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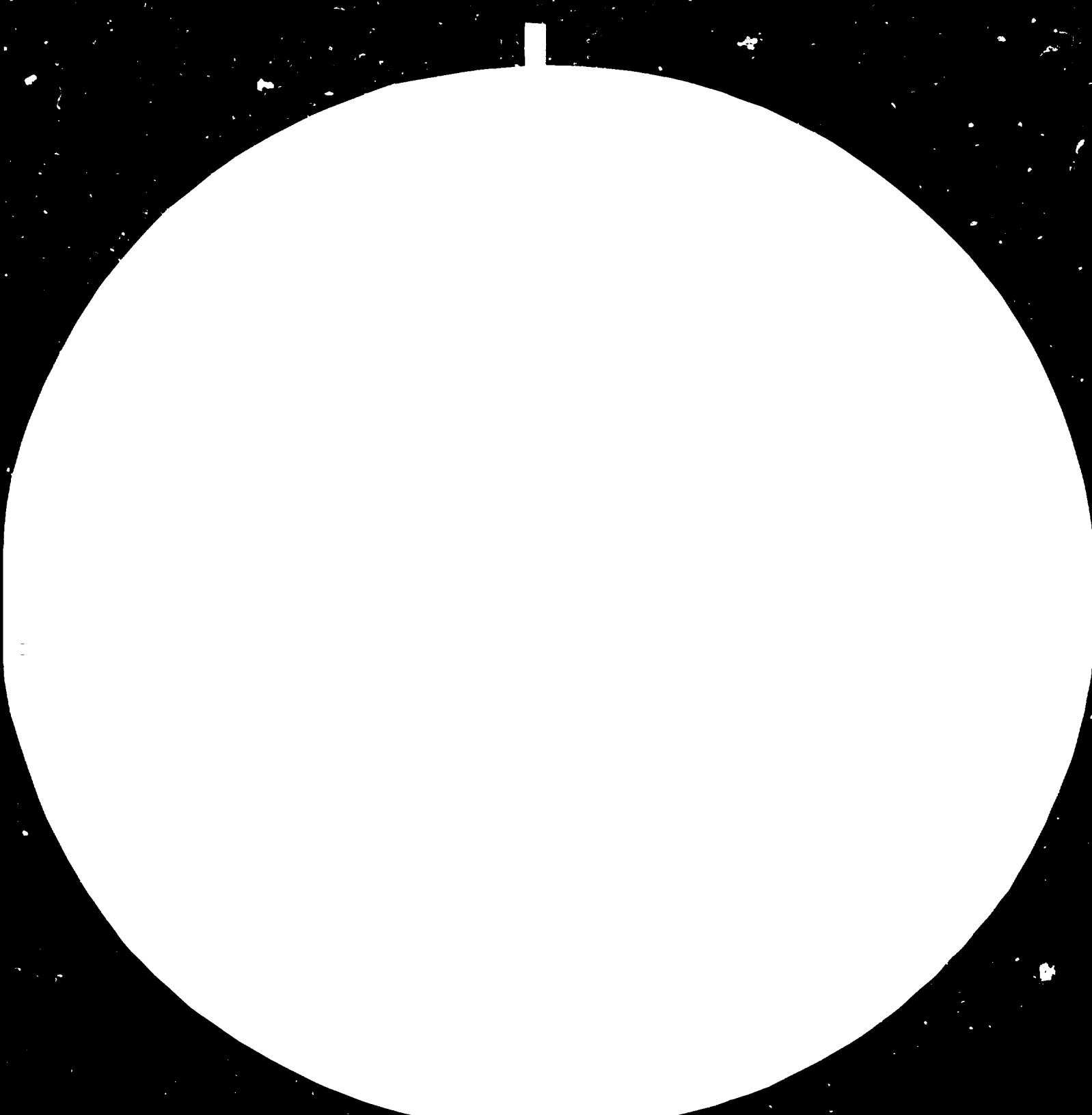

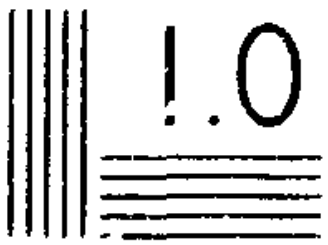
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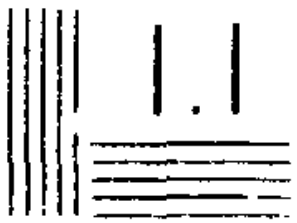
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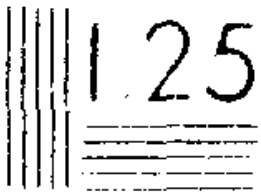
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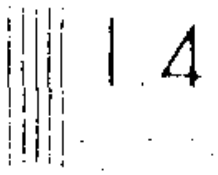
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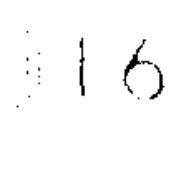
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20 August 1982
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Jordan. MAINTENANCE OF PHOSPHATE MINING MACHINERY AND EQUIPMENT.

DP/RAB/78/021

JORDAN

Technical report*

Prepared for the Arab Industrial Development Organization (AIDO)
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of N. Guha,
maintenance management expert

United Nations Industrial Development Organization
Vienna

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INTRODUCTION

The phosphate mining and processing is the largest natural resource based industry of the Hashemite Kingdom of Jordan. It provides the major share of export earnings of the national economy. Jordan Phosphate Mines Co. (JPMC) is the main producer of rock phosphate in Jordan. Majority shares of the company is owned by the Government. Currently JPMC operates three mines namely: (i) El-Hassa, (ii) Rusaifa, (iii) Wadi El-Abiad. The mining and ore processing, handling and beneficiation operations are being constantly expanded through sizeable capital investment with increasingly larger, more complex and sophisticated equipment. Owing to the absence of a well planned maintenance strategy and organisation the company and more particularly El-Hassa the largest of the three mine units is suffering from chronic ailment of frequent and unscheduled breakdowns leading to low utilization of established capacities.

The company has requested UNIDO through the Arab Federation of Chemical Fertilisers Producers (AFCFP) and the Arab Industrial Development Organisation (AIDO) to make available to it the services of a specifically qualified maintenance expert to study the existing maintenance practices in its various mine units, assess adequacy of the infrastructral facilities and recommend improved methods of maintenance planning and management.

UNIDO has obtained the services of Mr. N. Guha, an expert in maintenance and project management, on short term basis (one month) to study the local conditions at the phosphate mine units of JPMC and submit his findings and advice in a technical report to bring about improvement in maintenance system leading to higher equipment availability.

The expert arrived Jordan on 28th July 1982 and was there till 17th August, 1982 JPMC authorities at Amman informed the expert that maintenance problem was most critical in El-Hassa Mine unit and this was the largest and most important operation and therefore advised him that his excercise should be mainly concentrated at El-Hassa and cover more specifically the mobile mining (earthmoving) machinery care, maintenance and repair. In El-Hassa alone mobile equipment was more than 125 in number of bewildering variety, make and models (excluding newly acquired 40 cu yds electric walking dragline, reported to be the biggest in Middle East and Africa, and two 45R Bucyyus Erie, rotary blast hole drills).

