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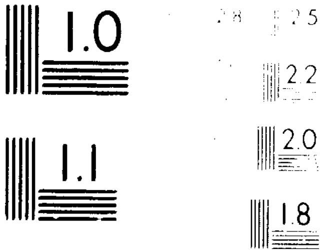

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ASSISTANCE TO CONSOLIDATE AND DEVELOP THE BENGHAZI CEMENT FACTORY.

TF/LIB/75/002

SOCIALIST PEOPLE'S LIBYAN ARAB JAMAHIRIYA

Prepared for the Government of the Libyan Arab Jamahiriya
by the United Nations Industrial Development Organization

Based on the work of Mehmet A. Basman, mechanical engineer

80-38370

Explanatory notes

References to dollars ($) are to United States dollars, unless otherwise stated.

The monetary unit in the Libyan Arab Jamahiriya is the Libyan dinar (LD). During the period covered by the report, the value of the LD in relation to the United States dollar was $1 = LD 0.296.

References to tons (t) are to metric tons, unless otherwise specified.

Besides the common abbreviations, symbols and terms, the following have been used in this report:

KHD	Klöckner Humboldt Deutz Industrieanlagen GmbH
LCC	Libyan Cement Company
tph	tons per hour
WEDAG	Westfalia Dinendahl Aktiengesellschaft Groppel

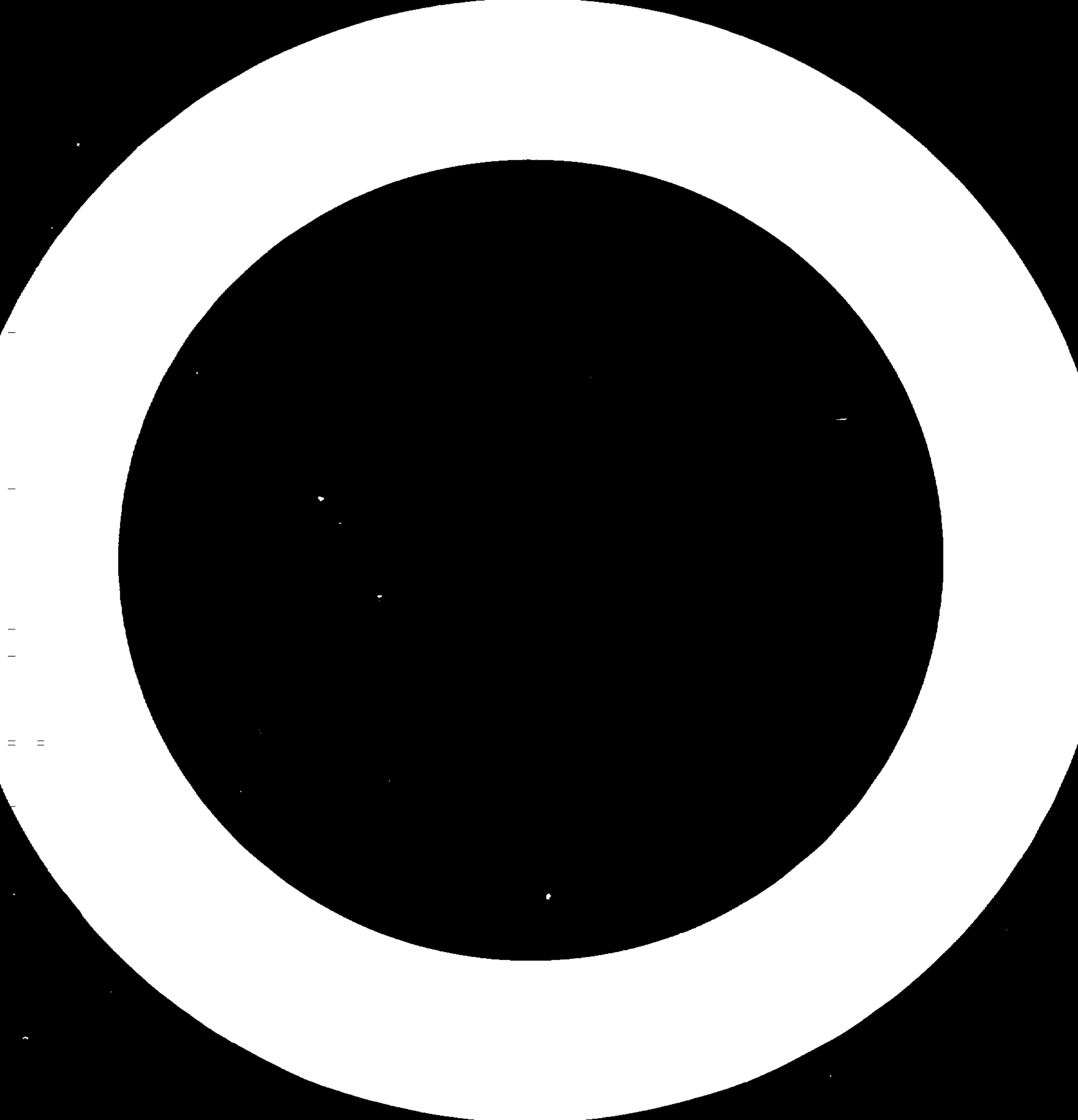
ABSTRACT

An expert was sent to assist the Government of the Socialist People's Libyan Arab Jamahiriya to establish preventive maintenance planning in the mechanical maintenance service of the Benghazi plant of the Libyan Cement Company. The initial mission of TF/LIB/75/002/ 11-02/32.1 was carried out from 7 August 1973 to 7 November 1978. A second part of the mission was carried out during December 1978 and January 1979.

The studies show that the plant equipment is poorly maintained, and that plant repair rates are very high. Reasons for these conditions included insufficient equipment; a dusty and improperly cleaned work environment; infrequent and insufficient equipment inspection; the scarcity of skilled Libyan labour; the irregular availability of Libyan labour; and the linguistic barriers faced by non-Arabic speaking, foreign labour. Preventive maintenence guidelines were established to ascertain whether equipment is to be operated under supplier instructions or under general mechanical engineering rules; to remedy breakdowns and repair damage as quickly as these occur; to programme systematic and periodic equipment overhaul; to decide on a spare part replacement program; and to study other improvements within the plant. Preparation of preventive maintenence planning included the consideration of prior studies at the plant.

A separate task was to prepare a set of check-lists for one of the production lines of the plant. The check-lists are a first step toward the establishment of preventive maintenence schedules in the future. Another task was to assist in an actual overhaul and to prepare and give lectures on preventive maintence planning to the mechanical maintenence staff.

It is recommended that equipment inspection and environment cleaning be given priority in preventive maintenance planning and that preventive maintenance planning be started for other plant maintenance services. It is further recommended that a general production overhaul be undertaken and that preventive maintenance training as well as Arabic instruction for non-Arabic labourers be instituted.



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INTRODUCTION

The mission was accomplished in two stages. The initial stage was of three months duration from 7 August to 7 November 1978. During this period:

(a) The framework, goals and targets of preventive maintenance planning were established;

(b) A check-list for production line I was prepared to allow the plant to begin preventive maintenance planning;

(c) The expert familiarized himself with plant layout and equipment, studied supplier instructions, drawings etc. and visited the production and the auxiliary units of the plant. He also compiled information related to maintenance from other departments of the plant.

In this report the recommendations of Mr A. Madsen, UNIDO expert, and the principles expressed in the training manual of Klöckner Humboldt Deutz Industrieanlagen GmbH (KHD), supplier of the plants of the Libyan Cement Company (LCC), which contains detailed courses on preventive maintenance, have been carefully considered. It should be noted that completion of the main goals of this project, preventive maintenance planning, scheduling, planning for spare part wear and replacement, and maintenance material requirements, require prior steps which are presented as a list of recommendations.

The second stage of the mission was of two months duration beginning 1 December 1978. The expert initially intended to begin the first step of preventive maintenance planning during this period, namely, to gather and compile information on the state of repair of the various units of mechanical equipment of the plant. However, this was not possible, due to a series of external circumstances. Therefore the expert, upon request of LCC:

(a) Assisted the mechanical maintenance service of the Benghazi plant in the preparation for and the actual overhaul of one of the production lines;

(b) Assisted the mechanical maintenance service in planning and executing routine maintenance;

(c) Lectured the mechanical service staff on the principles of preventive maintenance planning, and on overhaul programme preparations;

(d) Studied the problems caused by the cement storage silos and those within the clinker transport system.

