج :
وحدة الكروب :
علبة السرعة :

ملاحظات :

الوقت الذي استغرقه هذا التفحص عدد الفنيين

توقيع الفني توقيع رئيس الورشة توقيع المهندس

الجمهورية العربية السورية
شركة مصفاة حمص

الصيانة الوقائية
الكشف كل [redacted] ثلاثة اشهر

المضخات

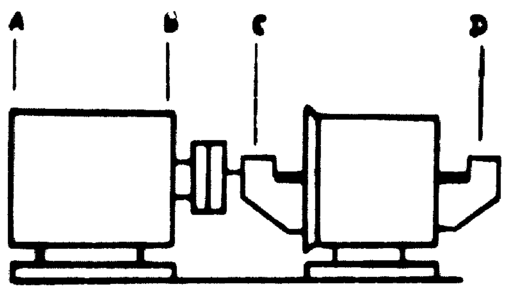
اسم الفني : ١ -
رقم الوحدة :
: ٢ -
رقم الآلة :
التاريخ / / ١٩
النوع : اقبية بنهـايتين

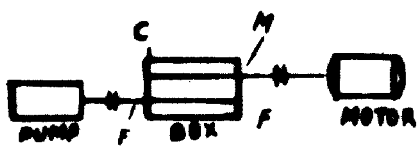
	غير مستخدم . . . ع . م	اجري	× لم يجري	ملاحظات م
١ - ريت المضاجع،اسكب كمية قليلة من الزيت ، افحصه ، اذا كان وسخاً ابدله				☐
٢ - افحص زجاجة تبيان الزيت للتأكد من عدم وجود تهريب .				☐
٣ - تأكد من حرارة المضاجع ومن الصوت .				☐
٤ - نظف خطوط ماء التبريد للمضاجع وعلب الشاق ، افحص بيانات جريان الماء				☐
٥ - تأكد من عدم وجود تهريب السائل ، شد براغي ظنجة السطمرة واذا كان جهاز الميكانيكل سيل يهرب دون ذاك .				☐
٦ - سجل امبير التحميل للمضخة .				☐
٧ - وصلة الكروب . اذا كانت زيت ؛ نظفها ثم اضف زيتاً او شحمة جديدة، افحص موانع الزيت				☐
٨ - علبة السرعة ، نظف الفلتر بالبنزين ، تأكد من ضغط الزيت ، يجب ان يكون بين ٥ر٠ كغ سم^2 - ٢ كغ / سم^2				☐
٩ - سجل حرارات علبة السرعة				☐

	المضجع الاول	المضجع الثاني
المحور القائد		
المحور التابع		

١٠ - سجل ضغط المضخة والكمية ☐
١١ - سجل الاهتزازات

السرعة مم/ثانية			الازاحة ميكرون			موضع القراءة
A	V	H	A	V	H	
						A
						B
						C
						D
						E
						F
						G
						H





الزيت　　　　النوع　　　　الكمية

المضاجع :
وصلة الكبلنج :
علبة السرعة :

ملاحظات :

الوقت الذي استغرقه هذا الفحص　　　　عدد الفنيين

توقيع الفني　　　　توقيع رئيس الورشة　　　　توقيع المهندس

حمص
شركة مصفاة البترول

الصيانة الوقائية
الكشف النصف السنوي
المضخات

اسم الفني : ١ ....
٢

التاريخ : ....

رقم الوحدة : ....
رقم الآلة : ....
النوع : المضخة بنهايتين

غير مستخدم ✓ أجري ✗ لم يجري

ملاحظات

١ ـ افتح أغطية المضاجع ، تأكد من عزقة الرولمانات والمضاجع

٢ ـ اذا كانت المضاجع أنتيمون ، فارفع الغطاء العلوي للمضجع
وقس الفراغ للمضاجع ، وافحص المضجع

٣ ـ اضف زيتاً جديداً بعد ان تسكب جميع الزيت القديم وتنظف
المضاجع بغسلها بالبنزين

٤ ـ افحص زجاجة بيان الزيت لتأكد من عدم وجود تهريب

٥ ـ نظف جميع خطوط تبريد الماء الواصل الى جسم المضاجع وعلب الشاق

٦ ـ أعد شد براغي القاعدة للمضخه

٧ ـ وصلة الكبلنج (الكروب)
غير الزيت أو الشحم بعد ان تنظف المسننات ، أبدل الجوانات اذا لزم
وتأكد من موانع الزيت

٨ ـ علبة السرعة . نظف الفلتر بالبنزين ، وغير الزيت بعد ان تنظفه
بزيت خفيف

٩ ـ اعد الكشف على ضبط المحورية سجل القراءات واعمل ضبط المحورية
اذا كانت القراءات أكبر من الحد المسموح به

١٠ - اوصل الكبلنج وشغل المضخة

١١ - تأكد من حرارة المضاجع ومن الصوت

١٢ - دون حرارة المضاجع لعلبة السرعة

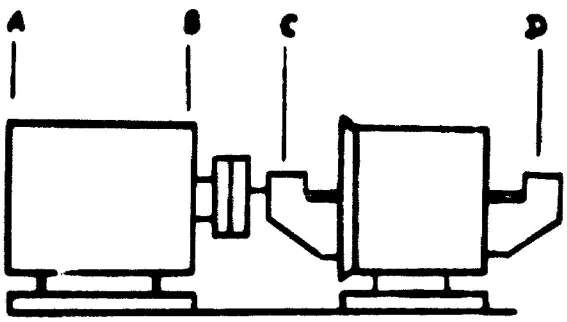
المحور القائد | مضجع اول | مضجع ثاني

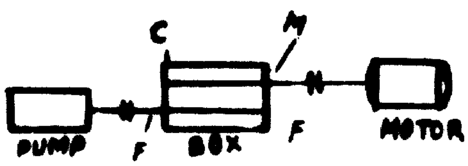
المحور التابع

١٣ - سجل امبير التحميل للمضخة

١٤ - سجل ضغط المضخة والكمية

١٥ - سجل الاهتزازات





السرعة مم/ثانية			الازاحة ميكرون			موضع القراءات
A	V	H	A	V	H	
						A
						B
						C
						D
						E
						F
						G
						H

الاجزاء التي استبدلت

ملاحظات

التزييت | النوع | الكمية

المضاجع :

وصلة الكبلنج :

علبة السرعة :

الزمن | عدد الفنيين

توقيع الفني | توقيع رئيس الورشة | توقيع المهندس

الجمهورية العربية السورية
شركة مصفاة حمص

الصيانة الوقائية
الكشف الشهري

المضخات

اسم الفني : ١ ـ   رقم الوحدة :

: ٢ ـ   رقم الآلة :

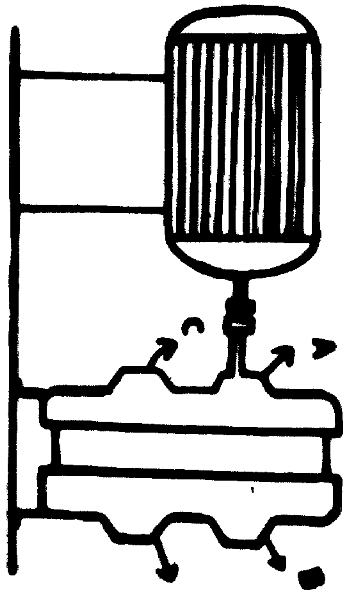
التاريخ / / ١٩   النوع : كبير

غير مستخدم . . . غ . م   اجري   X لم يجري   ملاحظات م

١ ـ التأكد من عدم التهريب سواء كان من موانع التهريب او السلسرة او جهاز الميكانيكل سيل .

٢ ـ التأكد من حرارة المضاجع ومن عدم وجود صوت .

٣ ـ دوّن الاهتزازات .



موضع القراءات	الإزاحة مكيرون			السرعة مم/ثانية		
	H	V	A	A	V	H
A						
B						
C						
D						

الوقت :   عدد الفنيين :

توقيع الفني   توقيع رئيس الورشة   توقيع المهندس

حمص

شركة مصفاة البترول

الصيانة الوقائية
الكشف النصف سنوي
المضخات

اسم الفني ١ ....
٢ ....

رقم الوحدة : ....
رقـــم الآلة : ....

التـــاريخ : ....

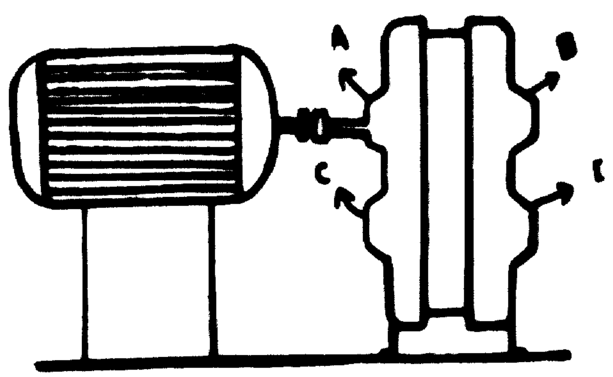
النـــوع : مضخة مسننة (صغير)

غير مستخدم ✓ أجري × لم يجري

ملاحظـــات م

١ ـ تأكد من عدم وجود تهريب من الساعرة او الموانع او جهاز الميكانيكل سيل ☐
٢ ـ تأكد من حرارة المضاجع ومن الصوت ☐
٣ ـ تأكد من تشحيم جميع المضاجع ☐
٤ ـ سجل الاهتزازات

موضع القراءات	الازاحـــة ميكرون H	الازاحـــة ميكرون V	الازاحـــة ميكرون A	السرعـــة مم / ثانية H	السرعـــة مم / ثانية V	السرعـــة مم / ثانية A
A						
B						
C						
D						



مـــلاحظات

التـــزييت النـــوع الكمية

توقيـــع الفـــني توقيع رئيس الورشة توقيـــع المهندس

حـــص

شركة مصفاة البترول

الصيانة الوقائية
الكشف كل ثلاثة أشهر
المضخـــات

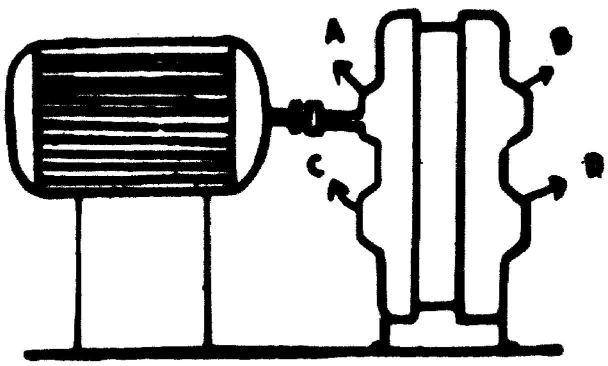
اسم الفني ١ ....
٢ ....
التـــاريخ : ....

رقم الوحدة : ....
رقـــم الآلة : ....
النـــوع : (مضخة)

غير مستخدم ✓ أجري × لم يجري

ملاحظـــات

1 - تأكد من عدم وجود تسريب من الحشوة أو الموانع أو جهاز الميكانيكل سيل
2 - تأكد من حرارة المضاجع ومن الصوت
3 - تأكد من تشحيم جميع المضاجع
4 - سجل الاهتزازات



موضع القراءات	الإزاحة ميكرون H	V	A	السرعة مم/ثانية H	V	A
A						
B						
C						
D						

ملاحظات

التـــزييت النـــوع الكمية

توقيـــع الفنـــي توقيع رئيس الورشة توقيـــع المهندس

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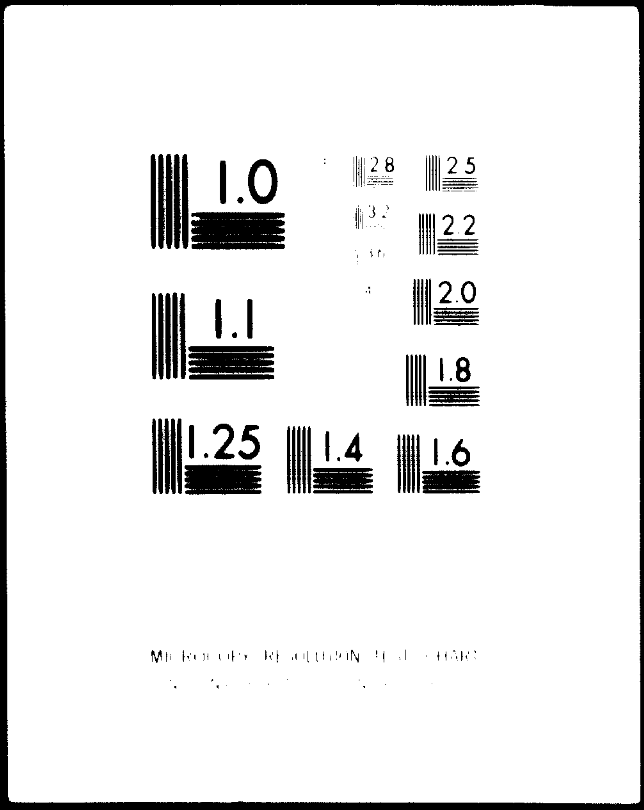