The effective period of mission is recognised to be too short for a very detailed report and recommendations. But the time constraint has been very largely made up through the support of UNDP office at Amman, and all out co-operation received by the expert from the top management of JPMC at its corporate office at Amman, and at all levels in the mine units and more specifically at El-Hassa.

Maintenance and production in mining operation are siamese twins. It can not be viewed in isolation and to be effective needs the support from the top level, its strategy needs to be dove tailed with corporate objective, planning and organisation. JPMC has in recent past commissioned a professional consultancy organisation, WS Atkins Ltd. to study maintenance of earthmoving machinery at El-Hassa, design and engineer maintenance workshop for the mine; requisition of an expert through UNIDO is yet another indicator of the priority the top management is according to maintenance. It is most encouraging that there exists a band of competent and dedicated engineers, experienced supervisors and some really good trades men at El-Hassa, very receptive and willing to be helped.

It is hoped this report will be found useful.

I. SUMMARY OF FINDINGS AND RECOMMENDATIONS

1. Maintenance system, facilities and organisation at El-Hassa, mine unit of JPMC are far from adequate.

2. El-Hassa unit has been constantly expanded over the years (rather rapidly during the past 6/7 years) leading to sub-optimisation and some imbalances in the system; the emphasis has been on production process and entry into production phase without commensurate attention and maintenance preparadness.

3. Happily, the redeeming feature is that the top management at the corporate office is deeply conscious of deficiencies and inadequacies and is showing greater awareness and appreciation of maintenance and keen to get to grips with the problem. The message has been percolated well at the mine management and maintenance division level, and they are willing to take steps to improve maintenance.

4. JPMC had in recent past commissioned a consultancy firm, W.S.Atkins, UK, to study maintenance at El-Hassa, engineer and design earthmoving equipment maintenance workshop for this mine. JPMC has initiated preliminary action to establish the workshop and facilities as early as possible.

5. Following study by the above consultancy firm some action to introduce lubrication schedule of a sort has been introduced about 4/5 months back. Though the above falls short of requirement this itself is reported to have improved matters.

6. The period between now and the establishment of new maintenance workshop should be utilised not only to introduce a very rigorous preventive maintenance system, maintenance culture, good house keeping but also to develop a planned strategy for systematic repair, implementation of documentation, monitoring and control system and refinements thereof.

7. It is strongly recommended that 100/125 hours maintenance of earthmoving equipment should be carried out in maintenance shop instead of mine faces as at present.

8. Not only the maintenance set up and organisation at El-Hassa needs to be streamlined and reinforced and its status enhanced but the entire organisation structure, at the mine level needs to be made more balanced and responsive. Instead of 14/15 people reporting directly to Mines Manager, the reporting through three Deputy Managers with equal status each responsible for field of action under his control has been suggested. This has been discussed with Mines Manager and he is in agreement with the structure recommended.

9. Stores department should not only be renamed Materials Management Department, but should also under-go structural changes and be made more technically oriented and placed under the control of Dy Manager (Technical Services) at unit level, but will report to Supplies Manager functionally at corporate office.

10. All the spare parts and other items should be codified on urgent basis to place inventory control and management on computer now being installed at corporate office. A survey of commonality of items between various equipment should be conducted speedily, and general items like bearings, 'V' belts, seals etc. should be stocked at a common place.

11. Standardisation and variety reduction of lubricants should be taken in hand. In all probability as against 47/48 grades now being stocked, through proper excercise it will be possible to bring down the list to less than twenty grades. Besides lowering the inventory, it will reduce possibility of stock outs as well as chances of mistaken application.

12. Consultancy firms' contrary view notwithstanding, both in the interest of JPMC as well as national interest the used oil reclamation plant at El-Hassa should be very seriously considered. It should be possible to make the used oil suitable for original application. Technology in this field has of late advanced significantly.

13. The new workshop to be built at El-Hassa should not be just a workshop for earthmoving equipment of El-Hassa mines only, but function as a central-workshop for all the mines including component repair and rebuilding facilities for the stationary plant and also well thought out expansion provision to meet the capital repair of Shidiya mines to come up in not too distant a future.

14. Stationary ore processing and beneficiation plant should be shut down periodically say every two/three months for 2/3 days at a stretch for thorough checks, adjustments, cleaning and minor repairs. This will result in improved overall plant availability and lower disruption of production operations.

15. No norms of availability for the plant and earthmoving equipment has been fixed. This should be fixed, through interactions between operation (mining) and technical services divisions in absence of down the earth records.

16. The present unbridled situation of maintenance divisions to have the luxury to carry out its function without any fiscal discipline and budgetary control should not be allowed to continue.

17. At the moment there is no co-ordinated policy in respect of equipment replacement. The present hit or miss method should give way to analytical approach and survey after taking into consideration present state of health, job requirement, spare parts in stock and on order etc. What the managements' plans are should be made known to maintenance engineer at mines so that spare parts indents for such machines to be retired are tapered off.

18. Training cell at El-Massa needs to be considerably activated. There is scope and also need for this cell to work on development of skill of operators, maintenance crew, supervisors and even the engineers at mine level.

19. The company has been quite liberal in sending its engineers, and supervisors abroad and shown earnestness to enhance knowledge and skill of their technical personnel. Deputation from maintenance divisions has been mainly at the premises of manufacturers. Such training is useful in a limited way and needs to be supplemented by field training and for engineers also through attendance of maintenance training courses, conferences and seminars.

20. Cost of materials drawn are not available at El-Hassa and is reported to be available only at corporate office at Amman. For cost control as well as cost reduction it is necessary that such data is available at El-Hassa and cost sheets from corporate office be made available to mines promptly. Cost of items like conveyor belts, transmission, motors etc, when drawn should be spread over a period instead of being reflected in cost sheet of the same month.

21. To motivate, particularly maintenance and operating personnel a scheme of reward and appreciation for good work should be instituted. The mines could organize "safety week", "breakdown-free week", "good house keeping week" and the like. Inter-mines sports meet may generate lot of zeal and enhusiasm.

22. A company with such large capital investment in plant and machinery, and where efficient and effective maintenance and repair is a vital owner requisite, should have a very senior executive responsible for co-ordinating all technical service work on corporate basis at its Head Office with supporting staff. Whatever system may be designed and even with proposed enhanced status at the level of Dy Manager (Technical Services) at El-Hassa very strong support from corporate office, guidance, and control is considered very

essential. Technical Service personnel should functionally report to this executive who should have the status of Head of a Department. Least that can be done is to place him just below the Technical Director.

23. A cadre for maintenance engineers should be developed. Each mines currently have different set ups, the structure should be institutionalised. The number of maintenance engineers appear to be less than what is required. It will be well to induct every years few engineers of mechanical/electrical/mining disciplines and build up a cadre of well-trained capable group of young managers. All these aspects can best be dealt through creation of Management Man Power Development cell at Head Office. Training of all categories of managerial personnel should be co-ordinated by this cell. Creation of such a cell will also help to develop career progression of the managerial cadre personnel not only of technical service group but the company as a whole.

