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PRACTICAL ASPECTS OF AVAILABILITY OF EQUIPMENT

by

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Organized in co-operation with the Government of Japan and the Japan Management Association (JMA).

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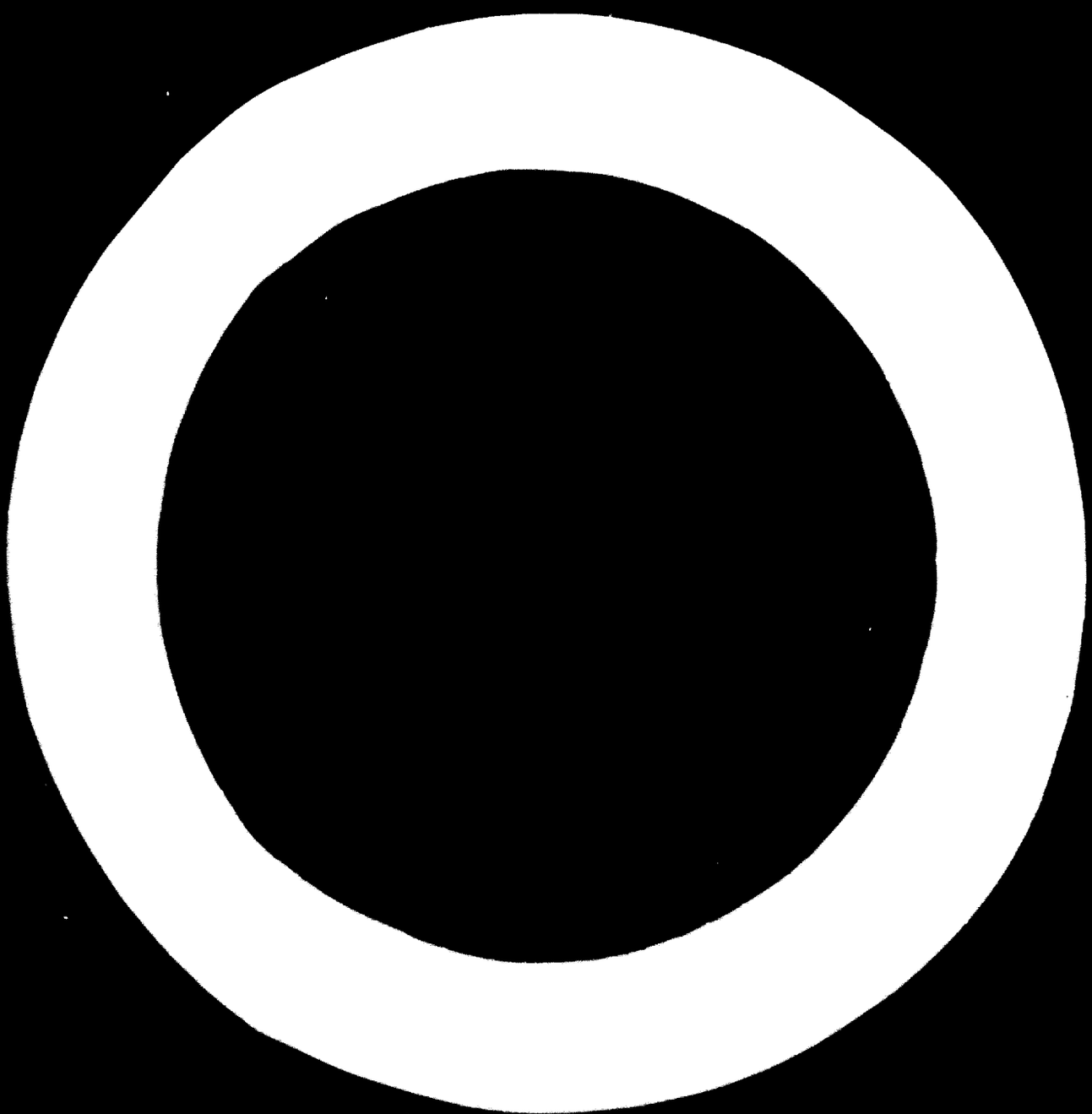


INDEX

INTRODUCTION

The activities for maintenance improvement of machine availability is a great subject to make the most use of facilities which is undertaken as one cycle of PE activities in the whole life span of machines which includes research engineering, process planning, designing, manufacture, installation, operation, maintenance, renewal and disposal of the machine.

In this case approaches should be appropriate to the organizational structure and size of each company.

It is beyond my ability and length of this report to handle all ranges of maintenance improvement activities of machine availability; the followings are the objects and scope of this report.

