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MISSION REPORT - FIRST MISSION

PRODUCTIVITY IMPROVEMENT THROUGH PREVENTIVE MAINTENANCE

DP/IND/84/020/11-10

DURATION : 2 MONTHS

DUTY STATION : New Delhi, INDIA

Prepared for the Government of India
by the United Nations Industrial
Development Organization

Based on the work of

L N WALLACE
Expert in Preventive Maintenance

R01

25th February 1987

C O N T E N T S

—oOo—

SIMPLE DESCRIPTION OF
STANDARD PORTLAND CEMENT

" CALCARIOUS, ARGILLACIOUS, SILACIOUS, FERROUS MATERIALS SINTERED TOGETHER TO FORM AN ALITE CRYSTAL FORMATION, KNOWN AS CLINKER, WHICH WHEN GROUND (WITH THE ADDITION OF, UPTO 3%, GYPSUM) TO A POWDER, FORMS A HOMOGENOUS BONDING AGENT FOR A WIDE VARIETY OF AGGREGATES"

(THE GYPSUM DOES NOT ADD TO, OR DETRACT FROM, THE STRENGTH OR QUALITY OF THE CEMENT. IT MERELY SLOWS DOWN THE SETTING TIME)

OBJECTIVES OF A MAINTENANCE DEPARTMENT

In order to achieve any degree of efficiency it is essential to have clear-cut objectives. For without these and the knowledge of how they can be attained no department can expect to function at its optimum ability.

These objectives can be split into two types, namely, functional objectives and cost objectives. To deal with the first, the functional objectives, it has to be remembered that the 'Goal' of maintenance in this area is both preventive and corrective. The normal functional objectives of the maintenance department may therefore be as follows :

1. To maintain plant, equipment and buildings at their best level to ensure that production is not held up and resulting in loss of production time and broken delivery promises.

2. To maintain the company's assets and keep them in good condition thereby prolonging their life and usefulness.

3. To ensure that all plant and equipment is sufficiently well maintained, in order that the quality of the final product is kept to the agreed standards.

4. To make emergency repairs as quickly and as efficiently as possible in order to ensure that production 'Down time' is kept to a minimum.

5. To suggest and assist in the development and implementation of improvements in the design or redesign of machinery and equipment to decrease the chances of breakdown, make available more easy methods of repair and lengthen service life.

6. To operate such service activities as may be required i.e. power, heating, water and compressed air, etc.

7. To carry out systematic inspection of all plant, equipment and buildings at sufficient control intervals, so that any wear or impending breakdown will be detected and to keep adequate records of these inspections.

As with other departments, the maintenance department must have its economic objectives alongwith its functional objectives. The costs of maintenance will vary depending on the age of the plant or the amount of mechanical/electrical equipment, the degree of continuous shift work and the policy of the company in relationto the type and amount of maintenance carried out.

Generally management are very wary of maintenance because it sometimes interferes with production time.

Accountants dislike maintenance because it is a non profit making but necessary evil. The engineer, usually a man dedicated to his profession, and the cement industry, eventually dies of shear frustration trying to keep both parties happy.

MAINTENANCE

Planned	- Overall title deals with overhauls and replacement
Preventative	- Regular lubrication, inspection and checking
Analysis	- Investigation of trouble spots shown by costs
Costing	- Continuous costing of maintenance, Material and Labour
Controller	- Prepares schedules, keeps records, enumerates to Engineers
Section Supervisor	- Follows work thro, checks work and job card entries
Mechanical Electrical	- Electrical/Mechanical maintenance and checking should be done at the same time wherever possible.
Instrument	- Repairs and replacement can usually be carried out at any time.
Job requests	- All dept. supervisors should use job request forms to bring to notice any faults
Work Load	- Maintenance schedules to be spread over reasonable period
Frequency	- Per manufacturers or works engineers recommendations.
Over inspection	- Continuous double checking by shift men and SUpervisors
Stores	- Welding rod, gases and all consumable items, materials and spares to be recorded.
Time	- Time taken on all maintenance work to be recorded
Who	- It is important to know who did the job so that experience will not be overlooked next time.
Plant alternation	- Redesign - replacement - movement - must all be recorded.

L. N. Wallace

November 16, 1974

PLANNED PREVENTIVE MAINTENANCE
(AS APPLIED OR SHOULD BE)

Planned preventive maintenance is basically the intelligent anticipation of essentials and covers regular and thorough inspections. Good housekeeping (i.e. clean & tidy plant), good lubrication, replacement of worn or broken parts, the repair of worn or broken parts and the carrying of the necessary, spare parts, equipment and tools in stock.

The 'Heart' of any cement factory is its kiln or kilns. Production time lost for any reason whatsoever is time lost forever, it can never be made up. It is vital therefore that none of the kilns accessories, ancilliaries or auxilliaries should give any trouble in between the normal refractory relining periods, hence 'Planned preventive maintenance'.

Refractory replacement is an expensive exercise, but the exercise becomes more infrequent if the kiln, 'Through Good Maintenance', can be kept running at constant speed, feed and temperature.

Stoppages of the kiln, for any reason, upsets the structure of the refractory by creating 'Spalling' or 'Crumbling, which in turn means loss upto 50mm of refractory surface at each stoppage. (depends on duration of stoppage).

Stressing (once again) the necessity for good 'Planned Preventive Maintenance' at 'Planned' kiln shut down time, it is essential that the mechanical and electrical departments are ready with their maintenance lists for a fully planned checking and maintenance procedure for the whole plant, 'not just the kiln'.

Just because other sections of the plant seemed to be running alright when the kiln was stopped, does not guarantee that they will be alright for the next 12 months run of the kiln. This is what we are aiming for, at least 12 months before the next refractory lining replacement (which is quite normal on many plants).

'So, we must be thorough'. - One item which tends to be overlooked is the grate cooler. This unit should be emptied right out, swept clean and thoroughly inspected both whilst stationary and whilst driven. Any loose or damaged plates must not go unnoticed. Spring loaded seals at roller and drive positions, rollers, bearings, side plates, fixed and moving plates, beams, main frames, nuts, bolts, refractory, clinker breaker hammers, curtain chains, breaker bars must all be thoroughly examined.

All cooler fans must be checked and all prepacked bearings cleaned out and repacked. (see separate write up on cooler and drag chain maintenance. Also kiln maintenance write up). Whilst the kiln is being fitted with new refractory in the burning zone, a thorough inspection of the refractory for the whole length of the kiln, the kiln inlet, the preheater vessels and flash furnace (if any) should also be made.

All elevators throughout the plant should be checked but especially any feed or clinker elevators which may affect the kiln. The drives, the motors, the bearings, the buckets, the bolts, the chains, the sprockets and/or wheels and the tensioning systems must all receive a thorough examination and attention where necessary.

Every nut, washer, bolt and screw even remotely connected to the kiln and its auxilliaries must be expected to last until the kiln is planned for its next refractory replacement 'shut down'. No other 'shut down' is excusable.

The old 'Patch up and carry on' days are over in the cement industry. Every job of maintenance must be a thorough job of good engineering expected to stand up 24 hours a day indefinately.

Where there are reoccuring breakdowns on the same item of plant or machinery, a thorough investigation must be made to find the cause of such frequent failures. It may be that the unit is being overloaded beyond its designed capacity, it may be a fault in manufacture or it may be faulty operation. Whatever the cause it must be discovered and corrected even if it means redesign or total replacement.

In some cases motors are found to be too low on power rating or speeds, especially in relation to elevators and sudden surges of materials. This is a common problem on many cement factories and it is often found that a change of motors is necessary.

Once one nagging problem is solved the engineer is then free to get on with the next one or with his routine maintenance.

Routine maintenance is mainly lubrication, adjustment and inspection and is usually carried out quite simply and easily, especially on a nice plant.

Good housekeeping or 'Factory Cleanliness' goes hand in hand with good maintenance of machinery and equipment and is basically essential towards the implementation of planned preventive maintenance. Clean machinery, clean approach roads, pathways, stairs etc makes for safer and more [illegible] working conditions, easier inspection and safe lubrication. Maintenance or lubrication carried out under dirty conditions will create more and greater problems for the future.

A dirty plant and dirty machinery only reflects the lack of interest shown by the people incharge.

All engineers will agree that good lubrication of machinery is the easiest and cheapest form of planned preventative maintenance so far invented. Yet on many engineering installations it is quite common to see drums of grease and oil left open to atmosphere absorbing dust, dirt and moisture.

It is not surprising that "Breakdowns" occur when such carelessness is tolerated.

Oil and greases should be issued from the stores in the correct quantities as and when required and to be used immediately for the particular lubricating job in hand. This way the lubricant is less likely to become contaminated.

All areas around oil filler caps and the cap itself should be wiped clean of dust before opening. Excess grease and dust should be wiped off grease nipples before regreasing. This prevents grit being forced through the nipple by the grease gun.

Regular inspection is the golden rule for all sections of the plant and machinery. This will ensure trouble free running for long periods and often prevent breakdowns if thoroughly carried out. Listening for unusual noises, feeling for vibration or overheating, looking for undue wear, checking oil levels and for general cleanliness should all be part of routine inspection.

Inspection should not be the sole responsibility of the engineering department. The plant operators and general process people should also be inspecting and checking the machinery and equipment of their department. They should immediately report any thing that may be a miss to the engineers. On some plants special report sheets are issued to each department for this purpose.

Regular inspection keeps the engineer ahead and through inspection he can often detect a small fault and cure it before it becomes a major catastroohe.

With all cement plants, (Preferably during the erection of the plant) once the permanent resident engineer is appointed, he in turn should appoint a good engineering draughtsman to draw up all the possible spare parts which will be required in the future. Most of these spares of course can be supplied by the equipment or machinery manufacturer. But this is sometimes difficult if the plant is from overseas and is also expensive. If good, properly dimensioned engineering drawings are made at an early stage, quotations and tenders for indigenous

suppliers can be called for. Some cement plants have excellent workshops where some items can be manufactured on the site, but without drawings nothing can be done locally.

With drawings such items as mill liner and diaphragm plates, cooler grate plates, kiln nose ring plates and a host of other castings can be obtained at competitive prices. A good draughtsman can save a cement company a lot of money just on spare parts and replacements and he is always there for future design or redesign of plant.

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LUBRICATION

After the initial changes of oil during the 'Running in Period' of a new installation, it is not always necessary to change oil so frequently on large slow running bearings and gear boxes.

Samples need to be taken from each unit about every six months for inspecting and testing. This sample should, if possible, be obtained from near the bottom of the sump or reservoir.

Oil does not wear out but its lubricating qualities will diminish with the addition of undesirable substances.

If a sample shows the slightest sign of being contaminated with grit, sludge, metal or water, the sump or reservoirshould be emptied, thoroughly cleaned out and recharged with fresh lubricant. The old lubricant can possibly be clarified when large quantities are involved.

If metal was found in the oil, check all bearings and gear teeth. If water was found in the oil check cooling system or perhaps 'weather proof' the unit.

Twenty Salient Points Towards The Implementation of Planned Preventative Maintenance

1. GOOD HOUSEKEEPING
2. GOOD LUBRICATION
3. REGULAR INSPECTION
4. GOOD ORGANISATION
5. SPEEDY ACTION
6. ACCURACY
7. EFFICIENCY
8. DILIGENCE
9. DEDICATION
10. KNOWING WHY
11. KNOWING HOW
12. KNOWING WHEN
13. KNOWING WHO
14. RECORDING WHY
15. RECORDING HOW
16. RECORDING WHEN
17. RECORDING WHO
18. REVIEWING
19. REVISING
20. PERFECTING

Lester N. Wallace
U.N.I.D.O.

