



INDIAN RAILWAYS

TRACK MACHINES DIGEST

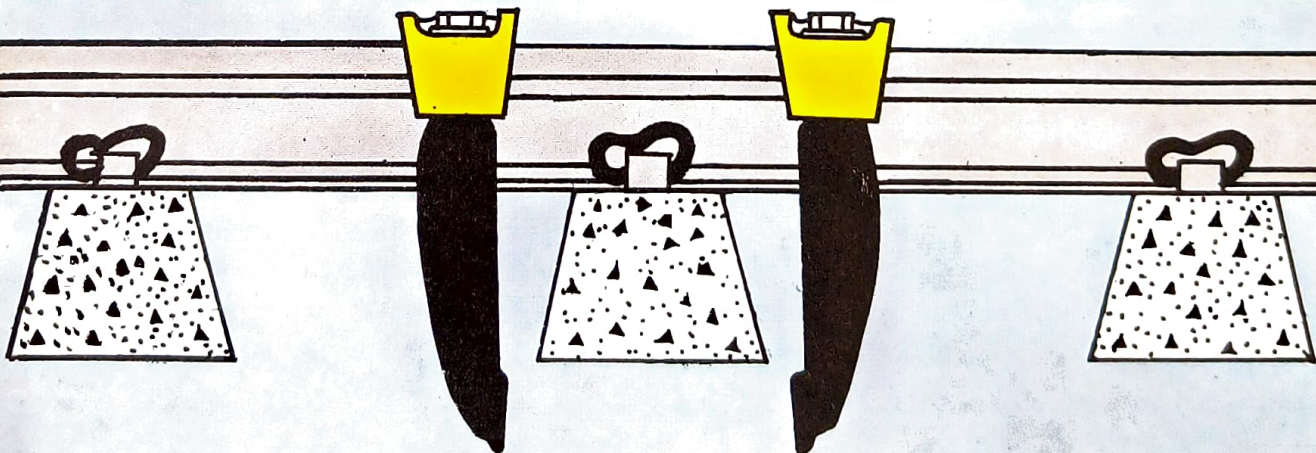
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TRAINING OF TRACK MACHINES STAFF

By Surya Prakash

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1. INTRODUCTION:

Tamping machines were inducted on the Indian Railways in 1967-68. These machines were simple to operate and maintain. As the machines were few, the staff strength was also less and only initial training was given by manufacturers. After mid eighties, various models of different type of Track Machines with sophisticated technology were inducted and presently about 300 track machines of more than 20 models are available for various track maintenance/renewal jobs i.e. tamping, ballast handling, track laying and miscellaneous works. These machines are worth approximate Rs. 400 crores.

The manufacturers generally impart initial training with limited exposure to operation and maintenance of the machine. There is no provision of repeat/refresher training.

Adequate training is necessary for proper operation and maintenance of the machines so that reliability and availability of machines with quality output is ensured. Further, adoption of wrong operation and non-standard maintenance system can cause serious and some time irreparable damage to the machines.

2. RECRUITMENT :

The track machines presently available on I.R. are having sophisticated technology. For understanding the system of machines the staff must have technical background with subjects like Mechanical Engg., Automobile, Hydraulics & Pneumatics, Electrical & Electronics. The staff is recruited at various levels. The required

technical qualification and experience for various categories is as per details at Annexure-A.

3. TRAINING:

The mechanisation of track maintenance started with tamping machines. Initially, few machines like SLC were inducted which needed a small complement of staff. The staff was arranged from sister departments and was given limited exposure for operating and maintenance of the machine by the manufacturers.

The staff has been operating and maintaining the machines with initial training by manufacturer. The staff improved their skill on the basis of experience only as the manufacturers were not conducting refresher courses as routine training.

With induction of high output machine for various jobs like tamping, ballast handling, track laying etc. the staff is to be inducted regularly and their proper training is a must to bear responsibility at various stages of their career for efficient and effective working and optimum utilisation of the very costly and vital assets e.g. track machines. To meet the ever increasing need of training in all sub disciplines related to the operation and maintenance of track machines, the Indian Railways Track Machines Training Centre (IRTMTC), Allahabad was established on 17.5.84. Till May '98, IRTMTC has trained 4303 track machine personnel in 302 courses.

The training can be divided into Institutional training and on-job training for each category

of directly recruited staff. While promoted staff is given only Institutional Training. On Job training is provided by corresponding zonal Railway and Institutional Training is provided at IRTMTC, Allahabad.

Directly recruited staff are imparted on-job almost half training on machine immediately after joining and after completing on-job probation period, are given institutional training. On completion of institutional training, they complete remaining part of on-job training before charge of the post. In case of promoted staff, they complete institutional training before taking charge of the post.

The institutional training at IRTMTC also provides limited exposure to on-job training through training at shop floor in CPOH Workshop and field visit to machines. The training covers various system of machines, safe working of machine, general administration etc.

4. TRAINING COURSES:

The courses are based on various modules approved by Track Machines Directorate of Railway Board. In addition to these, special need based courses are also conducted. Further, existing modules are also revised from time to time on getting feed back from field units.

The courses can be classified in five groups as per their objective.

These are as follows:

I. Foundation Courses:

Designed for direct recruits in category of fitter Technician and Chargeman/ Foreman, (JE/II, SE) to provide required knowledge on different system of machines as to enable them in the technique of fault finding, operation and regular maintenance system.

II. Promotional Course:

Designed for departmentally promoted staff in category of Fitter Technician/ Chargeman (JE/II) to upgrade their knowledge on different system of machines and general administration so as to equip them to take charge of the post to which they are promoted.

III. Refresher Courses:

Designed to provide knowledge at an advanced level and to update their working practices for operation, maintenance and fault finding for optimum utilisation of track machines.

IV. Courses on Particular Track Machine/ Important Assemblies:

Designed for indepth understanding of particular machine/important assemblies and related field problems for the staff working on related machine and supervisors of other track machines.