I. FINDINGS AND CONCLUSIONS

A. General plant features

The Libyan Cement Company (LCC) was established in 1968 by the Libyan Government which holds 99.4 per cent of the Company's shares. At present, the Company operates in the following plants in the Hawari district of the city of Benghazi:

(a) Two cement plants each of designed annual production capacity of one million tons of cement per year;

(b) One lime plant of designed annual production capacity of 43,000 tons of lime per year;

(c) One clay brick plant of designed annual production capacity of 60,000 tons/year;

(d) One paper bag manufacturing plant of designed annual production capacity of 100,000 bags per day;

(e) One concrete blocks plant of designed annual production capacity of 100,000 cubic meters of finished products per year.

The two independent cement plants of the LCC are located near to each other. They share the same quarry with the lime factory. The cement plants are the Benghazi plant consisting of three independent production lines commissioned in 1972, 1974 and 1977 successively; and the Hawari plant consisting of two identical independent recently commissioned production lines.

The main characteristics of the Benghazi plant are as follows:

(a) All the production lines use dry process technology and were supplied on turnkey contracts basis;

(b) The first production line consists of a kiln of 600 tons/day clinker production design capacity and was supplied by Westfalia Dinnendahl Groppel AG (WEDAG) and commissioned in April 1972;

(c) The second and the third production lines consist of identical kilns of 1,200 tons/day clinker production design capacity and were supplied by Klöckner Humbolt Deutz Industrieanlagen GesmbH (KHD) and commissioned in August 1974 and January 1977 respectively;

(d) The total plant designed capacity for cement grinding is 4,600 tons/day;

(e) The plant's total bag packing capacity, in two shifts, is 6,400 tons/day.

No bottle-necks exist in the flow-sheet of the plant. Some sections have over-capacities, for example, the clinker coolers. This allows kiln production to exceed design capacity.

The storage capacities have been over-designed, particularly for the finished products; such over-design is not necessary in the Libyan Arab Jamahiriya where seasonal sale fluctuations do not exist. However, these over-capacities can give flexibility to the plant in its production and maintenance planning.

B. Benghazi plant efficiency

Although the Benghazi plant was designed to easily produce one million tons of clinker per year, the actual production levels indicate that the effective production of the plant varies between 500 and 600 thousand tons annually. This means that the plant production is between 50 per cent and 60 per cent of designed capacity.

The main reason for such low plant efficiency is that the units of the production lines do not have stabilized, regular production levels. This in turn is due to the very rapid expansion programmes of the Company. Three expansion projects have been started in a period of six years. The rapid succession of new production line commissionings did not allow for or did not give enough time to the plant to stabilize the production levels of its previously commissioned production lines.[1/]

Consequently, at present, the efforts made by the plant in order to obtain the target production level of 1978, which is 75 per cent of the design capacity, are divided among three irregularly producing production lines and the results have not been satisfactory. Production up to the end of September indicates that the 1978 plant production will only reach 60 per cent of its design capacity.

Two tables indicate the change of the production levels over a period of 3 years and 8 months. Table 1 gives for 1975, 1976 and 1977 the output and the working hours of the raw and cement mills and the kilns which are the main production units of the plant. In the same table, for each kiln, yearly production averages and yearly efficiencies related to 330 and 300 working days per year are also given.

It can be clearly seen from the table that the kiln performances have decreased after the third line expansion project, and that the plant efficiency in 1977 was 47 per cent and 52 per cent, respectively, on a 330 and 300 working days basis.

Table 2 gives the output and the work-stop hours of the main production units of the plant for the raw and cement mills and the kilns, and a breakdown of the work-stop hours for the first nine months of 1979. The table shows that the daily production of the kilns is close to their design capacity. On the other hand, however, the kilns work very irregularly.

The work-stop hours of kilns I, II and III amount to 159, 121 and 114 days respectively. Furthermore, these figures will increase during the anticipated three months work-stop.

1/ In addition to cement production lines, the Benghazi plant also operates the lime factory located near the plant that was commissioned in 1975.

Table 1. Benghazi plant production 1975, 1976, 1977

Production unit	Working time (h)			Efficiency[a] on a 330 day basis (%)			Production per hour[b] or day[c]			Total output (tons)		
	1975	1976	1977	1975	1976	1977	1975	1976	1977	1975	1976	1977
Raw mill I	4 110	4 115	3 342	52	52	42	58[b]	57[b]	54[b]	237 539	233 726	181 946
Raw mill II	3 629	2 772	2 598	45	35	32	154[b]	116[b]	109[b]	557 544	321 968	284 283
Raw mill III	___	1 216	2 722		15	34	163[b]	145[b]		___	198 689	396 888
Total	7 739	8 103	8 662							795 183	754 383	863 117
Kiln I	6 050	5 988	5 761	76	75	73	531[c]	548[c]	475[c]	133 970	136 961	114 194
Kiln II	6 075	5 094	4 830	76	64	60	1 203[c]	1 187[c]	1 062[c]	304 555	251 999	213 798
Kiln III	___	1 268	3 120		16	39		1 216[c]	1 098[c]	___	64 278	142 822
Total	12 125	12 350	13 711			47				438 525	453 238	470 814
Cement I	759	792		10	10		45[b]	35[b]	0[b]	34 248	27 671	
Cement II	4 994	2 660	2 901	63	34	37	85[b]	85[b]	65[b]	423 207	226 530	188 686
Cement III	___	1 136	3 830		14	40		88[b]	57[b]	___	99 496	218 987
Total	5 753	4 588	6 731							457 455	353 697	407 673

a/ Efficiency on a 330 day basis is the number of working hours divided by 330 x 24 hours x 100; efficiency on a 300 day basis is the number of working hours divided by 300 x 24 hours x 100.

b/ Production per hour = $\frac{\text{Total output (tons)}}{\text{Working hours}}$

c/ Production per day = $\frac{\text{Total output (tons)}}{\text{Working hours}} \times 24 \frac{\text{hours}}{\text{day}}$

Table 2. Down time of the main production units of the Benghazi plant
(First nine months of 1978)

Production unit	Mechanical hours	Electrical hours	Production hours	Miscellaneous hours	Total hours	Efficiency a/ % 330 days	Efficiency a/ % 300 days
Raw mill I	349	37	4 537	-	4 923	-	-
Raw mill II	1 032	149	3 336	-	4 517	-	-
Raw mill III	762	160	2 812	-	3 734	-	-
Arithmetic mean (1)	714	115	3 582		4 411	-	-
Weighted mean (2)	787	131	3 366		4 284	-	-
Kiln I	1 838	170	1 759	51	3 818	52	47
Kiln II	1 042	134	1 753	49	2 978	62	59
Kiln III	533	191	1 984	31	2 739	66	62
Arithmetic mean (1)	737	165	1 832	49	3 783	52	47
Weighted mean (2)	978	164	1 847	42	3 031	61	58
Cement mill I	-	-	7 920	-	7 920		
Cement mill II	861	140	3 279	-	4 280	45	41
Cement mill III	660	79	3 473	-	4 212	46	41
Arithmetic mean (1)	761	101	4 890	-	5 751	27	20
Weighted mean (2)	761	101	4 285	-	5 147	35	28

Note (1) The arithmetic mean is the sum of down times divided by the number of production units.

(2) The weighted mean is arrived at by the formulae:

Weighted mean = $h_1 \times 0.2 \times h_2 \times 0.4 \times h_3 \times 0.4$ where h_1 = output of production unit I

h_2 = output of production unit II

h_3 = output of production unit III

a/ Efficiency (330 days) = $\frac{(330 \text{ days} \times 24 \text{ hours}) - (\text{down time})}{330 \text{ days} \times 24 \text{ hours}}$

efficiency (300 days) = $\frac{(300 \text{ days} \times 24 \text{ hours}) - (\text{down time})}{300 \text{ days} \times 24 \text{ hours}}$

It is to be noted that in the cement industry a commonly accepted industry figure for kiln work-stoppage including time for overhauls is 30 days per year. Experience has shown that this figure may reach 60 days in countries where the cement industry is being established.

C. Plant inspection

In general, production line equipment and auxiliary section equipment is not inspected efficiently by either the production or the maintenance services.

Production operators, who run the production sections from central panels, rely on the remote control devices of the panels and do not systematically inspect the production units and the equipment performance. On the other hand, maintenance teams, who are overburdened with daily repair work, have no time left to systematically inspect the equipment.