24. While contracting out the maintenance and operation of Ransomes & Rapier Walking Dragline, 45R Rotary Drills is considered right policy, it will be desirable that the maintenance division engineers are associated with care and maintenance of these machines, so that after some time the company can take over these tasks.

25. As per contract, several suppliers have deputed their representative for care and maintenance of some of the earthmoving equipment newly acquired. A very active participation by the maintenance division to associate with them is necessary, maintenance crews should get trained, breakdown pattern is likely to emerge during

latter part of economic life of the machines.

26. There should be a strong industrial engineering cell at corporate level as well as at El-Hassa Mines unit. Industrial engineering study will help to identify lacunae, areas of mismatch, assess adequacy in respect of men at various departments. Industrial engineering is a very vital tool, and needs to be employed on a continual basis to bring constant improvements.

27. The most encouraging aspects are that the managerial level group in the company is young, receptive and the atmosphere is conducive for good team work. Implementation will undoubtedly be the most difficult phase, some supporting role from outside experts will perhaps be desirable at least to initiate the process. Maintenance programme must operate continuously rather than on a crisis basis; Programme to be effective, calls for intensive planning, extensive action, system of records, proccess of analysis, close control, improvement of skill, and knowledge of those involved in managing maintenance, support and co-operation from lowly helper to top management.

II. JORDAN PHOSPHATE MINES CO.LTD

Jordan Phosphate Mines Co. (JPMC) incorporated in 1953 has three mines under production: (i) Rusaifa, (ii) El-Hassa (iii) Wadi El-Abiad. Annual aggregate production of the three mines is about 5 million TPY of dry product.

2. The mining is carried out by open pit methods. Total excavation of all the mines combined together comes to about 30 million BCM, out of which 4 million BCM represents run of mine ore, balance being mostly over-burden and some quantity of wastes. JPMC's own share of excavation is currently about 3.3 million BCM; rest of the excavations are carried out by contractors. The company has a fairly large fleet of earthmoving equipment at El-Hassa and has decided to increase its share of excavation substantially. The company also has a fleet of earthmoving equipment at Rusaifa, and very small number in El-Wadi El-Abiad for odd bit of jobs; the entire mining excavation there is done through contractors.

3. To put it simply the operations of JPMC mine units can be classified under two broad categories:

   i. mining excavation operation through deployment of mobile heavy earthmoving equipment such as loaders, dumpers, dozers, drills, compressors etc.

   ii. stationary ore processing, handling, benefication and drying plant, having crushers, screens, conveyors, feeders, agitators, pumps, thickeners, dryers etc, usually referred as plant.

4. Mining equipment are classified highly breakdown prone, and has relatively short economic life. During the life time cost of maintenance and repair equals the initial acquisition cost and sometimes even more. The equipment being multiple in numbers, in case one or more equipment is down it does not cause a total stoppage of production operation but affects overall production. Ore processing and handling plant is stationary in nature, configuration has to be decided in advance, economic life of the plant equals life of the mine itself, generally anything between 20 to 30 years. Plant is relatively easy to maintain compared to mining machinery, but in case any piece of equipment is down it means total cessation of production operation. It is therefore apparent that while mobile mining machinery maintenance and repair requires higher skill and is more arduous tasks, more attention is called for in respect of plant as down time here is much costlier in terms of opportunity losses, idle operatives all down the line.

5. Mine Units

Of the three mines of JPMC, El-Hassa was by far the biggest and its management very much more complex. JPMC management desired that while the expert may visit all the three mines, the problem of maintenance at El-Hassa being more acute and particularly as the management was most concerned to streamline maintenance of earthmoving machinery he should concentrate on El-Hassa and more specifically the thrust should be to equip the mobile mining machinery maintenance section to meet not only the present situation but to meet the future challenges.

6. Rusaifa Mines

This was the first mine unit of the company, started as underground mine but later converted to open cut operations. Fleet of earthmoving equipment maintenance is under the charge of mechanical division. All maintenance and repair of ore processing and beneficiation plant is under the operations division. A new integrated process and beneficiation plant was under advanced stage of erection. For some time both the new and the old plant (with reduced throughput) will be operated, the intention is to get full production in course of next years through the new line. Fresh improved facilities for earthmoving equipment maintenance and repair has been planned. During discussion management at corporate office indicated that by the time the new plant is commissioned the maintenance organisation will be revamped and re-organised. The maintenance (mechanical) engineers concerned were aware that planned maintenance system with proper documentation should be introduced, what they were practising was prescribed lubrication schedule. Engineers were knowledgeable. Time constraint did not permit penetrative study; general impression was that the maintenance problem was not alarming.

7. El-Hassa

As requested by JPMC study was concentrated at El-Hassa, observations and recommedations in the report have relevance mostly to El-Hassa; which is dealt later.

8. Wadi El-Abiad:

This was the newest of the three mines of JPMC, and gone into production in 1979. Unlike El-Hassa and Rusaifa, mining excavation is carried out wholly through the contractors. Maintenance and repair facilities created are meant to meet the need of the plant only and few odd bit of earthmoving equipment for support job in the plant and miscellaneous applications. Day to day repair of plant is carried out by the production (operation) divisions, the mechanical division was responsible basically for repair. House keeping of the plant was excellent. The mechanical engineer who had just only five years of experience appeared very mature for his experience, and was full of assurance with lot of innovative ideas.

Interdependability relations of maintenance with operation appeared to be healthy. No incisive study was attempted, but apparently the plant configuration, repair facilities appeared good and adequate and no major maintenance problem came to surface.

III. EL-HASSA MINES

El-Hassa is situated 140 Km south of Amman. The mining complex has a little over 2000 employees. In 1982 it is planned to produce about 2.5 million tons of dry depatchable product. Mine and the plant has capacity to produce more. During the past few years the mine has been expanded considerably, additional crusher, beneficiation line dryers have been installed, more and more mining equipment added. As it normally happens with this type of expansion, perforce one has to resort to sub-optimisation in respect on plant configuration, mine planning, in all its ramifications. Since this is the largest and main operation of JPMC, and the company has decided to increase its own share of mining excavation substantially the management is keen to stream line maintenance to achieve highest possible mechanical availability of plant and machinery.

2. Mining Machinery

There are about 125 pieces of mobile equipment, dumpers costitute the largest group, and these are of different makes and models: Mack, Caterpillar, Berliet, Perlini. The list of mobile equipment is enclosed. Maintenance and repair facilites have not been built in a planned and scientific manner, and maintenance organisation and system have not been able to keep pace with requirement and certain amount of helplessness appears to be pervading, notwithstanding that engineer in charge of this division appears to be earnest and possess good potential.

3. Plant:

There are three crushing stations at the mine; crushed ore is brought to a central multiple line process plant. Intermediate stockpiles have been created. There are three thickeners and 8 dryers, the beneficiation and drying plant is under the charge of an ore-dressing engineer, the crushing plant is under the charge of mining engineer who is also in charge of the mining excavations.