V. Seminars:

To provide forum for discussion of current technical problem and exchange of idea on the subject among field staff and manufacturers. This also provide an opportunity on latest development in related field and upto-date instructions on maintenance issued by manufacturer.

The list of various courses, alongwith duration, level of participants etc. is given in Annexure-B.

5. CONCLUSIONS:

To achieve optimum utilisation of existing Track Machines for improving the track maintenance and their upgradation in future, training of not only track machine staff is essential but also training of Permanent Way staff is required on regular basis.

RECRUITMENT AND PROMOTION OF TRACK MACHINE STAFF

Sl.No.	Designation and Grade	Recruitment System
1.	Sr. Section Engineer (TM/TT) 7500-12,500	By Promotion on seniority cum suitability from SE.
2.	Section Engineer (TM/TT) 6500-10500	80% by Promotion by selection from JE-I 20% of vacancies by direct recruitment of Engg. Graduates.
3.	Junior Engineer-Gr-I (TM/TT) 5500-9000	By Promotion of JE-II on seniority cum suitability.
4.	Junior Engineer Gr-II (TM/TT) 5000-8000	50% vacancies by direct recruitment of Diploma Holders. 25% vacancies by promotion of Sr. Technician by selection. 25% vacancies by departmental examination from amongst Technician Grade I & II who are matriculate & are below 45 years of age, employee working as Technician Gr.I & Gr. II should have a minimum 3 year service in that grade.
5.	Sr. Technician (Trade) 4500-7000	By promotion from amongst technician Gr.-I on seniority cum suitability through trade test.
6.	Technician Grade-I (Trade) 4000-6000	By promotion from amongst Technician Grade-II on seniority cum suitability through trade test.
7.	Technician Grade-II (Trade) 3550-4590	25% of vacancies by direct recruitment from ITI trained personnel/course completed Act. Apprentices/ Matriculates, serving employee with requisit qualification are also eligible. 50% of vacancies by promotion of serving employee in lower grade based on seniority cum suitability through trade test. 25% of vacancies by departmental examination from amongst serving employees in lower grade who have put in 3 years and are matriculates.
8.	Semi Skilled workers 2650-4000	100% by promotion from Khalasi in the grade 2550-3200 on passing trade test.

LIST OF COURSES FOR TRACK MACHINE STAFF

Sl. No.	Code	Course Title	Level of Participant	Duration
I. FOUNDATION COURSES:				
1.	CE-26	Initial Junior Engineer-II	Direct Recruit JE-II	26W
2.	CE-26	Initial Section Engineer	Direct Recruit SE	26W
3.	CE-28	Initial Technician Gr-II (Trade)	Direct Recruit Technician Grade-II.	13W
II. PROMOTIONAL COURSES:				
4.	CE-27	Promotional Junior Engineer-II	Promoted JE-II	8W
5.	CE-29	Promotional Technician Grade-II	Promoted Technician Grade-II	6W
III. REFRESHER COURSES:				
6.	CE-30	Refresher Technician	Working Sr. Technician Technician Grade I/II	2W
7.	CE-31	Refresher Junior Engineer	Working JE-II/JE-I	
8.	CE-32	Refresher Section Engineer	Working Section Engineer Sr. Section Engineer.	2W
IV. COURSE ON PARTICULAR TRADE MACHINE/IMPORTANT ASSEMBLIES:				
9.	CE-38	Continuous Tamping M/C 09-CSM	JE-I/II/Sr. Section Engineer	2W
10.	CE-41	Ballast Cleaning Machines	JE-I/II/Sr. Section Engineer	2W
11.	CE-42	Track Relaying Machines (PORS, AMECA TRT)	JE-I/II/Sr. Section Engineer	2W
12.	CE-43	Dynamic Track Stabilisers and Ballast Regulators.	JE-I/II/Sr. Section Engineer	2W
13.	CE-39	Hydraulic Circuit of Unimate	JE-I/II/Sr. Section Engineer	2W
14.	CE-40	Electrical/Electronics Circuits of 08-Duomatic.	JE-I/II/Sr. Section Engineer	2W
15.	CE-44	Hydraulic Circuits	JE-I/II/Sr. Section Engineer	2W
16.	CE-45	Maintenance Schedule	Technician/JE-I, JE-II/SSE	1W
17.	CE-46	Overhauling of Tamping Unit	Technician/JE-I, JE-II/SSE	2W
18.	CE-47	I.c. engine	Technician/JE-I/JE-II/SSE	2W
19.	CE-48	Overhauling of Gear Boxes.	Technician/JE-I, JE-II/SSE	2W
20.	Spl.-1	Basic Electronics for Technician	Working (Non electronic side)	3W
21.	Spl.-2	Basic Electronics for JE/SE	Working JE-I/JE-II-SEE (Non Electronic side)	2W
22.	Spl.-3	Advance Electronics	Working JE-I/JE-II,SEE (Electronic side)	4W
IV. SEMINARS:				
23.		Seminar on Hydraulic components Engines, Current Problems etc.	Dy. CE, SEN/AEN and Sr. Section Engineers.	

NOTE: The course CE-09, CE-49 and CE-50 each one week duration is designed for training of P. Way staff i.e. Permanent Way Supervisors, JE-I/II/SE/Sr. SE and Promoted AEN/DEN respectively on appraisal of Track Machines.

IMPROVING PRODUCTIVITY OF TRACK MACHINES

By V.K. Bali

Dy CE/TT/HQ, Northern Railway

1.0 INTRODUCTION (Track & Machines)

The track plays a decisive role in all modernisation, conversions, track upgrading and new track laying on the Railways. The best trains, time table and service offers bring effect if the track is not efficient, which means it must be laid, maintained and renewed to the highest standards. Optimisation of the Railway track is complex dynamic process requiring the best planning, fabrication and maintenance of all track components which are each necessary for the operation of a Railway.