As a result, production sections stop because of equipment malfunction or breakdowns and the maintenance services are then even more overburdened with repair jobs.

In fact, most equipment malfunction or breakdown is not and cannot be indicated in the sections' central panels. Thus raw material wastage, piping leaks, loose foundation bolts, equipment overheating, noise and vibration are only revealed after breakdown of the equipment or production unit stoppage. Furthermore, a general annual examination of the production line or overhaul with complete investigation of the state of equipment is not carried out in the Benghazi plant. Thus small equipment defects which can only be revealed by thorough inspection during overhaul remain unnoticed till they cause serious damage and production unit stoppage.

Moreover, cleaning the equipment and of the environment surrounding the equipment is not systematically undertaken by the plant. Dust and other material coming from leaks harms the equipment and makes inspections difficult or even impossible.

D. Plant labour force

There is a limited amount of skilled and unskilled Libyan labour available. Therefore, the Company uses foreign labourers to fulfil the plants labour requirements. Table 3 shows the distribution of labourers within the plant as of the end of 1977.

Table 3. LCC Benghazi plant staffing
(31 December 1977)

Section	Supervisors			Labourers			Entire staff		
	Libyan	Foreign	Total	Libyan	Foreign	Total	Libyan	Foreign	Total
Production									
Supervisors	6		6				6		6
Quarries	2	1	3	80	7	87	82	8	90
Kilns	1	2	3	65	6	71	66	8	74
Grinding	1		1	76	5	81	77	5	82
Packing	2		2	65	1	66	67	1	68
Laboratory	2	—	2	36	—	36	38	—	38
Total production	14	3	17	322	19	341	336	22	358
Maintenance and transport									
Mechanical	2	1	3	57	20	77	59	21	80
Workshop		1	1	76	14	90	76	15	91
Electrical	2		2	26	9	35	28	9	37
Transport and operation	4	—	4	87	3	90	91	3	94
Total maintenance and transport	8	2	10	246	46	292	254	48	302
Miscellaneous				30		30	30		30
Plant total	22	5	27	598	65	663	620	70	690
Management									
Management and advisors	4	2	6				4	2	6
Administrative department	3		3	36	4	40	39	4	43
Financial department	3		3	15	6	21	18	6	24
Commercial department	3	—	3	32	3	35	35	3	38
Total management	13	2	15	83	13	96	96	15	111
Company total	35	7	42	681	78	759	716	85	801

At first sight the number of labourers seems to be very high. 801 labourers and staff is large when the plant capacity, conception and layout are considered. A similar plant of international standard would require a maximum of 400 labourers and staff.

However, when the inefficiency of the labourers and staff, the high absentee rates of the Libyan labourers (which may reach 40 per cent), the linguistic barriers faced by the non-Arabic foreign labourers, and the different aptitudes and working methods of all the foreign labourers is taken into account, it is understandable that even with such a large labour force the plant may still have difficulties in meeting its labour requirements.

The senior staff and foremen of the plant consist of intensively trained Libyans and of experienced foreigners. It is difficult for the company to find interim staff to replace trained Libyans during their long military service and to get experienced foreign engineers and foremen.

E. Overall plant maintenance

The maintenance of the Benghazi plant is carried out as follows:

(a) The maintenance of all the mechanical equipment for the production lines and auxiliary departments such as fuel oil storage and distribution, water supply etc. as well as the maintenance of buildings and plant premises are carried out by the mechanical maintenance service of the Benghazi plant. The service is headed by a mechanical engineer and has one mechanical workshop and one woodworking shop;

(b) The maintenance of all electrical equipment for power supply and distribution of production lines and auxiliary departments, including control and measure instruments as well as electronic devices, is carried out by the Benghazi electrical maintenance section, a subdivision of the Company's electrical maintenance service, which has also the responsibility of the electrical maintenance of the Company's Hawari plant. The section is headed by an electrical engineer and has one small workshop;

(c) The maintenance of all earth moving, heavy transport and material handling equipment of both plants, and of all the Company's cars, mobile compressors and combustion engines is carried out by the Company's transport service which has also the responsibility for raw material handling and personnel transport. The service is headed by an engineer and has one workshop for servicing mobile equipment.

The Company's electrical maintenance and transport services share the mechanical workshop as well as its staff for maintenance and repair works.

The mechanical maintenance service and the electrical maintenance section also have responsibility for the mechanical and electrical maintenance of the lime factory.

F. Plant mechanical maintenance

The mechanical maintenance service of the Benghazi plant, which has the responsibility for the maintenance of the plant's mechanical equipment, has 70 workers. The service has one mechanical workshop and one woodworking shop which have a total of 80 more workers. Duties of the staff of the service and workshops as well as the specifications of main machines of the workshop are given in annex II.

Annex II shows that maintenance service and workshops have a relatively large labour force, if the plant's layout consisting of three new nearly identical modern and well equipped production lines is considered. On the other hand, the annex shows that the labour force is short of foremen, team leaders, clerks and draughtsmen. The workshop of the plant is adequately equipped for the usual plant repairs. However, the addition of a new lathe of bigger turning diameter and a planing machine of bigger planing stroke would increase the repair capability of the workshop.

Concerning the staff shortage, the service manager notes that the service faces difficulties in finding supervisory personnel who in addition to having technical skills must also have a good knowledge of Arabic and English.

The service is overburdened by daily repair jobs of the plant. There is not enough time left to inspect the plant and to plan regular preventive maintenance.

In fact, down time on the kilns for only mechanical repairs amounted to 131 days in the first nine months of 1978. Those of the raw and cement mills add up to 90 and 66 days respectively. The packing plant is kept running 24 hours per day by 3 repair shifts of the maintenance service. Details of this stoppage together with those resulting from other reasons are given in table 2.

The extent of these repairs is easily seen from the operational cost of the plant. A brief analysis of the costs of the three previous years indicate that the maintenance cost (which includes electrical maintenance and excludes packing plant and transport equipment maintenance) is more than 20 per cent of the total operational cost. The main reason for such a high repair rate is insufficient routine inspection and repair of equipment.

Though the maintenance service keeps teams in each section of the production line for equipment inspection, the time required for daily repair jobs does not allow the teams to regularly perform their inspection tasks. Insufficient cleaning of the equipment and of the surrounding environment makes inspection of the equipment difficult, and even sometimes impossible.

Lubrication of plant equipment, which is also the responsibility of the maintenance service, is carried out by a special team of greasers, and they face the same difficulties that the inspection teams face.

In order to plan preventive maintenance and to supervise the lubrication of plant equipment the maintenance service has established a system of equipment data registry cards and cards recording periodic lubrication. Unfortunately both of the systems, which are very well prepared, are not working satisfactorily The systems do not receive adequate information and they are not kept current. This is because the service lacks a sufficient number of foremen and clerks who have the technical knowledge to use the system properly.

As a result and because of other plant circumstances (three lines, speed expansion, inadequate plant inspection etc.), and because of staff shortage the maintenance service of the plant is more involved in repair work than in its main task which is the preventive maintenance of the plant.

G. Preventive maintenance planning targets

The aim of the plant is to produce as much cement of acceptable standard as possible; to do so on a regular basis, and at minimum cost. To attain this goal, the production sections and the services of the plant must adjust their programmes and organize their activities accordingly.

The aim of the mechanical maintenance service is to keep the plant equipment in good condition and working regularly, so as to perform its designed tasks, and to prevent costly repairs. The service can reach this aim by organizing and implementing appropriate preventive maintenance planning.

The preventive maintenance service of the Company's Benghazi plant must perform regular, periodic and systematic inspections and keep records of the state of plant equipment.

The following five specific tasks must be accomplished in order to satisfactorily perform preventive maintenance:

(a) The determination of whether mechanical equipment is to meet standards set by the supplier and/or standards of general mechanical engineering rules;

(b) The repair of equipment failure and damage as soon as it occurs;

(c) The programming of systematic and periodic equipment servicing and overhauls;

(d) The establishment of spare part requirements;

(e) The study of continuing improvements within the plant.

The implementation of preventive maintenance should be done by a central office which has engineers, foremen, draughtsmen and clerks who would perform registry and administrative tasks. Teams of checkers or inspectors consisting of foremen and trained fitters performing inspections within the plant would supplement the central office.