4. Study by W.S. Atkins Ltd.:

JPMC had commissioned in 1981 W.S. Atkins, Ltd. (WSA) UK, a consultancy organisation to study the maintenance system of earthmoving machinery and also design and engineer workshop and incidental facilities for maintenance and repair of the mobile machinery of El-Hassa mines. WSA have submitted their report. In a limited way a documentation together with lubrication schedule as suggested by the WSA has been introduced, JPMC management at Head Office has also initiated steps to set up the workshop as expeditiously as possible. It is expected in about 18 to 24 months time the setting up of the facilities will be complete.

5. There can be no two opinions that the existing facilities and work sheds are much too inadequate and better maintenance and repair facilities should be created as early as possible. Decision to set up the new maintenance and repair shop appears to have created high expectancy and fond hopes. It also appears to have generated inertia that things can wait. A very aggressive maintenance policy needs to be pursued without delay and the period from now and the next 18 to 24 months is too long a period to put things in abeyance; certain practices must be curbed ruthlessly and system and organisation developed during the intervening period so that the benefit of better facilities being created can be fully availed of.

6. Daily Checks:

Mining machinery has necessarily to be checked daily in the field. For the beneficiation plant this check should be conducted by operating crew of the plant, which is not the case at present. For mobile machinery, the present practice of four separate trucks/ groups, one for lubrication, the other for filter change, the third for auto-electric and yet the fourth for tyre inflation is not only wasteful, but also inefficient on many counts There should be a group well trained, to carry out the checks under supervision of a Chargeman/Fore-man. Mobile machinery should be checked, filter changed, turn by turn, in the field. Argument that filter change should be done before the operation shift has no rationale. Presence of

operator must be made compulsary when the daily check of the machine is carried out. Like a car driver operator must check water in radiator, engine oil level etc, before he starts the equipment.

7. 100/125 hrs checks:

Some organisations prefer to do this weekly, but if the maintenance department is properly tuned and documentation satisfactory, checks at designated hours will be better practice. Currently at El-Hassa these checks are carried out at the mine field. It is contended that when the new workshop comes up. 100 hrs checks will be carried out there as it will be nearer to the minefield. This is the most critical of all schedules. It is not just greasing and oiling. At this stage certain physical checks, tightening of loose bolts and nuts from where usually lot of mischief begins is to be done. Adjustments are also carried out during 100 hrs schedule. The machines should also be given a thorough wash which can not be carried out in the field. Quality of maintenance, supervision in field is bound to be inferior. Change of engine oil in the mine field is not recommended. It is very strongly urged that 100 hrs maintenance be done in the maintenance yard right away, one can not afford to keep this in abeyance till establishment of the proposed new workshop. Maintenance check cards for 100 hrs must be signed by a foreman. Presence of operators of the machine during 100 hrs maintenance should be made mandatory. Operator knows his machine best. his sense, touch, smell, vision are very important to diagnose any defects. It will

be good practice to induce him to participate during 100 hrs (along with maintenance crew) schedule, but if this can not be done even then he should be made to remain present during the time maintenance is carried out.

8. House Keeping:

House keeping at El-Hassa leaves much to be desired. For some time this needs to be insisted upon to the point of being fastidious. The maintenance yard gives a dilapidated look, equipment which are being repaired/ attended to can certainly be kept in a line. When an assembly, sub assembly is opened same can be kept in position which will facilitate proper movement. Several junk yards which are eye sore exists in and around the shop and the repair yard, most earthmoving machines appear to have never received a fresh coat of paint. Engines when overhauled could also be painted. There is so spray painting facilities. In this context it may be considered whether or not automobile (vehicle) repair facilities should not be set up adjacent to earthmoving heavy repair section. Both have engines, batteries, similar auto-electric circuits, and this may lead to better utilisation of common facilities.

House keeping of the beneficiation plant also needs to be substantially improved. Mucks are getting accumulated, unlike Wadi El-Abiad where fore thought has gone into planning and design stage about plant cleaning and washing, due to a variety of factors same could not

be the case at El-Hassa. However a serious study should be made as to what improvements are susceptible to incorporation to facilitate easier cleaning. In the plant periodical plant cleaning drive should be initiated. Orderly planned shutdown will result better housekeeping and maintenance.

9. There is no hard stand at the maintenance repair yard, and what goes in the name of washing allows additional ingress of mucks at critical areas of the machines. Hard concrete platform is not so expensive and should be provided with proper drainage facilities. There is no steam jenny, procurement of this should not wait till new workshop comes into existence.

10. When machines are bought manufacturers provide recommended lubrication schedule. This is a very general guide line and one should frame schedule based on severity of operation and experience. For daily, 100/500/1000 hrs schedules card with colour code (similar to SAE code) and pictorial illustration should be printed defining the checks to be carried out. All that maintenance crew have to do is "tick" mark on the card as a token of carrying out the check. Tickler system is eminently suitable for developing countries where the workmen are not educated.

11. Planning & Scheduling:

While schedules as above if religiously followed should reduce unscheduled down time, this can not be eliminated altogether. Maintenance divisions should be so geared that whenever there is a breakdown it is able to mobilise men, materials, and tools to press back the machine into commission expeditiously. If the field is very wide spread-out one or two mechanics have necessarily to be kept in the field to meet emergent need for minor repair. Any major breakdown repair has to done through support group from the shop. The maintenance divisions should also prepare a schedule of planned major repairs and overhaul for plant as well as earthmoving equipment. Needless to say that despite meticulous care these schedules may have to be altered due to unavoidable and uncontrollable factors. These schedules should be drawn 18 months in advance and reviewed every six months. Principle of exception has to be part of overall maintenance management system, for, maintenance is not an end in itself. It may not be possible for operations to release a piece of equipment according to predetermined schedule and such deviation calls for flexibility in maintenance planning and utilisation of resources.

12. Basic domment (Earthmoving Equipment)

Log book. The specimen proforma of log book is annexed. The log book should record consumption of fuel, lubricant, and spares used. For each mining equipment two log books one for even month and the other for the odd months should

be maintained to enable scrutiny by maintenance and finance divisions and pickup summary of records relevant to these divisions.

History Sheet:

At El-Hassa details of equipment are currently being kept in a loose file. History sheets should be in the form of a bound book. It should contain date of purchase, price, equipment data, basic performance data; history book specimen is enclosed.

13. Documentation for plant

For the plant the following documentation is suggested. (i) Shift report, (ii) Inspection check sheets, (iii) Defects compilation register, (iv) Pending works register, (v) Major repairs and overhauling registers, (vi) Lubricating register, (vii) History sheet - record for each principal equipment, say, crusher, dryer, conveyor etc.

14. Lubricants:

At El-Hassa there are 47/48 varieties of lubricants. Through a careful exercise it should be possible to bring this down to less than twenty grades. In choosing lubricants one should go for premium quality particularly so if this helps to reduce variety. Greater care in storage of lubricants is necessary than at present.

15. Re-refining of used oil:

Lubricating oil is a costly item, and its consumption in El-Hassa is quite large. Used oil should not just be drained but collected properly. A survey may be done of quantity of used oil available for all the three mines. It will be adviseable to consider feasibility of setting up used oil re-refining facilities at El-Hassa. It should be possible to bring the used oil to quality as good as original oil through re-refining and doping with additives and small addition of virgin oils. A number of process technology is available.