- 1.1 Notable Track optimization of the railways have been achieved in the past years by mechanisation Through Track Machines. Today almost all P. Way work can be performed by machines very quickly and efficiently with greater accuracy at lower cost with fewer restrictions to train services.
- 1.2 Through the mechanisation of Permanent way the railway could not only greatly improve the quality of track but at the same time, the procedures, the amount of time, the personnel required and above all the cost were greatly reduced.
- 1.3 Without mechanisation of Permanent way work the Railways would never have been able to achieve today's standard of track & transport quality, nor the reduction in costs.
- 1.4 Accordingly Track Machines had been introduced on Indian Railway in late sixties. In the beginning slow speed low

output track machines had been introduced but with the passage of time higher output sophisticated heavier tamper BCM, TRT, Unimats, Shoulder Ballast Cleaner were introduced. The machine with higher speed & faster capacity of working can work in shorter blocks also as longer blocks are not made available.

2.0 HIGH OUTPUT TRACK MACHINES:

Where do the advantage of high output track machine lie.

- 2.1 Looking at this question from the standpoint of operating department, then the minimal occupation of the work site by the machine will be one of the most pertinent argument for its use. Particularly in today's world of high speed and high capacity traffic very little time is left for track work. The machines have to achieve maximum performance in a minimum of time available. Just as this demand leads to the development of high capacity machines it also requires the step into further development the development for the all-in-one machine.
- 2.2 The sophisticated machines help to lower the track maintenance costs, by ensuring Minimum occupation of work site. Even better utilization of train intervals. Lesser restriction to train services. Lower staff & Administration costs.
- 2.3 This brings "almost undisrupted train services" for Operating department.

3.0 DEPLOYMENT OF TRACK MACHINES:

Headquarters Office is responsible for making the machines available as per yearly programme of deployment of machine for their efficient working.

- 3.1 The output target of various machines per month have been stipulated by Board as under:-

CSM	110 Km.	DGS	100 Km.
Duomatic	88 Km.	BCM	12 Km.
Unomatic	56 Km.	FRM	25 Km.
Unimat	100 T/Outs	BRM	100 Km.
PQRS	5 Km.	T-28	12 T/Out
TRT	12 Km.		

- 3.2 These targets need to be achieved in a total block of 4 hrs. per day for 25 days a month. These blocks have to be arranged as one of the following.

- 4 hrs. block on UP or DN line on alternate day.
- 2 -2½ hr. spell blocks on the same line, UP or DN on alternate days.
- 1-1½ hrs. block on each line daily.

- 3.3 These blocks need to be nominated/made available for optimum utilization of the machines as under :-

Inclusion of corridor block in working time table.

Signing of MOU's between engineering & Traffic Deptt. at Headquarter & Divisional level.

Monitoring of block at DRM's level.

- 3.4 Average block granted per day in Hrs. over Northern Railway are as under:

4.0 PRODUCTIVITY OF THE MACHINES:

The productivity of the machines with all present constraints has been affected and their utilization remains upto 40-45% of the real target. This needs efforts to increase productivity of machines.

A few measures which have been introduced over Northern Railway to increase output are as under:-

4.1 Monitoring of Working of Track Machines:

Monitoring of machines is very essential. This reduces idle period of machines. The items which need special attention

MACHINE	Y E A R		MACHINE	Y E A R	
	1996-97	97-98 (Upto Oct '97)		1996-97	97-98 (Upto Oct '97)
FTM TTM	2.09	2.06	RM-76	1.49	2.27
UNI	2.05	2.07	FRM-80	2.22	1.46
PQRS	1.36	1.39	BRM	1.42	2.11
RM-80	1.25	1.48	DGS	1.53	1.43
			T-28	1.55	2.04

The position of blocks needs to be improved.

4.1.1 Failure of Machines:

Immediate information regarding cause of failure, spare/repair/help this reduces the idle period and enhances productivity.

4.1.1.1 This is ensured by following:

- a) As soon as the failure occurs the machine staff informs concerned MTS, SFO, AEN or SEN on Rly. & P&T Phone indicating help required.
- b) A track machine man is kept in Central MTS office who contacts all MTSS of all division to collect information regarding working of machine for previous day.
- c) A daily computerised report on working of machine is made daily and put up to all HOD's.

4.1.1.2 Prevention/Monitoring of failures:

- a) Immediate rectification action is taken
- b) A imprest of spares is kept at site for day to day use.

c) Failure analysis is done-by feeding the data in computer. .

4.1.1.3 In case of failure occurring repeatedly the cause is analysed and action taken.

4.1.1.4 Over Northern Railway the down time during last few years has been as under:-

4.1.1.5 The major failures affecting output of machines and also down time are failure of T/Unit and need improvement.

4.1.1.5.2 The engine failing most is MWM 232 Model engine of M/S. Greaves. The services/availability of spares are not satisfactory. Also 234 Model Engine fitted on FRM-80 has frequent trouble.

M/S Plasser and M/S Greaves need to look into this on urgent basis.

4.1.2 Comparative Efficiency Chart

4.1.2.1 The progress of track, machine is analysed every month and the

YEAR	TTM	UNI	PQRS	RM-80	RM-76	DGS	T-28	FRM-80	BRM
1996-97	12	13	1	24	5	0	0	13	13
1997-98 (Upto Oct '97)	9	9	1	2	0	0	0	28*	74*

* Due to Engine failure not attended by M/S Greaves.

** Due to failure of Hyd. Pump & Motor not available.

expected output and achieved are compared. The details are as under:-

Machine	Expected Output per eff. Hr.	Output achieved during	
		1996-97	1997-98 (upto Oct.97)
CSM	1.30	1.36	1.37
DUO	1.00	1.07	1.04
UNO	0.50	0.58	0.57
UNIMAT	1.50	1.57	1.64
PQRS	0.25	0.24	0.24
RM-80	0.25	0.27	0.21
RM-76	0.15	0.17	0.18
FRM-80	0.40	0.43	0.50
DGS	2.0	1.61	2.10
BRM	2.0	3.28	4.16
T-28	0.65	0.55	0.75

The figures are quite satisfactorily.