24x

C

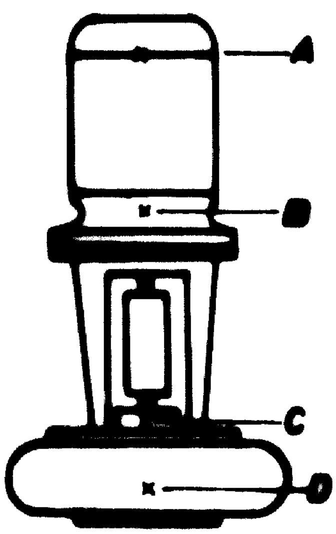
ح ـــ ص
شركة مصفاة البترول

الصيانة الوقائية
الكشف النصف السنوي
المضخـــات

اسم الفني : ١
٢
التاريخ :

رقم الوحدة : ....
رقم الآلة : ....
النوع : طارده مركزية عمودية

غير مستخدم ع - ٠ م	✓ أجري	× لم يجري	ملاحظات
١ - أسكب زيت المضاجع ، نظف جسم المضاجع بواسطة البنزين أو زيت خفيف ، املأ زيت جديد			
٢ - أفحص زجاجة بيان الزيت للتأكد من عدم وجود تهريب			
٣ - أفحص حرارة المضاجع وتأكد من عدم وجود صوت			
٤ - نظف خطوط ماء التبريد للمضاجع وعلب الشاق			
٥ - تأكد من عدم وجود تهريب السائل ، شد براغي فلنجة العصرة إذا لزم ، إذا كان الجهاز الميكانيكال سيل يهرب ، اكتب ذلك			
٦ - سجل امبير التحميل المضخة			
٧ - سجل ضغط المدخنة والكبسة			
٨ - سجل الاهتزازات			



موقع القراءة	الإزاحة ميكرون		السرعة مم / ثانية	
	V	H	H	V
A				
B				
C				
D				

زيت المضاجع ______ النوع ______ الكمية ______

الزمن

عدد الفنيين

توقيع الفني

توقيع رئيس الورشة

توقيع المهندس

الجمهورية العربية السورية
شركة مصفاة حمص

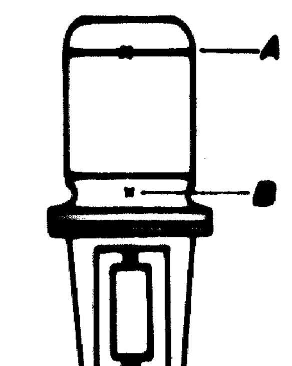
الصيانة الوقائية
الكشف كل [redacted] ثلاثة اشهر

المضخات

اسم الفني : ١ - رقم الوحدة :
: ٢ - رقم الآلة :
التاريخ / / ١٩ النوع : عمودية

غير مستخدم . . . ع . م اجري × لم يجري ملاحظات م

١ - امسك كمية قليلة من زيت المضاجع وافحصه اذا كان وسخ ابدله
٢ - افحص زجاجة بيان الزيت التأكد من عدم وجود تهريب
٣ - افحص حرارة المضاجع وتأكد من عدم وجود صوت
٤ - نظف خطوط ماء التبريد للمضاجع وعلب الشاق
٥ - تأكد من عدم وجود تهريب السائل ؛ شد براغي ظرفة السطرة اذا لزم ، اذا كان الجهاز الميكانيكل سيل يهرب ؛ اكتب ذلك
٦ - سجل امبير التحميل للمضخة
٧ - سجل ضغط المضخة والكبيه
٨ - سجل الاهتزازات



موضع القراءة	الاراحة ميكرون		السرعة مم / ثانية	
	V	H	V	H
A				
B				
C				
D				

النوع ______ الكمية ______
زيت المضاجع
ملاحظات :

الوقت الفني لازم لاجراء الصيانة عدد الفنيين

توقيع الفني توقيع رئيس الورشة توقيع المهندس

الجمهورية العربية السورية
شركة مصفاة حمص

الصيانة الوقائية
الكشف الشهري

المضخات

اسم الفني : ١ –
٢ –

رقم الوحدة :
رقم الآلة :

التاريخ / / ١٩ النوع : عمودية

غير مستخدم . . . غ . م أجري × لم يجري ملاحظات م

١ – زيت المضاجع – امسك كمية قليلة من الزيت ؛ افحصه اذا كان وسخاً أبدله.

٢ – افحص زجاجة بيان الزيت لتأكد من عدم وجود تهريب .

٣ – افحص حرارة المضاجع وتأكد من عدم وجود الصوت .

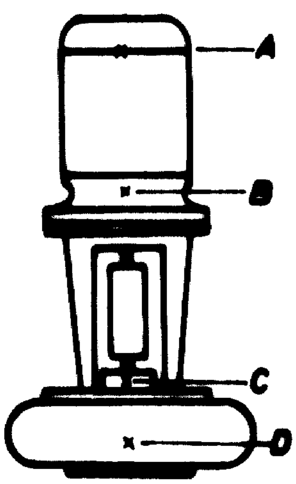
٤ – تأكد من وصول ماء التبريد الى جسم المضاجع وعلب الشاف .

٥ – تأكد من عدم وجود تهريب سائل ؛ شد براغي فلنجة الطمرة .
اذا لزم ؛ اذا كان جهاز الميكانيكل سيل يهرب . اكتب ذلك .

٦ – سجل أمبير التحميل .

٧ – سجل الضغط والكمية .

٨ – سجل الاهتزازات .



موضع القراءة	الازاحة ميكرون		السرعة مم / ثانية	
	A	V	A	V
A				
B				
C				
D				

زيت المضاجع النوع ______ الكمية ______

ملاحظات :

الوقت الذي لزم لاجراء العملية عدد الفنيين

توقيع الفني توقيع رئيس الورشة توقيع المهندس

شركة مصفاة البترول

الصيانة الوقائية
الكشف كل ثلاثة اشهر
المضخات

اسم الفني : ١ ....
٢
التاريخ :

رقم الوحدة : ....
رقم الآلة : ....
النوع : الطاردة طرف واحد

غير مستخدم - ع م   ✓ أجري   × لم يجري   ملاحظات م

١ - زيت المضاجع - اسكب كمية قليلة من الزيت ، أفحصه ، أذا كان وسخاً أبدله .
☐

٢ - أفحص زجاجة بيان الزيت للتأكد من عدم وجود تهريب
☐

٣ - أفحص حرارة المضاجع وتأكد من عدم وجود الصوت
☐

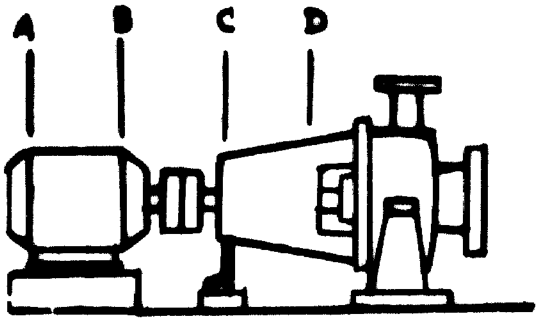
٤ - نظف خطوط تبريد الماء لجسم المضاجع وعاب الشاق
نظف الفلتر ، تأكد من بيانات جريان الماء
☐

٥ - تأكد من عدم وجود تهريب السائل ، إذا كان الجهاز يهرب دون ذلك
☐

٦ - سجل امبير التحميل المضخة

٧ - وصلة الكبلنج (الكروب)
اذا كانت تزيت او تشحم ، نظفها ثم أضف زيتاً أو شحماً جديداً
استبدال الجوانات اذا لزم ، افحص موانع التهريب الزيت .
☐

٨ - سجل ضغط المضخة والكمية



٩- سجل الاهتزازات

موضع القراءة	الإزاحة ميكرون		السرعة مم / ثانية	
	V	H	H	V
A				
B				
C				
D				

التزييت ________ النوع ________ الكمية ________

المشاحم
وصلة الكروب

ملاحظات

الزمن عدد الفنيين

توقيع الفني توقيع رئيس الورشة توقيع المهندس

ح ـــ س
شركة مصفاة البترول

الصيانة الوقائية
الكشف النصف سنوي
المضخات

اسم الفني : ١ .... رقم الوحدة : ....
٢ رقم الآلة : ....
التاريخ : .... النوع : الخلفية بطرف واحد

غير مستخدم - غ م ✓ أجرى × لم يجري ملاحظات م

١ - أبدل الزيت للمضاجع بعد ان تسكب الزيت القديم بعد تنظيف جسم المضاجع بالبنزين .

٢ - أفحص زجاجة بيان الزيت للتأكد من عدم وجود تهريب

٣ - أفحص حرارة المضاجع وتأكد من عدم وجود صوت

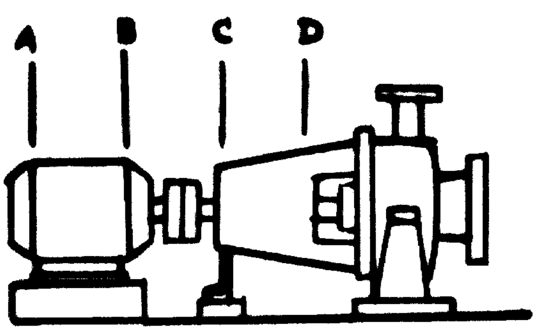
٤ - نظف خطوط تبريد الماء لجسم المضاجع وعاب المشاق

٥ - تأكد من عدم وجود تهريب السائل ، إذا كان الجهاز يهرب دون ذلك

٦ - سجل امبير التحميل للمضخة

٧ - وصلة الكبلنج (الكروب)
اذا كانت لزيت او لتشحيم . نظفها ثم أضف زيتاً او شحماً جديداً
استبدال الجوانات اذا لزم ، افحص موانع التهريب للزيت .

٨ - سجل ضغط المضخة والكمية



٩ـ سجل الاهتزازات

السرعــه مم / ثانية		الإزاحـــة ميكرون		موضع القراءة
V	H	H	V	
				A B C D

الكمية   النوع   التزييت

المضاحع
وصلة الكروب

ملاحظات

عدد الفنين   الزمن

توقيع المهندس   توقيع رئيس الورشة   توقيع الفني

الجمهورية العربية السورية
شركة مصفاة حمص

الصيانة الوقائية
الكشف الشهري

المضخات

اسم الفني : ١ ـ　　　　رقم الوحدة :
: ٢ ـ　　　　رقم الآلة :
التاريخ / / ١٩　　　　النوع : افقية طرف واحد

غير مستخدم . . . غ . م　　　　اجري　　　　× لم يجري　　　　ملاحظات م

١ ـ زيت المضاجع : اسكب كمية قليلة من الزيت ، افحصه .
اذا كان وسخاً أبدله .

٢ ـ افحص زجاجة بيان الزيت للتأكد من عدم وجود تهريب

٣ ـ افحص حرارة المضاجع وتأكد من الصوت .
حرارة المضاجع العادية بين (٤٠ ـ ٧٠° م)

٤ ـ تأكد من وصول ماء التبريد الى جسم المضاجع وعلبة المشاق .

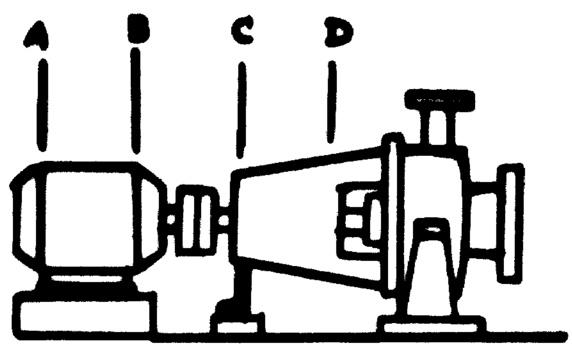
٥ ـ تأكد من عدم وجود تهريب السائل : شد براغي فلنجة الملسرة اذا لزم اذا كان جهاز الميكانيكل سيل يهرب اكتب ذلك .

٦ ـ سجل امبير التحميل للمضخة .

٧ ـ سجل الاهتزازات .

٨ ـ سجل ضغط الطرد للمضخة و الكمية و .