LNW/sw

PLANNED PREVENTIVE MAINTENANCE PROCEDURE AND CONTROL PROCEDURE.

Lester N. Wallace
U.N.I.D.O.

GOOD HOUSEKEEPING

Regardless of the size or type of Engineering Installation, whether it be light precision production machinery or heavy cement manufacturing machinery, Good Housekeeping is a basic essential towards the implementation of planned preventive maintenance.

Clean machinery, clean approach roads, pathways, alleyways, stairs etc makes for safer and more congenial working conditions, easier inspection and safe lubrication. Maintenance of lubrication work carried out under dirty and dusty conditions will create more and greater problems for the future.

Dirty machinery is usually neglected machinery and only reflects the lack of interest shown by the people in charge.

LUBRICATION

All Engineers will agree that good lubrication of machinery is the easiest and cheapest form of planned preventive maintenance, yet on many engineering installations it is quite common to see drums of grease and oil left open, to atmosphere, collecting dust, dirt and moisture.

It is not surprising that 'Break Downs' occur when such carelessness is tolerated.

Oils and greases should be issued from the Stores as and when required and in the right quantities for the particular lubricating job in hand.

All greasing points should be wiped clean before applying grease.

All areas around oil fillers should be wiped free of dust and dirt before removing caps or lifting lids.

Cleanliness is the golden rule for all lubrication and will, in most cases, ensure trouble free running for long periods.

INSPECTION

Regular and thorough inspection of all sections of the plant and machinery will often prevent major breakdowns. Listening for unusual noises, feeling for vibrations or overheating, looking for undue wear, checking oil levels and for general cleanliness should all be part of regular routine inspections.

Regular inspection will keep the Engineer one jump ahead since he will be able to take corrective action before a slight fault can grow into a major problem.

SCHEDULED MAINTENANCE

With a New Plant, manufacturers usually supply some details on lubrication and maintenance procedure. Where this information is not supplied the Engineer can only base his schedules on his own knowledge and experience. From thereon it is a matter of installing a simple system of control so that the replacement off wearing parts, the general maintenance and the lubrication are carried out at the specified time.

CONTROL OF MAINTENANCE

A great deal of writing has been done on planned preventive maintenance and its control and it is at this point that the Engineer needs to be most careful in selecting his system to avoid making the whole thing so complicated and cumbersome that it becomes unworkable. First, as everyone will agree, there must be the absolute minimum of paper work, therefore we must stick to basic essentials.
Secondly, the system must not tie up an Engineer who would be better employed on maintenance work.
Thirdly the system must give a complete description of every item of plant with its scheduled maintenance periods and, gradually, a full description of all work done, with materials used. From which will develop a full set of statistics for future planning.
The initial installation of such a system is the hardest part of the job. Starting with the plant registar it is necessary to number and itemise all parts or units of plant and machinery. This will, in most cases, neccessitate 'on the spot' checking to find the more relevant details. A little team work by the electrical and mechanical staff will make this 'once in a lifetime' task much easier.

MASTER CARD

Once all the information of an item of plant or machinery has been obtained, it can then be detailed out on the 'Master Card' with its mechanical, electrical and lubrication maintenance frequencies.
To avoid unnecessary duplication of stoppages, all motors should be included on the card with the driven unit so that electro-mech maintenance may be planned and carried out at the same time. This requires the complete co-ordination and co-operation of electrical and mechanical maintenance departments.

MAINTENANCE CARD

With each Master Card, there will be a 'Follow-up' maintenance card on which will be entered all work actually carried out on that particular item of plant or machinery, all materials used and the name of the man or men who have done the job. This card will develop into a complete and invaluable history sheet.

JOB CARD

The 'Job Card' is the only travelling card and will be issued to the workshops by the clerk controlling the maintenance system.
He will examine his Master Cards daily and from the colour coding system (see attached sheet) will know what maintenance work is scheduled for the particular period.

He will take the details from the Master Card and enter them on the front of the job card with the Job No. or Cost, Coding No. The job cards will then be issued to the Superintendent concerned and he will enter the name and clock number of the man who is to do the job.
The man who does the job will enter the time that he takes on the job with any relevant details on the front of the card.
On the back of the job card will be entered all items of spares etc drawn from the stores and this will be signed by the Storekeeper.
When the job is completed, the Superintendent will sign the job card and return it to the clerk controller of maintenance.
The clerk will then enter all the details on the maintenance card and then pass the job card to the accountancy department for costing.

Except for the job card the only paper work necessary, once the system is installed is a book recording of all job cards issued so that they may be checked and crossed off as the job is completed and the card returned.

The whole system is so basically simple that once it is in operation it almost chases its own tail. With the numbering of the machines and items of plant and possible colour coding of the machinery itself in relation to the maintenance periods everyone on the site will understand the SYSTEM.

PROCESSING JOB CARDS FROM VISUAL CONTROL CARDS

Hourly and Daily Maintenance Schedules which are mainly a matter of adjustment or lubrication although recorded on the Visual Card System, should normally be a matter of routine with a job card issued by the supervisor concerned. The job card will, ofcourse, still go to the controller of the visual card system for recording.

Weekly Maintenance Schedules should be brought forward on Monday of each week by the visual card controller and job cards issued accordingly. The weekly maintenance should be carried out as soon as possible and the completed job card returned to the controller for the recording of the details thereon.

YELLOW

Monthly Maintenance Schedules should be brought forward, as close to the 1st of the month as possible, by the controller of job cards issued and processed in a similar manner to the weekly cards.

GREEN

Quarterly Maintenance Schedules should be brought forward in January -April - July and October, as close to the 1st of each of those months as possible by the Controller and job cards issued and processed in a similar manner to the weekly and monthly cards.

BROWN

Half Yearly Maintenance Schedules should be brought forward in January and July, as close to the 1st of each of those months, by the controller and job cards issued and processed as above.

BLUE

Yearly Maintenance Schedules should be brought forward, as close to the 1st of January as possible, by the controller and job cards issued and processed as above.

BLACK

Planned Kiln Shut Down Maintenance Procedure although there will be standard maintenance procedure for the Kiln, its accessories, ancilliaries and auxilliaries there will also be a list of extra items, to be checked, or receive maintenance, which the Chief Engineer, has been compiling during the run of the Kiln.

R E D

At this time the Chief Engineer, apart from his usual interest in the maintenance procedure, should sit with the card controller to be sure that job cards are issued for every item of plant, of which there might be the slightest doubt about, even remotely connected to the Kiln.

The Chief Engineer should also check all jobs and cards to be sure the work is completed before the job cards are returned to the controller for recording.

COLOURED IDENTITY SIGNALS WILL INDICATE MAINTENANCE PERIOD

YELLOW	-	WEEKLY MAINTENANCE
GREEN	-	MONTHLY MAINTENANCE
BROWN	-	QUARTERLY MAINTENANCE
BLUE	-	HALF-YEARLY
BLACK	-	YEARLY
RED	-	PLANNED KILN MAINTENANCE AT 'SHUT DOWN'

MAIN UNIT

GENERAL INFORMATION

MAKE _____ SIZE/CAP _____ MODEL _____

SERIAL Nº _____ MOTOR Nº _____ FRAME SIZE _____

VENDOR _____ P.O. Nº _____ DATE INSTALLED _____

COST CENTRE _____

DRAWING NO.	COMPT. NO.	DESCRIPTION	MATER'L	LUBRICATION	FREQ.	MAINT.	FREQ.

DRAWING RE-ORDER NO. SUC.03527-LL

Work Process Card

MAINTAINANCE | | Y | | | M | W | D | H |

LOCATION

UNIT

ATE	WORK DONE MECH/ELEC/INST LUB	COMP'TS. & MAT'L USED	REF. NO	[illegible]	WHC

ON RE-ORDER NO. [illegible].23529 [illegible]

INDUCTION TRAINING

A copy of the standard one day Induction Training Programme is attached. This has been designed to cover most personnel, and this training should be given to all new employees on their first day with the Company.

The objectives of the programme is to introduce a new employee to the Company and familiarise him with the Company's activities, his job conditions and his role in a Works or Department., as well as to ensure that everything a new employee should know is adequately covered and properly presented.

The depth of the Induction Training required will, of course depend upon the level of the new employee and variations may have to be made to the content of the programme and the prescribed timetable for individual trainees.

OUTLINE OF PROGRAMME

1st Day :-

1. Reception.
2. Remuneration.
3. The Company.
4. Welfare and Employment Conditions.
5. Safety and Hygiene.
6. Department.
7. Tour of Works.
8. Trades Unions and Joint Consultation.
9. Explanation of Job.
10. Job Instruction.

2 or 3 days later - Short follow-up with Welfare Officer.

At a convenient time - Interview with Works Manager.

INDUCTION PROGRAMME

Objective - Standard One Day Off the Job Programme to cover all Works Personnel

ITEM	KNOWLEDGE	PLACE	INSTRUCTOR & TECHNIQUE.	TIME	REMARKS
Reception.	Explanation of Induction Programme. Daily Routine Information - Hours of Work, Travel, Location of Toilets, Canteen and Parking facilities.	Welfare Office. Talk, Discussion, Questions.	Welfare Officer	9-9.30 a.m. ($\frac{1}{2}$ hr).	Hand out Induction Timetable.
Remuneration.	Introduction to Wages Clerk by Welfare Officer. System of Remuneration - Clocking procedure - clock cards traced from rack to pay packet. Coding and pay slips explained - Deductions - Pay and Tax queries - Shift and Overtime rates - Holiday Pay - Graduated Pension Scheme - National Insurance Cards - P.A.Y.E. Income Tax - Profit Sharing and Superannuation Schemes.	Wages Office.	Wages Clerk. Talk, Examples and Questions.	9.30 - 10.00 a.m. ($\frac{1}{2}$ hr).	Hand out updated N.J.I.C of Craftsmen's Agreement Book where applicable
The Company.	Brief History - products and their uses. Organisation of Company and Works. Names of Management. Relationship of trainees job to finished product.	Lab. Office Production Office	Technical Manager. Production Supervisor.	10.00 a.m. 10.15 a.m.	
Welfare and Employment Conditions.	Purpose of Work and co-operation. Terms of employment - Rules on Day work, Overtime, Holiday - Medical facilities.			10.15 a.m. 10.30 a.m.	

ITEM	KNOWLEDGE	PLACE	INSTRUCTOR & TECHNIQUE.	TIME	REMARKS
Contd.. Welfare and Employment Conditions.	Sickness and absence procedure.) Sickness and accident schemes - Pension) Scheme- Suggestion Scheme - Social and) Sports activities.) Personal problems. Education and Training) as applicable.)	Walfare Office	Personell Officer	10.30 10.45 a.m.	
Safety & Hygiene.	Safety in the Works - How to prevent) accidents. Accident Prevention Committee) First Aid - Safety equipment and use of) protective clothing - Good housekeeping) lifting and carrying - fire prevention) and emergency drill.)	Welfare Office.	Welfare Officer. Talk, Questions, Discussion,	10.45 11.30 a.m ($1\frac{1}{2}$ hrs).	
Department.	Introduction to Supervisor. (a) Personal details - help and co-operation Requests - Time off. (b) Safety Clothing allocated. (c) Locker allocated. Tour of Department - Introduction by Supervisor to a colleague who can act as adviser (Sponsor).	Supervisors Office and Work situation.	Supervisor Talk, Discussion, Questions,	11.30 a.m. 1.0 p.m. ($1\frac{1}{2}$ hrs).	The Sponsor is someone specifically looking after the new employee in his or her early days and for helping him or her to settle in the job.