4.1.3. Group working of Machines- Northern Railway has been the pioneer in adopting group working. Group working of CSM, BCM has been carried out and the results achieved had been extraordinary as under:-

a) Group Working of CSMs.	Achieved Improvement	
i) Average block per day	3.2 hrs.	11.3%
ii) Average No. of days machine available per month.	28 days	17%
iii) Average output per machine per month	72.5 Km.	188%

iv) Achieved an average output per machine per working day. 3.08 as against 1.12 Km. in piecemeal blocks.

b) Excellent co-ordination amongst all departments. Engineering, operating, Signal & Telecommunication etc. has been achieved which has been appreciated by Chaimran Railway Board. Group working of 2 CSM is generally planned and worked successfully.

c) Group Working of BCMs:

Deep Screening of 1.93 Km. of Track with 2 machine in a day has been achieved with monthly output of 20 Kms.

d) This group working of machines: has reduced requirement of staff. Inventory of spares at site has reduced. Level of maintenance has improved.

4.1.4 Spares parts management:

All inventory of spares has been computerised. Monthly issue/receipt of material is up-dated which helps in locating spares and thus reduces break-down.

4.1.4.1 The procurement process of spares is persued by T.T. officers in HQ Office who monitor all store/finance cases and hold regular meetings with the stores officers for early finalisation of procurement cases. This system has been found to be beneficial. But still the lead period for procurement of spares remains to be 12 to 18 months.

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- 4.1.5 Better availability of machine is ensured with reduced down time by doing timely preventive maintenance. For timely maintenance service contracts with M/S. Plasseer and Engine manufacturer like Greaves, Kirloskar Oil engines Ltd., & Cummins Diesel Sales & Services, have been made. The list of spares with Service Contracts is reviewed every year.
- 4.1.5.1 CFO's have been made incharge of only one type of machine instead of territorial basis so that they can monitor and organise the working properly. This will go a long way in improving quality control of maintenance of machines.
- 4.1.6 Except for tamping machine no other machine is worked at night because of lack of facilities like lighting arrangements etc. But in view of the increased traffic during day blocks are readily available on many section during night. The difficulties experienced during night working are
- Staff does not get rest during day especially during Summer Season.
- The maintenance of machines suffer because of improper rest to staff.
- 4.1.6.1 But the working at night can not be avoided. Even Amtrack (U.S.A.) has moved the majority of its track maintenance to overnight between 22.00 hrs to 06.00 hrs.
- 4.1.6.2 But with increased traffic on & over route decision will have to be taken to work heavy machine like BCM, FRM etc. also at night by making sufficient lighting.
- 4.1.7 Higher speed after work-Normally a speed restriction of 20 KMPH is imposed just after track renewal/deep screening. But on Northern Railway Track after such works is opened for 40 KMPH by doing immediate tamping. Also by using DGS & BRM track was opened for 60 KMPH immediately after renewal with TRT. This has helped in lesser speed restriction and faster movement of traffic thus coaxing operating department to give more blocks.
- 4.1.8 Increasing productivity by improving living conditions of staff.
- 4.1.8.1 At present there is hardly any category of staff who is subjected to such difficult working condition as that of TT staff. In fact this is the only cadre which is actually working. It is therefore not unnatural that the present day TT staff though have pride in their work but still prefer to change to unit like CPOH/IRTMTC/Line Office/HQ Office etc.
- Though there seems to be no improvement in the working condition in near future but still effort is being made to give comfort to TT Staff working at site.
- 4.1.8.1.1 Existing camp coaches for TT Staff are being got modified from C&W Workshop as per RDSO drawing. Two such camp coaches
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are in operation and six more are due to come.

4.1.8.1.2 All rest house facilities like beds, Mosquito Net, utensiles, water Jug, desert cooler, pedestal fan, shoes, helmets, DG Sets etc. are being provided to the staff.

4.1.8.1.3 Now as per Railway Board's instructions Refrigerator, Gas connection will be arranged for staff.

4.1.8.1.4 Pools of quarters are being created at various HQ of staff so that they & their families can have proper place to live.

4.1.8.1.5 Hq of staff is fixed as demanded by staff, card passes for N. Rly., journey time to & from HQ to site is given.

4.1.9 Training of staff-During initial recruitment of staff they are deputed to the works of M/s. Plasser for about a month where they are exposed to the various assemblies, their construction and manufacture of a machine. Thereafter they are sent to IRTMTC/CPOH for training. This helps them understand the machine and its operation to achieve higher results.

4.1.10 The productivity of machines also gets improved by safe working.

Safety Rules:- There were instances on Northern Railway of damage to machine, accidents resulting in loss of life of staff. These not only affect productivity of machine by

making machine un-available for working due to damage or staff not available for operation. A few examples.

912- Met headon collision in block section when entered block section without block. It remained out of use for 4 months.

8033 & 8117: Hit by a light engine in siding during shunting. Got damaged and remained idle for a week.

Four of TT staff lost life during working on machine after getting hit by a train ?

4.1.10.1 A small vehicle like Towar Wagon for OHE is provided with a shed for its stabling but Track Machines worth crores of rupees are stabled in opens, Rain/Dust affect the life of these machines. It is very necessary to arrange for sheds for Track Machines also. This will help in safe custody of Track Machines.

4.1.11 Longer Blocks: Although MOU is being signed between Engineering Operating Branches on the Division but due to various operational reasons full optimum blocks are not available. Now this matter is being monitored at highest level in the HQ Office and means are evolved to make available periods of longer duration.