موضع القراءة	الازاحة ميكرون		السرعة مم / ثانية	
	V	H	V	H
A				
B				
C				
D				



التزييت　　　النـــوع　　　الكمية

المضـاجع :

وصلة الكروب :

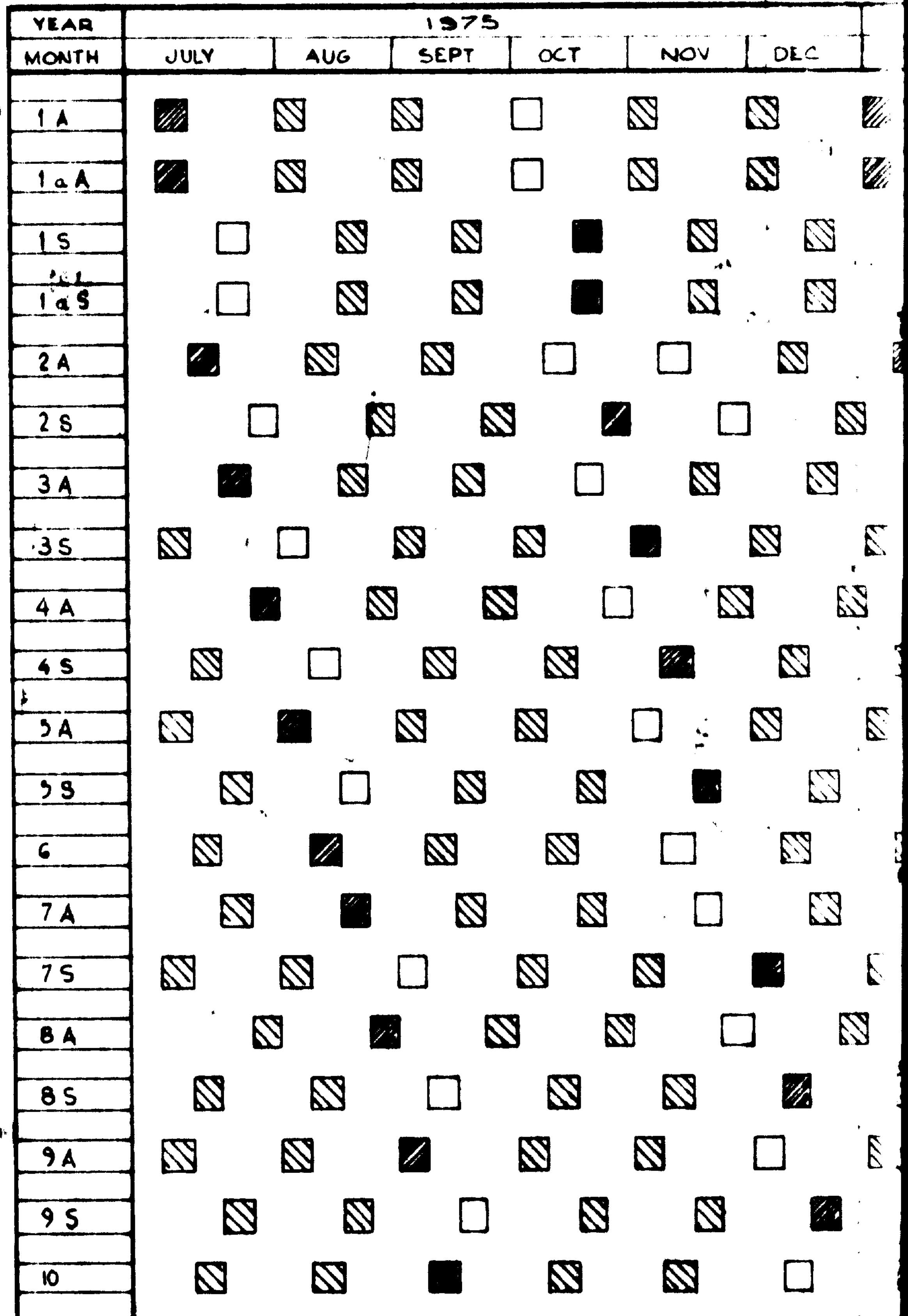
ملاحظـات :

الوقت الذي لزم لاجراء هذا الفحص　　　عدد الفنيين :

توقيع الفني　　　توقيع رئيس الورشة　　　توقيع المهندس

P M INSPECTION SCHEME CA

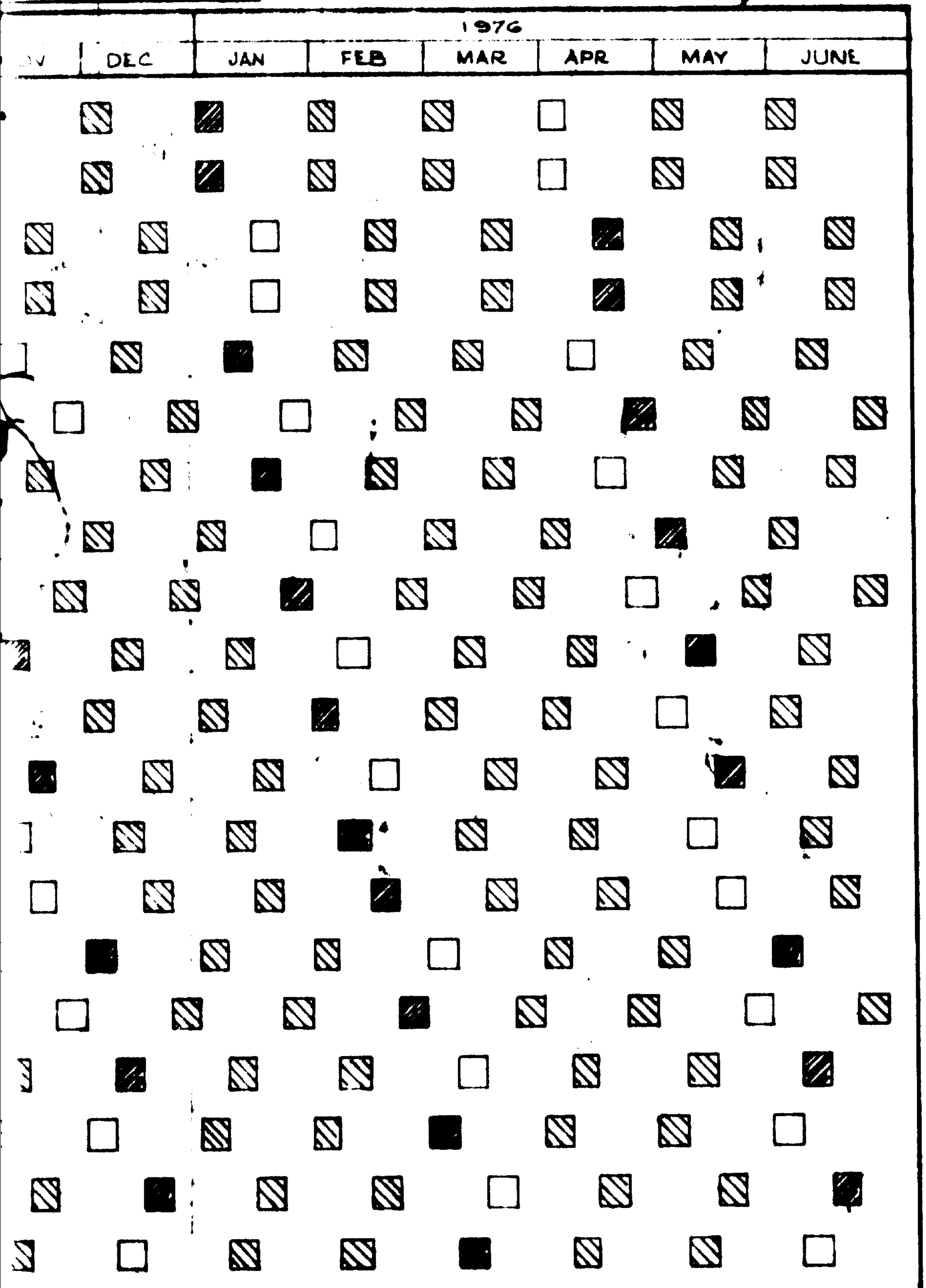
UNIT 14
HOMS REFINERY



SECTION 1

ENGINEERS INDIA LIMITED NEW DELHI	DWG NO	REF DRAWING		NO	DATE

...ON SCHEME CARD



NOMENCLATURE
YELLOW 6 MONTHLY
GREEN 3 MONTHLY
BLUE MONTHLY
CHECK DONE
PARTIALLY DONE

SECTION 2

NO	DATE	REVISION	BY	CK	APPD.

DISTRIBUTION CODE

ANNEXURE D

CSO/COP-10
MANUAL FOR
MEASURING CORROSIVITY OF COOLING WATER

CENTRAL SERVICES ORGANISATION
ENGINEERS INDIA LIMITED
NEW DELHI

JANUARY 1974

MANUAL FOR MEASURING CORROSIVITY OF COOLING WATER

1.0 INTRODUCTION

The waterside corrosion of ferrous and non-ferrous metals in petroleum, chemical and petrochemical process industries can often adversely affect the "On-stream efficiency" of the plant if not controlled properly. The control of corrosion assumes more importance in the condensers and coolers besides the water distribution system. In order to counter-act the corrosive and scaling tendencies of the cooling water, a chemical water treatment is generally resorted to in one form or the other. The water treatment generally takes into account the specified limits of water composition or the contents of inhibitors and other chemical additives and except the analytical data of water composition, no data is available as guidelines for "affective control" to the operating personnel. The control of the water treatment frequently is rendered more difficult due to seasonal variation of raw water quality and often, the service failures alone have to be taken as the criteria of the adequacy of the treatment or otherwise. Thus, there exists scope for having a dependable and regular feed-back regarding the adequacy of the treatment and the corrosive and scaling tendencies of cooling water.

The manual for measuring corrosivity of cooling water is intended to supply the operating personnel with the basic data on the corrosion characteristics of the cooling water and its effect on the materials of construction. The monitoring of the corrosion by exposing coupons as per the manual will not only help in the proper corrosion control of the cooling water but also equip the operating personnel with the tool useful for evaluation of different cooling water treatments. Improvements of currently operating water treatments often becomes necessary in the light of new developments in the field or due to considerations of higher pollution load of the existing systems. In either case, the monitoring of the corrosive character of cooling water becomes imperative as a positive indication of the cooling water performance.

The present manual describes the methods which are essential for evaluation of water quality and the water treatment

(a) Coupon Test

(b) Standard Heat Exchanger Test

../..

2.0 COUPON TEST

2.1 Specimen Preparation

2.1.1 Size

Rectangular specimens of size 100 x 25 x 1.5mm will be machined from rolled sheets of materials having composition as close to the metal being investigated as possible.

2.1.2 Surface Preparation

The coupon surface will be polished to a finish by 'O' grade emery paper and then degreased by rubbing with MgO paste. The coupon from this stage onward will be handled carefully so as not to touch it with bare hands. These will be weighed to an accuracy of 1 mg and kept in a dessicator prior to use.

The brass & copper specimens should be exposed in the as rolled condition after degreasing. The use of emery paper should be avoided.

2.2 Method of Testing

2.2.1 Specimen Mount

The specimen mount shall be a 20 mm dia x 150 mm long water resistant plastic or fibre laminated bakelite rod (Hylam). This rod will be inserted in a pipe plug either by means of a drive fit or by means of a threaded hole in the plug. The dimensions of the rod and method of fixing the specimen are shown in Fig.1. The nut and bolt used for fixing should preferably be of the same material as the coupon or nylon.

2.2.2 Coupon Holder Assembly

The coupons will be exposed in a special by-pass from the main line. The arrangement ensures exposure of a group of coupons in the water stream under essentially identical condition. Further, it is not necessary to shut the main line for the fitting or removal of the coupons, closing of by-pass valve being sufficient. The flow of water and therefore its velocity past the specimen surface can be controlled by the by-pass valve. The assembly shown in Fig.2 consists of a back-and-forth arrangement of pipe (40mm) nipples and tees. Full bore flow is ensured by connecting the assembly so that the water flows upward through it.

2.2.3 Location of Coupon Holder

For assessing the corrosivity of the water at points of high temperatures in the circulating system, specimen holders will be located at the exit of the heat exchangers. The general corrosivity of raw water and circulating water will be obtained by locating the specimen holder to the make-up water pipe near the outlet of the cooling tower and to the cooling tower risers respectively.

2.3 Procedure

The metal coupons prepared, weighed and fixed to the plastic holder will be screwed into the specimen holder assembly shown in Fig.2. The water will then be turned on through the assembly by operating the globe valve and the flow rate adjusted to desired value, depending on the actual system under study. Depending on circumstances, flow rate measurement system can also be included.

2.4 Retractable Rack

Where necessary, retractable racks can also be used. The details of the rack are given in CSO/COP-9. These can be fitted at suitable bends shown in Fig.3 of CSO-COP-9.

2.5 Duration of Exposure

The duration of test for the corrosion test coupons will depend on the type of material, previous knowledge of the corrosion rates, the type of water treatment and the period within which the results are desired. Test duration of 30 days in the case of c.steel and 60 days in the case of brass will provide useful data. However, duration should be as long as possible commensurate with the resistence of the material under test and should not exceed 6 months.

2.6 Assessment

After completion of the test, the coupons in as the removed condition will be examined for the nature of corrosion attack and the corrosion product. The photographs of the specimens should be taken. The coupons should be weighed after drying.

2.7 Cleaning of the Coupons

The coupons will be first mechanically cleaned using a soft brush under a stream of tap water to remove loose deposits or corrosion products.

The coupons will be cleaned using the following solutions:

(a)	Carbon steel and low alloy steel :	5 p.c. sulphuric and solution with 0.5 p.c. beta-naphthol or 0.1 p.c. di-o-tolyl thiourea. The cleaning should be done at room temperature.
(b)	Copper Alloys :	Dip for 2 to 3 min. in 18 p.c. Hydrochloric acid or 10 p.c. sulphuric acid at room temperature.
(c)	Stainless Steel :	10 p.c. nitric acid at 60°C.

../..

After dipping in the cleaning solution, coupons should be scrubbed with bristle brush.

The coupons should be photographed after cleaning and drying and should be examined for the following:

1) Loss in weight determination.

2) In case of pitting type of attack on the coupons, the number, size, depth and distribution of pitting should be noted.

3) In case of intergranular attack e.g. stainless steel or dezincification in case of brass coupons, detailed metallurgical examination should be carried out.