A scheme indicating preventive maintenance process and tasks of the central office is given in annex III. The main tasks of the central office would be:

(a) To prepare from supplier instructions or mechanical engineering general rules weekly department check-lists, equipment standstill check-lists, and an equipment periodic check-list;

(b) To evaluate checked lists and then issue job orders, interservice notes and new periodic check-lists;

(c) To evaluate performed job orders and then register performed jobs in the life card of equipment, issue, interservice notes and issue new periodic check-lists;

(d) To file all issued periodic cards in periodic card timing files, in periodic card item files and in periodic card issue date files;

(e) To schedule daily checks from periodic time files and standstill checks from equipment files and to issue job orders and interservice notes;

(f) To prepare overhauls and spare part requirement programmes from equipment life cards and from standstill files.

H. <u>Preparation for preventive maintenance planning</u>

The purpose of this mission was to assist the Mechanical Maintenance Service of the plant to establish and implement programmes for preventive maintenance planning.

The first step of preventive maintenance planning was that of obtaining and recording information on the state of repair of the mechanical equipment units of one production line of eight sections.

Forms for recording information on the state of the production line's mechanical equipment had been prepared during an earlier mission. The forms had to be reviewed by the management of the maintenance service and then be translated, typewritten and photocopied.

Personnel required to gather and record data could have been trained on the spot with the photocopied forms. A period of eight weeks would normally have been sufficient to complete these programmes. Unfortunately difficulties arose during the beginning of the extension period of the mission, in December 1978, because of plant inventories which had to be taken before the end of the year. Further obstacles to implementation resulted from general restlessness due to uncertainties in obtaining release from military services for most of the leading staff of the plant. These releases were finally obtained on the last day of December. Thus the information gathering and registering programme was delayed. During January 1979, unavailability of dynamite caused the shut-down of all the LCC kilns. At that time it was decided to overhaul one of the production lines and to repair and provide preventive maintenance for other lines.

This work overburdened the Mechanical Maintenance Service and delayed, once more, the implementation of preventive maintenance planning. For this reason the preventive maintenance planning programme was limited to lectures on maintenance procedures and on cement plant overhaul programme planning.

I. Production line I overhaul

The overhaul of the production line I had not originally been part of the scheduled work. Thus planning and implementation of the overhaul proceeded step by step. During overhaul of the line, the expert assisted and advised the Mechanical Maintenance Service as well as the Electrical Maintenance and Production Services of the plant on preparations for their overhaul programmes, and inspected the overhaul.

A special report including work progress, findings and recommendations on the overhaul has been submitted to the Company. This report is summarized in annex VI.

J. Plant cement storage silos

The plant has three large cement silos of 6,000 tons storage capacity each. Hardened cement crust formations have been formed on the walls of the silos and the silos are clogged; these silos, which are estimated to be clogged with 10,000 tons of cement, are out of service. Cleaning attempts made by the plant have not been successful.

At present, the plant is facing difficulties in storing all of its cement production in the remaining four small storage silos. The small silos, of only 1,750 tons each, are not large enough to provide sufficient storage for plant cement production sales. The expert studied this problem and submitted to the Company a special report including findings and recommendations. This work is summarized in annex VIII.

K. Plant clinker transport system

The clinker transport system of the Benghazi plant is a bottle-neck in the production stream of the plant. The system does not allow sufficient time for preventive maintenance. The clinker transport system poses serious environmental hazards. As a result both the maintenance and production service cannot perform their tasks properly. Findings and recommendations regarding this problem were submitted to the Company and are summarized in annex VII.

II. RECOMMENDATIONS

The following recommendations are based on the findings and conclusions of this report:

1. The maintenance service of the Benghazi plant has established periodic card and equipment life card systems for lubrication which are not used properly because of lack of personnel trained to use them. This personnel must be trained to properly use the system and to keep very valuable information of state and requirements of the production line equipment current.

2. Suitable offices and facilities have to be provided in order that the service may establish its preventive maintenance planning office. In this office technical documentation, drawings etc. may be stored; and all filing, registry and planning related to preventive maintenance jobs must be done.

3. After these two recommendations are implemented, the actual preventive maintenance planning should be begun by adding two foremen, two clerks and one draughtsman to the preventive maintenance service.

4. It will then be necessary to improve the existing lubrication schedule using the existing periodic card system. This will ensure that the preventive maintenance staff will not be overburdened with minor routine tasks and allow its staff to perform their main tasks more efficiently.

5. Periodic maintenance equipment life cards etc. for preventive maintenance planning of the Benghazi plant should be made to conform with those of the Hawari Plant Mechanical Maintenance Service. The Hawari Plant cards have been prepared and printed by Mr. Madsen, UNIDO expert.

6. The description of production line items and the classification of technical documents and drawings etc. should be carried under a single principle to be established by the mechanical maintenance services both plants.

7. Exchange of information between company's plants, which is very important for both maintenance services and for the company as a whole, should be begun. This will require transfer of data from old cards to a set of new cards. To facilitate this task, which otherwise might prove to be overwhelming, it will be necessary to attach the old cards to the new ones.

8. The personnel to be assigned to the preventive maintenance planning office as well as to its inspection teams should not take part in any other activities of the maintenance service and of the plant as well. The personnel, before undertaking their jobs, should be intensively trained on maintenance procedures. Such training course exists in KHD Technical Training Manual.

9. Priority should be given to systematic weekly inspection and to annual planning for general production line equipment overhaul. These steps are the very heart of the preventive maintenance planning in the cement industry.

10. As a first step in the establishment of preventive maintenance planning in the Benghazi plant's mechanical maintenance service, to begin training of service teams in maintenance procedures, and most importantly to ensure inspection of the production line equipment, a weekly check of production line units should be carried out by the existing personnel of the maintenance service of the Benghazi plant.

11. Check-lists, as shown in annex IV, should be used. These will enable the plant to take a beginning step in the establishment of the preventive maintenance planning. The expert has prepared complete check-lists for the six sections of production line III, starting with its crushers up to its clinker storage. These check-lists aim to ascertain whether the section's equipment is functioning under supplier instructions and/or mechanical engineering general rules, and relate to all of the section's equipment. For each piece of equipment there are empty comment blanks to be filled by check-maker, for visible (leak, level, line etc.), audible (noise, vibrations etc.) and its manually sensible (vibration, heat) state of repair.

12. Priority should be given to equipment and to cleaning the surrounding environment.

13. Similar preventive maintenance programmes should also be undertaken in the other maintenance services of the plant.

14. General overhauls of the production unit should be planned.

15. Arabic courses for non-Arabic labourers should be begun.

16. The commissioning of the Company's Hawari cement plant in August 1978 enabled the Company to fulfil all the cement demand of the sector, to build up reserve clinker stock for both plants and to generally assist Benghazi plant operations by providing production flexibility. The Benghazi plant should take advantage of this opportunity to plan the complete overhaul of all production lines to stabilize the output of production units and to establish preventive maintenance planning.

Annex I

JOB DESCRIPTION

POST TITLE	Mechanical engineer for maintenance planning in the cement industry
DURATION	Twelve months; possibly in several short missions
DATE REQUIRED	As soon as possible
DUTY STATION	Benghazi
DUTIES	The expert will be assigned to the Libyan Cement Company and will assist the cement industry in the Benghazi area. The expert will work on the shift system and will specifically be expected to:

1. Study procedures of preventive maintenance and conclusion of systems capable of its rationalization.
2. Study records maintained for machinery and equipment, analysis of particulars recorded about life history of each part and average consumption of spares and maintenance material.
3. Study technical documents, drawings, suppliers' instructions and establishment of security fundamentals for machinery and equipment.
4. Study procedures for oiling and greasing, revision of specifications for oils and greases and analysis of circumstances of operation and maintenance.
5. Apply thes findings to planning preventive maintenance and its organization over time units.
6. Programme oiling and greasing procedures, oil changes, tabulation of oil and greases with running hours.
7. Simplify reference numbers for greases and oils, unifying the distinguishing marks and specifications for rational application of local products.
8. Keep records for applied spare parts for conclusion of average consumption and analysis of anomalies in machine life.
9. Revise reference numbers and technical specifications of spare parts for simplification of nomenclature to comprehensive marking.
10. Stipulate basic substantials for spares and production materials in terms of minimum, maximum and ordering stocks.
11. Programme systematic supplies of spares and production materials and establish follow-up system for the whole cycle.