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- 4.1.12 Pre & Post Working operations: The quality/quantity of work of Track Machines get affected thus reducing their output if advance preparation, during operation and post operation works are not carried out sincerely & thoroughly. Various Pre & Post works have been specified for all types of machines and are ensured to be implemented.
- 4.1.13 Shifting of Machines: The planned working of machine is ensured as per yearly programme to avoid shifting of machine frequently which involves loss of days on shifting. Machine are not allowed to shift without approval of CE/TMC.
- 4.1.14 Communication: The Communication with staff at site needs improvement. Use of walkie talkie sets had helped during group working ensuring.
- a) One machine which had failed had called other for help.
- b) Extension of block was known. Staff talks to TT Officer on P&T Phones to inform break-down or any untoward incidence for early action.
- 4.1.15 Unit Exchange: Unit exchange system during repairs of machine/maintenance schedule has greatly helped in reducing idle period of machine. Assemblies like Engine, Tamping Units, Excavating Chains, Axles etc. are changed at site in one or two days which helps in saving time of to & fro movement of machine to workshop.
- 4.1.15.1 The Productivity of Track Machines can be further increased if the IOH/POH time of the Track Machines is reduced by CPOH. Presently time taken by CPOH is 4 month which is too long.
- 4.1.16 Powers: Powers for emergent pro-curement of spares have a very special bearing on out-put of machines. Presently the powers being used are as under:-
- SEN/TT 7500/- per item per case with ceiling of Rs. 5 lakh PA.
- Dy.CE/TT/L- Rs. 15000/- per item per case but for PAC above 10,000/- with Finance concurrence, with a ceiling of 10 lakh PA.
- CE, CE/TMC Rs. 50,000/- per item per case without any ceiling limit with finance concurrence.
- 4.1.16.1 These powers need revision as even small jobs like repair of self startter, alternator or calibration of FIP of engine also cost more than 15000/- so every case has to go to Dy. CE, CE, CE/TMC with finance concurrence. This caused delay in repair of machine and thus affecting productivity.
- The procurement of spares through stores also takes 12-18 months. This is too long a lead period.
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4.1.16.2 The powers for emergent procurement need to be revised as under:-

SEN/TT/L	Rs. 25000/- per item per case with a limit of 10 lakhs without finance concurrence.
Dy. CE/TT/L	Rs. 50000/- per item per case without finance concurrence with a ceiling of 20 lakhs.
CE,CE/TMC	Rs. 1,00,000/- per item per case without any ceiling.

4.1.16.3 In fact procurement of spares should be done by TT Organisation themselves by giving powers of stores department to SEN/TT & Dy. CE/TT.

This will definitely help in reduction of down time of machine thus enhancing their productivity.

4.1.17 Awards: The staff of Track Machines is awarded for their performance on monthly basis.

Yearly awards are also given to the outstanding persons. This helps in motivating staff for improved performance to get recognition.

4.1.18. Coasting of Machines:

4.1.18.1 All the items discussed above are required to improve productivity of track machines. The improved productivity of the machine has direct relation to the unit cost of working of these machines. Higher the productivity lesser the cost.

Details of costing of machine for last 2 years is as under:

	1995-96	1996-97
	Rs. Per Km	Rs. Per Km.
CSM	10766	13089
DUO	8409	6288
UNO	10682	9204
Unimat	11052	10016
BCM	344349	122236
FRM	325595	16651
RM-76	224025	93244
PQRS	68202	33508

CONCUSLUSION:

1. MOU's for grant of block are a must and operating brach need to know that the importance of machine working for betterment of train operation.
2. Group working of Track Machines need to be introduced in a big way.
3. Night working of Track Machines like BCM/FRM etc. to be tried.
4. Living conditions of TT staff need to be improved.
5. A system of 15 days working & 15 days rest in a month with increasd hours of working should be tried so that TT staff can spend more time with families and can avail better rest.
6. Emergent powers for procurement of spares need to be enhanced and TT officers should be made stores officer for TT Organisation.

RELIABILITY - BASED MAINTENANCE

1. INTRODUCTION:

Intensive competitive pressure is compelling industrial maintenance organisations to make the transition from being repair departments for fixing broken machines to that of high-level business units for assuring production capacity. Downtime is extraordinarily expensive, often greater than maintenance costs. Before talking what is Reliability-Based Maintenance, let us talk very briefly about the various other maintenance practices in vogue.

2. PREVENTIVE MAINTENANCE:

The goal of Preventive Maintenance (or interval-based maintenance) is to provide control of planned maintenance activities, rather than allow machine breakdowns and unanticipated expenses to control plant outputs and profits. The work order administrative capability of the CMMS (Computerised Maintenance Management System) provides for the routine execution of normal maintenance activities and tracks their associated costs. Studies have shown that a successful program of preventive maintenance can provide a 30% decrease in maintenance costs relative to expenses resulting from Reactive Maintenance (or break down maintenance). However a strictly preventive or interval-based strategy for maintenance carries a number of risks associated with it. For example, the interval chosen for the "life" of the equipment (and therefore the maintenance activity) may not have a strong statistical base, and/or the statistics may have a large standard

deviation from average, making the the likelihood of overmaintaining or under-maintaining equipment very high.

3. PREDICTIVE MAINTENANCE:

More recently, Predictive (or condition-based) Maintenance has provided the ability to measure machinery condition and significantly modify the implementation of interval-based maintenance. If the results of the predictive investigation show that the machine is in good condition and its components are stable, major maintenance can be delayed for several months or eliminated from the interval-based schedule. In many cases, developing faults are detected months before corrective action is required, thus providing ample time to schedule the material and labour needed. Usually the work can be included in a planned production outage so that no additional production time is lost. Studies have shown that Predictive Maintenance can reduce cost by more than 30% from that of a simple preventive program.