4) The dimensions of the coupons should be recorded and compared with the originals.

2.8 Corrosion Rates

The corrosion rates will be determined using the following formulae:

1. Based on Weight Loss

$$\text{mils per year (mpy)} = \frac{\text{22.3xweight loss in milligrams}}{\text{specific gravity of the metal x exposed area of coupon in square inches x time in days.}}$$

Specific gravities of Metals are :

Admiralty brass	8.17
Low carbon steel	7.85
Stainless steel	7.9

2. Based on Maximum Pit Depth

$$\text{Pitting rate (mils penetration per year (mppy)} : \frac{\text{max. pit depth/inter granular penetration x 365}}{\text{time of test in days.}}$$

../..

3. <u>Based on Measured Change in Thickness</u>

Reduction of Thickness millimeters per year (mmpy) = $\frac{\text{Average reduction in thickness in mm} \times 365}{\text{time of test in days} \times 2}$

3.0 HEAT EXCHANGER TEST

The objective of this test is to evaluate fouling and corrosion of heat transfer surfaces by cooling water encountered in coolers and condensers.

3.1 Heat Exchanger Design

The heat exchanger unit consists of twelve 18 mm dia 14 BWG & 1200 mm long tubes on 25 mm triangular pitch. Tubes are fitted with O-rings which makes the removal and replacement of tubes easier. The details of the design are given in Fig.3.

3.2 Operating Conditions

3.2.1 Flow rate of water through the tubes is an important parameter of study. Depending on the material of construction, flow rates of 0.5, 1.0, 1.5 and 2.5 meters/sec. can be used. The flow rate should be manually controlled. To some extent, it is better that automatic flow controllers are used. Flow will be controlled in the exchanger outlet line.

3.2.2 The hot medium in the exchanger should be 2 kg/cm^2 steam. It is essential that a steam pressure regulator is used.

3.2.3 Pressure drop of water across the exchanger will be measured. A suitable manometer will work satisfactorily.

3.2.4 Arrangement for measuring the inlet and outlet temperature of water will be provided. However, the inlet and outlet water temperature shall not be controlled.

3.2.5 All relevant data, e.g., temperature, pressure, flow, etc. described above will be recorded once for shift.

../..

3.2.6 Period of test will be minimum 30 days for evaluating c.steel tubes and 60 days for brass tubes.

Note: Special conditions in a plant may require different conditions in the test exchanger.

3.3 <u>Evaluation of Results</u>

3.3.1 <u>Corrosion</u>

3.3.1.1 The tubes after the test will be removed, marked for identification, and split into two equal halves. The slit will be horizontal as seen in the original position in the tubes. The nature of the fouling (deposit, corrosion product, etc) will be noted and photographed. The deposits will then be removed as far as possible by rubbing with stiff bristle brush under running water and the tube surface examined carefully for its appearance. This is specially important for the evaluation of brass tubes where dezincification may take place. If facilities exist, the mechanical cleaning should preferably be done with fine sand blasting.

The tubes will otherwise be cleaned using acids as given in para 2.7.

3.3.1.2 Approximate percentage of total area of any localised corroded region, e.g., pitting, dezincification, etc. will be determined. Pit depth will also be measured and recorded.

3.3.1.3 In case of suspected dezincification, a section of affected tube will be examined under miscroscope and the depth of attack determined.

../..

3.3.2 Fouling and Friction Factor

The fouling and friction factor calculations will be helpful in giving the effectiveness of water treatment and inhibitor additions. The test heat exchangers give necessary data from which those two factors can be calculated using standard formulae.

4.0 CRITERIA FOR FINAL ASSESSMENT

The results obtained by these tests offer valuable data regarding the corrosivity and/or scaling of water. The final criteria for the success of any cooling water treatment should be the inspection of the equipment in which the cooling water is being used.

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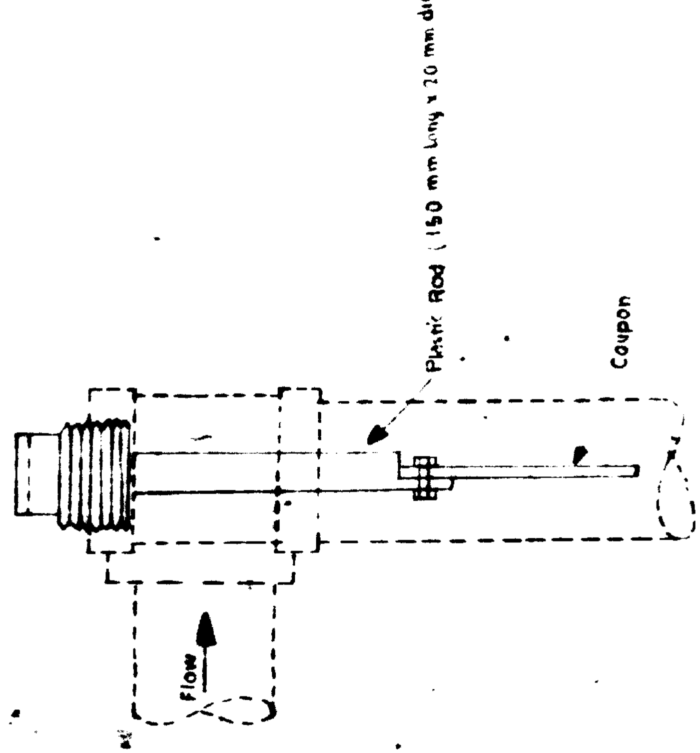


FIG. 1.

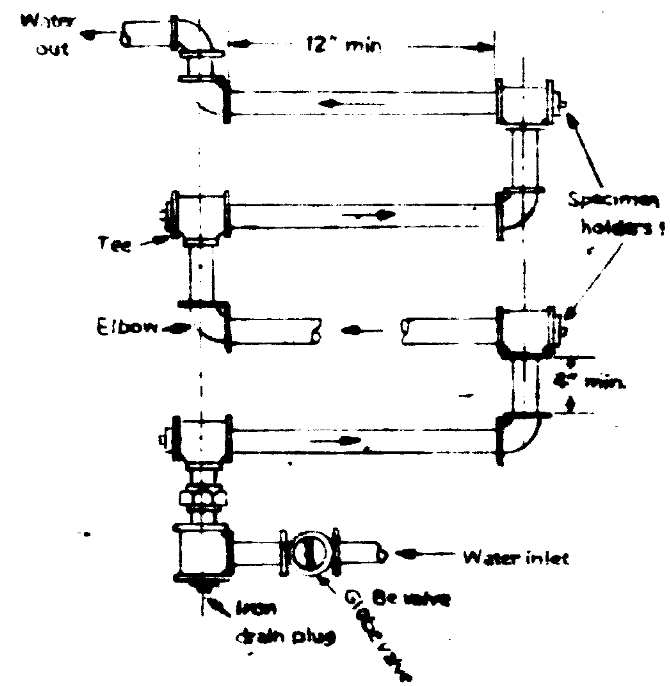


FIG. 2.

ENGINEERS INDIA LIMITED
NEW DELHI

CENTRAL SERVICES ORGANISATION

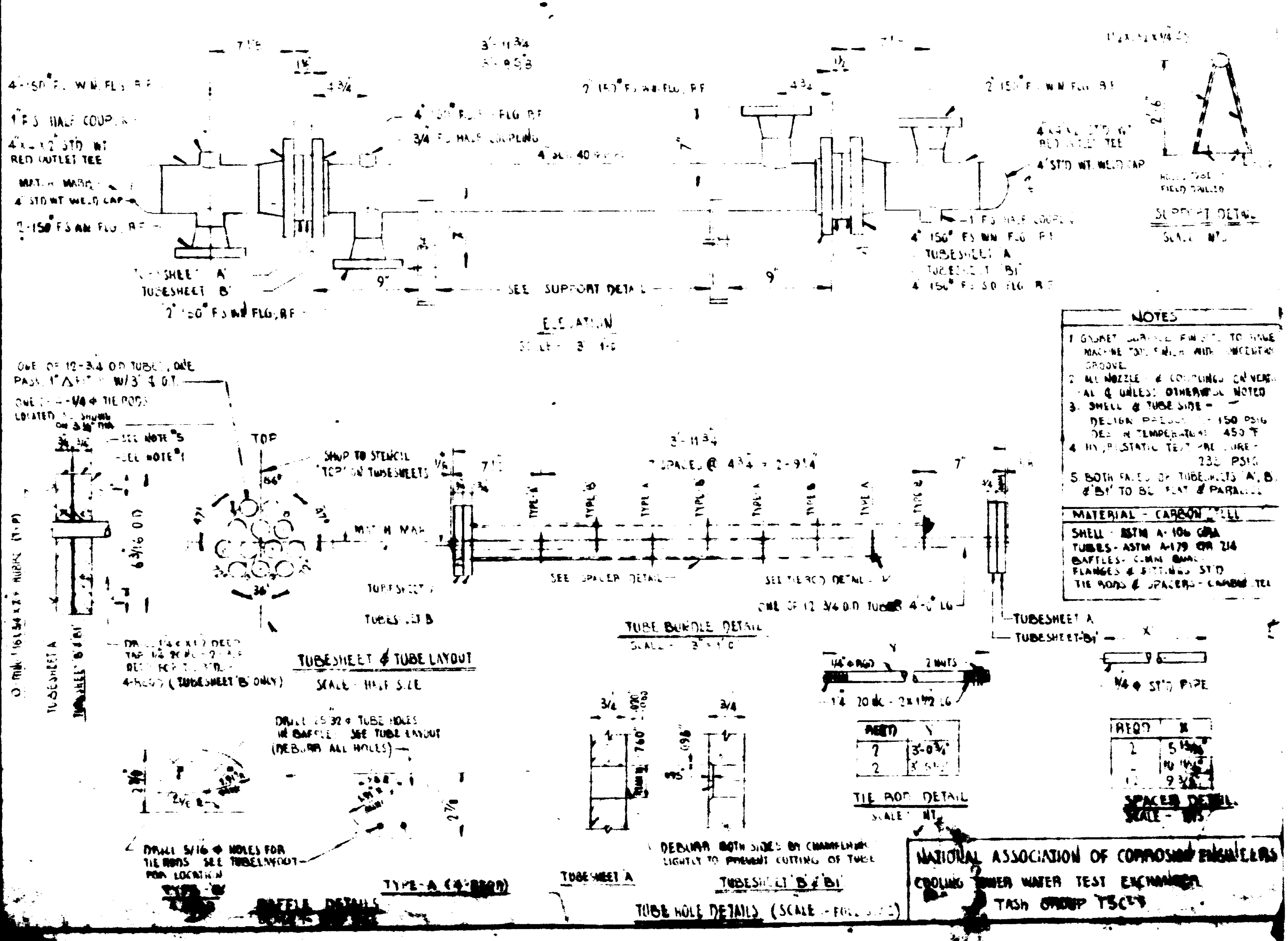
SPECIFICATION

REV.

ENGINEERS INDIA LIMITED
NEW DELHI

CENTRAL SERVICES ORGANISATION

SPECIFICATION



NATIONAL ASSOCIATION OF CORROSION ENGINEERS
COOLING TOWER WATER TEST EXCHANGER
TASK GROUP T5C

ANNEXURE I

HOMS REFINERY
INSPECTION DEPARTMENT

PROCEDURE FOR SHUTDOWN PLANNING AND EXECUTION OF WORK.

SCHEDULED SHUTDOWN

(i) **Organisation**

Before the shutdown the Chief Inspector will constitute a shutdown team which will be headed by Area Inspector of the particular area as Shutdown Inspector. He will be assisted by inspectors and inspector assistants. Though inspectors and inspector assistants are assigned to definite areas they will be required to work in the shutdown as decided by chief inspector. In such cases the assisting inspectors after completing the shutdown work and submitting reports to the Shutdown Inspector will resume normal work in his own area. A shutdown organisation shall be as follows:

Shutdown Inspector
(Name)

Inspector (name)	Inspector (name)	Inspector(name)
(columns and vessels)	(heater)	(heat exchangers pipelines, pumps)

Of course the division of areas (equipment-wise) shall depend on the size of the Units.

Copies of the shutdown organisation will be sent to all Departments, engaged in the shutdown for information.

(ii) **Planning**

Each Inspector will review the past history of the equipment, he will be inspecting in the shutdown and note down the data and highlights of the previous findings on the prescribed field sheets. He will also prepare gauging sheets and collect sketches for reference.

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Inspection work must be accomplished during scheduled shutdown period. Actual performance of inspection should be effected as quickly as possible so that Inspection will not prolong the down time. The findings and recommendations of Inspectors [illegible] result in the greater part of the maintenance work done on shutdown, for these reasons it is imperative that shutdown inspection be well planned that the Inspection force be properly organised, that it be well versed in inspection methods and that it is equipped with proper tools. A pre-shutdown meeting may be arranged for briefing the members. Before the shutdown, concerned Inspectors shall mark the insulation on bends, tees, junctions and other locations as required for stripping off for hammer testing and gauging.