12. Inspect work sections for revision of execution, analyse occasional difficulties and propose suitable solutions.

QUALIFICATIONS

University degree in mechanical engineering with extensive experience in planning for mechanical maintenance and organization of spare parts in cement industry.

LANGUAGE

English

BACKGROUND INFORMATION

The development of the building materials industry started in Benghazi by installation of the cement works in Hawari which was put into operation in 1972, with 200,000 tons annual production capacity. Vast extensions have been realized that raise the production capacity up to 2 million tons per year. Furthermore, several building materials industries are being installed, for production of building lime, ceramic bricks, concrete blocks and cement products, in addition to production of paper bags for packing of cement and lime.

The rapid growth of industries in general and in particular the cement manufacturing area with its subsequent industrial extensions, has led to this request for technical assistance. It is expected that through such assistance appropriate cement industry personnel will be fully trained, enabling them to ensure the required daily production output.

Annex II

DUTIES OF THE STAFF OF THE MECHANICAL MAINTENANCE SERVICE

Mechanical maintenance and workshop staffs

1 mechanical maintenance chief engineer

1 mechanical maintenance assistant engineer

1 mechanical maintenance foreman

1 mechanical maintenance clerk

1 mechanical workshop foreman

1 mechanical workshop clerk

1 mechanical woodwork foreman

Worker qualifications

Duty	Maintenance	Workshop	Total
Fitters	20	5	25
Helpers	25	10	35
Welders	4	15	19
Helpers	4	15	19
Compressor mechanics	2	-	2
Helpers	1	-	1
Turners	-	9	9
Helpers	-	6	6
Tool keepers	-	4	4
Blacksmiths	-	4	4
Helpers	-	2	2
Plumbers	-	2	2
Helpers	-	2	2
Greasers	14	-	14
Wood workers	-	6	6
Total	70	80	150

Workshop equipment

1 lathe, length 3,000 mm. Working swing of 400 to 500 mm.

2 lathes,length 1,500 mm. Working swing of 250 to 300 mm.

1 vertical drill, height 2,000 mm.

1 planing machine, stoke 300 mm.

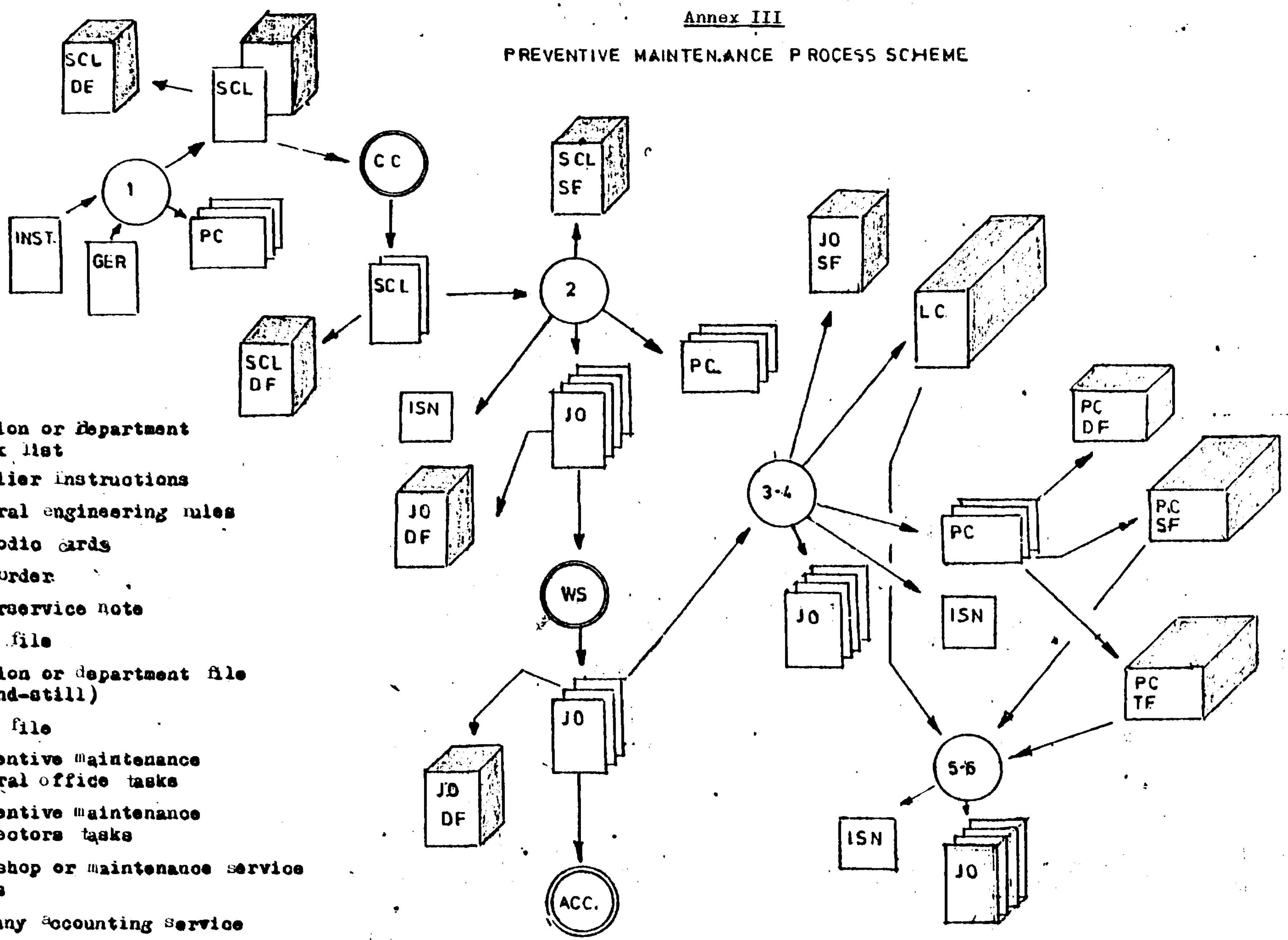
1 milling machine, height 250 mm.

1 universal shear.

1 plate bending machine, length 3,000 mm.

Annex III

PREVENTIVE MAINTENANCE PROCESS SCHEME



Key:

SCL	Section or department check list
INST	Supplier instructions
GER	General engineering rules
PC	Periodic cards
JO	Job order
ISN	Interservice note
DF	Date file
SF	Section or department file (Stand-still)
TF	Time file
(1-6)	Preventive maintenance central office tasks
CC	Preventive maintenance inspectors tasks
WS	Workshop or maintenance service teams
ACC	Company accounting service

Annex IV

SAMPLE CHECK-LIST FROM PRODUCTION LINE III

Limestone crushing plant

Abbreviations:

DIST.	Distribution
PIT.	Pittings
COM.	Comments
TEN.	Tension
GREA.	Grease
O. LEVEL	Oil level
O. LEAK	Oil leak
TIGH.	Tight
TURN.	Turning
VIB.	Vibrations
FC.	Further check is required
UC.	Urgent check is required
S.	Have to be stopped

These lists are prepared as basis for the implementation list. Item numbers are those of KHD, supplier of the plant.

Limited printing of the lists is recommended as they will be modified with experience.

LIMESTONE CRUSHING PLANT No. (1-2)-(3) CHECK DATE

ITEM. NO.	ITEM.		OK	FC	UC	S	OBSERVATION	RESULT
1.B 1	BUILDING	COM.						
1.L	LIGHTING	COM.						
1.01	BIN STEEL CONSTRUCTION	COM.						
1.02	PLATE FEEDER - BODY	COM.						
1.02.01/03. (03.03)	GEARBOX	VIB.						
		NOISE						
		HEAT						
		O.LEV.						
		O.LEAK						
1.02.02	COUPLING-GEAR-FEEDER	COM.						
1.02.03	COUPLING-MOTOR-PIV	COM.						
1.02.04 (03.05)	PIV VARIATOR	VIB.						
		NOISE						
		HEAT						
		O.LEV.						
		O.LEAK						
1.02.05 (03.04)	PIV COUPLING-PIV-GEAR	COM.						
1.02.06-7-8	FIRST SHAFT ROLLERS	HEAT						
		VIB.						
1.02.09-10-11	DRIVE-SHAFT-ROLLERS	HEAT						
		VIB.						
1.02.12	CHAIN DRIVE WHEEL	LINE						
		WEAR						
1.02.13-14	SPUR WHEEL & PIGNON	OIL						
		VIB.						
1.02.15-17-18-25	REVERSING SHAFT ROLLERS	HEAT						
		NOISE						
1.02.16	CHAIN WHEEL TENSION	LINE						
		WEAR						
1.02.19-20-21	TENSION SPRINGS	TIGHT						