ITEM	KNOWLEDGE	PLACE	INSTRUCTOR & TECHNIQUE.	TIME	REMARKS
Lunch.	Show Canteen and have lunch with newcomer.		Sponsor.	1 - 2 p.m. (1 hr).	Lunch for both at Company's expense.
Tour of Works.	Tour of Works and Offices and visits to other Departments, as applicable.	Factory Plant.	Works. Foreman. Visits, Talk, Demonstration, Discussion.	2 - 3 p.m. (1 hr).	
Trade Unions & Joint Consultation	Introduction to Trade Union Representative. Purpose, methods and election of representative to consultative committee. Attitude of Company to Trade Unions. Recognised Representatives. Methods of presenting the points of view of the employees to Management. Procedure to settle grievances. Where to get help for personal problems or information on matters not connected with work.	Assistant Manager's Office.	Assistant Manager and T.U Rep. Talk, Discussion, Questions.	3-3.30 p.m. ($\frac{1}{2}$ hr).	
Explanation of Job	Explanation of Job - what he does and where it fits - re-emphasise safety. Control of work. Overtime work.	Supervisor's Office.	Supervisor, Talk, Discussion, Questions.	3.30 - 4.15 p.m. ($\frac{3}{4}$ hr).	

ITEM	KNOWLEDGE	PLACE	INSTRUCTOR & TECHNIQUE.	TIME	REMARKS
Job Instruction	Job Instruction in outline with reference to Job Training Programme.	Work Situation.	Instructor, Talk, Demonstration.	4.15 p.m. end of day.	
2 or 3 days later.	To ensure that new employee has assimulated the important knowledge, to answer further queries and provide further clarification where necessary.	Welfare Officer.	Welfare Officer. Talk, Discussion, Questions.	To be fixed with Supervisor.	
At a convenient time.	Interview with Works Manager.	Manager's Office.	Manager.	¼ hr.	

QUARTERLY ROUTINE QUARRY MACHINERY MAINTENANCE

By Lester N. Wallace
U.N.I.D.O.

1. Check compression to determine condition of rings, pistons and valves - make corrections as needed.

2. Check fuel injection system - nozzles, pumps, governors - replace worn parts.

3. Check and clean cooling system, water pumps, water passages, etc. Clean radiator inside and out.

4. Check lube system - pumps, lines, filters etc.

5. Check bearings, main and rods.

6. Check electrical system, wiring harness etc.

TRANSMISSION AND DIFFERENTIALS

1. Check gear and pinion backlash.

2. Check bearings for looseness

3. Flush out oil passages etc.

4. Check gear teeth, especially those speed change or sliding gears.

FINAL DRIVES & TANDEMS

1. Check bearings for proper adjustment, wear, etc. Replace any worn parts such as gears or shafts.

2. Clean inside of cases and fill with new oil.

HYDRAULIC OR CABLE SYSTEMS

1. Check hoses, valves, controls, pumps etc., for worn or damaged parts and replace as needed.

STEERING SYSTEMS AND BRAKES

1. Check steering gear, controls.
2. Check brake linings and drums.
3. Replace any excessively worn parts and adjust as needed.

UNDER CARRIAGE, TRACKS, ROLLERS AND IDLERS

1. Check alignment
2. Check condition of track, truck wheels, Rollers etc.
3. Tighten to proper torque all bolts and other capscrews in undercarriage system.

EXCAVATORS

1. Check clutches and brakes
2. Check Jib Slides, Racks and Pinions
3. Check for damaged Ropes
4. Check Control Linkage and adjust where necessary
5. Check Bucket, Door Latch and Bucket Teeth for wear and build up where necessary.

NOTE

It is important that after repairs in the actual quarrying area that all tools, discarded parts and pieces of metal are taken back to the quarry workshops.

Any of the above items left on the quarry floor are likely to be shovelled up with the material and finally end up in the crusher at the factory. This could cause the fracturing of the grate bars in the crusher which means expensive replacements and a loss of material to the process.

If you see an item on the Quarry Floor likely to cause this sort of trouble —

"PICK IT UP AND GET RID OF IT"

LNW/sw

1st September, 1971

CRUSHER MAINTENANCE

Most limestone crusher, these days, are either the hammer mill or Blow Bar type. With either type there is often a prescreening unit of some sort which also conveys the larger rock into the crusher throat. The motor drive eccentric weight type vibrator screening except for normal wear and tear of screening surfaces and drive belts, is usually trouble free. The electro-magnetic vibratory units are nothing but trouble.

The hammers or blow bars should be checked frequently for wear. If templates are made when these items are new it will be easy to measure the wear. The wear should not be allowed to go above about 15 mm. before build up. The surface should first be given a layer of stainless steel weld before applying the hard facing. This prevents cracking and loss of hard facing. When hammers are removed for rebuilding with weld that should be weighed, paired and refitted opposite each other to maintain balance.

The breaker bars or grids should also be examined for wear. Some of these can also be hard faced. Crusher liner plates usually last a long time but should be checked for loose holding bolts. All bolts around the crusher must be checked, especially foundation bolts since the constant vibrations, due to hammering can often cause, bolts to come loose. Vibratory screen motor and drive belt should be checked. Main drive motor, belt tensioning and belt condition must be checked. The automatic greasing unit should be run whilst lines are disconnected one by one at the discharge points to make sure all points are being properly greased.

One some crushers travelling breaker plates are fitted to prolong the life of the crusher in between

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breaker plate changes. But the changing of the travelling type breaker plates is such an arduous exercise that it seems of little advantage. Just another piece of driven machinery to maintain. The fixed plates of Manganese steel give excellent services.

When the crusher is not in operation this is a good time to check the discharge conveyor from the crusher and all belts right through the raw material system.

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[illegible]

[illegible] gear and [illegible]

[illegible] systems. [illegible] after long [illegible] Regular [illegible] inspection.

3 Regular internal inspection of inlet liners, mill liners, diaphragm plates, outlet liners and ball charge if balls are mis-shaped and splitting or badly worn, the mill should be emptied and recharged.

4 All end plates, end diaphragm and liner plates bolts receive a continuous head hammering from the inside chatge, which tends to thrust the bolt deeper into its recess and in turn pushing it towards the outside of the mill causing the nuts to come loose. All nuts should be checked and tightened each time the mill is stopped, otherwise plates can become detached and then smash up other plates in the mill.

5/ Power factor. Mag/Amps or Thyristor

...

MILL GRINDING MEDIA
DRY MILL LOADING 26% TO 32%

Galle	Mill	2.6	Metres	Dia.	26%	Variable
	"	2.8	"	"	27%	"
	"	3.0	"	"	28%	"
	"	3.2	"	"	29%	"
Puttalam	"	3.4	"	"	30%	"
	"	3.6	"	"	31%	"
	"	3.8	"	"	32%	"

(Maximum loading is controlled by the height of the Grinding Media in relation to the Inlet and Diaphram Apertures)

Puttalam Cement Mill 3.4 Dia. x 8.1 Metres Long
Less Plate Thickness x 2

$$\frac{3.3^2 \times \pi}{4} \times 8.1 \times 30\% \times 4500 = 94 \text{ Tons}$$

Puttalam Raw Mill 3.4 Dia. x 7 Metres Long
Less Plate Thickness x 2

$$\frac{3.3^2 \times \pi}{4} \times 7 \times 30\% \times 4500 = 81 \text{ Tons}$$

PREVIOUS LOADING BASED ON 27%

Cement Mill	84.5	Tons	- (Actual 85 Tons)
Raw Mill	73	Tons	- (Actual 72 Tons)

The percentage loading may be varied either way to suit general efficiency and production requirements. The Table above is set on the high side to allow for already well worn, well polished plates and existing charge.

With new Plates and new Charge 28% loading should give excellent results in a 3.4 Metre Dia. Mill. It is a matter of using ones own judgement.

4500 kg per m³ = 7730 lbs per cub yard

Lester N. Wallace
U.N.I.D.O.

is made between revolving roller and grinding table. Material is ground on material.

5 Hot gases (from kiln) are induced into the bottom of the mill to give a flow which dries and transports the ground material particles through the dust collector system to silo storage.

6 To assist in maintaining the necessary fineness a revolving fan type classifier is included in the upper casing.

7 Although costly to buy and install, the roller mill is far more economical to run, production, power and maintenance wise.

8 Maintenance of rollers is a simple operation done by jacking the units out of the mill on their special hinges, then replacing the roller tyres when necessary.

9 The rotary grinding table surface wear segments can also, if necessary, be easily replaced at the same time.

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11 The classifier drive [illegible] hydraulic motor and requires [illegible] unless a hydraulic [illegible]

12 Inlet and outlet [illegible] controls should be checked at each [illegible] operational period.

13 The rotary airlock feed valve and drive, all material conveyorisation and drives, and all weigh feeders and right back to the reclaimer at the stockpile should be checked.

14 This is also a good time for crusher and quarry machinery maintenance.

ANCILLIARY EQUIPMENT IN ROLLER MILL CONTROL ROOM (NEAR MILL)

1 Classifier hydraulic drive pump and control console.

2 Roller and grinding pressure hydropump and control console.

3 Roller circulating oil pump and control.

4 Gear box lubrication and high pressure table (grinding) thrust pumps and control.

5 Grease pump and control.

6 Water spray pump and control.

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KILN OPERATION

Operating a rotary kiln for the production of clinker in the cement industry is basically a matter of balancing four main factors :

1. Kiln speed
2. Material feed
3. Fuel volume (or oil pressure)
4. Draught

Assuming that the raw material is of consistent quality and fineness the above four factors, correctly balanced, will give clinker production at consistent quality at the desired tonnage capacity of the kiln.

1. Kiln Speed :

The optimum kiln speed should not exceed 90% of its maximum speed. This gives the kiln burner a little 'Reserve' for adjustment in emergencies such as sudden back end temperature rises through possible feed delays or blockages. With a little extra speed in hand an adjustment can be made to bring the feed down the kiln a little faster and so prevent a dangerous rise in the temperature. The speed can also be increased to create a surge of material, which is sometimes desirable for the removal of ring formations in the kiln.

When conditions are normalised the kiln should be gradually returned to its optimum speed.

2. Material Feed :

Ths optimum setting for material feed is usually based on the kiln's basic capacity, as designed. But the final setting is usually found after months of experimenting. The optimum is not always as high as desired but the optimum even at slightly lower output, is better than 'high - low' fluctuations and the resultant poor quality clinker.

The optimum setting, for the material feed, is, therefore, based on the experience of the kiln burner in conjunction with the calculations of chief chemist.

With the maintained optimum feed setting, the thermal efficiency will remain steady. The coating on the refractory will be maintained and the refractory will give a longer life alongwith long and satisfactory production periods.

3. Fuel Volume (or Oil Pressure) :

Tha optimum setting for fuel is also found from experience gained over months of production. But, once the efficient (kilo calories per kilogram) setting has been found, it should be consistently maintained.

Where fuel oil is used sudden increases of pressure should be avoided, since the oil heating systems cannot always cope with the extra flow. This means cooler oil to the burner pipe, loss of thermal efficiency in the kiln and a complete waste of good oil.

4. Draught : (Dealing only with primary and Secondary air)

Primary air is used mainly for shaping of the flame from the burner nozzle. This air should be adjusted to give a short clean flame to the normal burning zone of the kiln.