The Inspection force shall move in the shutdown as soon as the Unit is handed over to Maintenance. As soon as clearance is obtained from operating Department hammer testing shall be carried out by all Inspectors. The shutdown Inspector shall divide the Unit into areas and Inspector shall be assigned to each area for hammer testing. The hammer testing should be completed on the 1st day of the shutdown and worklist issued, if necessary, to allow Maintenance to start repair/replacement of the lines which are not predicted and pre-planned.

(iii) Shutdown Work List

A detailed inspection work list shall be prepared sufficiently in advance of the shutdown, listing all the equipment to be opened as per inspection frequencies, and also the equipment whose conditions demand inspection/repair/replacement on the basis of previous inspection findings. Work list shall clearly specify the work to be done, method, materials to be used and testing on each equipment. The operating Department shall prepare an worklist showing equipment to be cleaned, serviced etc. from an operating standpoint. Worklists shall also be prepared by Maintenance disciplines like Instrument, Electrical, Civil etc All work lists shall be sent to Maint. Planning Section who will convene a pre-shutdown meeting of all concerned Departments.

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The work lists shall be reviewed and any questions resolved. Then the Maint. Planning Section shall compile all work lists and issue a final work list. All modifications and new installations should also be included in the work list. The Technical Services Department issues drawings for such work.

(iv) <u>Work list during the shutdown</u>

After inspection if any repair replacement becomes necessary which was not anticipated, an worklist in triplicate will be prepared by the Inspector concerned and approval to be obtained by the Shutdown Inspector and the representative of the Operating Department. Then it will be issued to the Maintenance Department for execution with a copy to the Operating Department.

(v) <u>Decision</u>

In case of a repair/replacement of a routine nature decision will be taken by inspectors. Any unusual corrosion or any other form of deterioration will be immediately brought to the notice of the Shutdown Inspector who will also inspect the affected equipment and take decision on repair/replacement if deemed necessary. Shutdown Inspector will keep the Chief Inspector informed of unusual conditions and progress of the shutdown.

(vi) <u>Post Shutdown Meeting</u>

An equipment purchase and repair committee shall be constituted with representatives from Operation, Maintenance, Stores, Technical Services, as members and Chief Inspector as Chairman of the committee. Following the shutdown the Chairman will convene a meeting and submit recommendations for major repair/replacement to be made in the next shutdown. Necessary actions for material procurement, prefabrication, drawing shall be taken by the concerned Department. Inspection shall also follow up and ensure that the equipment/material are available during the next shutdown.

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(vii) **Shutdown Inspection Report**

Inspector shall prepare a report for the equipment inspected by him with all findings recorded by him in the field notes. He shall work out corrosion rates, remaining life span and predict future repair/replacement. Shutdown Inspector will review, compile them and submit to the Chief Inspector for approval.

The final report shall be sent to the Manager of Engineering Services.

The report shall include the following parts:

1. Title page :

2. Table of contents.

3. Shutdown period and interruptions during the last run (Date, off-stream period and reasons).

4. Summary : Highlights of observation and recommendations.

5. Detailed findings (equipment-wise).

a) **Heater**

   i. Tubes-Internal and External.
   ii. Return bends.
   iii. Plugs, Holding members & screws(Stopper, Traverse & Bolts)
   iv. Masonry.
   v. Appurtenances(tubes hangers, supports, burners, skin points etc.)
   vi. Stack.
   vii. Foundation and structure
   viii. Hydrostatic Test.

b) **Columns**

   i. Shell & Heads
   ii. Trays
   iii. Appurtenances(Manways, Steam coils etc)

c) **Vessels**

   i. Shell & Heads
   ii. Appurtenances

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d) Heat Exchange Equipment

i. Shell
ii. Tube Bundle
iii. Shell cover, channel box, channel cover, floating head.
iv. Test.

e) Lines & Fittings

f) Safety Valves

g) Rotating equipment

7. Anticipated Repair/Replacement (Equipmentwise)

8. Equipment purchase recommendations

ANNEXURE I

INSPECTION HIGHLIGHTS OF MAY 1975 SHUTDOWN

Inspection Specialist has been fully associated in advising in day-to-day problems and also during the May shutdown. Some of the highlights of the findings and recommendations are given below:

(i) In the Kero zone of the main Column of Unit 10, the shell had bulged inside, apparently caused during 1973 war, and the ss 410 cladding inside torn. Details of the repair carried out are being requested for study and advice.

(ii) All heat exchangers do not have test rings which makes testing for tube leaks time consuming. Rings for all exchangers were recommended.

(iii) Shell side fouling in exchangers is generally mild and no problem in cleaning with hydroblast is experienced. Fouling is however severe in stabiliser overhead condenser shell. The problem of stabiliser overhead condenser will be studied in detail after pertinent data are collected.

(iv) Tube side fouling of coolers and condensers was comparatively heavy and some of the tubes were found to be completely plugged.

This is connected with water side problem. CSO would study in detail the operating conditions and water treatment to find most economical solution to the problem. Possibilities of chemical cleaning will also be examined based on scale analysis, locally available facilities and experience & economics.

(v) The minimum gaged thickness at the outer radius on a long radius bend was 4.5 mm against original 10 mm on overhead vapour line of unit 100. As the material had reached retiring limit as per API standard, replacement of affected portion was recommended.

Corrosion of O/H vapour line is low and causes of attack in this localised area would be examined in detail and recommendations, if any, given.

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(vi) The top section of the crude fractionating tower was reported as problem area. This section is lined with 600 x 450 x 3 monel plates. On inspection 40 % of lining was found to have bulged. Previous repair procedure consisting of drilling small holes in the lining, hammering the lining back into shape and closing the drilled holes with copper plug did not improve the situation. The lining procedure recommended is that bulged section of the lining be cut out, shell inspected and ultrasonically gauged from outside for any reduction in thickness of the c.s. shell and then relined using 100 or 150 mm wide monel strips without plug welding or with wider sheets with plug welding.

Alternately in the bulged plate cut holes 20 mm dia 100 to 150 mm apart (in triangular pattern for 450 mm wide existing plate) heat the lining back and then plug weld the strips to the shell. The plug welding should be done in two passes, the first pass being made around the periphery of the hole, to provide required joint between the liner and the shell. The hole is then filled by the 2nd pass, the welding starting in the centre of the sheet and then progressing outwardly to the edges. Monel electrodes (Monel 198) will be used for welding. Determine any loss in thickness by ultrasonically gauging from the external face.

(vii) Bridge wall of the heater on unit 100 was inspected thoroughly. While brickwork was generally in good condition slight inward tilting at tube support location was observed.

It was recommended that misalignment of bridgewall and deflection of tube support be recorded periodically. From the condition it was not considered necessary to change the tube sheet or to re-do the bridgewall. The convection tubes were considerably fouled and adequate cleaning is essential during shut downs to improve heat transfer and to prevent attack on the tubes during shutdowns due to acidic nature of the deposits.

Washing of the tubes with very dilute ammoniated water may prove to be adequate. Preventive measures against undue soaking of refractories should be taken. Heating up should be as for new lining.

ANNEXURE IG

PM HIGHLIGHTS OF MAY 1975 SHUTDOWN

During the May 1975 shutdown CSO site leader helped in preparing the shutdown work list for pumps and a work-plan and bar chart schedule. In addition, advice on major day-to-day problems requested for was also given. Some of the highlights of the specific problems studied and advises given are as under:

(a) Flange on a bearing house had cracked. This shows the importance of checking and controlling flange face with respect to the bearing location area.

(b) Two coupling failures occurred due to caking of grease and consequent loss of lubrication. A periodic PM check on coupling conditions avoids this type of failure. The PM list contains this inspection and the PM schedule ensures periodic checks.

(c) Use of 'Molykote' or similar molybedenuim disalphide grease on mating surface for high temperature rotating equipment was recommended to prevent galling. This should not be used for s.s., nickel and copper alloys where attack due to sulphide is possible.

(d) For overhauling of four nos. of reciprocating compressors in the LPG plant, attention was drawn to checking of items, e.g. bearing clearances, condition of cylinder liner, condition of piston shoe and babbit, alignment of crank and condition of cross head and its clearance etc. Need for check by magnaflux and dye penetrant of the weld repaired area of one of the damage piston was emphasised.

(e) Regular vibration survey of critical equipment is useful and for this purpose purchase of a hand held vibration meter was suggested.

(f) For field work, use of pneumatic wrenches and torque multipliers for bolting instead of slogging spanner being presently used would speed up work.

(g) Use of Decron or nylon belts instead of wire slings for the handling of tube bundles was suggested and this has been agreed by the Refinery Management. The aquablasting machine is put to good use for cleaning.

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(h) Danger involved in any hose leak of hydroblast operated at 6000 psig was pointed out.

(i) Numerous bearing failures with resultant shaft scoring in some cases have been experienced. In good majority of the cases such failures can be avoided by systematic and periodic checks of lubrication, bearing condition, cooling water flow and vibration. These checks are included in the check lists finalised.

(j) During discussion Homs Refinery management requested for a manual listing all columns and exchangers for units 10 and 100. The manual will include information on material, size, quantity, bolting and gasket details alongwith detailed maintenance job breakdown with standard time for job steps.

(k) Specialists have been requested to help in making a S/D work plan for Unit 10 scheduled for Sept. 1975. In this connection work lists have been requested for well in advance.

ANNEXURE H

HOMS REFINERY

INSPECTION DEPARTMENT

VESSEL CHECK LIST

UNIT :

VESSEL:

DATE :

	REMARKS
1- SHELL AND HEADS	
a) Visual Inspect inside surface	☐
b) Measure thickness	☐
c) Inspect lining/cladding	☐
d) Inspect internals	☐
2- MANWAY AND OTHER NOZZLES	
a) Hammer test	☐
b) Measure thickness	☐
c) Check gasket faces	☐
3- INSPECT EXTERNAL Insulation	☐
4- Hydro. test.	

ANNEXURE I'

SCHEDULE OF REQUIREMENTS FOR SEAL-WELDING

Seal-welding practice A; Sealweld to first valve all threaded connections on equipment, nipples and piping which cannot be blocked off, or beyond the first valve as required for systems which cannot readily be blocked off;

Sealwelding practice B: Sealweld all threaded connections;

SERVICE	Above Ground Below	TEMPERATURE	PRESSURES	SEALWELDING PRACTICE
1) Hydrocarbons all columns & vessels		All	All	A
2) Hydrocarbons excluding volatile	Above	Under 450°F	100-230 psig	A
Hydrocarbon such as	Above	Under 450°F	Over 230 psig	B
L.P.G., Fuel Gas & Hydrogen	Above	Over 450°F	All	B
	Below	All	All	B
3) Volatile Hydrocarbons such as L.P.G Fuel Gas & Hydrogen.	Above	All	Under 100psig	A
	Above	All	Over 100 psig	B
	Below	All	All	B
4) Hazardous Chemicals including Caustic &	Above	All	All	B
Acid and Mixtures of these with Hydrocarbons	Below	All	All	B

ANNEXURE I

CSO/COP-6
CODE OF PRACTICE
FOR
SKIN TEMPERATURE THERMOCOUPLE FOR HEATER TUBES

CENTRAL SERVICES ORGANISATION

ENGINEERS INDIA LIMITED

NEW DELHI

JULY, 1973

CODE OF PRACTICE FOR SKIN TEMPERATURE THERMOCOUPLE FOR HEATER TUBES

1.0 INTRODUCTION

The failure of heater tubes by stress rupture is often due to inadvertent operation at higher temperature as a result of coking or severity of operation and is caused by factors stress and temperature indicated respectively by pressure gauge reading and a skin thermocouple indicating tube wall temperature.

Installation of the thermocouples for tube wall temperature therefore has to be done with extreme care so that a correct and dependable reading is obtained and the heater firing can be controlled in order to prevent tube burst.

2.0 DESIGN OF HEATERS

The design of a heater is based on certain maximum conditions of product temperature, pressure and throughput. The temperature of heater tubes which governs tube life is higher than that of the product and depends on heat flux which is non-uniform over the length of the heater, the maximum being 3 times average flux in a vertical flame heater existing on the outlet tubes at 1/3 height from the floor when the tubes are internally clean.

Normal design criteria provide for more than ten years life of the heater tubes.

3.0 OPERATING VARIABLES

Following operating factors influence the design conditions and have a good bearing on tube life:

3.1 Incorrect assumptions in design

3.2 Flame Impingement

This can be due to incorrect design or operation and can be corrected by improvement in operation or changing the design (usually burner). The external refractory coverings can also prove helpful. Flame impingement cannot be taken into account for determining tube life and this must be prevented.

3.3 Corrosion

3.4 Low stream velocity through tubes

This is sometimes observed due to unequal flow through the coils of multipass heaters resulting in bad heat transfer especially in the down flow tubes giving rise to higher tube wall temperature. This should be prevented by design and/or operation.

3.5 Coking

Coking or internal scaling by creating a barrier in heat transfer from tube wall to product, raises tube-wall temperature thus lowering allowable stress value and if uncontrolled can lead to tube burst.

3.6 Increase in operational severity

With the increase in operating conditions like throughput and product temperature skin temperature generally gets raised because of heavier heat flux. This can also lead to coke formation and, if uncontrolled, can lead to premature tube burst.

4.0 SELECTION OF TUBE MATERIAL

Tube materials in the heaters operated under corrosive conditions and/or high temperature are generally 2¼ Chrome 1 Moly, 5 Chrome ½ Moly, 9 Chrome 1 Moly or austenitic steels.