16. It has been observed that from some equipment oil is leaking. Leakage of one drop every ten seconds makes it 3¼ gallons per month, one drop every second means 34 gallons a month- and if it breaks into droplet it will mean 546 gallons a month! This is only to emphasize how staggering the loss could be due to oil leakage which does not appear to have attracted enough attention at El-Hassa.

17. Repair practices:

These require considerable improvement. Inefficient labour practices now in use should be pruned out. Engines of all equipment should be repaired in one section. The present practice of repair/overhaul of engine in a semi-open shed should be discontinued. In fact there is a closed shed available to carry out this repair. All dumpers could be classified

under one group, dozer/wheel loaders could be in another, compressors drills etc a separate group. To keep the removed parts in an orderly manner should be insisted upon. Except throw away parts old parts should be returned to stores, serviceable components should be returned to stores after repair to be taken in stock separately. There is no regular system in vogue.

If a capital repair is undertaken, estimate of repair should be invariably made. Till such time the division is equipped to make PERT chart, a bar chart should be prepared. Such estimate will also help to make a cost-benefit analysis and to arrive at a decision if a particular capital repair should at all be undertaken.

Earthmoving maintenance section has several auto electricians, and they are not fully occupied. They can be kept busy if trained for repair of batteries, re-winding of self starter, dynamos etc.

Supervision for repair practices are left to foreman/ chargemen. Engineers should spend time in field and also on the shop floor.

18. The cost of items drawn are not reported to be available at El-Hassa. Even if all materials issue vouchers are to come to corporate office for the accounting system and procedure of the company and there would be obviously some good reasons for the same, cost information

should be available at the mine unit. One of the weakest link in maintenance management is the antipathy towards paper work, lack of sufficient and accurate data. Relevance, timeliness, accuracy and presentation are the essential elements for usefulness of any record system. Maintenance budget is difficult and some fluctuations have to be accepted. At El-Hassa maintenance division works without any budget, without any control. The division should forecast how much materials/spares will be procured, what is expected to be consumed in value. Currently all materials issue requisition requires signature of the engineer in charge of division irrespective of value. There should be a value limit, individual item-wise, which can be drawn by foreman, by junior engineer, by head of the division. Beyond a certain value the material issue should be approved by the Mines Manager.

19. There are no norms and targets of equipment availability. It is a cardinal management principle that there must be a goal, and what has been achieved co-related with goal. Without any norms fixed, there being no target, there is no pressure on maintenance division. Under such situation creation of zeal, a sense of mission and enthusiasm is not possible. Maintenance division should be put on search-light and whatever help and assistance is required should be provided. Currently no one knows what is wanted, and this applies equally both to earthmoving maintenance and plant mechanical division.

20. There is cry both in plant mechanical division and earth-moving equipment maintenance division that they do not have adequate men both in terms of quality and quantity. They may be right. If the maintenance divisions are to generally carry out all the tasks in a manner they should, rule of thumb excercise supports the need for more men. But the situation is some-what paradoxical, in some category, clearly there are surplus men and existing crew utilisation by maintenance division also without doubt poor. Industrial engineering study should be conducted to determine category wise requirement of men with job title and description. The study has revealed that at least two more engineers should be inducted in earthmoving maintenance division immediately, pending positioning of a Dy Manager (Technical Services) who after detailed study could put up appropriate proposal.

21. <u>Operating abuse:</u>

In case of mobile mining machinery careless and inept operation can cause havoc, and several cases of mal operation were noticed. It is understood that contractors lure away good operators and there is a dearth of skilled operators. Review of wages, incentives and training are the only possible answers. Training of operator should be taken on special footing. A good and practical way will be to choose good and experienced operators from the mine to train others after office hours pay them some honorarium. On operators' training there are also films generally available with equipment manufacturers and the same could be used as training aids.

It is understood that mine management takes punitive action against operational abuse, but punitive action alone is no solution, the problem must be attacked where it lies.

22. Tyre care and retreading:

Tyres of earthmoving equipment are very costly. Tyre life will depend on correct inflation, use of right size and tread pattern, care by operators etc. For each tyre there should be a tyre history card.

Tyres if taken out in time are susceptible to retreads. Usually two retreads can be done economically. Retreaded tyres should give 80/85% of the original life. It is gathered that experience of the mine of tyre retreading at Amman through Vaculug process has not been found satisfactory. The matter should be investigated, as to whether the process adopted is adequate or not. It will be advisable to induce the party to put up proper facilities. But if the present party at Amman or any other party can not be induced to set up suitable facilities, a full circle mould tyre retreading as a central facility near the proposed workshop should be considered.

23. In El-Hassa day-to-day maintenance of crushing and conveying plant is under mining (production) division, but for beneficiation plant day-to-day maintenance is under mechanical division while the operation is under a separate division. Except electrical divisions, work which was relatively better defined

there appeared to be a dichotomous situation and no clear and rational work division. The operators of beneficiation plant should carry out day-to-day maintenance themselves. Crushing, beneficiation and drying section should be shut down periodically for thorough electrical and mechanical checks say every 2/3 months, when plant too must be thoroughly cleaned and all minor repairs done. Mechanical division should also prepare planned major repair annual plan in consultation with operation division.

24. **At the present as many as 14 people are directly reporting to Mines Manager. The problem at El-Hassa was diverse and numerous. As a chief executive of the problem mine like El-Hassa he has to get lot of thinking time and need to concentrate on essentials. It is just not physically practicable for the Mines Manager to do full justice and give personal attention to 14/15 divisions. In mechanised mines maintenance has a very pivotal role; in fact in the ultimate analysis under proper mine planning situation it is the input of maintenance which determines the output. The authority relationship between maintenance and operation is an extension of age old management dilemma, which industry has not been able to satisfactorily resolve. In mining organisation, that there will be greater scope for development of engineers of mining discipline is recognised and have to be accepted. But surely there has to be scope for more for the mechanical-electrical group rather than being kept as specialists and opportunity should be provided for near parallel development, and beyond a stage the criterion should**

be managerial skill and not the discipline. Suggested organisation structure for El-Hassa mine is enclosed. The organisation proposed not only strengthens the maintenance (Technical Services) function, essential for improvement of maintenance but also Mines Manager to exercise better control through three wings, all at the same level of Dy Manager. The organisation proposed also envisages vesting greater decision-making authority at the mine level.

25. Stores:

One of the essential ingredients for effective maintenance and repair is availability of spares and materials. Sizeable money is also unproductively blocked in inventory, and its impact on the cost of production may not be just trifling. Indenting, procuring, storing, conserving replenishing, disposing of materials are no simple tasks. Materials management is more and more becoming a technical function. Very close interaction with maintenance divisions who are the main users of materials is necessary. In the organisation chart this section has been placed administratively under Technical Services Division at El-Hassa mine unit level, Supplies Manager at Corporate Office having functional control. JPMC is installing a computer at its corporate office. Inventory management should be brought on computer as early as possible. This will entail codification of all items: about 40,000 items are in El-Hassa alone. Codification should be taken up on a priority basis. ABC analysis and VED classification should also be conducted, as it is understood such exercise has not been carried out so far.