-2-

ITEM. No.	ITEM.		OK	FC	U C	S	OBSERVATION	RESULT
1.02.22-24	CHAIN ROLLERS	TURN						
		WEAR						
		GREAS						
	RAILS	WEAR						
		BEND						
	PLATES	BEND						
1.02.18.25	CARRYING ROLLERS	GREAS						
		WEAR						
		TURN.						
1.02	PLATE	BEND						
		WEAR						
1.04.01	GREASE PUMP	LEAK						
		PRES.						
1.05	HAMMER CRUSHER BODY	COM.						
.06	ROLLERS DRIVE SIDE	GREAS						
		HEAT						
		VIB.						
	ROLLERS OTHER SIDE	GREAS						
		HEAT						
		VIB.						
	COUPLING	O.LEAK						
		HEAT						
	V-BELTS	TENS.						
		WEAR						
		TEAR.						
1.08	BAG FILTER	COM.						
	PIPINGS-CURTAINS	LEAK						
	STUCK	DUST						
1.08.04.11	VIBRATORS & SPRINGS	VIB.						
	COMMANDS	COM.						
1.08.03	SCREW CONVEYOR							
	ROLLERS	HEAT						
		VIB.						
		GREAS						

ITEM. NO.	ITEM.		OK	FC	UC	S	OBSERVATION	RESULT
.18	COUPLING	COM.						
	GEAR	O.LEV.						
	CHAIN & WHEELS	WEAR						
		GREAS						
	VENTILATOR BODY	COM.						
	SHAFT & ROLLER	VIB.						
		GREAS						
	V-BELTS	WEAR						
		TENS.						
1.15	WATER PUMP	VIB.						
1.18	ELECTRO MAGNET							
	ROLLERS	HEAT						
	BELT	WEAR						
		TEAR						
1.13	ELECTRICAL ROPE HOIST	COM.						
	CABLE	WEAR						
		TEAR						
	GREASE PUMP	COM.						
	PIPINGS GREASE	LEAK						
		PRES.						
.01	DUST SLUICE	NOISE						
		GREA.						

NAME OF THE CHECKER : ____________________

CHECK DATE : ____________________

SIGNATURE : ____________________

COMMENTS :

SERVICE COMMENTS :

Annex V

OFFICIALS OF THE LIBYAN CEMENT COMPANY MET DURING THE MISSION

Ali M. El-Gheriani, General Manager
Mohammed El-Neihum, Deputy General Manager
Abubaker Saitani, Production Service Chief
Essam Shehadeh, Benghazi Maintenance Service Chief
Mustafa Taema, Benghazi Maintenance Service Engineer
Hussain Feituri, Transport Service Chief
Ahmed Berruin, Hawari Maintenance Service Chief
Mohammed Berruin, Commercial Service Chief

Annex VI

OVERHAUL OF PRODUCTION LINE I

A. General considerations

The overhaul of the production line I was carried out by the mechanical and electrical maintenance and the production services of the Benghazi cement plant in January 1979. It had not been previously scheduled. It was done to bring into profitable use the time during the long kiln stoppages which occured in the first days of 1979 because of raw material shortages resulting from the unavailability of dynamite.

The work programmes of the overhaul were established soon after the decision to begin work. The overhaul was expected to take one month.

B. Overhaul programmes

The overhaul work programme predicted by the Benghazi mechanical and electrical maintenance and the production services was as follows:

1. Mechanical maintenance service overhaul programme

The work programmes foreseen by the mechanical maintenance service, which fixed the duration of the whole overhaul, consisted of big-scale repair jobs and jobs of preventive maintenance.

The big-scale repair jobs were:

(a) Repair of the kiln cooler deduster multicyclones, "Tubix", which were worn out;

(b) Repair of the ventilator fan of the deduster, and of the controls of the ventilator body, the expansion joints, flaps and the drive system;

(c) Overhaul of the first compartment of the kiln clinker cooler including replacement of the main drive shaft of the cooler which had been temporary repaired in the plant workshop;

(d) Repair of the kiln inlet seal. Replacement of the worn-out pieces and plates.

The spare parts for the above jobs were in the plant stores.

The preventive maintenance jobs were:

(a) Checking and repair of all equipment of the raw material transport and storage, the raw material grinding, the raw material transport and storage, kiln and preheater, clinker cooler and clinker storage and transport sections. Replacements were made where necessary;

(b) Testing and maintenance of all water, oil, compressed air pipings and their accessories including pumps and compressors of the aforesaid sections.

Among these preventive maintenance jobs, those involving the raw material transport and storage sections were planned to be carried out while the sections were operating. These sections could not be stopped for long times. The raw material transport and storage sections had to supply the lime factory with lime and all LCC cement mills with gypsum. The clinker transport and storage sections had to supply the same mills with clinker.

2. Electrical maintenance service overhaul programmes

The work programmes planned by the electrical maintenance service consisted of: cleaning and checking of all electrical power, control and command panels; and cleaning and checking of all electrical motors and instruments of production line I.

3. Production service overhaul programmes

The work programmes planned by the production service were:

(a) To lay refractory bricks in a radius of approximately 10 m around the burning zone of the kiln;

(b) To check all refractory bricks of the production line I, the kiln, clinker cooler, heat generator, cyclones and cyclone pipings;

(c) To clean all sections of the production line, particulary the raw mix transport and storage section and to clean the underground floor and the clinker transport and storage section where huge quantities or raw mix and clinker respectively had accumulated. Cleanings of the storage sections were not planned to be done during the overhaul period. Instead, during overhauls, cleaning team efforts would be concentrated at points where maintenance services have a task to perform.

C. Production line I section not included in the overhaul programmes

As mentioned in the beginning of this report, the overhaul of production line I has not been originally planned. Because of this a few sections of the line could not be included in the overhaul work programmes. These sections were:

1. The limestone crushing section of the line

The crusher, the crusher bin and especially the crusher apron conveyor are in very poor mechanical condition. The section may break down at any time. It needs a complete overhaul.

As the section must also supply production line II and the lime factory with limestone and the Benghazi and Hawari cement mills with gypsum, its overhaul should be undertaken after a stockpile of limestone and gypsum supplies sufficient to cover the requrement of the LCC cement mills in gypsum and sufficient to cover the limestone needs of production line I. During its overhaul the lime factory would stop and production line II limestone needs could be supplied by production line III.

Thus the overhaul of this section should be planned to be done in the shortest time, preferably during the overhaul of line II.

The required spare parts for this overhaul are already in the stores of the plant.

2. The clay crushing section

The crusher itself and its apron conveyor are in poor mechanical condition. This section needs a complete overhaul which should be undertaken any time after that of the limestone crushing section. The overhaul could use the reconditioned spare parts of the latter said section.

3. The raw mix storage section

The cleaning and the checking of the storage and homogenization silos should be undertaken during the operation of the kiln by successively emptying the silos.

D. Overhaul of the production line I

The mechanical service overhaul work programmes' big-scale repair jobs have been carried out by service teams assigned to these jobs. Overhaul programmes' preventive maintenance jobs have been done by routine maintenance teams. Overhaul of the line's sections and water, oil and compressed air systems has been done by the workshop specialists.

The maintenance jobs have not been continuously and systematically performed. This is because the teams also had the task of inspecting the producing units of their section which include three production lines, and the task of carrying out emergency jobs which arose in these and other sections where the maintenance service faced labour shortages.

The electrical maintenance service overhaul work programme, which consisted only of preventive maintenance jobs, was carried out by the service maintenance team who had also the task of inspecting all producing units of the Benghazi plant and the plant electrical power distribution.

Consequently, the overhaul programme has been split with other work. Thus it has not been systematically performed.

The implementation of the product service overhaul work programme was carried out by the production line I operating team and by cleaning teams.