5.0 CONTROL OF TEMPERATURE

Allowable stress or stress rupture life decreases with increasing metal temperature. Hence it is very vital to have proper skin couples to control tube wall temperature.

5.1 A standard design of skin couples is shown on drawings CSO-004, Sheets 1 and 2 whereas sheet 3 gives instructions for installation. It is necessary that the skin couples are fitted at places of maximum temperature. Under non-coking conditions or uniform coking conditions, maximum temperature is on the outlet tube at 1/3rd height from bottom. However, in some heaters, maximum coking may occur in intermediate tubes, e.g., in the heating section of a Visbreaker and not in the soaking section. Experience on the unit is then the guide for location of skin couples.

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5.2 Normally the limitation of skin temperature is, by design, based on 100,000 hours life but operational needs may require to exceed the normal limitation. Any increase in temperature will of course reduce tube life and hence inspection procedure should be established to measure creep and prevent stress rupture failure by timely renewal of tubes.

5.2.1 Maximum temperature limits on the basis of high temperature oxidation are shown in the following table:-

Material	Scaling Resistance upto - °C
2¼ Cr 1 Mo steel	635
5 Cr ½ Mo steel	650
9 Cr 1 Mo steel	705
18/8 Cr-Ni steel	870

5.3 It may be noted that the skin couple readings are not 100% reliable and the operator should check between the correct and incorrect readings and ask the Instrument Department to investigate the source of incorrect indications.

6.0 INSTALLATION

6.1 Standard design thermocouples are manufactured for measuring skin temperatures. Since indications obtained from these are of great importance in controlling the operation so that tube skin temperature does not exceed and cause tube burst, their installation has to be in correct manner so that faulty reading and/or premature failure of the couples may not result.

6.2 Good performance depends on correct ordering and installation. The drawings show directions for ordering and installation.

6.2.1 Care should be taken that maximum metal to metal contact is ensured between the "pad" and the heater tube. The pad should have correct curvature to fit closely on the tube. Welding installation should be supervised to prevent high welding temperature.

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6.2.2 The clamping ensures contact of the thermocouple tube with colder heater tube wall till it reaches the shadow zone. The double hairpin of thermocouple tube safeguards against damage by thermal movements.

6.3 Thermocouple tube is rather brittle when cold and therefore the inspectors and repair crew should take care not to damage these during shutdowns.

6.4 Inspection should be fully consulted and this work of installation must always be with inspection approval as regards procedure.

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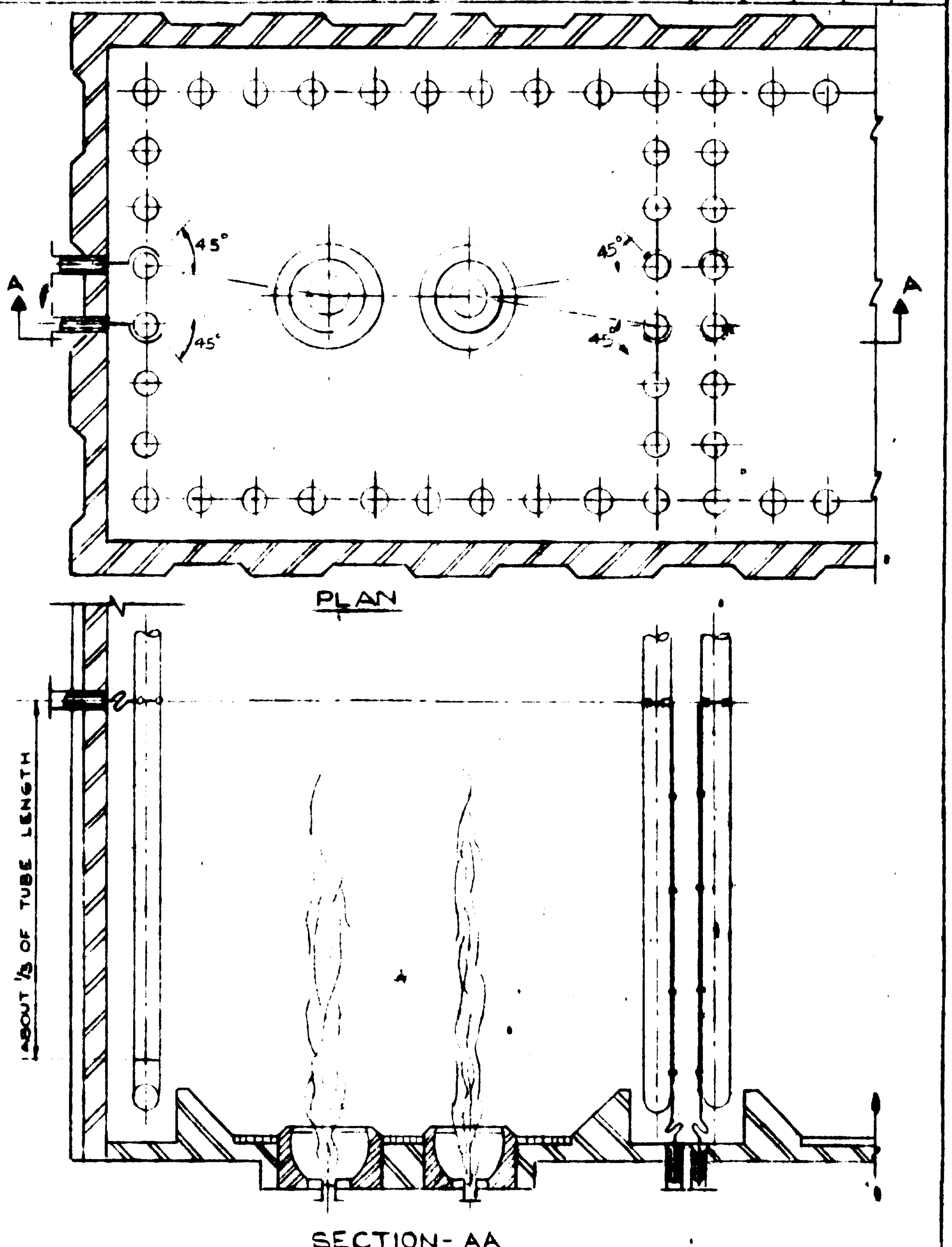
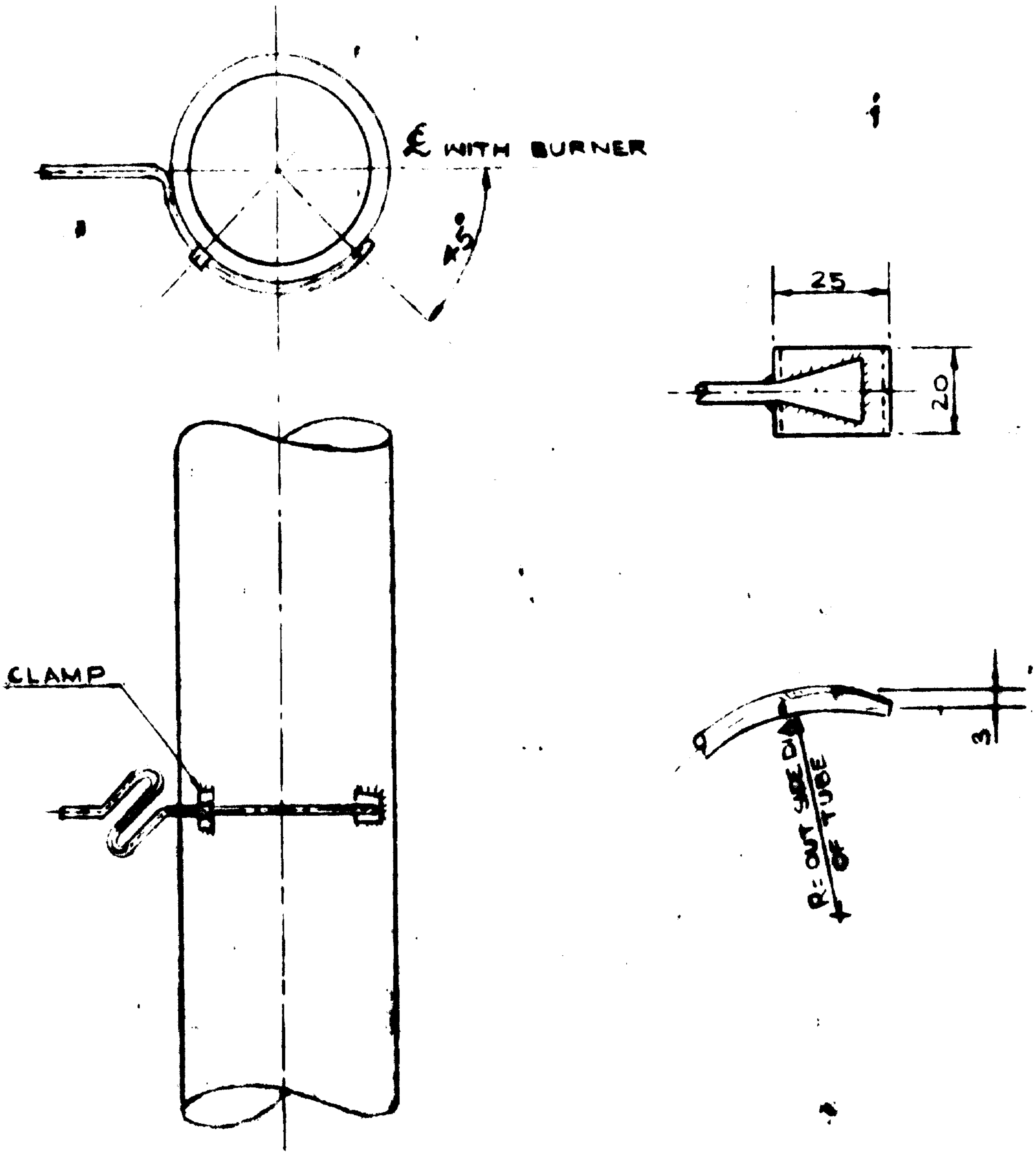
NO.	DATE	REVISIONS	BY	CH'K	APPROVALS		



ENGINEERS INDIA LIMITED NEW DELHI	STANDARD DESIGN OF SKIN COUPLES	DRAWING NO.	REV.
		4.4005/K-1 SHT 1 OF 3	

NO.	DATE	REVISIONS	BY	CH'K	APPROVALS		



ENGINEERS INDIA LIMITED NEW DELHI	STANDARD DESIGN OF SKIN COUPLES	DRAWING NO. 4·4005 / K-2 SHT 2 OF 3	REV.

DISTRIBUTION CODE

NO.	DATE	REVISIONS	BY	CH'K	APPROVALS		

INSTALLATION OF THERMOCOUPLE FOR MEASUREMENT OF SKIN TEMPERATURE OF FURNACE TUBES

TUBE SKIN THERMOCOUPLES:

WELDING-PAD-TYPE THERMOCOUPLE WITH MAGNESIUM OXYDE INSULATION IN AISI 310 STAINLESS STEEL HASTELLOY-X CLADDED SHEATH HAVING AN OUTSIDE DIAMETER OF 4.76 mm (3/16"). THERMOCOUPLE TO BE "TIPGROUNDED".

WIRE MATERIAL:

a) NO. 24 B&S GAUGE (0.46-0.5 mm) PLATINUM/PLATINUM 13% RHODIUM WIRES IN ACCORDANCE WITH NBS STANDARDS:
b) No. 20 B&S GAUGE (0.8 mm) CHROMEL ALUMEL/WIRES IN ACCORDANCE WITH NBS CIRCULAR 561.

THE WIRE MATERIAL AND LENGTH OF TOTAL THERMOCOUPLE SHALL BE AS SPECIFIED ON REQUISITION.

WELDING:

AFTER THE LOCATION SELECTED ON THE FURNACE TUBE HAS BEEN THOROUGHLY CLEANED BY GRINDING, THE "PAD" SHALL BE CAREFULLY WELDED AS SHOWN TO THE TUBE ALONG ALL FOUR EDGES WITH A 2[illegible] mm [illegible]-20 Cr-Ni ELECTRODE. TACK WELDING IS NOT SUFFICIENT. THE WELDING PROCEDURE SHALL CONFORM TO SHOP PRACTICE. CARE SHOULD BE TAKEN THAT MAXIMUM METAL-TO-METAL CONTACT IS ENSURED BETWEEN THE "PAD" AND THAT THE THERMOCOUPLE IS NOT DAMAGED BY THE HIGH WELDING TEMPERATURES.

A PORTABLE INSTRUMENT MAY BE USED TO INDICATE THE RISE IN THERMOCOUPLE TEMPERATURE AFTER WELDING EACH EDGE AND THE WELDING OPERATIONS SHOULD BE INTERRUPTED FOR A PERIOD OF 5 MINUTES IF THE MEASURED TEMPERATURE EXCEEDS 500°C.