Secondary air is used to fully complete the combustion of the fuel. The constant optimum is obtained by adjustment of the cooler fans and the maintenance of a constant thickness of clinker on the cooler grate plates.

Kiln inlet gas analysis will also help towards efficient optimum settings.

- : -

THE CEMENT COMPANY OF NORTHERN NIGERIA LIMITED

CLINKER QUALITY

The good quality of clinker is the result of good co-operation between the Laboratory and the Kiln Burner. Good quality material properly burned will produce good clinker. Poor quality material will not make good clinker no matter how the kiln is manipulated.

-------- oOo --------

Good clinker is mainly a crystaline structure and with the De watering and Decarbonisation there are three main stages in the burning of the raw materials.

FIRST STAGE: Up to 1000°c all the Aluminium oxide reacts with the Lime. Generating NoNo Calcium Aluminate (CaO, Al_2O_3). The silica also starts to combine with the Lime, turning into dicalcium Silicate ($2\ CaO, SiO_2$): At this stage of formation of the clinker compounds Dicalcium Silicate concentration is low.

SECOND STAGE: Between 1200°c and 1300°c the Monocalcium aluminate formed during the first stage is further saturated with lime converted to Tricalsium Aluminate ($3CaO, Al_2O_3$). Simultaneously the lime reacts with the Iron oxide creating Dicalcium Ferrite ($2CaO, Fe_2O_3$) as well as a more complex compound, Tetra Calcium Alumino Ferrite ($4CaO, Al_2O_3, Fe_2O_3$) which is refered to as brown Millerite.

Formation of Dicalcium Silicate started in the first stage is now being completed.

Depending on the Chemical composition of the Raw Mix, the reactions Described above occur mostly in the solid state if the burning temperature at this stage has not exceeded 1300°c.

THIRD STAGE: Between 1300oC and 1450oC one part of the material is in a liquid state. This partially fused condition of the material permits one part of the Dicalcium Silicate to be saturated with the remainder of the free lime and is converted to tricalcium Silicate ($3CaO, SiO_2$) or what is known as 'Alite' Crystal formation. This completes the formation of Clinker.

The following minerals are considered to be the Principal Clinker constituents:-

(1) Tricalcium Silicate $3CaO, SiO_2$ (C_3S) or 'ALITE'
(2) Dicalcium Silicate $2CaO, SiO_2$ (C_2S) OR 'BELITE'
(3) TRICALCIUM Alumino Ferrite $3CaO, Al_2O_3$ (C_3A) OR 'CELITE'
(4) Tetracalcium Aluminate Ferrite $4CaO, Al_2O_3, Fe_2O_3$ (C_4AF) OR 'BROWN MILLERITE'.

The Alite Crystal formation (C_3S) which makes for easier grinding can be controlled to a certain extend by the Kiln Burner and the best results are obtained by final sintering of the materials through a short flame area and a fairly rapid after cooling.

A crystal formation of 10 to 15 Microns will give 3 day strengths in excess of 4000lbs. per square inch.

Long flame burning or overburning will cause a decomposition of the clinker when the 'Alite' (C_3S) may decay into Dicalcium Silicate 'Belite' (C_2S) and CaO, thus degrading the clinker quality.

L. N. WALLACE
WORKS MANAGER

LNW/Ade'
Sokoto, 14/4/70.

[illegible]

[illegible]

[illegible]

Constant kiln [illegible]

Efficient inlet and [illegible].

Adequate instrumentation to [illegible]

Adequate heat transfer to keep waste gases to a minimum.

Efficient cooler for quick [illegible] to heat to the kiln.

-.-

[illegible]

When the kil[illegible] inspection of th[illegible] refractories shou[illegible]

3 Inlet and outlet seals [illegible] replaced if necessary.

4 The main gear drive may [illegible] change and gear tooth insp[illegible] motor should be checked at the [illegible] the auxiliary turning motor.

5 All supporting roller bearings should be checked and oil changed. The roller adjustment skew can only be made whilst the kiln is running.

6 Kiln tyres, or riding rings, need little attention unless very old when sometimes the gap at the top between tyre and chair becomes excessive, the chairs may need to be shimmed. Regular greasing between tyre and chairs can prevent this.

7 Check kiln outlet nose ring plates and replace if necessary.

-•-

COOLER MAINTENANCE (MOVING GRATE TYPE)

1 Cooler maintenance must be done when the kiln is shut down. Any other time means loss of production, since kiln will also be stopped.

2 The cooler should be emptied right out and swept out clean.

3 Inspect all moving plates, fixed plates and side plates for damage and make sure they are all properly anchored. Replace where necessary.

4 Inspect moving and fixed grate plates for gap which should be 3 to 4 mm.

5 If moving plates and fixed plates are rubbing together, it means the beams on which they sit are not properly adjusted and may need packing or the beams may be distorted through overheating.

6 Run the reciprocating grate section whilst inside the cooler, listen for scraping noises, locate noises and correct the cause. Then whilst running check underside the grates at the bolts and nuts, the main beams, the supporting rollers and rails, check compartment lights and ports.

7 Check clinker breaker hammers for wear. Check grid bars, hanging baffle chains, side plates and replace if necessary.

8 Check roof and wall refractory.

9 Check fans and motors and bearings.

10 Check drive gear box, crank bearings and drive motor.

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11 Check clinker drop out valve systems at each cooler chamber.

12 Check clinker drag chain links and pins, support rollers and bearings. Check bottom wear plates.

13 Check clinker drag chain drive and gear box, check tensioning roller surface and bearings.

14 Check automatic greaser by opening line at strategic points whilst grease unit is running. If grease does not flow, find out why, then correct fault.

When kiln and cooler are once again in pproduction make sure that the recommended depth of clinker is spread over the grate plate surface before starting to discharge clinker from the cooler. If the clinker is too thin on the grate plates, the air blowing through will create a situation similar to a blacksmiths forge and will melt, even heat resistant, grate plates. Supporting beams will also become bent and distorted and could result in a total collapse with serious damages to the whole cooler structure. On some plants cool clinker is placed on the inlet and plates of the cooler before start up. This is an excellent idea.

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Points to be observed in order to maximise collection efficiency.
WITH COTTRELL TYPE UNIT PRECIPITATORS

1. Gas Division

In a multi unit installation, control dampers must be fitted and adjusted such that the total gas flow is equally divided between the units.

2. Gas Distribution

In practice, it is not possible to achieve perfect distribution of gas through the collector system of a precipitator and variations in gas velocity of ± 25/30% of the average gas velocity are typically quoted as being acceptable. However, if it is suspected that severe imbalance is occurring then it is recommended that experiments be made with various types of baffle, at the inlet to the unit, in an attempt to effect an improvement.

3. In-Leaking Air

The efficiency of an electrostatic precipitator is inversely proportional to the gas flow rate and it is vitally important that all sources of in-leaking air be eliminated and excess air be reduced to a minimum. In-leaks in the precipitator casing are particularly damaging to performance since they can distort the gas flow and lower the spark-over threshold.

4. Collector Electrodes

Every tube must be truly vertical and free from ovality, bows, dents or any other form of distortion. There must be no sharp projections, cracks or holes which could give rise to the formation of a positive corona and thus lower the breakdown voltage.

5. Discharge Electrodes

Every discharge electrode must, throughout its length, be positioned exactly in the centre of its tube and to maintain this alignment against the influence of the gas flow, electrostatic forces etc. the stabilizers, together with the vibrator, must be correctly fitted and adjusted.

Each precipitator should have its full complement of electrodes or, where removal is unavoidable, any tubes without electrodes must be blanked off. The importance of this will be readily appreciated if one considers the inlet dust burden to each tube in an ideal precipitator having perfect gas distribution. This burden will be $\frac{1}{180}$ or 0.56% of the total, thus for every tube without a discharge electrode 0.56% of the inlet dust burden will pass to atmosphere.

/Cont....

6. Rapping Gear

Adjustment of the rapping gear (amplitude, duration of rapping and interval between successive raps) is largely a matter of trial and error. For the collectors, the object is to find the mean between rapping too frequently, thus promoting re-entrainment, and not rapping frequently enough, which will lead to an excessive build up of dust on the collecting surfaces and a reduction in precipitator efficiency. Although it should be noted that a thin layer of dust is always present under normal operating conditions. For the discharge electrodes, the object is to maintain the electrodes in as clean a condition as possible, since any build up in excess of a film will tend to suppress the corona and, again, reduce the efficiency of the precipitator.

7. Rectifier Equipments

The efficiency of a precipitator is a function of the voltage which is applied to the electrodes and it is essential that the rectifier equipment be adjusted such that this voltage is a maximum at all times. With manually controlled equipment it is necessary to operate at a compromise level, somewhat lower than the maximum possible, in order to avoid frequent 'trip-outs' and it is, therefore, strongly recommended that all manual equipments be scrapped and replaced with modern equipments having automatic control facilities.

A direct relationship exists between electrode voltage and sparking and, for maximum efficiency, the electrode voltage must be maintained, commensurate with the operating conditions, at the level necessary to achieve a controlled spark rate of between 60 and 100 sparks per minute. It follows, as a generalisation, that any precipitator which is operating at an input power level below that required to cause sparking is not being used to full advantage.

STORAGE & BLENDING SILOS

RAW MEAL HOMOGENISING

To ensure continuous operation of the kiln it is necessary to keep at least a few hours, preferably a few days, stock or raw meal in hand. On some plants several silos are provided for this purpose leaving the homogenising silo free to blend material either direct from the mill or through recycling from the storage silos. This can be a distinct advantage on a site of variable materials.

The modern homogenising silo is basically an air agitated mixer with the floor being angled in two sections from a centre trough which is also angled from a centre discharge up to the inside walls.

On the silo floor and the bottom of the trough are fitted air fluxing pads (or elements) which are a flat steel box with a thick strong fabric stretched and bolted to the upper side. The pads in the trough are for air transporting the raw material to the pnuematic pumps below. The pads in the sloping floor are arranged in a pattern of upto six segments around the floor area and are used on a time cycle system to lift and blend the raw material by air pressure. The timing of each 'Blow' can be set as required alongwith time cycle for the whole six segments. In between cycles a more moderate air supply is induced to keep the material in a flux like state.

(A blending silo can be useful for cement when several kilns are producing clinker of varying characteristics).

CEMENT SILOS

Cement silos are very similar except that they are generally for storage only and require less air servicing than a blending silo. The only air requirements are the fluxing of the cement and air transport to the bag packer or bulk loader.

MAINTENANCE OF SILOS

Most problems with the above type of silos are caused through water leaks through the roof, wet air from compressors or the careless burning or damage to fabric covers of the pads. The latter two items usually occur during construction before the silo is put to use and are usually corrected.

BELT CONVEYOR MAINTENANCE

Belt conveyors once properly set up and aligned should run trouble free for years if designed for the job.

Sometimes design is at fault i.e. under powered, underwidth, underspeed and sometimes thin and weak through lack of ply fabric.

Otherwise with other regular checks to make sure the belt is tracking correctly (running in a central position on its support rollers) and regular lubrication at drive, tensioning pulley and all troughing rollers there is very little that can go wrong except through accident or carelessness.

Sometimes material finds its way on the return side of the belt and it becomes necessary to fit a scraping device in the form of a 'VEE' to remove and prevent this material from running back to the tail end tensioning roller and possibly sticking to both belt and the tensioning roller. A build up of material on drive or tension rollers can upset and even damage the belt if left to build up indefinitely.