The technical basis behind this concept is that most ailing components give some warning of the fact that they are on the verge of failure. These warnings include changes in vibration levels, heat dissipation, thickness changes, presence of oil wear particles, etc. Predictive methodology is composed of several technologies, when combined, can predict most mechanical and electrical problems found in plant equipments. The technologies include intrusive and non-intrusive methods as well as the use of process parameters to

determine overall equipment condition which in turn will allow an assesment of the performance degradation from the designed condition. Following are some of the Predictive technologies deployed:

- a. Vibration Analysis.
- b. Tribology and Lubrication.
- c. Thermography (Thermal imaging and temperature measurement)
- d. Electrical testing-Motor Current Signature Analysis and Insulation Resistance Measurement.
- e. Oil and Lubrication Analysis.
- f. Flow Measurement
- g. Leak Detection.
- h. Corrosion Monitoring
- i. Process Paramater Monitoring
- j. Visual Observations and other sensory inputs.

Some of the above technologies are elaborated below:

a. **Vibration Analysis:**

The cornerstone of predictive maintenance is vibration-based machinery monitoring. Vibration analysis technology, when applied routinely and systematically to plant rotating machiner, can produce significant savings.

b. **Tribology and Lubrication:**

Definition of Tribology is. The study of Surfaces in relative motion. It encompasses all the influences within a

where two or more surfaces are interacting. From a maintenance point of view we are concerned with the practical elements of what occurs within this interaction, wear, friction, system cleanliness and the thickness and stability of the fluid film are all key units of the maintenance equation.

Lubricant analysis is simply an important tool for providing an understanding of the influences between surfaces.

c. **Thermography (thermal imaging and temperature measurement):**

Thermography is a versatile technology that can be used for electrical surveys, piping surveys, valve leak and faulty steam trap detection, refractory breakdown and facility insulation surveys.

In Thermal imaging, infrared camera is used. Following are some of the features of an infrared camera:

- the image of the object is obtained without touching the object.
- the lens has a high resolution and it can recognise a 10th of a degree.
- it is a portable one and can be taken to field/site.
- it records only the surface temperature of the object (for ex. if there is water on the hot slab, the camera measures only water temperature.
- the distance between the camera and the object should be less than 10m.
- temperature of the area between

the object and the camera has no effect on the readings.

- 10 deg C is the lowest temperature that can be measured.
- the camera has a built-in-refrigerator (now-a-days liquid nitrogen is used).
- the system is LCD based and Windows based.

d. **Electrical testing-Motor Current Signature Analysis and Insulation Resistance Measurement:**

Electrical equipment monitoring can be accomplished on a repeatable basis by using Motor Current Signature Analysis and Insulation Resistance Measurements. This is a non-intrusive method of monitoring. This can be used in conjunction with vibration analysis to support diagnosis. Insulation Resistance Measurement, when done with consistency, can alert an analyst to improper cleaning, repair and wear of insulation due to improper routing of cables or excessive vibration.

e. **Oil and Lubrication Analysis:**

Detailed analysis of oil for viscosity, acid number, water content and chemical constituents provides early warning of oil breakdown, contamination prior to use, excessive wear on moving components and premature failure of components due to manufacturing defects.

4. **PROACTIVE MAINTENANCE:**

The goal of Proactive (or root cause-based) Maintenance is to apply advanced investigative and corrective technology towards solving the root cause of any machinery problem, thereby significantly extending the machinery life. In its ideal form, the goal of proactive maintenance is to eliminate failure in plant components. Proactive maintenance consists of several technologies or methods which, when combined, can lead to consistent life extension of plant components. Following are some of the proactive technologies adopted.

a. **Root Cause Failure analysis**

RCFA is the process of discovering the fundamental causes that lead to machine failure. Predictive techniques can predict a bearing failure, but not necessarily address the problem of why the bearing failed. Traditional post-mortem RCFA techniques have centered around metallurgical analysis of fractured or fatigued metals. Recent advances in multi-channel vibration analysis techniques relating to operating deflection shapes and modal shapes are now commonly employed in diagnosing design and installation deficiencies. Failed bearing analysis provides methods to visually categorize scoring, color, fretting, and pitting, and to relate these finds to the most probable cause of failure.

b. **Precision Rebuild and Installation:**

Whether you are procuring a new

machine or rebuilding on existing machine, precision rework and installation procedures can significantly extend its life. Two common rework activities which are often poorly performed, or neglected entirely, are rotor balance and shaft alignment. Results arising out of precision alignment programs are reported to be as follows:

- Average bearing life was increased 8-fold.
- Maintenance budget was reduced by 7%.
- Machine availability increased 12%.
- Breakdown maintenance attributed to misalignment reduced 50%.

c. **Performance Specifications for Purchased and Reworked Equipment:**

When purchasing new equipment or having a machine rebuilt at a vendor's shop, requirements for mechanical specifications need to be included in the purchase specification: Vibration measurements specific to the various mechanical conditions, and tolerances for acceptable limits are essential for determining acceptability and assuring high quality equipment.

d. **Rebuild Certification/Verification:**

When a new or rebuilt machine has been secured to its foundation and coupled to its functional train assembly, it is essential to verify proper operation of the finished assembly. Many maintenance managers have estimated that as much as 20%

of this type of maintenance was improperly performed, resulting in machines that fail prematurely. Verification of post-overhaul machine quality results in significantly improved workmanship and equipment reliability.

e. **Reliability Engineering:**

As a result of various proactive technologies, the need to redesign, modify and improve existing components or specify new components becomes a significant factor. The bench mark plants added a dedicated reliability engineer to the staff of the Reliability Improvement Group to assure this capability.