26. Training cell:

In addition to training apprentices, which is an obligatory function, training cell at the mine can undertake a number of training programmes for maintenance workmen, supervisors and even engineers. (training of operators have been earlier referred). Skill improvement of maintenance crews, refresher courses and inter disciplinary/inter departmental, exposure through training programme for supervisors and engineers will be profitable. Training cell should not wait for suggestions to come from the various departments, but take the initiative on itself.

27. Due to critical nature and stakes involved the company has rightly awarded care, operation, maintenance and repair responsibility of 30 cuyds new walking dragline and 45R rotary blast hole drills to specialised competent contracting agencies for a designated period. None from the earthmoving equipment maintenance division has so far been attached to get trained; considering the capital investment for a machine of this size, the mine management may consider few engineers or educated foremen trained to operate this equipment.

28 Equipment replacement:

Age of the equipment, accumulated service hour, technological obsolescence, productivity of new equipment vis-à-vis the old ones, cost of new equipment, duty conditions, physical state of health of the old equipment, breakdown pattern of equipment etc are all to be taken into consideration.

If the capital is scarce and dear as it happens for most developing countries it may pay to carry out capital repairs and prolong economic life through superior maintenance. Just as all human being do not die at the same age, it has been found by research and experience that even between the same make and having identical hours of service in similar conditions two pieces of equipment behave differently in terms of breakdown pattern. Change of a major assembly, sub-assembly carried out in a equipment also needs to be investigated in taking decision. In mines there are miscellaneous jobs which may not be so arduous in nature. In other words instead of discarding the equipment relegation to inferior use could also be considered, particularly in a situation if there is no prospect for a trade-off. It is gathered that the hour metres of some equipment were not working. The hours based on clock-hour records are not reliable indicators. Fuel consumption record could be another good indicator, but this also is not available. It is suggested that physical state of health, breakdown pattern of each invidual machine which, as per mine records, have exceeded 17000 hrs be studied at the first instance. Study will surely throw some very useful data which together with considerations referred will help to formulate a strategy on the titled subject.

29. Two specimen documentation forms are enclosed; one is a log book page specimen and the other equipment-history book. It is suggested that documentation based on manual system should start, data base created. After some period the company should consider modified documentation system for computer adaptation

30. El-Hassa Mines Manager has taken lot of interest in this study and lent good deal of his time, shown deep concern about the problem of maintenance and keenness to support system and organisation which will yield positive result in improving higher availability of plant and equipment. Head of the mechanical division, and Head of earthmoving equipment division, are aware of present weakness and deficiencies, and are earnest to bring about improvements. Competent guidance and support will be needed. Bulk of the job in maintenance is managerial rather than technical. In the report emphasis has been to go all out for preventive maintenance. PM does take a bite from the potential to produce. Functional replacement of part and component are made at a predetermined designated hours, when the components may in effect have many more hours of useful life, this can be termed wasteful, and is not a virture in all cases; too much obsession have pi falls and in the name and guise of preventive maintenance some none too

good practices are perpetuated. In the ultimate, things have to boil down to efficiency and cost balancing, and in El-Hassa situation spending a little extra on preventive maintenance rather than being niggardly will be well worth. Once things are brought into shape, condition based maintenance and other concepts and techniques can be applied. The ingredients required for good maintenance are planning, scheduling, training, measurement of performance, documentation, good workshop and tools.

ANNEX

LIST OF ALL MINING EQUIPMENT
AT EL-HASSA

	MINE PLANT ITEMS		MODEL	EFFECTIVE WORKING HRS	REMARKS
1	**BULLDOZERS:**				
1.1	D9G	No. 6	1974	13875	Until 30.6.1982
	D9G	No. 7	1975	10484	
		No. 8	1975	10781	
		No. 9	1975	10788	
		No.11	1975	8632	
	D9H	No.13	1977	10818	
	D9H	No.14	1977	12466	
	D9H	No.15	1977	11183	
	D9H	No. 1	1980		Part of the Draline plant
	D9H	No. 2	1980		
1.2	KOMATSU	No. 1	1981	2726	Until 31.7.1982
	KOMATSU	No. 2	1981	2366	
2	**LOADERS:**				
2.1	CAT.988	No. 1	1974	15000	Until 30.6.1982
	CAT.988	No. 2	1974	15376	
	988	No. 3	1974	15112	
	988	No. 4	1974	11602	
	988	No. 5	1975	14877	
	988	No. 6	1975	13446	
	988	No. 7	1975	14933	
	988	No. 8	1975	14466	
	988	No. 9	1975	12975	
	988	No.10	1975	12972	
	988	No.11	1975	10680	
	988	No.12	1975		
	988	No.13	1976	9498	
	988	No.14	1976	9733	
	988	No.15	1981	2904	Until 31.7.1982
	CAT.988	No.16	1981	3011	
	988	No.17	1981	2966	
2.2	CAT 966	No. 6	1973	7888	Until 1.8.1982
	966	No. 8	1974	6812	
	966	No. 9	1974	4055	
	966	No.10	1975	3477	
	966	No.11	1975	3627	
	966	No.12	1975	5523	
	966	No.13	1976	4320	
	966	No.14	1976	2174	
	966	No.15	1976	6359	
	966	No.16	1976	4436	
2.3	CAT 920	No. 1	1975	Not Available	Used for general purposes of Millsite
	920	No. 2	1975		
	910	No. 1	1976		

	MINE PLANT ITEMS		MODEL	EFFECTIVE WORKING HRS	REMARKS
3.	DUMP TRUCKS:				
3.1	CAT.769	No. 1	1974	17367	Working hrs.
	769	No. 2	1974	12140	until 30.6.1982
	769	No. 3	1974	19583	
	769	No. 4	1974	16435	
	769	No. 5	1975	14475	
	769	No. 6	1975	13000	
	769	No. 7	1975	13717	
	769	No. 9	1976	17750	
	769	No.10	1976	19612	
	769	No.11	1976	15740	
	769	No.12	1976	15282	
3.2	MACK 20	No. 1	1975	17200	Until 30.6.1982
	20	No. 2	1975	8000	
	20	No. 3	1975	16100	
	20	No. 4	1975	14650	
	20	No. 5	1975	16200	
	20	No. 7	1975	15100	
	20	No. 8	1975	8500	
	20	No. 9	1975	18400	
	20	No.10	1975	17150	
	20	No.11	1975	15350	
	20	No.12	1975	19000	
	20	No.13	1975	17750	
	20	No.14	1975	18100	
	20	No.15	1975	16700	
	20	No.16	1975	21300	
	20	No.18	1975	17950	
	20	No.19	1975	17850	
3.3	MACK 35	No. 1	1975	7600	
	35	No. 2	1975	6000	
	35	No. 3	1975	6100	
	35	No. 4	1975	8900	
	35	No. 5	1975	6500	
	35	No. 6	1975	8100	
	35	No. 7	1975	7300	
	35	No. 8	1975	6800	
	35	No.10	1975	4780	
	35	No.12	1975	9500	
	35	No.13	1975	11000	
	35	No.14	1975	11500	
	35	No.15	1975	9200	
	35	No.16	1975	5000	
	35	No.17	1975	3700	
	35	No.18	1975	6500	
	35	No.19	1975	4300	
	35	No.20	1975	8100	