E.- Preventive maintenance work partially or not performed during overhaul

During implementation of the mechanical service overhaul work programme's preventive maintenance jobs, because of labour shortages, spare parts non-availability or for other reasons, the following works have been partially performed or not handled at all:

(a) The apron feeder of the raw mill (for clay) was partially repaired. The apron feeder is in bad working condition, all its plates chains have to be repaired and its body and bin have to be overhauled. The required spare parts for this overhaul are already ordered and are expected to be in plant store in March. During the overhaul of the line the feeder was repaired;

(b) The kiln raw mix bucket elevator was partially repaired. The elevator bottom pulleys have not been adjusted because the bottom level of the elevator was not sufficiently cleaned to allow the maintenance team to do this;

(c) The clinker transport bucket elevators have also been partially overhauled. Their bottom levels are still covered with clinker. Cleaning continues in both raw mix and clinker elevators at ground levels. Overhaul of the elevators will be done after these cleanings;

(d) The cleaning and the adjustment of the main mechanical components as gears, cog wheels and their pinions, shaft and bearings, mill neck bearings, kiln rollers, roller bearings, tyres and drive system, water, oil and compressed air pipings and their accessories, raw material and clinker sluice-gates and flaps, gas piping and ventilator flaps etc. was not done during overhaul. These inspections and cleanings, which are normally carried out during overhaul by labourers under the supervision of maintenance service fitters, are the very heart of the preventive maintenance planning;

(e) The kiln body tyres and rollers and mills bearings alignment inspections checks were not done during the overhaul. No data was available from earlier checks;

(f) Inspection and maintenance of civil engineering works as channels, roads, silos etc. and of buildings roofs, windows, stairs etc. were not done.

F. Comments on production line big-scale repair works

After examining the state of the worn-out spare parts which were repaired during the big repair jobs of the line I overhaul, the following observations can be made on spare part wear and unit operations:

1. Clinker cooler deduster

Wear of the multicyclones of the third section of the clinker cooler is greater than that of the other two sections. Wear gradually increases from the first to the third section.

It can be concluded that the gases to be dedusted are not equally distributed to the three sections of the deduster. This may happen because of the design of the deduster, or because of the adjustment of the deduster flaps. In the first case, during operation of the kiln, the flow of the gases to be dedusted must be gradually increased to the first and second multicyclones, while recuperated clinker dust quantities must be measured so as to obtain equal dust recuperations in the third section of the deduster.

2. Deduster ventilator fan

The abnormal wear of the ventilator fan of the clinker cooler deduster is the result of the abnormal wear of the deduster third section multicyclones.

3. Kiln inlet seal

The kiln inlet seal spare parts wear relatively quickly. After maintenance service they lost approximately three months; indicate that kiln while its running has tendency to climb.

During operation of kiln the lubrication and the inclination of the rollers have to be carefully inspected to allow the kiln to run more smoothly.

G. Difficulties faced during overhaul

The difficulties faced by the plant services during the overhaul can be classified as follows:

(a) Overhaul planning difficulties. As the overhaul of the line had not been previously studied or planned, the overhaul work programmes of the services were established without general guidelines. Thus work began without general guidelines. The services were overburdened by daily jobs and faced difficulties in preparing detailed work programmes, including manpower distribution, spare part requirement etc.:

(b) Labour shortage difficulties. The overhaul was carried out while other lines were in production. These lines required daily teams, and thus labour available for the overhaul was limited. This labour limitation has limited the overhaul programme. Moreover, emergencies occurring in the producing units disturbed the programmes already established and delayed the work;

(c) Spare parts availability difficulties. The unavailability of some spare parts in the store of the plant postponed a few work programmes of the overhaul. Futhermore, the shortage of acetylene and oxygen, which occurred during overhaul, delayed the programmes.

H. Conclusion

Overhaul of the production line I was of necessity undertaken without having been previously studied and scheduled. This overhaul, if complete, could have increased the efficiency of the line and would have reduced line stoppages. However, the overhaul was not complete, and the production line has many weak points, which still can cause its partial or total breakdown. These weak points have to be seriously monitored during the operation of the line.

Annex VII

CLINKER TRANSPORT AND STORAGE

A. General clinker transport considerations

The clinker transport system of the Benghazi plant is a major bottleneck in the production line and it decreases the clinker and the cement production of the plant. This remains an unsolved problem which began during the last plant extension.

The clinker transport system, apart from its kiln number three clinker storage hall section, is designed to provide flexibility for the production and maintenance services in the accomplishment of their tasks. In fact, all transport equipment is duplicated and each has a designed transport capacity which can easily handle the produced clinker quantities. There is the capability of switching the material flow from one transport to another.

On the other hand, due to dirty surrounding environment conditions and to frequent failures and of improper disposition of transportation equipment, the production and maintenance services of the plant face difficulties in getting regular and sufficient quantities of clinker to cover the plant requirements. These dirty conditions and frequent failures adversely affect the ability to do preventive maintenance and perform transportation repairs.

The guidelines of a programme for improving the clinker transport system can easily be established by a brief review of the causes of system failure.

B. Causes of system failure

The causes of system failure are:

(a) The overload of transports (bucket and belt conveyors and elevators) from time to time by clinker flow surges resulting from kiln production fluctuations or changes in the physical properties of stored clinkers;

(b) The inability of panel operators to take preventive measures to reduce surges (reduction in the speeder frequency of the kiln cooler grate and reclaim vibrators) before the surges reach the elevators and over-load them. Among the transport, only the elevators have ammeters on panels which inform panel operators of overloads;

(c) The accumulation of large quantities of clinker which have fallen from transports during surges. Fallen material harms the working parts of the transport and makes access to transports as well as to other equipment of sections difficult;

(d) The removal of clinker debris is hampered by poor environmental conditions, by access difficulties resulting from residual clinker debris and dust from past surges, from equipment failures or leaks and by non-stop use of the production line;

(e) The maintenance of the sections is hindered by a dirty working environment and difficult of access;

(f) The cleaning and maintenance difficulties in turn worsen the environment conditions of the section and cause new failures and new clinker and dust accumulations. The deduster of the system, which seems to be inadequate for the task required, cannot be properly maintained because of the same cleaning and environmental conditions.

These conditions lead to breakdown of one of the system transports. Then, due to time limitations and labour shortages, cleaning occurs only while maintenance teams perform their repair tasks. After the repairs, the system is again put in operation, and the cycle repeats itself.

C. System improvement programmes

From a review of the causes of system failure, the goals of a system improvement programme are:

(a) To eliminate transport clinker overflows resulting from surges;

(b) To eliminate transport clinker overflow and leaks resulting from equipment failures;

(c) To ameliorate the environmental conditions of the system;

(d) To simultaneously undertake the cleaning and the overhaul of the transport;

(e) To monitor system performance to bring about further improvements.

D. Elimination of clinker overflow resulting from surges

1. Transport from the storage hall

Transport of clinkers from the storage hall to the cement mill bins is done by two interconnected transport lines consisting of one belt conveyor of 45 metre length and 240 tph transport capacity located underneath the hall, of an elevator of 175 tph transport capacity and of one belt conveyor of 50 metre length and 240 tph transport cap ity, located on the top of the mill bins.

Both lines are fed by two covered belt conveyors, of 40 metre length and of 240 tph transport capacities. Each covered belt conveyor is supplied by three vibrator feeders of 100 tph capacity each, which reclaim the clinker from hall.

The interconnection of the system's electrical controls allows the feed of transport lines by the two covered belt conveyors simultaneously. That is to say, by six vibrators may feed the two covered belts.

This is a weak point of the system: To prevent covered conveyors from being overloaded, it is recommended that they be equipped with automatic belt conveyor material level limiting devices, similar to those of Hawari plant raw material transports, which shut off, after a pre-set time, if the material on belts exceeds a certain weight level. These devices should be located after each vibrating feeder of the covered conveyors and when activated must shut off all conveyor feeders behind them.

Moreover, it is also recommended that control and command panels be equipped with ammeters indicating conveyor motor currents. As these coveyors are used to lift material, the ammeters would indicate whether the load was too heavy for the conveyor.

2. Transport from the clinker silos

The clinker transport from clinker silos to cement mill bins can be improved. It is recommended that the reclaim belt be equipped with automatic material weight limiting devices and that the control and command panel be equipped with an ammeter indicating the load of the conveyor motor.

At present this clinker transport section is out of service because the clinker silos are clogged. Thus clinker reclaim is not now possible.

E. Elimination of transport clinker overflows and clinker leaks resulting from equipment failures

Clinker transport overflows are the results of improper functioning of the conveyor belts, of belt slidings and of belt climbing tendencies, or (in the case of the final conveyor of one of the clinker transport lines) of poor design.