FURTHER INSTALLATION:

AFTER WELDING, THE COUPLE SHALL BE SENT AWAY FROM THE FLAMESIDE OF THE TUBE TO THE SHADOW SIDE AND BE PROPERLY ATTACHED TO THE TUBE BY MEANS OF CLAMPS, THE ENTIRE LENGTH OF THE COUPLE CONNECTION BEING IN CONTACT WITH THE TUBE FOR THE PURPOSE OF COOLING. TO RELEASE THE COUPLE FROM STRESSES, AN EXPANSION LOOP SHALL BE USED TO PROVIDE A FLEXIBLE CONNECTION TO THE COMPRESSION FITTING IN THE THERMOCOUPLE HEAD EXTENSION PIECE.

ENGINEERS INDIA LIMITED NEW DELHI	STANDARD DESIGN OF SKIN COUPLES CSD-004	DRAWING NO. 4.008/K-3 Sheet 3 of 3	REV.

DISTRIBUTION CODE

ANNEXURE K

CSO/COP-17
CODE OF PRACTICE FOR
PERIODIC TESTING OF GAS CYLINDERS

CENTRAL SERVICES ORGANISATION

ENGINEERS INDIA LIMITED

NEW DELHI

SEPTEMBER 1975

PERIODIC TESTING OF GAS CYLINDERS

1.0 HYDRAULIC STRETCH TEST

1.1 Each cylinder shall be subjected to a hydraulic stretch test by the water jacket method in every five years. No pressure greater than the working pressure shall have been applied to the cylinder before the test.

1.2 The water jacket method is that in which the cylinder is enclosed in a vessel filled with water and which is fitted with a gauge glass projecting from its upper cover. The change in volume of the cylinder on applying and after removal of the internal hydraulic pressure are measured by the changes in level of the water in the gauge glass.

1.3 The permanent stretch shown by the test shall not exceed 10 per cent of the total stretch under the test pressure.

1.4 Test Pressures

1.4.1 Cylinders for gases which at the usual working temperature and pressure remain in a gaseous state in the cylinder shall be subjected to a hydraulic stretch test and the test pressure applied shall be 210 kg/cm^2 or the test pressure stamped on the cylinder whichever is higher.

1.4.2 Cylinders for gases which are generally reduced to the liquid condition by the pressure used in charging them into the cylinder shall be subjected to a hydraulic stretch test by the "water-jacket" method and the test pressure applied shall be calculated from the formula;

$$P = 2\,ft/D-t$$

where P = test pressure in kg/sq.cm.

f = 2362 kg/sq.cm.

t = thickness of cylinder wall in cms.

D = outside diameter of the cylinder in cms.

Test pressures calculated from the formula are given in Table 1.

The test pressure for cylinders for carbon dioxide, nitrous oxide and ethylene is 236 kg/cm^2 in all cases.

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1.5 Oxygen, nitrogen and LPG cylinders which are filled by the Refinery shall be tested by the Refinery Inspection Department. Other gas cylinders shall be tested by the outside agencies filling them.

1.6 No cylinder shall be filled with gas unless such cylinder has been subjected by the person filling it to the hydraulic test specified in para 1.4 within the preceding five years and has passed that test.

1.7 Test pressure and date of the last hydraulic test shall be clearly stamped on the neck end of every cylinder.

1.8 All test results shall be recorded in the prescribed form shown in Appendix A.

1.9 Inspection Department shall maintain a record of all cylinders.

1.10 Any cylinder which fails to pass the hydraulic test or which for any other reason is found to be unsafe for use shall be destroyed or rendered useless.

1.11 Preparation for Test

Cylinders shall be cleaned for inspection so that inside and outside surfaces and all conditions can be observed. This shall include removal of scale and caked paint from the exterior and the thorough removal of all internal scale. Cleaning by high pressure water jet is preferable. Oxygen cylinders shall be finally flushed with carbon tetra chloride to remove traces of oil which forms a combustible mixture with oxygen.

1.12 Test Procedure

i) Fill up the cylinder with water.

ii) Put the cylinder into the water jacket.

iii) Connect the cylinder to the pump.

iv) Close the lid of the jacket.

v) Fill up the jacket with water and vent.

vi) Read the water level in the gauge glass and record (V_1).

vii) Start the pump and raise the pressure to the required test pressure.

viii) Stop the pump when the test pressure is attained. Read the water level in the gauge glass and record (V_2).

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ix) Release the pressure and read the water level in the gauge glass and record (V_3).

$\therefore$ Total stretch = $V_2 - V_1$

Permanent stretch = $V_3 - V_1$

If the permanent stretch (V_3-V_1) is more than 10 per cent of the total stretch (V_2-V_1) the cylinder shall be considered unsafe for filling and shall be rejected.

2.0 VISUAL INSPECTION

2.1 External

Cylinders shall be inspected externally for corrosion, dents, bulges or any other defect that might create a weakness which/would render it unfit for service. This inspection shall be carried out at least every time the cylinder is periodically retested.

2.2 Internal

Cylinders shall be inspected internally for corrosion or any other internal defect at least every time the cylinder is periodically retested. This examination shall be made with a light of sufficient intensity to clearly illuminate the interior walls. Flamable gas cylinders shall be purged before being examined with a light. Lamps for flamable gas cylinders shall be vapour-proof.

2.2.1 Corrosion

If corrosion is observed the acceptance of the cylinder shall be based on the combination of the hydraulic test and the judgement of the Inspector. Ultrasonic thickness measuring and flaw detector devices may be used in measuring and evaluating any specific defect.

2.2.2 Internal Defects

Internal defects other than corrosion are uncommon. Any such defects can be evaluated to some degree by the following

2.2.2.1 If the bottom of the defect can be seen it may be possible to evaluate the defect with judgement.

2.2.2.2 Where the bottom of the defect cannot be seen and where its extent cannot be measured the cylinder shall be rejected.

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2.2.3 <u>Hammer Test</u>

A hammer test consists of tapping a cylinder with a light blow of a 1/2 kg. hammer. A cylinder emptied of liquid content with clean internal surface will have a clean ring. Cylinders with internal corrosion will give a duller ring depending upon the amount of rust accumulation. Such cylinders shall be investigated.

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TABLE 1

Dia-meter in cm	Internal Test Pressure (Gauge) Kg/Cm^2													
	7.03	14.06	21.09	28.12	35.15	42.18	49.21	56.25	63.28	70.31	77.34	84.37	91.40	98.43
7.62	138.51	146.24	154.68	163.11	171.55	173.66	176.47	179.28	181.39	184.20	187.72	189.83	192.64	195.45
10.16	120.23	128.66	136.40	144.83	153.97	158.19	162.41	166.63	171.55	175.77	179.28	184.20	188.42	193.34
12.70	108.98	116.01	124.44	132.88	141.32	146.94	152.57	158.19	163.82	169.44	175.77	180.69	186.31	191.94
15.24	99.84	106.87	115.30	123.74	132.88	139.21	146.42	152.57	158.89	165.22	171.55	177.83	184.20	191.24
17.78	92.81	100.54	108.27	117.41	126.55	133.58	140.61	147.65	154.68	161. 1	163.74	175.77	182.80	189.83
2032	87.18	94.91	102.65	111.79	120.93	128.66	136.40	144.13	151.16	158.89	166.53	174.36	182.10	189.83
22.86	82.26	89.99	98.43	107.57	116.71	124.44	132.88	140.61	149.05	156.79	165.22	172.96	181.39	189.13
25.40	78.04	86.48	94.21	103.35	113.99	121.63	138.07	137.80	146.24	154.68	163.32	171.55	180.69	189.13
27.94	75.23	82.96	91.40	100.54	110.38	118.82	127.26	136.40	144.83	153.27	162.41	170.85	179.99	189.13
30.48	72.42	80.15	88.59	97.73	107.57	116.71	125.15	134.29	143.43	152.57	161.00	170.14	179.28	188.42

APPENDIX A

HOMS REFINERY
INSPECTION DEPARTMENT

FIVE YEAR CYLINDER TESTING REPORT

DATE	CYLINDER DATA			HYDRAULIC STRETCH TEST						VISUAL INSPECTION		REMARKS	INSPECTOR'S INITIAL
	Sr.No.	Type	Test Pr. KG/Cm^2	Gauge V1	Glass V2	Reading V3	Total Stretch V2 - V1	Permit Stretch V3 - V1	10% of V2-V1	Int.	Ext.		

APPROVED SIGNATURE

ANNEXURE I

CSO ... 14

RECOMMENDED PROCEDURE FOR MAXIMUM UTILIZATION OF THE POTENTIAL LIFE OF 5CR-½MO TUBING OF REFORMER HEATERS, HOMS REFINERY, SYRIA

CENTRAL SERVICES ORGANISATION

ENGINEERS INDIA LIMITED

NEW DELHI

OCTOBER, 1975

RECOMMENDED PROCEDURE FOR MAXIMUM UTILISATION OF THE POTENTIAL LIFE OF 5Cr-½Mo TUBING OF REFORMER HEATERS, HOMS REFINERY, SYRIA

1.0 INTRODUCTION

The 5Cr-0.5Mo furnace tubes of reformer unit have been in service since [illegible], i.e., approximately for 16 years. The unit has been shutdown for certain periods, however, an accurate record of these things could not be obtained. Since the period of operation in service exceeds 100,000 hours, a recommendation was asked for continued use of these tubes in service for an estimated futûre period.

The maximum operating conditions of the tubes are following:

	F-201	F-202	F-203
Inlet pressure kg/cm2	39.0	37.0	36.0
Outlet pressure kg/cm2		No gage	
Inlet temp. °C	288	416	490
Outlet temp. °C	505	502	504

The tube dimensions are as follows:

	F-201	F-202	F-203
Outside diameter, mm	152	219	219
Wall thickness, mm	15	19	19

2.0 DESIGN CRITERIA FOR NEW TUBES

According to accepted standards, the nominal design stress corresponding to operation with clean tubes is usually the lower of the following stress values:

i) 100% of the stress required to produce a creep rate of 0.01%/1000 hrs. based upon a conservative average of reported test as evaluated by an authoritative committee.

ii) 60% of the average stress required to produce rupture at the end of 100,000 hrs or 80% of the minimum stress required to produce rupture in 100,000 hrs. Modern trend is to calculate allowable stress on the basis of 60% of the average stress required to produce rupture at the end of 100,000 hrs.

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3.0 For many years, engineers have needed a successful method of determining the residual life of components subjected to creep. It is especially difficult to decide when to replace components in the most economical manner when there is uncertainty about their particular thermal history. In the past, generally, a limit of 100,000 hrs has been set as a limit for creep life in the absence of reliable experimental data and/or experience. This is because the creep rupture tests data were available only upto 100,000 hrs. However, it has been established recently that the most critical failure parameter is the 1% creep strain rather than the time limit. Further data for periods over 100,000 hrs are also available. On these basis, it has been possible to extend the service life of material in high temperature service tube heater and superheater tubes to more than 100,000 hrs.

4.0 It is generally observed in Refinery heaters that actual operating stress is considerably less than the design stress. The following recommended procedure is based on this fact and newly available stress rupture data of 5Cr-$\frac{1}{2}$Mo material (finalised in March 1974 by ISO) for periods upto 250,000 hrs, given in attached figure.

4.1 **Procedure**

4.1.1 Determine external tube diameter and tube wall thickness preferably to an accuracy of 0.15 mm.

4.1.2 Calculate operating stress for the measured wall thickness using the formula given below:

$$t = \frac{PD}{2\,SE + 2\,YP}$$

$$\text{or} \quad 2\,SE = \frac{PD}{t} - 2\,YP$$

Where S = Operating stress in psi
E = 1.0
P = Operating pressure in psi
t = tube wall thickness in inch
D = O.D. in inch.
Y = 0.7

4.1.3 Multiply the operating stress by 1.67 to determine the maximum allowable stress.

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4.1.4 Assume the tube (not wall) temperature about 30°C above the minimum operating temperature or actual value, if available.

4.1.5 Based on the new design rupture stress and tube wall temperature determine the rupture time from stress/time/temperature curve for creep rupture of 5Cr-0.5Mo given in the attached figure.

4.1.6 As original and subsequent periodic tube wall thickness measurements are not available for first calculation of rupture time consider that present thickness has operated for the previous run.

4.1.7 For future campaign consider the change in wall thickness expected due to corrosion and oxidation at the end of the campaign to determine rupture time. Average corrosion rate can be determined from change in wall thickness since commissioning.

4.1.8 Total remaining life for the tube will be rupture time (as determined from 4.1.5) minus operated time. However, at each shutdown it is to be ascertained that the remaining life is more than twice the period of next campaign between inspections.

4.1.9 If OD measurement show the change to be more than 2% of original diameter, the tube should be discarded even if the remaining life is favourable.

4.1.10 It is important that internal surface is free from sulphide scaling which can cause increase in heater tube temperature leading to rupture or decrease in tube life. The internal surface should be inspected at each shutdown and if the scale thickness is over 1 mm the surface cleaned or tube taken out of service.

4.1.11 One or two tubes from maximum severity areas (thought to have experienced the highest metal temperature) should be removed during the next shutdown and the material tested metallographically for spherodisation and also for mechanical properties, i.e., yield stress, ultimate tensile stress, % reduction in elongation and area and impact value.