On some inclined belts material tends to run backwards from the dischatge chute with the eventual build up around thetail pulley and also on to the underside of the belt and around the pulley. This can usually be corrected by fitting rubber skirting at the back of the discharge chute. Material should not , at any time, be allowed to build up around drives or pulleys.

Belts sometimes suffer from surface wear and the fabric begins to show through. The rubber manufacturers supply a liquid solution which can be painted on

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to such surfaces, when dry, and thus lengthen the life of the belt. It also keeps moisture away from the fabric and prevent strinkage of the belt. Strinkage of the belt causes overtensioning with damage to drive and tail pulley bearings and eventual breaking of belt.

Where there are heavy discharges, on to a belt, impact rollers should be fitted under the belt, at the discharge position, to prevent the belt sagging and possibly cause spillage.

Sometimes a belt will track correctly when empty and then tend to run to one side when loaded. This is because when loaded the belt makes contact with all the troughing rollers by the pressure of the material. If some of the roller sets are at a slight angle the belt will tend to follow that angle but this is easily adjusted by slightly moving the rollers in the opposite direction. Sometimes conveyors are fitted with automatic self adjusting rollers.

Most of the troughing rollers, today, are supposed to be grease packed for life, but they still need to be checked regularly to be sure that they are not jamming up. Any faulty rollers should be replaced to prevent belt damage.

It is customary, on many plants, to have at least one good man engaged, full time, on belt maintenance and adjustment. He is, usually, also able to splice and vulcanise the belts when required. On large plants with belt conveyorisation from the quarry, stacker and reclaimer conveyorisation plus all the plants general conveyors a full belt conveyor department is required.

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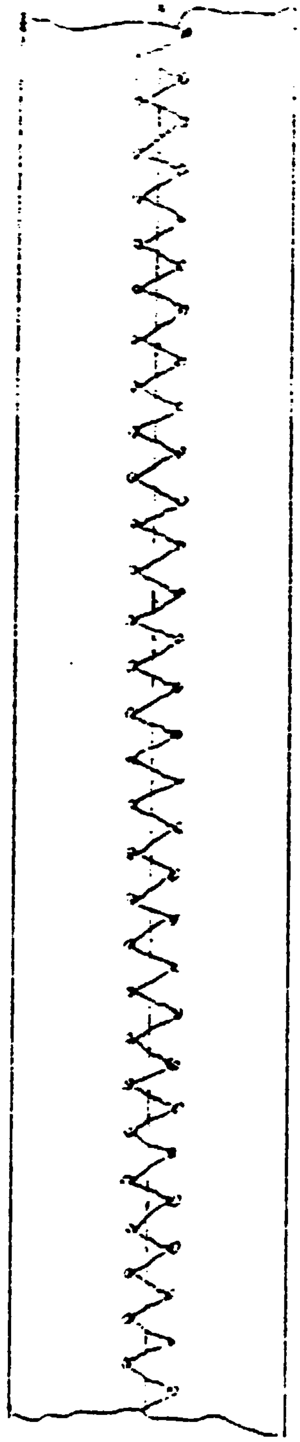
TEMPORARY BELT [illegible]

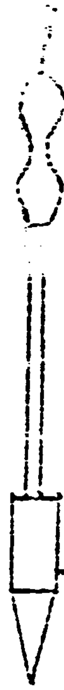
[illegible]RARY [illegible]
[illegible]NVEYOR [illegible]
[illegible] LENGTH [illegible]
TEAR.

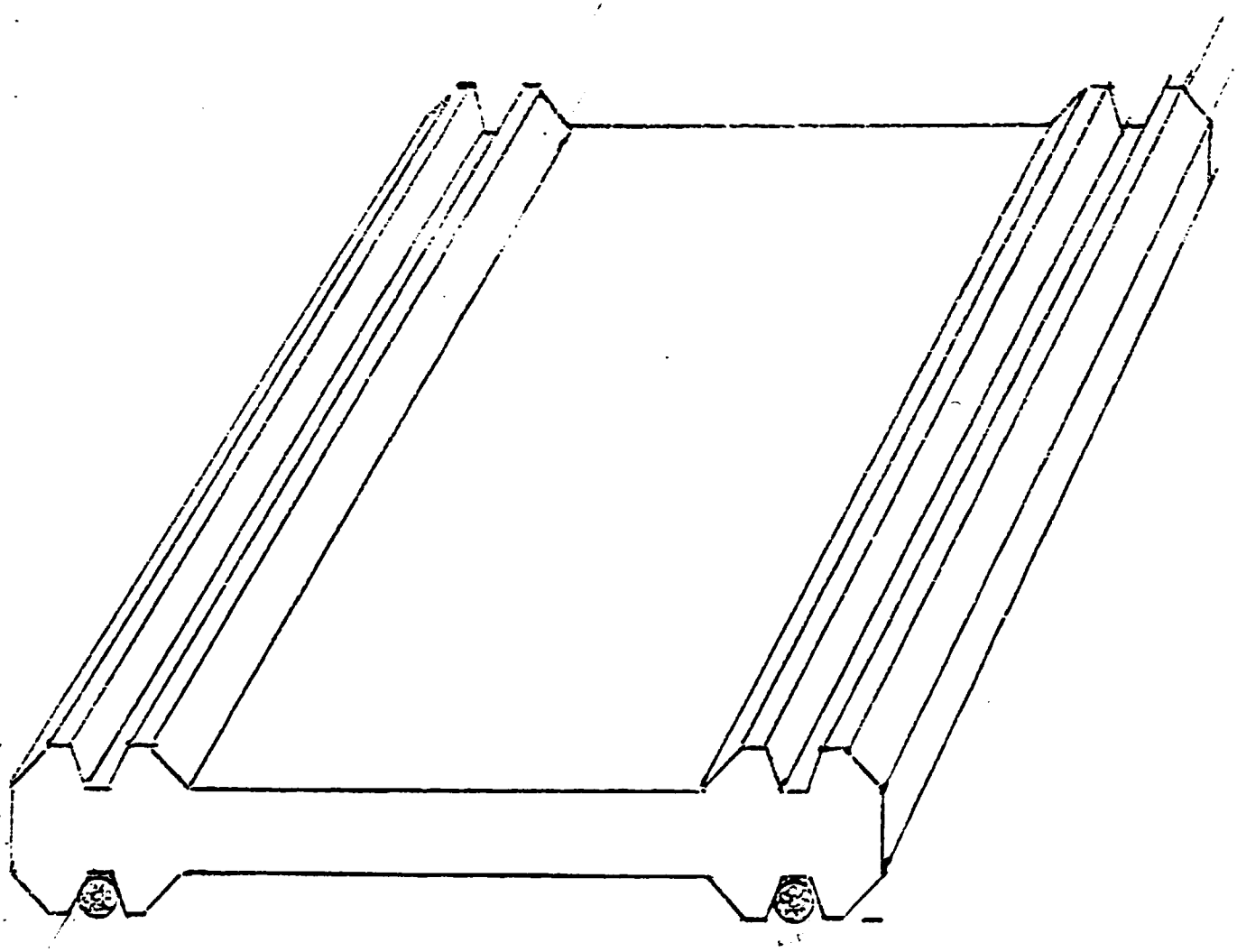
[illegible]
THRO' BELT USING A
SMALL ELECTRIC
SOLDERING IRON WITH
CORNERS REMOVED.
THEN THE BELT WAS
STITCHED UP WITH A
STRONG 6MM DIA CORD.

LEATHER THONG WOULD
WOULD LAST LONGER IF
AVAILABLE

THIS METHOD IS NOT
SUITABLE FOR ACROSS-
BELT REPAIR DUE TO
TENSION.







WAGON TIPPLERS AND THEIR MAINTENANCE

Wagon tipplers come in various sizes depending on the material requirements and size of wagons. Some companies own their own wagons and some companies depend upon the state railways to supply the wagons. But the tippler is usually designed for one particular design of wagon. The wagon must fit inside the tippler structure to within reasonable tolerances for clamping down purposes.

The wagon must be firmly clamped on to its rails before the tippler does its 180° turn to discharge material into the hopper below. On modern units the clamping is done automatically and the tippler will not revolve unless the wagon is properly positioned and clamped.

The tipplers circular frames at each end have circular rails which run on double flanged rollers. Sometimes there are two sets of pivotted rollers at each end to spread the bearing loading.

At the drive end is fitted a part circle gear or rack for two or three teeth over the 180°. Although some of the tipplers are still designed for a complete revolution and the gear or rack is a complete ring.

The pinion drive and the gear or rack are, except for cover guards, usually exposed to atmosphere and any dust which may be discharged with the materials (depends on how good the dust collecting system may be). The primary gears are usually enclosed and running in oil.

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The positioning of the tippler at 180° top and bottom is usually controlled by a limit switch which stops the motor and engages the solenoid brake.

The last piece of machinery is the unit for pulling the wagons on to the rails of the tippler. There have been many ideas for this operation but the favoured one, today, is the simple electric winch and a length of wire cable with a hook on the end of it. A shunting engine is of course, necessary to bring the wagons to within reasonable distance of the tippler.

MAINTENANCE

Tippler wagon rails must be kept in their correct alignment and level with the main line rails. If they are below level, it means that wear has taken place on the tippler circular rails and/or the supporting rollers. This could be quite normal and can be corrected by shimming the rollers up. The tooth gap at the pinion and circular gear should be checked when the shimming is being done.

The clamping units for the wagons must be checked and kept in good condition.

The circular gear and pinion should be washed with kerosene and regreased weekly.

Supporting rollers should be kept clear of material build up and given a few shots of bearing grease weekly.

The primary gear box should be checked for oil level weekly and oil changed every six months.

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Limit switches need checking for dust and dirt and possible adjustment, at daily intervals, along with the solenoid brake.

The wagon positioning winch is usually a totally enclosed unit and only requires a change of oil every six months.

Wagon tipplers are, generally, of very sturdy construction and give very little trouble if the few points above are observed.

Wagon tipplers are expensive units to buy and to install and today where rail type wagons are used the drop out bottom discharge design is usually more preferable. The discharge rate and waggons per hour rate is also much faster.