The operational defects can be eliminated by systematic checks and maintenance, by proper tensioning of the belts, by changing stuck pulleys and by reducing the slope of the conveyor belts where belt climbing occurs. The sharp vertical ascent of the final conveyor of one of the clinker transport lines must be made less steep by addition of a few adjusted sets of pulleys. The clinker wastage and droppage can be completely eliminated by systematic maintenance of the chutes. It is strongly recommended to give priority to these routine maintenance jobs after first eliminating the clinker overflow resulting from surges.

F. Improvement of the environment conditions of the system

First, the bag deduster of the system must be put in good working condition. It is recommended that automatic suction controls be placed at all dedusting points of the clinker transport system.

These automatic controls would improve the environmental conditions of the important sections of the system. At present, existing conditions harm the equipment and make the tasks of the plant production and maintenance personnel difficult. During the operation of the automatic environmental control, dedusting at some of the less important section dedusting points could temporarily be reduced or even shut off to allow full dedusting of the important sections. In addition, at selected points in the buildings, bridges, channels etc. of the system the removal of corrugated plate or making windows or even simple hole openings will impr e the environmental conditions of sections where more sophisticated environmental improvement at least for the time being is not possible.

G. Cleaning and overhauling of the system

After the above are completed, complete cleaning of the system and simultaneous complete overhaul of the system's equipment should be begun. Planning equipment overhaul should be an easy task as there is stand-by equipment for all transports.

H. Further improvement programmes

It is recomm nded that detailed surveys of equipment performance be made. Such a survey would enable the plant to find inherent weak points of the system and to establish definitive work programmes. This will resolve the problems of the clinker transport system. These programmes would include improvement of the existing equipment, new equipment additions and the replacement of defficient equipment.

I. Conclusion

It can be concluded that the clinker transport system can be improved, to some extent, by small modifications to its electrical system, to its equipment and to its buildings - and by undertaking systematic overhaul of its equipment. The real weak points of the system can only be established by detailed surveys which in turn can be carried out only after first implementing the initial recommendations on elimination of overflow, equipment failures, environmental conditions and cleaning and overhauling the system.

Annex VIII

BENGHAZI PLANT CEMENT SILOS

A. General

Of the seven cement silos of the Benghazi plant, the three largest silos with a storage capacity of 6,000 tons each are clogged with big round stone shape hardened cement formations. These formations obstruct the bottom discharge openings of the silo and make cement extraction impossible. In addition, the silo walls are covered with hardened cement crusts 10 to 200 cm thick. These silos are out of service.

Similar formations are in the four small capacity silos of 1,750 tons each. However, these formations are not large enough to clog the silos.

These formations, which are assumed to be chemically bound to the produced cement, are being studied by the plant contractor and consultant.

The emptying and the cleaning of the unserviceable silos has not been begun by the plant. It will be a large-scale job which requires special equipment and skill. No outstanding response has been received to inquiries made by the plant on this matter to various consulting firms.

The plant is now facing difficulties in storing its daily cement production in the remaining four silos due to their small storage capacities.

B. Recommendations

Although emptying and cleaning of the plant silos is large-scale work requiring special skill and tools and which normally has to be contracted to a specialized firm, it could also be undertaken by the plant itself. This would require that the the work be carried out by a team of workers selected from those plant la urers able to work on elevated platforms, supervised by foremen and equipped with special equipment which could be manufactured in plant workshop.

The silo cleaning and emptying by the plant itself would, over a predetermined span of time, work out the difficulties that the packing plant is facing. Furthermore, it would in the future enable the plant to control the operation of all their silos. In other words, if the plant undertakes the work itself, it will be able to maintain the large silos and remove any cement formations as they begin to develop.

Despite preventive measures which may be undertaken by the packing service to prevent silos from developing such formations (by partially filling the silo and by shortening the cement resting time in silos), due to some chemical properties of the produced cement, the cement will continue to adhere to the walls.

To make the operation of the packing plant of Benghazi smoother, it is strongly recommended that the three large silos be equipped with cement conveying systems to allow cement recycling in the silos and trans-shipment of cement to other silos. The cement conveying systems will pay back their capital investment by conveying recoverable cement from the packing plant to silos, and especially by allowing cement mixing to improve or standardize cement quality.

C. Silo cleaning and emptying

Silo cleaning and emptying done by the plant could proceed as follows: The cleaning of silo wall crust would be carried out manually, by labourers working on a movable hanging platform inside the silos, and the emptying of the silos would also be carried out manually, by labourers underneath silos and on hanging platforms outside the silos to recover silo cement. Labourers inside the silos would take out the large hardened cement stones.

1. Silo wall crust cleanings

Silo wall crust cleanings should be done using a movable hanging platform consisting of a beam composite supporting a circular or a rectangular wooden floor and equipped with safety and anti-swing devices. The supporting beam would have a length of 13.0 m and in cross section would be 0.5 m x 0.5 m (silo inside diameters are 14.0 m and the silo top manhole dimensions 0.6 m x 0.6 m). The beam would be made at a composite of units of maximum 4.0 m length manufactured in the plant workshop.

The supporting beam units would be assembled on top of the silos and introduced into silos through manholes. After assembly, the supporting beam would be hung up by cables of four manual capstans installed on the silo top floors, at the corners of a square which would have one corner at the manholes and would have as diagonals the diameters of the silos.

The capstans which would also be used during the assembly of the supporting beam would lower and raise the supporting beam into the silos. They would also in case of a rectangular platform covering the beam rotate the platform. Cable attachments would have to be arranged to allow a complete rotation of the supporting beam. The wooden floor would be attached to the beam units in workshop during manufacture.

The safety and anti-swing devices of the beam, the parapets and the special equipment to attach the beam to the walls of the silo would be prepared together with the beam units and would be set up inside the silo with bolts after the beam assembly.

The cleaning of the silo crusts would be performed by a team of seven or nine workers and supervised by a foreman. Two or four workers would have the task of cleaning on the straight or circular platform respectively, while the others would work the capstans. The cleaning and the capstan workers would be interchanged from time to time. The platform workers would be equipped with steel rods and pneumatic tools and would wear safety belts and dust masks.

2. <u>Silo emptying</u>

The emptying of the silos would be carried out by three teams, which would be:

(a) The first team which would remove cement from underneath the clogged silo discharges. The team would work on the silo underground floor and would be equipped with steel rods and quarry rock drills;

(b) The second team would remove cement from inside the silo. This team would puncture holes in a vertical line along the full height of the silo, beginning at the top and ending at the bottom. A discharge tube, initially stretching the full silo length, would be used to remove the cement to a waiting truck. As the workers remove more and more cement, they will work their way lower along the silo. The tube may be progressively shortened as the work proceeds. The team would be equipped with pneumatic concrete breakers and steel rods, and would wear safety devices. The platform and the tube would be manufactured in the plant workshop;

(c) The third team would work inside the silos and would have the task of removing the hardened cement stones and wall crust pieces, which would come from the work inside the silos, done from the inside hanging platform. The hardened cement stones would be thrown through holes in the silo walls made by the second team and also through the silo main manholes.

The number of workers in teams one and three would depend on working conditions. The second team would have four workers. Two of them would work on the platform. The other two would work on the top of the silo and would operate the platform capstans.

3. <u>Recycling of recovered cement and hardened cement crusts and pieces</u>

The recovered cement could be recycled and transported to the packing machines by the elevators. This cement would have to be sifted.

The hardened cement pieces and wall crusts could be crushed together with plant gypsum, in fixed proportions. The mixture could be added to the cement mills by proper adjustment of the gypsum feeders. The dimensions of the silos and a possible shceme for cleaning them are shown in appendix I.

D. Conclusion

The cleaning and emptying of the plant clogged cement silos is a large-scale task, most of which must be carried out manually, by labourers. It is difficult to anticipate all of the requirements for this task as some will only become evident during the cleaning and emptying process. Mechanization of this task would be very difficult.

Contracting of this work to an outside firm will be difficult. A large firm would not be interested and small firms, being aware of the scope and difficulty of the work, would have to cover themselves against all possible risks and could well propose lump sum contracts of astronomical costs, or expense basis (cost plus) contracts with huge inherent profit margins. In both cases there will be many reserve clauses for dead lines.

At present, it can be concluded that the solution to the problem of cleaning and emptying the clogged cement silos of the plant is that the plant itself undertake this work. In fact, the equipment for the work either exists in the plant or can be easily manufactured in the plant workshop; and, suitable labourers for this work are available among plant packing and other service workers.

Appendix

DIMENSIONS OF CEMENT SILOS