4.1.12 From the available limited minimum wall thickness measurements and taking the bulk tube temperature to be 560°C (a conservative figure), the rupture life of the tubes will be more than 180,000 hours of actual service (calculated from 16mm WT 219mm OD tube)

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5.0 In case metallographic/mechanical testing indicate adverse tendency, further test should be carried out for extending service life. One or two tubes will be removed from the area or areas of heater tubes thought to have experienced the highest metal temperature (as for example section of outlet tubes directly opposite a burner) and "accelerated" rupture tests performed on the sample tubing. Here accelerated rupture test means getting creep rupture data in a short time relative to that under design temperature and stress conditions. This is achieved by increasing the test temperature to values higher than the design. S.I. From the "accelerated" creep rupture data of used tube and of similar new material, a fraction representing the remaining creep life is obtained;

$$\frac{\text{Test life (tt)}}{\text{Life of new material under the same test conditions (Tt)}}$$

This expression can be linked to the service condition by the 'life-fraction' rule to get the following expression:

$$\frac{ts}{Ts} + \frac{tt}{Tt} = 1$$ where ts = time in service.

or $$Ts = \frac{ts}{1 - \frac{tt}{Tt}}$$

Ts = rupture time under service conditions.

tt = time to rupture of sample from used tube in "accelerated" test.

Tt = rupture time of new tube of same material under "accelerated" test conditions determined from attached figure

The method has been developed by CEGB, UK and arrangements can be made to get samples tested according to this method. It will require 6 to 8 months for arranging and completing the test.

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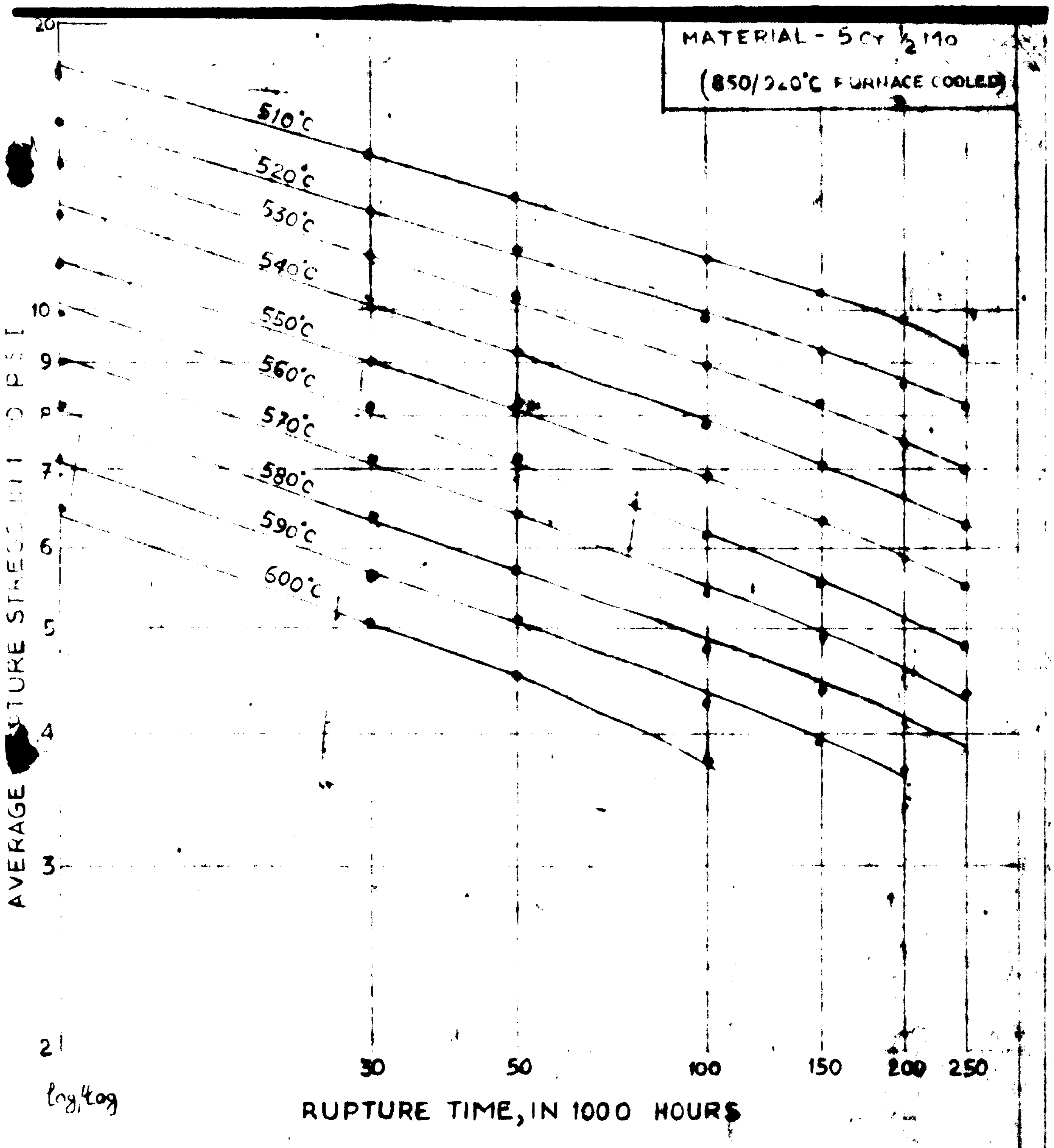

STRESS RUPTURE CURVES BASED ON
ISO DOCUMENT ISO/TC 17/SC 10/ETP-SG (SECRETARIAT-72) 86
MARCH 1974

ANNEXURE M

TABLE NO.1

ARBITRARY MINIMUM PIPE WALL THICKNESSES TO BE USED WHERE CALCULATION RESULTS IN A SMALLER VALUE

NOMINAL PIPE SIZE		MIN. ALLOWABLE THICKNESS	
Inch	m.m.	Inch	m.m.
½	13	0.07	1.75
¾	20	0.07	1.75
1	25	0.08	2.00
1¼/	32	0.09	2.30
1½	38	0.09	2.30
2	50	0.10	2.54
2½	62	0.10	2.54
3	75	0.10	2.54
4	100	0.12	3.05
5	125	0.14	3.55
6	150	0.15	3.80
8	200	0.18	4.55
10	250	0.19	4.80

NOTE: The above minima are the same as those given in A.P.I. Recommended Practice for Refinery Inspections, Part I- Process Equipment

Hammer testing is recommended for nominal pipe sizes of ½" to 3" inclusive.

ANNEXURE N

CSO/RP-15
RECOMMENDED PROCEDURE FOR VIBRATION MONITORING AND ANALYSIS
(Non-destructive Inspection)

CENTRAL SERVICES ORGANISATION

ENGINEERS INDIA LIMITED

NEW DELHI

SEPTEMBER 1975

VIBRATION MONITORING AND ANALYSIS

(Non-destructive Inspection)

1.0 INTRODUCTION

1.1 All types of rotating machinery have acceptable limits of vibration. Machinery vibration due to mechanical defects is common. Increasing vibration severity invariably announces impending trouble. Vibration monitoring is the key to machinery control. Periodic vibration checks detect signs of trouble before failure can occur. When trouble is indicated, vibration analysis pin-points source of trouble.

1.2 Vibration is generally caused by:

Unbalance, which is the most common;	Bent shaft;
Misalignment;	Bad gears;
Looseness;	Electrical trouble;
Bad anti-friction bearings;	

1.3 Parameters of Vibration are:

- Displacement .. Maximum deviations, peak to peak, measured in mils or microns.
- Frequency .. The number of times the vibration repeats itself, expressed as cycles per minute.
- Phase .. Describes the vibration of a moving part with reference to a fixed reference.
- Velocity .. Speed at which part is vibrating, expressed as in/sec. or mm/sec.

1.4 Each mechanical defect causes vibration in its own particular fashion. Vibration frequency is usually the same as that of part RPM or a multiple. Larger the displacement and velocity, more serious is the trouble. Vibration is often complex since various parts cause vibration. Hence, vibration analysis can reveal the offending part. Vibration standards provide guidelines to whether an overhaul is required or not.

1.5 Vibration measurement and analysis help in a sound engineered maintenance system, providing adequate warning in time. Vibration monitoring is done with equipment running and this does not involve stoppages.

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2.0 VIBRATION MONITORING PROGRAMME

2.1 The salient features of the programme are:-

Detection - Periodic vibration checks help in controlled maintenance. Vibration gives early warning of impending danger and thus helps in scheduling repairs in advance.

Analysis - A complete frequency analysis is performed when periodic check indicates trouble. A vibration analysis can pin-point misalignments, imbalance, looseness and bad bearings.

Correction - The first two steps protect and analyse the equipment condition. Corrective action can be planned.

2.2 Vibration Pick-ups

Different types of pick-ups and applications are necessary depending on machine.

In centrifugal compressors with sleeve bearings, most common defects are imbalance, oil whirl or misalignment. Because visually the rotor is of light mass and casing heavy, it is necessary to measure shaft vibration. A new contract type pick up is used to measure shaft movement with respect to bearing.

In fans, the common problem is imbalance. Unbalance forces can be easily measured, as displacement at the bearing housing.

Motors, pumps and other similar machinery suffer from imbalance, bad bearings, misalignment, looseness. Vibration velocity is a good indicator of condition.

2.3 Vibration Limits

Naturally after acquiring data, it is necessary to have limits on what is tolerable, and what values would indicate requirement of corrective action.

An initial vibration analysis is required to establish realistic values. It is normal to monitor equipment when it is in good condition and fix a level of 2 or 3 times, this vibration as the alarm limit. This value should however not fall in the rough or very rough region in the general severity chart for machinery. This severity chart provides an excellent guideline. A copy of the chart prepared by IRD Mechanalysis International, USA is available with the Homs Inspection section.

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2.4 Measurement Locations

Usually bearing housings are selected because it is through the bearing housings that vibration forces of rotating elements are transferred. Typically readings are taken in the horizontal, vertical and axial directions.

Imbalance is exhibited as high vibration in the horizontal plane. Misalignment shows up in the horizontal and vertical planes. Also the axial vibration is 50% or more of the horizontal and vertical vibration levels.

2.5 Vibration Identification

Vibration identification chart (Table 1) shows the amplitude, frequency and phase characteristics of most defects.

Change in machinery condition produces change in vibration levels and thus vibration is a good indicator of equipment condition. Trend of vibration level over a period of time is important. Constant vibration level would indicate satisfactory condition, whereas a machine heading for breakdown would show a rising trend.

Vibration tolerance is the level below which there is a reasonable confidence in a machine's satisfactory condition. Vibration tolerances are usually available from equipment manufacturers, industry experience from the general machinery vibration severity charts.

Vibration velocity is good indicator of equipment condition, regardless of equipment speed. Different components like anti-friction bearings, journal and thrust bearings, thrust collars, shaft sleeves, mechanical seals, gear teeth, coupling are subjected to different vibration frequencies. In spite of these various possible sources, and vibration frequencies, a single set of velocity standards can tell us whether a machine is running smoothly or corrective action is required. Velocity standard given in Table 2 can be used as a guideline to develop ones own standard based on experience over the years.

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TABLE 1 - VIBRATION IDENTIFICATION CHART

Cause	Amplitude	Frequency	Phase	Remarks
Unbalance	Proportional to unbalance, larger in radial direction	1XRPM	Single reference mark	Most common type of defect
Misalignment couplings or bearings and bent shaft	Large in axial direction, 50% or more of radial	1XRPM normal, 2 or 3XRPM sometimes	Single, double or triple	Best found by axial vibration, use dial indicator for positive identifications. If machine has sleeve bearing and there is no coupling misalignment, balance rotor.
Bad bearings Anti-friction type	Use velocity measurement	Very high- several times RPM	Erratic	Offending bearing likely to be nearer the high frequency vibration.
Eccentric Journals	Usually not large	1XRPM	Single mark	If largest vibration in line with gear centes, gear is the problem; if vibration disappears on turning off power, it is at motor, if on pump, try to balance.
Bad gears or gear noise	Low - use velocity if possible	Very high gear teeth times RPM	Erratic	
Mechanical looseness		2XRPM	Two reference marks, slightly erratic	Usually accompanied by imbalance or misalignment
Electrical	Disappears when power is turned off	1XRPM or 1 or 2XSynchronous frequency	Single or double rotating mark	

NOTE: Above information collected from chart prepared by IRD, Mechanalysis International, USA.

TABLE 2 - VELOCITY STANDARDS

Overall Velocity, ips	Classification	Severity Rating	Approximate Interpretation
Above 0.5	AA	Extremely Rough, danger, consider shutdown	Oil film destroyed. Metal-to-metal contact, seizure, breakage
From 0.3 to 0.5	A	Very Rough, correct soon, major damage may occur	Oil film breaks if viscosity or temperature not controlled, rapid wear
From 0.2 to 0.3	B	Rough, correct to save wear	Gradual wear over period of time expected.
From 0.1 to 0.2	C	Fair, minor fault, correction uneconomical	Little or no wear expected
Up to 0.1	D	Smooth, well balanced, well aligned equipment	Normal trouble-free installation. Components will last several years

Note: Values are for bolted-down and steady rotating equipment. Before using the table, multiply the actual vibration readings by 0.4 if the equipment is lightly mounted or for overhung bearing housings on machinery rotating at 3,600 rpm or engines and small reciprocating compressors.

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