	MINE PLANT ITEMS		MODEL	EFFECTIVE WORKING HRS	REMARKS
3.4	BERLIET: DUMP TRUCKS				
	BERLIET	No. 1	1980	3275	
		No. 2	1980	4735	
		No. 3	1980	908	
		No. 4	1980	4422	
		No. 5	1980	2004	
3.5	PERLINI		1981		Until 31.6.1982
		No. 1	1981	3300	
		No. 2	1981	3600	
		No. 3	1981	3200	
		No. 4	1981	3300	
		No. 5	1981	3400	
		No. 6	1981	2900	
		No. 7	1981	3200	
		No. 8	1981	2900	
		No. 9	1981	2900	
4.	WHEEL DOZERS:				
	CAT 824	No. 1	1976	4000	Estimate
	824	No. 2	1976	4000	
5.	CRANES:				
	LIBHERR		1973	-	
6.	GREADERS:				
	CAT 16	No. 1	1974		Not Available
	CAT 14	No. 2	1977		
7.	COMPRESSORS:				
	INVERSOLL RAND				Not Available
	ATLAS-COPCO:				
		No. 1	1974		
		No. 2	1974		
		No. 3	1975		Not Available.
		No. 4	1975		425 cfm
		No. 5	1975		
		No. 6	1975		
	HOLMAN:				
	1.2.3.4		1975		450 cfm
	5.6.7		1975		450 cfm
	ATLAS-COPCO				
	1.2		1980		750 cfm
	HOLMAN:				
	1.2.3.4	1977			600 cfm

	MINE PLANT ITEMS	MODEL	EFFECTIVE WORKING HRS	REMARKS
8.	DRILLS:			
	INGERSOL-RAND	1974		
	HOLMAN 1.2.3.4	1975	Not Available	MK 3
	HOLMAN 5.6	1975		
	HALCO G25	1975		
	ATLAS-COPCO TWIN BOOM 1-2	1980	ROC 302	
	SALZGITTER	1980		
9.	MAINTENANCE MOBILE EQUIPMENT:			
	MERCEDEC Mob.Filter No.1	1977		
	ELECT. No.2	1977		
	Tyre Truck	1980		
	Maintenance Truck No.1	1981		
	No.2	1981		
	No.3	1981		
	CHEVEROLET Water Tank	,66		
	DODGE W.T. No.1-2	1976		

A LOG BOOK SPECIMEN PROFORMA

The daily record of operation as in proforma given below:

Date	Shift	Hours Worked	Progress in total hours	Down time		Nature of breakdown.	Reasons for idle hours
				Breakdown hrs.	Idle hrs.		
1	2	3	4	5	6	7	8

Gauge reading (to suit each equip.)	POL drawn (to suit each equipment)	Defects observed by operator	Remarks of shift Incharge	Signature of	
				Operator	Shift Incharge
9	10	11	12	13	14

Record of shutdown and repairs carried out during operation of the equipment as in the proforma given below:

Sl. No.	Date	Time taken for repairs/replacement/maintenance		Time lost due to		Total time loss	Brief description of repairs carried out reason if any for delay in repair should be recorded	Signature of Foreman/ Shift Incharge
		Started	Completed	Replacement	General Maintenance			
1	2	3	4	5	6	7	8	9

Parts consumed during operation/breakdown as in the proforma

Sl. No.	Date	Particulars of assemblies repaired	Description of parts used	Part No.	Qty. used	Store I.V. No.	Signature of Foreman/ shift I/C
1	2	3	4	5	6	7	8

HISTORY SHEETS SPECIMEN

For each equipment there should be History sheet where all the relevant information from the date of commissioning to the date of disposal shall be entered in brief. History sheet should contain the following information:

a) The date of purchase/commissioning, original cost of individual prices of equipment or section of the plant.

b) Details of the works carried out at the market along with the cost.

c) Details of the preventive planned development done.

d) Details of usage of assemblies/sub-assemblies and the repairs carried out on them.

e) Details of periodical maintenance done.

f) Details of repairs carried out.

g) Details of day to day spares used.

h) Monthly record of performance.

i) Details of inspection by senior officers.

History sheet books should be printed for each and every equipment with sufficient pages to cover all the information mentioned above for the life time of the machines.

The proforma used for recording the above information are given below (for heavy earth moving equipments and vehicles only).

(A) Particulars of the equipment:

---

1. Make
2. Model
3. Country of origin
4. Servicing Agencies in India, if any
5. Machine Sl. No.
6. Project/Department Sl. No.

7. Engine Sl.No.
8. Chassis Sl.No.
9. Transmission Sl.No.
10. Fuel Pump No.
11. Horse power of the engine with details of make & model etc.
12. Other details if any.
13. Date of receipt.
14. Date of commissioning.
15. Value of purchase.
16. Details of gurantees.
17. Life of Machine.

(B) Battery Account

Voltage _____ Plates _____ Sl.No. of battery Originally fitted_____

Date	Stores Issue Note No.	Sl.No.	Recondi-tioned or new	Batt-ery make	Amp.Hr. rating	Replacing Battery No.	Life obtained	Return Voucher No.	Remarks	Signature of Section I/C
1	2	3	4	5	6	7	8	9	10	11

(C) Tyre Account

Size_____ P.R. _____

Date	Stores issue Note No.	Tyre	Retre-ded or new	Meter reading (initial)	Meter reading (final)	Life obt-ained	Return Vouch-er No.	Rema-rks	Sign-ature of Sec ation
1	2	3	4	5	6	7	8	9	10

(D) Details of repairs done at market

Date	Authori-ty	Name of the firm	Details repairs done	parts used if any	Cross refer-ence inj	Cash Memo/ Bill No	Amount	Reasons for repairs	Signa-ture of A.E
1	2	3	4	5	6	7	8	9	10

(E) Preventive planned development:

Date	Authority	Reasons for alteration/ addition	Details of works carried out	Cross ref. in hand J.	Value	Remarks	Signature of Section In charge
1	2	3	4	5	6	7	8

(F) Record of assemblies/sub-assemblies:

Sl. No.	Description of assemblies	Sl.No. of assys.	Date installed	Date removed	Reasons for Removal	Signature of AE/EE
1	2	3	4	5	6	7

(G) Details of periodical maintenance:

Date	Name of Mechanice	Meter Reading	Periodical maintenance for 10 hrs. 100 hrs.etc	ref.to proforma No.	Details of any abnormalities date/ cted repairs done	Signature of Section Incharge
1	2	3	4	5	6	7

(H) Details of repairs carried out:

Date	Name(s) of Mechanic (s)	Hr.meter/ KM meter reading	Details of repairs done	Date/time In	Date/time Out	Remarks	Signature of Section Incharge