5. **RELIABILITY-BASED MAINTENANCE:**

Now-a-days Reliability-Based Maintenance is the state-of-art concept in maintenance. The Reliability-Based Maintenance (RBM) strategy employs preventive, predictive and proactive maintenance technologies in an integrated manner to increase the confidence that a machine or component will operate dependably over an extended life cycle. This integrated approach offers the best strategy for achieving maximum equipment reliability. (Any one maintenance strategy alone cannot cater to the maintenance needs/requirements of all the installed equipments in a plant. RBM is a comprehensive strategy that is changing the way the world performs maintenance. RBM is achieved by integrating multiple technologies such as: vibration analysis, oil analysis, infrared thermography, motor diagnostics and alignment & balancing. In addition, implementing the RBM strategy supports ISO 9000 goals by aiding in the reduction of process variations and the

number of shutdown and startup process interruptions.

6. RBM CONCEPTS DEPLOYED IN INDUSTRIAL HYDRAULIC SYSTEMS:

In the steel industry, modern rolling mills employ a large number of sophisticated hydraulic systems. Rolling Mills in steel industry is one of the very few areas in the total industrial world, where large number of hydraulic systems are deployed. Now-a-days modern Hot Strip Mills employ very costly and sophisticated hydraulic systems for various applications including Automatic Gauge Control (AGC) and Hydraulic Gap Control (HGC) using a number of servo valves. Presently many modern mills abroad are covered by the RBM concepts. Since hydraulic systems are very crucial for the operation of the mills, it is but natural that the hydraulic systems are also covered by the RBM concepts.

Under RBM concepts, hydraulic oil analysis is used as one of the maintenance tools. Following is the profile of oil analysis:

- a. Particle Count
- b. Viscometry
- c. Spectro Metals (additives)
- d. FTIR Molecular Spectroscopy
- e. Total Acid Number & Total Base Number
- f. Demulsibility.

Following are the various capabilities of oil analysis technology:

a. Particle Count:

Particle Counting measures solid contamination within a system. Solid contamination in clean oil systems is the single most important contributor to wear, the primary root cause of failure. It is therefore necessary to maintain determined cleanliness levels within sensitive system. Proactive contamination control consists of the following essential principles:

- i) Contamination Analysis: the measurement and understanding of the amount type and composition of contaminants.
- ii) Contaminant Exclusion: the identification and minimizing of contaminant sources.
- iii) Contaminant Removal: the practices and procedures for removing contaminant that cannot be excluded, such as, residual manufacturing debris or generated contaminant within a fluid system.
- iv) Contaminant Tolerance: ensuring that components can tolerate (not degrade performance beyond allowable limits) the level of contaminant that is not excluded or removed.
- v) Systems Approach: establishing a systematic approach that ensures that the system Target Cleanliness Level is achieved and maintained.

Having an accurate particle counting capability on site as part of the testing capability, provides an effective solution. For particle counting Particle Size Analyser is used. It is an infrared sensor. In the memory of Computer NAS values and the

corresponding maximum contamination limits (micron rating of particles per 100 ml. of oil) are available. When the oil sample is kept inside the analyser, the oil is sucked inside the apparatus and the size and No. of particles present in the oil sample are counted and compared automatically with the standards available in the memory. Accordingly NAS value is assigned to the oil sample. The analyser is basically a comparator.

b. **Vicometry:**

Viscometry indicates firstly whether one is using the correct grade of oil and secondly viscosity increases or decreases measure certain physical effects on the oil. Viscosity is an extremely important parameter to measure as it determines the thickness of the fluid film.

The viscosity of a lubricant is the essential lubricating property of the fluid. Variations in viscosity are an indication of fluid degradation or contamination. Kinematic viscosity of oil is measured with the help of Kinematic Viscosity testing apparatus.

c. **Spectro Metals (additives):**

Spectro Metals Analysis provide elemental analysis (Fe, Cr, Zn, Si, Cu, Sn, Pb etc.) gives information on:

- Wear Metals.
- Metallo Organic Additives Depletion.
- Solids and Fluid Contamination

Spectro Metals Analysis has the

limitation of detecting particles less than 8 microns in diameter. SMA is basically a chemical analysis. Typical profile of SMA results may consist of in excess of 30 different parameters and the generation of huge amount of data may be confusing to the end user.

d. **FTIR Molecular Spectroscopy:**

FTIR Molecular Spectroscopy (Fourier Transform Infrared Spectrometry) measures the degradation of functionality within the oil. This chemical technique has been developed around the use of the instrument in combination with computerised techniques for large volume of data manipulation and storage. This technique is able to give a measure of water content in the oil.

e. **Total Acid Number (TAN) and Total Base Number (TBN):**

Total Acid Number (TAN) and Total Base Number (TBN) measures acid build up, and reserve alkalinity depletion respectively. With the help of titration using an Automatic Titrator total acidity or total alkalinity of oil (in mg KOH/gm) can be found out.

f. **Demulsibility:**

Demulsibility is one of the essential qualities of any hydraulic oil. Using a Demulsification Apparatus demulsibility of any oil can be determined. The test oil is mixed with water and stirred well with paddles. After thorough mixing, time taken for separation of water from the oil is noted. That gives a measure of demulsibility of an oil.

7. **MINI-LAB CONCEPT AS AN AID TO MAINTENANCE ENGINEER:**

In order to ensure the availability of the hydraulic equipments, the maintenance engineer need to be equipped with the information about the condition of the hydraulic oil and the equipments so that he can take actions as deemed fit. A Mini-Laboratory at the oil cellar to analyse some of the parameters mentioned above helps the maintenance engineer in arriving at the right maintenance decision. Under the Mini-Lab concept, following equipments can be deployed in the cellars of hydraulic systems:

a. **Electrostatic Liquid Cleaner:**

ELC is capable of removing fine particles of metals, non-metals, organic and inorganic substances. It can remove moisture as well. However ELC can only be used with oils of the following conditions.

Temperature	:	below 60 deg C.
Viscosity	:	below 100 cst.
Moisture	:	below 500 ppm.