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[illegible] ER COMPANY
[illegible] COMPANY
[illegible] 2040, BETHLEHEM, PA 18001

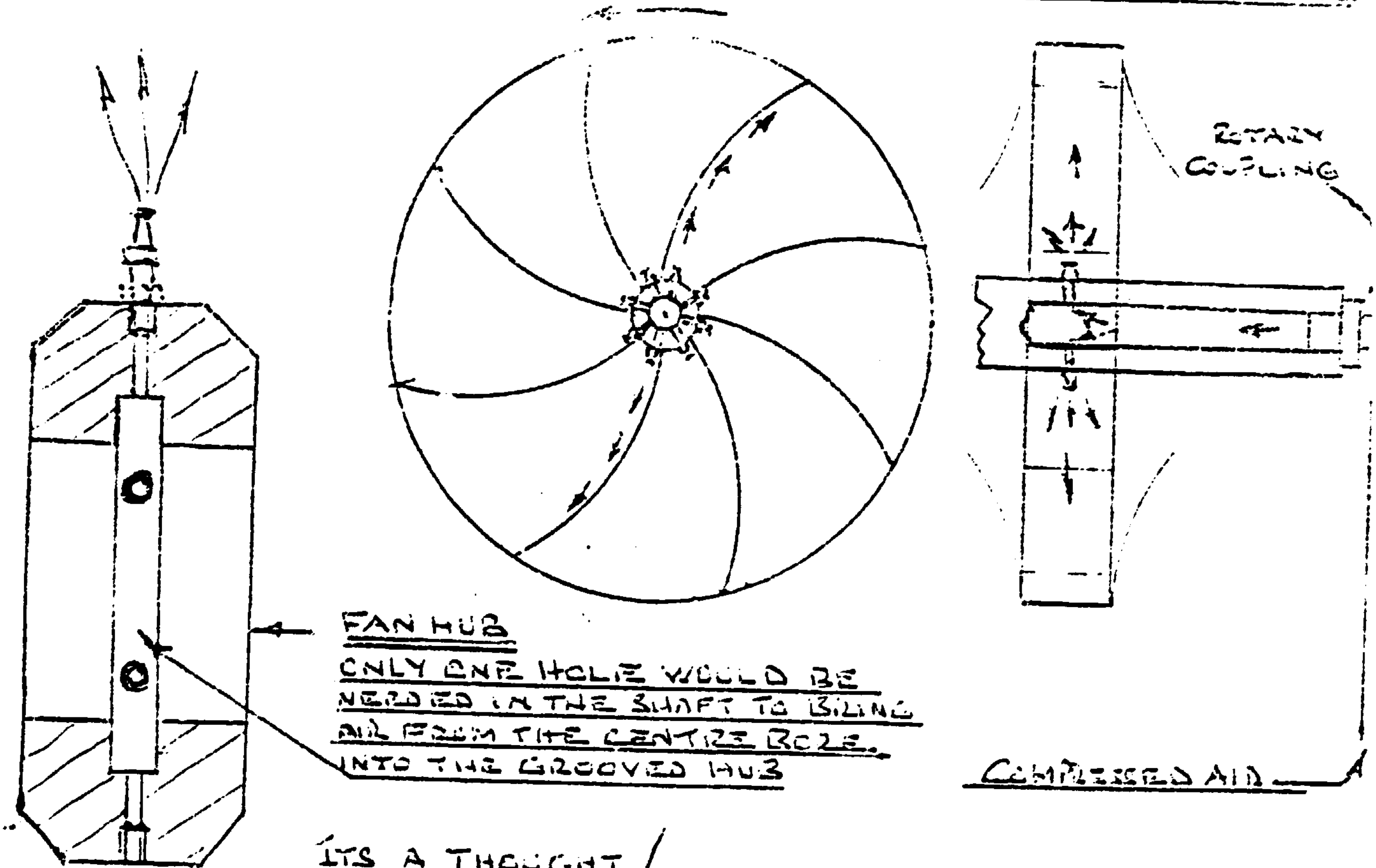
REFERENCE [illegible]
BY [illegible]

POSSIBLE SOLUTION TO [illegible]
[illegible] ON THE BACK OF [illegible]

[illegible] EVE T [illegible]
[illegible] OF THE [illegible]
[illegible] IS [illegible]

[illegible] WOULD [illegible] WITH DIFFERENT
[illegible] AND THE [illegible] CLEANING SYSTEM
WOULD NEED TO [illegible] OILING [illegible]

IT COULD POSSIBLY [illegible] WITH THE FAN EFFICIENCY.
THE FAN MANUFACTURERS COMMENTS WOULD BE INTERESTING.



ITS A THOUGHT!

ANOTHER THOUGHT IS THE STRATEGIC PERFORATION OF THE FAN BLADES!
THIS ONE WOULD CERTAINLY CONFOUND THE MANUFACTURERS!

COMPRESSOR MAINTENANCE

On a cement factory, two main types of compressors are used.

1. PISTON COMPRESSOR :

It (Sometimes air, sometimes water cooled) is used generally where a head of air, usually 100 lbs/in^2 is required to be stored in a receiver for the operation of pneumatic switches, valves and hopper gates, air lancing etc, and also for clean air for instrumentation.

1.1 This type of compressor has many moving parts and when in operation should be regularly checked for smooth running.

1.2 If the compressor is in good condition, and adequate for the job it is doing, it should provide the desired pressure to its storage receiver in a given time.

1.3 If it is lagging or labouring and does not reach the given pressure, in the given time, it should be stopped and first an examination of the air intake filter should be made. Under dusty conditions the air intake filter can block up very quickly and needs to be changed or cleaned more often. Do not at anytime run a compressor without air filter.

1.4 If the filter is not causing the trouble then the spring loaded plate valves must be examined.

The spring will probably need replacing on the valve but if the compressor has been running for months without similar trouble,it is better to change all plates and springs, the others may be ready to break at any time.

1.5 At this time, it will also be a good idea to check the crankshaft bearings, the connecting rod bearings, the lubricating pump and filter and also change the crank case oil. If, after this, the compressor is still unable to delivery full pressure, it will be obvious that the Piston Rings are in need of attention or that there is a leak in the line to the receiver or in the receiver itself.

1.6 Compressors are usually duplicated, on a continuous process plant, so that the above problems, and normal maintenance, can be carried out at any time.

1.7 A manual is usually supplied with all compressors and the instructions for lubrication water cooling and maintenance should be strictly adhered to.

2.0 ROTARY COMPRESSOR :

Always water cooled is used mainly where volumetric flow is required, with pressures not, usually, exceeding about 45 lbs/in^2 (in the cement industry) for fluxing, blending (homogenising) and pneumatic transporting of materials in powdered form.

2.1 This type of compressor has only one major moving part which is the bearing mounted, rotor fitted with hard fibre flinger blades.

2.2 The blades slide into deep slots and when the rotor is revolving in its eccentric bore the blades are centrifugally forced to follow the bore surface creating pockets which pick up the air from one side of the pump and discharge it at the other side.

2.3 Any pressure showing on the discharge side depends entirely upon any resistance either in or at the end of the line. For instance, if discharging air to the homogenising pads of a silo, pressure will only show if all pads are covered by a reasonable amount of material.

2.4 The maintenance of this type of Pump is very simple. The intake filters are usually large oil type and only require periodical washing and oil change. (Depending on dust and atmospheric conditions).

2.5 The compressor is automatically fed with oil from a drip feed unit which continuously lubricates the bearings and the rotor bore. It is important that this lubrication unit is never allowed to run dry.

2.6 If the compressor bore is starved of oil the friction of the sliding blades on the bore will create intense heat, only in a few minutes. This will carburise the blades which will then tear metal from the bore before finally smashing up and seizing up.

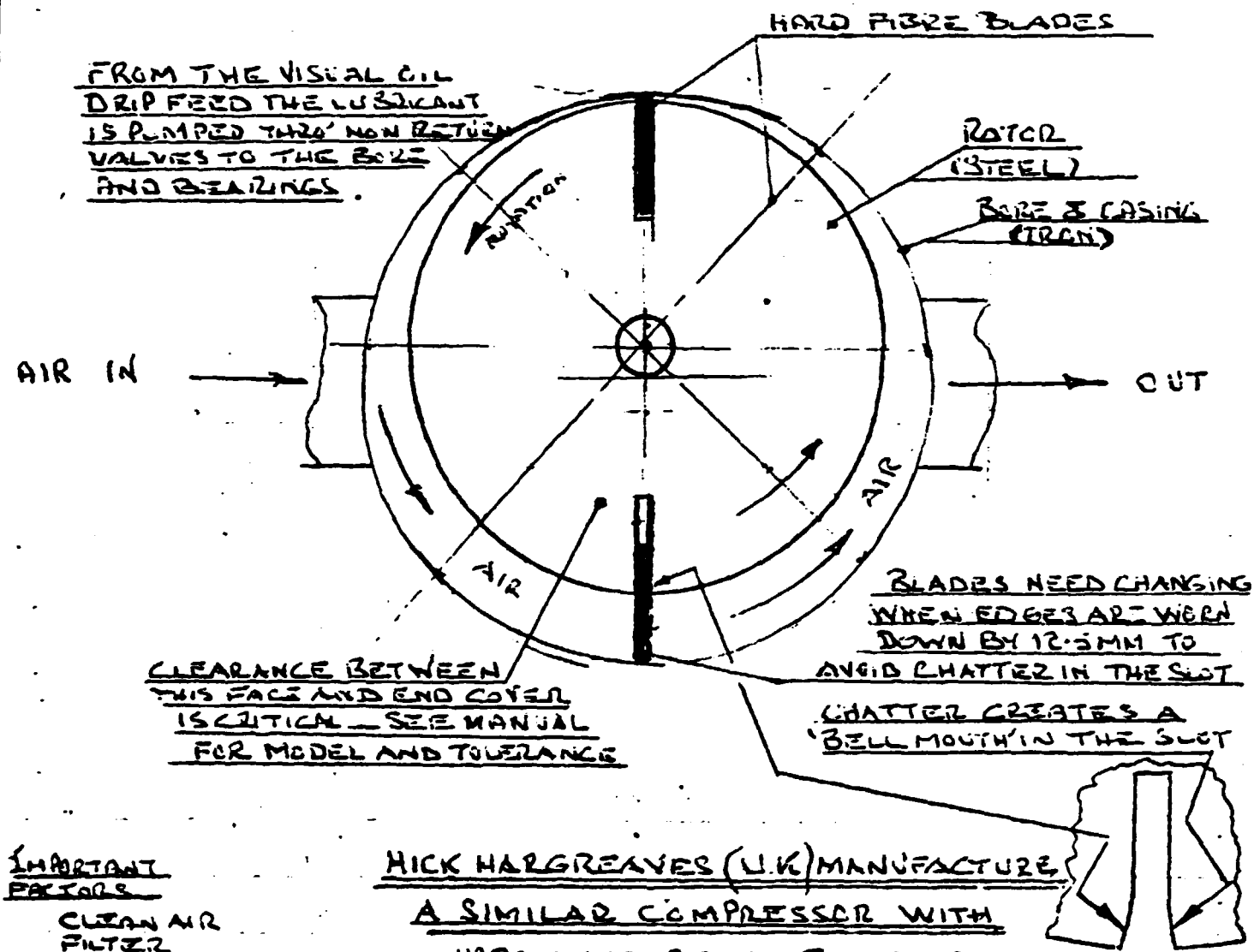
Lack of water cooling will bring a similar result. So, watch that lubricator and water.

2.7 The rotor blades should be replaced when 12.5 MM has been worn off the edges but should normally last for six to eight months.

2.8 When an end cover is removed, it must be replaced with the same (shim) gasket thickness. The rotor end clearance is critical.

A FEW POINTS ON WATER COOLED FULLER TYPE ROTARY AIR COMPRESSOR. DIRECT OR BELT DRIVE.

(ALSO USED AS VACUUM PUMPS)



IMPORTANT FACTORS

- CLEAN AIR FILTER
- CONTINUOUS LUBRICATION
- CONTINUOUS WATER COOLING
- BLADE WEAR

HICK HARGREAVES (U.K) MANUFACTURE A SIMILAR COMPRESSOR WITH HARDENED STEEL BLADES.

MORE EXPENSIVE BUT IF PROPERLY MAINTAINED OIL AND COOLING AND FILTER WISE ONLY NEEDS INSIDE CHECKING ABOUT EVERY TEN YEARS.

LNW FEB87.

REPORT ON
VISIT TO UPSCC DALLA
11 - 13 Jan'87

TEAM :

UNIDO EXPERT MR L N WALLACE
NCB EXPERT MR J P SAXENA

The plant visited, employs both the wet and dry process of clinker production. It operates two streams of wet process consisting of Wet Raw Grinding Mills having capacities 50 TPH each and kilns (3.75 m dia x 135 m long) having capacities 600 TPD each. The other two streams of dry process consists of Raw Mills each having the capacity of 115 TPH and kilns (4.2 m dia x 65 m long) of capacity 1200 TPD each. During the visit a number of problems were discussed including mining machinery and other machinery at the plant site.