(I) Details of capital repairs/overhauling

Date	Name (s) of Mechanic(s)	Hr.meter/ KM meter reading	Details of repairs done	Date/time In	Date/time Out	Remarks	Signature of Section Incharge
1	2	3	4	5	6	7	8

(J) Details of day to day spares used:

Date	Stores issue Note No.	Part No.	Description of materials	Cross ref. in section D.F.G.H & I	Qty. issued	Remarks for disposal of old materials	Signature of Section Incharge
1	2	3	4	5	6	7	8

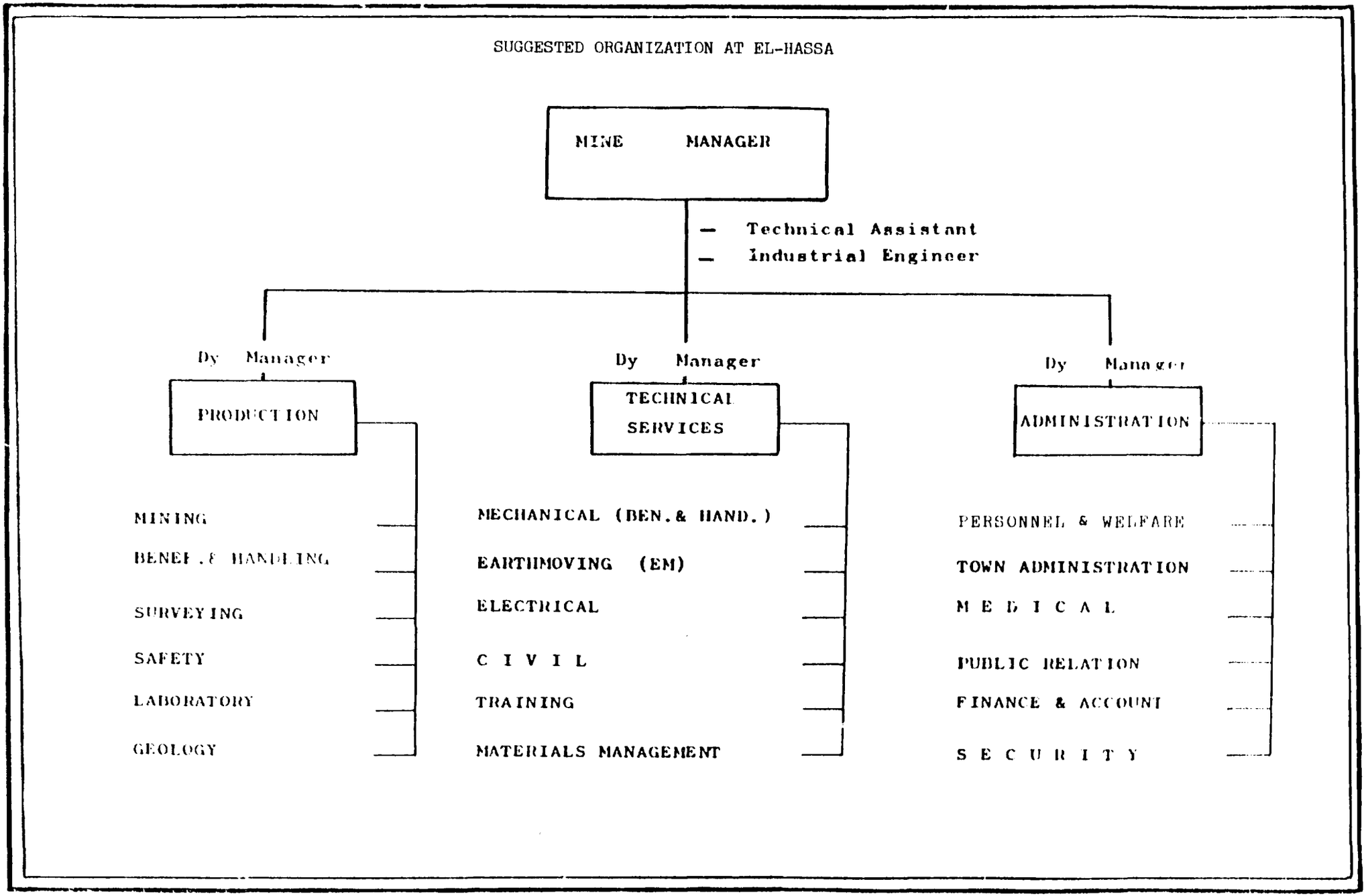
(K) Monthly record of performance:

Sl. No.	Month & Year	Hrs./ Kms. run during month	Total Kms/ hrs. run	Quantum of work done	Fuel	Lubricants	Total down time during month	Reasons in brief for down-time	Sign.of Section Incharge
1	2	3	4	5	6	7	8	9	10

(L) Details of inspection by Sr. Officers:

Date	Observation	Action taken	Remarks
1	2	3	4

SUGGESTED ORGANIZATION AT EL-HASSA



FUNCTIONARIES MET AT JPMC

01	MR ALI AL NSOUR	GENERAL MANAGER & MANGING DIRECTOR AMMAN, POBox-30
02	DR ISHAQ SALIM JALLAD	AST.GENERAL MANAGER(TECH.AFFAIRS)
03	DR ABDELFATTAH ABU HASSAN	PRODUCTION MANAGER
04	DR G. KALCOV	TECHNICAL ADVISER.
05	MR ALI H. ABU-SITTA	SUPPLIES MANAGER
06	MR JAMEL A. WOREIKAT	MINES MANAGER, EL-HASSA MINES
07	MR AHMED MUBAIDEEN	MINES MANAGER, EL-ABIAD MINES
08	MR ISSAM A. ATTIAYAT	MINES MANAGER, RUSAIFA MINES
09	MR MOH'D A. MUBAIDEEN	HD.MINING DIVISION, EL-HASSA
10	MR ALI ABDULLA YUNIS	HD.HEAVY EQUIPMENT DIVISION, EL-HASSA
11	MR YOUSR BASHAYRAH	HD.MECH.DIVISION, EL-HASSA
12	MR M. HASHIM TANASH	HD.SAFETY & INDUSTRIAL SECURTY, EL-HASSA
13	MR J. AL ZAIBUK	HD.TRAINING DIVISION, EL-HASSA
14	MR IBRAHIM AL-KHATIB	HD.BENEFICATION & DRYING DIVISON EL-HASSA
15	MR FUAD KHOULI	HD.ELECTRICAL DIVISION, EL-HASSA
16	MR DARWESH AMARA	HD.MECH.DIVISION, EL-ABIAD
17	MR. RAM MOHAR	CONTROL ENGINEER , EL-ABIAD
18	MR SHUKRI OKLA	CHIEF MECH.ENGINEER, RUSAIFA
19	MR GHAZI KHORSID	HD.EARTHMOVING DIVISION, RUSAIFA
20	ZUHAIR RASHID	MECH.ENGINEER, RUSAIFA MINES
21	ANWAR SUNNA	PROJECT DIVISION, RUSAIFA MINES