Following fluids cannot be cleaned by ELC:

- Oils with moisture content more than 500 ppm
- Oils with detergent dispersant (for instance HLPD oil)
- Synthetic oils.
- Conductive oils.

b. **Portable Contamination Analyser:**

PCA is capable of measuring, analysing and reporting the particulate level,s in

numbers of particles and in both ISO and NAS standards. Having an accurate particle counting capability on site as part of the testing capability, provides an effective solution. PCA is an infrared sensor. In the memory of Computer NAS values and the corresponding maximum contamination limits (micron rating of particles per 100 ml of oil) are available. When the oil sample is kept inside the analyser, the oil is sucked inside the apparatus and the size and No. of particles present in the oil sample are counted and compared automatically with the standards available in the memory. Accordingly NAS values assigned to the oil sample. The analyser is basically a comparator.

Solid containinants in fluid power systems vary in size, shape, form and quantity. The most harmful contaminants are normally between 15 micron. The ISO code is the preferred method of reporting quantity of contaminants. The ISO code number corresponds to contamination levels. pertaining to two sizes. The first scale number represents the number of particles larger than 5 micron per 100 ml. of fluid, and the second number for particles larger than 15 microns per 100 ml. of fluid.

The Analyser has micropocessor control. It is a totally portable instrument that can be used as easily in the field as in the laboratory. Computer interfacing is available for downloading data into a computer. Readings can be taken at full 420 bar (max.) pressure. Particle count for 5, 15, 25 and 50 micron particles will be displayed either in ISO codes or

NAS codes. All particle counts are representative of 100 ml. samples.

This is basically a comparator.

c. **Viscosity Testing Apparatus:**

This is used to test the viscosity of oils. Hydraulic oils are heated upto 40 deg. C in this apparatus and Kinematic viscosity is determined.

8. **MEASURES DEPLOYED TO ENSURE RELIABLE OPERATION OF HYDRAULIC SYSTEM:**

For reliable operation of hydraulic systems, some of the following measures are adopted:

a. **Polishing and Pumping Station:**

Separate polishing and pumping stations are envisaged for pumping make-up oil into main system tanks. Oil from barrels may not have the cleanliness required for proper functioning of servo valves. For proper functioning of servo valves NAS class 4 or 5 is required at system tanks. But the oil in varrels may have a NAS value of 10 or 12. By polishing this oil in a separate pumping station, NAS Class 4 or 5 is achievable. (We intend to install these systems at CS P Mill at Ispat Industries Ltd. at Dolvi).

b. **Centrifuge:**

Centrifuges are deployed to separate and take out the water that might have got into the oil.

c. **Ventilation systems:**

Inspite of having the provision of air-

breathers with filters for the oil tanks, still provision is made to avoid the dirt ingress into the oil cellar by creating some positive pressure inside the cellar with the help of supply and exhaust ventilation fans. Ventilation systems enable the oil cellars to have an ambient temperature suitable for reliable operation of the hydraulic systems by taking out the excess heat developed by the systems.

d. **Precautions during fabrication, testing and commissioning:**

Following precautions are taken at various stages of fabrication, erection, testing and commissioning of the systems:

- During fabrication stage the pipelines are fabricated using TIG (tungsten inert gas) welding in the root run. This is to avoid slag inclusion on the inside surface of the pipes. And 25% of the welded joints are inspected by Radiographic Testing (Under NDT) as a quality assurance measure.
- After the fabrication is over, just before pressure testing and trial runs, in order to ensure trouble-free operation and reliable performance the pipelines are chemically cleaned on the inside. This cleaning process ensures that the inside surface is free of oil, grease and mill scale.

9. **COMPUTER SOFTWARE FOR RELIABILITY - BASED MAINTENANCE:**

One of the companies in USA has developed the computer software having

six modules for the following six aspects related to Reliability-Based Maintenance.

- a. Vibration
- b. Oil Analysis
- c. Infrared Thermography
- d. Motor Diagnostics
- e. Alignment
- f. Balancing.

The software is Windows-based and user friendly. Database creation is simplified. Software's exception report program automatically sifts through layers of data to detect emerging problems, then prints a summary of all points deviating from acceptable patterns. Software has knowledge-based expert system which helps in automating the machinery condition analysis process and providing a prioritized list of problem machines. Specific faults are identified and machine case histories are updated automatically. Documentation is an integral part of this software for RBM program. Case histories of the machines are recorded. Printouts of fault histories of the machinery failures can be taken out. The fault history program is compatible with Computerized Maintenance Management System. Because of the Network capability of the software, multiple users anywhere in the company (for ex. Engineering, Production and Planning departments) can access the data and review, discuss the problem at the same time.

10. CONCLUSION:

Now-a-days, there is a tendency to

measure the performance of the maintenance function from a business viewpoint. Some of the Universities abroad have placed maintenance training or maintenance management in their course curriculums. Today's competitive environment requires a smarter more technically equipped maintenance function whose performance is equally important as all other aspects of the business.

The purpose of maintenance is to provide capacity. Plants running at or near design capacity depend upon "capacity availability", and it is the function of maintenance to deliver this capacity availability. Hence in some of the developed countries there is a tendency to redefine Maintenance as Capacitance. The Capacitance concept suggests that the business of maintenance is to produce quality capacity in a efficient and profitable manner, unconstrained by the original plant design or the design capacity of a specified process. The present trend in industrial plant maintenance is to improve manufacturing productivity and to reduce equipment redundancy without sacrificing availability by investing in more high-tech and expensive equipments.

Corporations need to strategically invest in the wealth of new predictive technologies and proactive techniques. These are the tools by which maintenance will be revolutionised, much like the computer revolutionised the office, or the airplane revolutionised military warfare. Unutilised capacity and redundant systems are both examples of poor utilisation of assets. Excessive preventive activities are costly by any measure.

(COURTESY FLUID POWER SOCIETY OF INDIA)

EDITORIAL

Dear Reader,

Now 17th issue of IRTM digest is with you. It is your digest. Please contribute articles on Track Machines based on experience like improvement in operation, Maintenance overhauling, Quality control.

Surya Prakash
Principal.



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