. Assembly type industry as a company(System of Nihon Denso Co.)
. Steps in the life cycle of machine from design to its operation and maintenance, that is, explaining "maintenance improvement activities of availability on the currently operating machines in a typical assembly type factory".

2. Maintenance improvement activities of machine availability

2.1. Definition of availability

Reliability terminology JIS Z8115 (Japan Industry Standard) defines "Availability" as follows:

> Probability of repairable system, equipment, parts maintaining its expected function in a specified length of time. It is in most cases found in the following equation:
>
> Availability (A) =
>
> $$\frac{\text{Capable Operation Time}}{\text{(Capable operation time) + (Incapable operation time)}}$$
>
> Capable operation time: Length of time when systems, equipment and parts are in functionable condition as stipulated.
>
> Incapable operation time: Length of time when systems, equipment and parts are not in functionable condition as stipulated.
>
> Remarks: Consisting of maintenance time, delay time and management time.

To improve availability is to lessen incapable operation time and increase capable operation time.

2.2. Maintenance improvement of machine availability

We apply the concept of the above mentioned "Availability" to control activities of currently used machines in assembly type industry. That is in the following manner. In other words, to successively produced quality goods satisfying the quality standard during the net cycle determined at the time of equipment planning, aiming at active and systematic and stabilised

activities of maintenance improvement, both in terms of qualitative capacity and quantitative process capability. (i.e. machine operation rate (MOR)

The major stress to maintain and improve machine operation rate (MOR) is placed on how to reduce incapable operation time (at Nihon Denso Co. it is called "down-time").

To maintain and improve this qualitative capacity and quantitative process capability (MOR):

- Relationship among Planning, Maintenance and Operation departments is improved.
- with participation of all personnel from top management to first line worker who will be
- engaged in PM activities within small voluntary groups.

I am to provide you with some ideas showing examples of practical applications.

3. Maintenance Improvement Activities of Qualitative Process Capability

To maintain and improve product quality, maintenance and improvement of four factors which make up process, that is, machine, man, material and method are necessary.

As for machine, improvements such as in expansion, high capacity, automation and unattendance have been taking place. Thus machine's role of producing quality good is increasing and qualitative process capability of machine is now receiving a great attention.

3.1. Definition of Qualitative Process Capability

Qualitative process capability in machine industry, the scale for evaluating Process capability in producing standard products is shown in the following Process capability Index (Cp).

(1) How to figure out Cp (Fig. 3-1)

Standards	Cp	Symbols
Both sides	$\frac{T}{6\sigma p}$ or $\frac{T}{6\sigma m}$	T: Blueprint common difference Tu: Upper limit standard Tl: Lower limit standard $\bar{X}$: Average value σp: Process Capability standard deviation *Note σm: Machine capability standard deviation
Upper side	$\frac{Tu - \bar{X}}{3\sigma p}$	
Lower side	$\frac{\bar{X} - Tl}{3\sigma p}$	

Note: How to figure out σp:

Generally, make histogram from Process capability chart (one point graph) and X-R control chart and calculate σp:

(2) Evaluation Process Capability

Process capability can be evaluated as follows (Fig. 3-2):

Capability Index	Evaluation	Class
Cp $\geq$1.33	Process capability is fully satisfactory to standard.	1
1.33 $\geq$Cp $\geq$1	Process capability is satisfactoey but needs control.	2
1 $\geq$ Cp	Process capability is not satisfactory.	3

In the case of general purpose machine where Cp application is difficult, Static Accuracy Index(T) is used to confirm machine accuracy for quality assuarance.

- How to figure out (T):

$$T = \sqrt{\frac{(Tp/Ts)^2}{n}}$$

Tp: Actual Value

Ts: Allowable Value

n: Number of measurement items

- Evaluation standard of static accuracy (Fig. 3-3)

Accuracy Index	Evaluation
T $\leq$ 1	Satisfactory
1 < T $\leq$ 4	Careful examination on items not fitting with Ts and decide whether or not to repair
T > 4	Objectives for reapir