Apart from the following machinery problems, the main problem observed is that of cleanliness. Several inches (FEET) of dust has been observed in all sections of the plant. It is felt that the dust collecting units seem to be at a minimum and those which may be there are not being properly maintained. A good clean up and efficient dust collection must be at a top priority at Dalla.

I. MINING MACHINERY :

A new ropeway system is used to transport raw material from the new crushing plant to old ropeway bunker. It is felt that due to high gradient of 18°, the system is susceptible to frequent breakdowns.

The availability of old ropeway system which transports crushed limestone to the plant is also poor due to frequent breakdowns.

It is, therefore, suggested that a strict system of lubrication at the drive station and all overhead pulleys should be followed to reduce the breakdowns.

II. PROCESS PLANT MACHINERY

A. Wet Process :

It has been pointed out that there is excessive settlement of slurry in the slurry silos and mixture basin.

This problem is generally overcome by means of compressed air in conjunction with mechanical stirrer units. But due to higher depth of silos, the mechanical system cannot be used in the present situation. The remedial action suggested is to use closer pattern of air distribution system utilising the reduced diameter pipelines thereby increasing the air velocity.

B. Dry Process :

a/ Pressurisation of ducts : The problem of pressurisation of ducts of raw mill and kilns and the ESP has been identified which is hampering the kiln output. The low pressure drop across the preheater cyclones was expected to be the main cause.

During the discussion, it is revealed that due to low calorific value of coal an attampt had been made to increase the primary, secondary and I.D. (fan) air velocity to meet the process requirements. But this, in turn, is now creating positive pressure downstream.

Since, it would seen that the present method of burning has to be maintained, the only way to even things out is to speed up the ESP exhaust fan or to replace it with one of the greater capacity.

b/ ESP (Kiln No. 3) : To recommission the ESP for kiln No. 3, which had met an accident a few years ago, it is recommended to consult the manufacturer as the unit was supplied by indigenous supplier.

c/ Flushing of Weigh Feeders : The problem of flushing of coal weigh feeder and also the Raw Meal weigh feeder is being faced by the plant.

The coal weigh feeder is, in turn, being fed by the twin screw conveyor. By experience, better operational results had been obtained when coal was fed directly by the screw conveyor by-passing the weigh feeder. It has been agreed upon that the precision timed screw conveyor are better choice, thus eliminating the weigh feeder, to feed the metered quantity of coal to the kiln.

In case of Raw Meal weigh feeder, it is suspected that the blades of rotary feeder are worn out badly and hence creating the problem.

d/ Isolation of Raw Mills from Kiln Hot Gases : For complete isolation, it is suggested that fully seal dampers must be used in place of existing dampers.

e/ Girth Gear Lubrication System : The coal mills, kilns and raw mill of dry process plant have been provided with Girth Gear spray lubrication system. It has been found very difficult to maintain this system and sump type lubrication system is being thought of as a remedial measure.

Considering the dusty condition of the plant, the use of sump lubrication system is not recommended. It has been suggested to use other simple models of spray lubrication system.

f/ Burning of Clinker Belt : To prevent this problem, it is suggested to use water spray nozzles on both sides of clinker discharge chute.

g/ Shell cooling by Air Blower : The kiln shell cooling over the main burning zone by using air blower has been suggested to improve upon the life of refractory lining.

h/ Kiln feed F.K. Pumps and Prefeeders have the problems of getting tripped frequently. This could be due to the surges of material but could also be due to lack of power factor control.

- : -

DALLA (DRY PROCESS) KILNS (POOR OUTPUT)

Whilst visiting the Dalla Plant site (13th January 1987), it occured to me that although poor quality coal is much to blame for the production problems, of these two kilns, the proolems may be partially reduced by lowering the % $CaCO_3$ of the raw material, which would make for easier burning. This in turn would mean that primary air, secondary air and the I.D. Fan gases velocities could be reduced, thus bringing the general kiln operational conditions back towards, something like, normal and also reducing the pressure on the water spray recovery unit, the ESP and the raw mill.

I believe the total calcium-carbonates to the kilns are at present around 77.5% and would suggest a trial run at 76%. At this figure an excellent cement of world wide (Portland) standards will be obtained, if it is burned properly.

When $CaCO_3$ is reduced, it is very easy to 'overburn' unless the fuel and draughts are also reduced or hopefully feed increased. This requires very carefull kiln burning with continuous clinker analysis and weights taken until the correct optimums are found. (Overburning will cause any tricalcium silicates to revert back to dicalcium silicates).

If the trial is successful the % $CaCO_3$ could be reduced even further and there will bound to be

'some' normalisation of the kiln's operational performance, with increased production.

I did mention the possible improvement of the general operational conditions, by the reduction of % $CaCO_3$, to Mr Jain (Production Manager), whilst I was at Dalla, but he said that it had been tried and that bad clinker was produced.

This can only be due to overburning since there are many plants around the world, burning and producing good clinker at 74% and less in $CaCO_3$. I have experienced this low $CaCO_3$ clinker production myself and was delighted with it, because of the long life of the kiln refractory due to the 'Softer' burning.

I will admit that low calcium carbonate burning can really test the skills of a kiln burner. 'Looking up the kiln' becomes a most important and essential factor since the control panel will have to be reset from his, and the chemists findings.

THE POSSIBLE RESULTS :

Increased kiln speed Increased material feed Reduced kcal/kg Reduced draught Reduced kiln gas pressures from I.D. Fan	Increased production and longer refractory life.

TABLE

AS CALCULATED BY : OTTO LABAHN (Germany)

% $CaCO_3$ in the raw meal	74	75	76	77	78
% CaO in the clinker	63.17	64.40	65.64	66.87	68.11
KG Raw Material/KG Clinker	1.524	1.533	1.541	1.550	1.558
KG Clinker/KG Raw Material	0.656	0.652	0.649	0.645	0.642

It is obvious from these figures that reducing the % $CaCO_3$ brings a natural increase in Productivity regardless of the extra feed that can be put through the kiln.

NARMADA CEMENT COMPANY
JAFARABAD

27 - 31 JAN' 1987

1. After over four years since commissioning the plant at Jafarabad, it was very pleasant to visit the site, once more and find that due to good management and good maintenance, the plant is running so well.

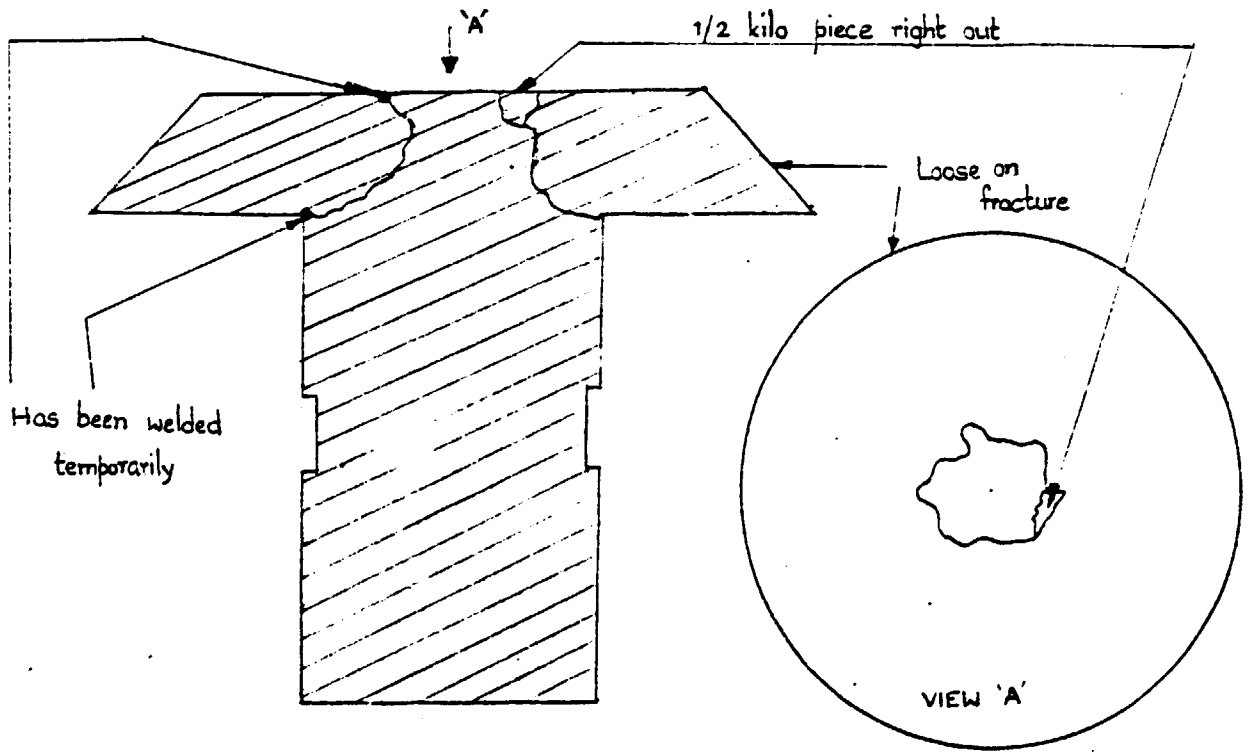
Except for an accidental fracture of two roller tyres and roller head bearings, due to 'Tramp' iron getting into the mill, the roller mill (raw material) gives no trouble at all. The other two tyres, the table wear plates and casing liners are all original after 4½ years of operation. A larger and more powerful electro-magnet has now been placed over the feed conveyor to the raw mill. This should be quite adequate for the removal of any future tramp iron.

2. The coal mill unfortunately is not giving such good operational life in between roller tyres and turn table wear plate changes.

Due to the poor quality coal, with its highly abrasive ash content, the tyres and wear plates have to be changed every three months. There is very little time lost in renewing these items now that Narmada Maintenance Staff have it listed as routine.

3. Other problems were mainly to do with the kiln i.e. :

A KILN 'UPHILL' THRUST ROLLER, FRACTURE OF SOLID FORGINGS

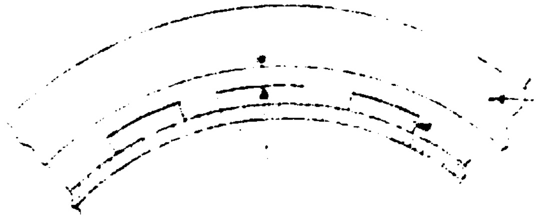


The roller was repositioned after welding, but the kiln was adjusted on its riding rollers to rest lightly on the 'Down Hill' roller. An alarm switch has also been installed to give instant warning, to the operator, of any tendency for the kiln to ride Uphill.

The Fuller Company will be supplying a replacement for the fractured roller.

[illegible] BACKLASH

This, it would seem, is mainly wear between the inside of the kiln tyre surfaces of the tyre chairs.



To correct this, the shimming [illegible] tyre chairs is necessary to bring the kiln 'UP' as to its original centre. This is a long and time consuming job.

Narmada Engineers have corrected the [illegible] gear and pinnion tooth gap by packing the kil[illegible] rollers up. This was also a big job but quicker [illegible] packing the chairs. Of course, eventually will come the time when the shimming of t[illegible] [illegible] will have to be done. This will a[illegible] mean [illegible] packing under the rollers will hav[illegible] [illegible]

In the meantime, since the kil[illegible] s opera[illegible] so well I have [illegible]sed [illegible] regular gre[illegible]ng [illegible] chairs and tyr[illegible] [illegible] prolong the life of the surfaces and may be delay packing of [illegible] for several years.

SEMINAR

OPERATION AND MAINTENANCE OF ROLLER MILLS

(JAFRABAD 27 - 31 JAN'87)

The above seminar held at the Narmada Cement Plant was quite a success with a lot of questions asked and answered. The fact that the Seminar was actually held on a cement plant site operating rollers mills was in itself a great idea.

Some of the participants had never seen a roller mill before and a lot of their preconcieved ideas were changed after seeing these units in action.

A Speaker (Mr Naras) of Larsen & Toubro Ltd. gave an excellent talk on roller mills, starting with the preparation of the mill foundations right through the erection and general fitting and on into the production, operation and maintenance. In fact, there was little or nothing, of roller mills, that he did not cover.

The Narmada Manager (Mr Patel) also gave an excellent series of talks during the Seminar on his own practical experience in the productive operation and maintenance of roller mills. I also learned quite a lot about roller mills since my own experience only runs to installation and commissioning of such units.

There was a talk by an expert in lubricants and the use of lubricants since good lubrication is the first, finest and cheapest form of planned preventative maintenance known. I think this was a valuable part of the Seminar.

There was an informal session when myself and Mr Patel gave out whatever information that we could by question and answer. Mr Patel was able to give more answers than I since, as previously stated, my own experience was mainly gained on installation and commissioning.

Mr Shanmugam did an excellent job of compering and managing the whole Seminar and I am sure that it's success was due to his whole hearted efforts.

NOTE : I, spent considerable time looking for and asking Narmada Engineers where all the problems lay. But I could not find any and was told that there were no problems. (other than those already solved).

LESTER N. WALLACE
(UNDP PROJECT IND/84/020)
29 Dec '86 - 25 Feb '87

To

Dr H C Visvesvaraya
Chairman & Director General &
Project Director
National Council for Cement and
Building Materials
New Delhi 110 049

Dear Sir:

During my brief visit to India on this assignment I have tried, by word of mouth and by writing, to leave behind as much information on the Operation and Maintenance of Cement Factories as possible. Forgive me if I have deviated a little, from the listed program, on such items as power factors, calcium carbonates, job responsibilities, induction training etc; but all these items lend themselves to the harmonious running of a cement plant.

Most of my writing and talking has been about the **nuts and bolts** of the business which is primarily practical maintenance and the planning of maintenance in relation to the continuous processing of materials in the cement industry.

Amongst my writings you will find one set of papers which I think are the most important, entitled **Planned Preventive Maintenance Procedure and Control Procedure.** This system is so simple that once the information is fed into it an intelligent clerk can run it. Even computerisation could not make it any easier.

This system is now being used on several cement plants in various parts of the world.

I mentioned the system to the General Manager, at Dalla Cement Plant, and he said that he would like a copy of it. I informed him that he would probably receive a copy from NCB in due course.

The management and maintenance staff at Dalla need all the help that they can get both production and maintenance-wise. I have put forward suggestions that may go towards solving some of the problems, but, an expert would need to live on the Dalla site for months to really sort things out.

Narmada Cement Factory was quite a contrast. Narmada have had a few problems to overcome, since commissioning, but the engineers just rolled up their sleeves and got on with the job. The whole plant is now running like clock work and can look forward to some excellent production figures.

The management and maintenance staff at Jafarabad are mainly made up of people who grew up with the plant as it was being built.

Most of them have also had previous experience in cement or heavy engineering and this makes all the difference. The success of any enterprise depends entirely on the experience and skills of its employees (practical experience is the all important factor).

The cement industry has expanded rapidly over the last thirty years but unfortunately the training of operational and maintenance people has not kept up with this expansion.

I wonder what happened to the old apprenticeship system ? Or even the trainee system ? I think what it boils down to is the fact that employers do not feel that it is worth the effort, and time, to train people for the benefit of some other company.

This makes sense, up to a point, but if all cement companies started a training scheme, regardless of how much time the trainees moved around, there would eventually be created a pool of skilled people who would benefit the industry as a whole.

I understand NCB are encouraging and also sponsoring this type of training. I wish NCB every success in this venture and I hope that NCB will be able to persuade the cement industry throughout India to adopt this procedure. Professionally dedicated cement men cannot be produced overnight but a good trainee scheme is certainly a push in the right direction.

There is little more that I can add. I hope that what I have done here will be of some help.

I wish the National Council for Cement and Building Materials a long and successful future in their efforts to improve the efficiency of the industry.

I remain, Sir

Yours faithfully

LESTER N. WALLACE

PLANNED PREVENTIVE MAINTENANCE PROCEDURE AND CONTROL PROCEDURE.

Lester N. Wallace
U.S.I.D.O.

GOOD HOUSEKEEPING

Regardless of the size or type of Engineering Installation, whether it be light precision production machinery or heavy cement manufacturing machinery, Good Housekeeping is a basic essential towards the implementation of planned preventive maintenance.

Clean machinery, clean approach roads, pathways, alleyways, stairs etc makes for safer and more congenial working conditions, easier inspection and safe lubrication. Maintenance or lubrication work carried out under dirty and dusty conditions will create more and greater problems for the future.

Dirty machinery is usually neglected machinery and only reflects the lack of interest shown by the people in charge.

LUBRICATION

All Engineers will agree that good lubrication of machinery is the easiest and cheapest form of planned preventive maintenance, yet on many engineering installations it is quite common to see drums of grease and oil left open, to atmosphere, collecting dust, dirt and moisture.

It is not surprising that 'Break Downs' occur when such carelessness is tolerated.

Oils and greases should be issued from the Stores as and when required and in the right quantities for the particular lubricating job in hand.

All greasing points should be wiped clean before applying grease.

All areas around oil fillers should be wiped free of dust and dirt before removing caps or lifting lids.

Cleanliness is the golden rule for all lubrication and will, in most cases, ensure trouble free running for long periods.

INSPECTION

Regular and thorough inspection of all sections of the plant and machinery will often prevent major breakdowns. Listening for unusual noises, feeling for vibrations or overheating, looking for undue wear, checking oil levels and for general cleanliness should all be part of regular routine inspections.

Regular inspection will keep the Engineer one jump ahead since he will be able to take corrective action before a slight fault can grow into a major problem.

SCHEDULED MAINTENANCE

With a New Plant, manufacturers usually supply some details on lubrication and maintenance procedure. Where this information is not supplied the Engineer can only base his schedules on his own knowledge and experience. From thereon it is a matter of installing a simple system of control so that the replacement off wearing parts, the general maintenance and the lubrication are carried out at the specified time.

CONTROL OF MAINTENANCE

A great deal of writing has been done on planned preventive maintenance and its control and it is at this point that the Engineer needs to be most careful in selecting his system to avoid making the whole thing so complicated and cumbersome that it becomes unworkable. First, as everyone will agree, there must be the absolute minimum of paper work, therefore we must stick to basic essentials.
Secondly, the system must not tie up an Engineer who would be better employed on maintenance work.
Thirdly the system must give a complete description of every item of plant with its scheduled maintenance periods and, gradually, a full description of all work done, with materials used. From which will develop a full set of statistics for future planning.
The initial installation of such a system is the hardest part of the job. Starting with the plant register it is necessary to number and itemise all parts or units of plant and machinery. This will, in most cases, neccessitate 'on the spot' checking to find the more relevant details. A little team work by the electrical and mechanical staff will make this 'once in a lifetime' task much easier.

MASTER CARD

Once all the information of an item of plant or machinery has been obtained, it can then be detailed out on the 'Master Card' with its mechanical, electrical and lubrication maintenance frequencies.
To avoid unnecessary duplication of stoppages, all motors should be included on the card with the driven unit so that electro-mech maintenance may be planned and carried out at the same time. This requires the complete co-ordination and co-operation of electrical and mechanical maintenance departments.

MAINTENANCE CARD

With each Master Card, there will be a 'Follow-up' maintenance card on which will be entered all work actually carried out on that particular item of plant or machinery, all materials used and the name of the man or men who have done the job. This card will develop into a complete and invaluable history sheet.

JOB CARD

The 'Job Card' is the only travelling card and will be issued to the workshops by the clerk controlling the maintenance system.
He will examine his Master Cards daily and from the colour coding system (see attached sheet) will know what maintenance work is scheduled for the particular period.

He will take the details from the Master Card and enter them on the front of the job card with the Job No. or Cost, Coding No. The job cards will then be issued to the Superintendent concerned and he will enter the name and clock number of the man who is to do the job.

The man who does the job will enter the time that he takes on the job with any relevant details on the front of the card.

On the back of the job card will be entered all items of spares etc drawn from the stores and this will be signed by the Storekeeper.

When the job is completed, the Superintendent will sign the job card and return it to the clerk controller of maintenance.

The clerk will then enter all the details on the maintenance card and then pass the job card to the accountancy department for costing.

Except for the job card the only paper work necessary, once the system is installed is a book recording of all job cards issued so that they may be checked and crossed off as the job is completed and the card returned.

The whole system is so basically simple that once it is in operation it almost chases its own tail. With the numbering of the machines and items of plant and possible colour coding of the machinery itself in relation to the maintenance periods everyone on the site will understand THE SYSTEM.

Yearly and Daily Maintenance Schedules which are mainly a matter of adjustment or lubrication although recorded on the Visual Card System, should normally be a matter of routine with a job card issued by the supervisor concerned. The job card will, ofcourse, still go to the controller of the visual card system for recording.

Weekly Maintenance Schedules should be brought forward on Monday of each week by the visual card controller and job cards issued accordingly. The weekly maintenance should be carried out as soon as possible and the completed job card returned to the controller for the recording of the details thereon.

YELLOW

Monthly Maintenance Schedules should be brought forward, as close to the 1st of the month as possible, by the controller of job cards issued and processed in a similar manner to the weekly cards.

GREEN

Quarterly Maintenance Schedules should be brought forward in January -April - July and October, as close to the 1st of each of those months as possible by the Controller and job cards issued and processed in a similar manner to the weekly and monthly cards.

BROWN

Half Yearly Maintenance Schedules should be brought forward in January and July, as close to the 1st of each of those months, by the controller and job cards issued and processed as above.

BLUE

Yearly Maintenance Schedules should be brought forward, as close to the 1st of January as possible, by the controller and job cards issued and processed as above.

BLACK

Planned Kiln Shut Down Maintenance Procedure although there will be standard maintenance procedure for the Kiln, its accessories, ancilliaries and auxilliaries there will also be a list of extra items, to be checked, or receive maintenance, which the Chief Engineer, has been compiling during the run of the Kiln.

RED

At this time the Chief Engineer, apart from his usual interest in the maintenance procedure, should sit with the card controller to be sure that job cards are issued for every item of plant, of which there might be the slightest doubt about, even remotely connected to the Kiln.

The Chief Engineer should also check all jobs and cards to be sure the work is completed before the job cards are returned to the controller for recording.

COLOURED IDENTITY SIGNALS WILL INDICATE MAINTENANCE PERIOD

YELLOW	-	WEEKLY MAINTENANCE
GREEN	-	MONTHLY MAINTENANCE
BROWN	-	QUARTERLY MAINTENANCE
BLUE	-	HALF-YEARLY
BLACK	-	YEARLY
RED	-	PLANNED KILN MAINTENANCE AT 'SHUT DOWN'