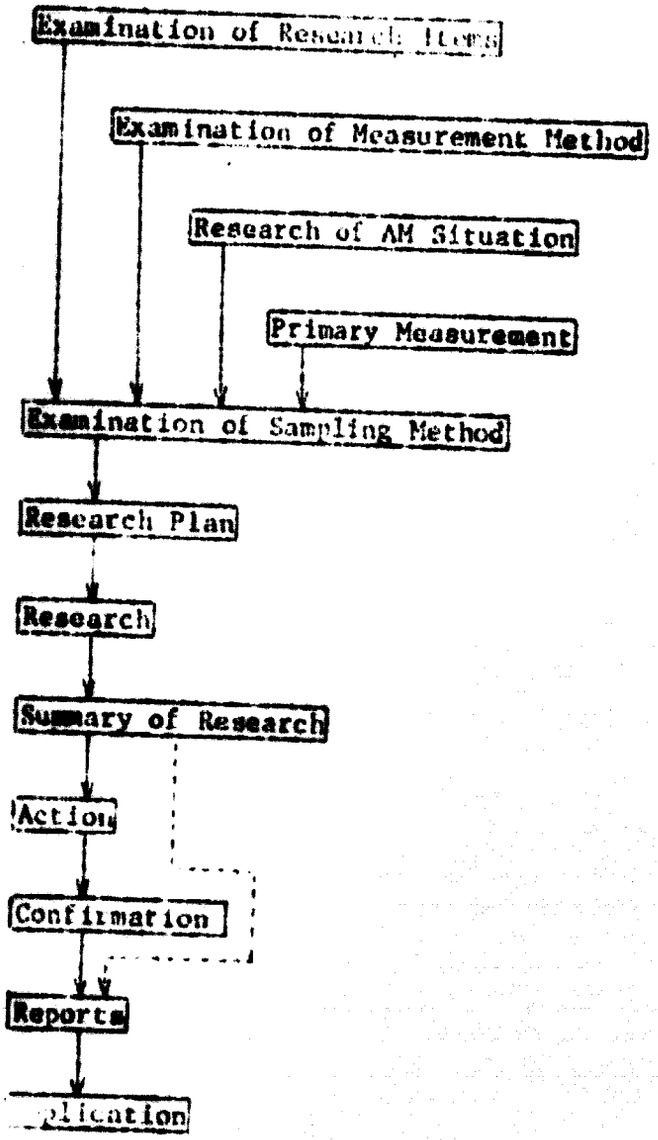
3.2. Research methods and utilization system of qualitative

Qualitative process capability research is done in the procedure shown in chart 3-1(B): Start systematic research from machine planning stage as shown in (A). These research results as shown in (C) are used in process design, machine design, machine maintenance, production process and also used as data for examining blueprint standards in production planning stage and in establishing production standard. In developing process capability research, in order to make most efficient use of research information, careful analysis should be done on various factors and alternatives, making a summary of each report.

Research method and utilization system of Qualitative Process Capability

Chart 3-1.

(A) Procedures for Process Capability Research



(B) Application of process capability research results

Applicable functions	Application items
Process design	o Basic materials for process design o Materials for machine planning o Materials for production standards
Machine design	o Materials for design objective establishment o Confirmation after completion
Machine maintenance	o Materials for maintenance items and check-up cycle o Evaluation materials for repair time o Evaluation materials for receiving inspection
Production	o Materials for production standards o Materials for critical control o Materials for failure analysis

3.3. Cases of process capability research activities on existing machines.

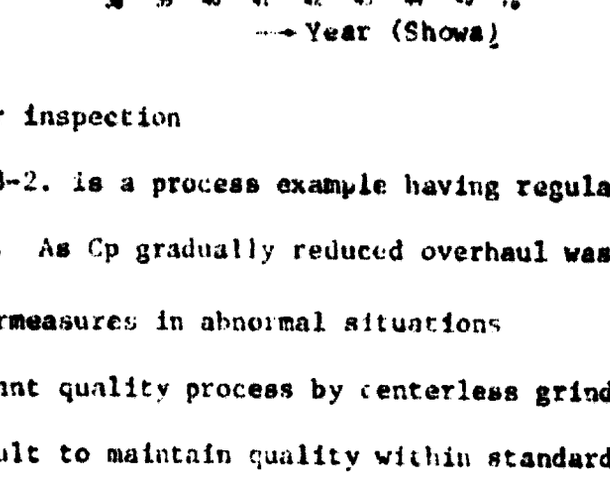
As shown in Chart 3-1, result of qualitative capability research includes not only process plan, machine plan, machine manufacture, installation, operation and maintenance but also used in production plan.

Here, cases of process capability research activities on currently operating machines are introduced.

Chart 3-2. Armature core outer-radius finishing process

Ohsumi high speed lathe

Main axis: 1,500 rpm



(1) Regular inspection

Chart 3-2. is a process example having regular process capability. As Cp gradually reduced overhaul was scheduled.

(2) Countermeasures in abnormal situations

Important quality process by centerless grinder is currently difficult to maintain quality within standard; this information was brought to Maintenance Dept. from Operation Dept. So far 2 million pieces have been produced.

In process capability research result after production of 500,000 pieces, Cp was satisfactory by 1.43 (8σm - 0.056). Accuracy check-up was conducted by maintenance crew. The actual result is that Cp is reduced to 1.03 (8 m = 0.078). The result was found there was a big backlash of 0.08 at the point of feed screw of regulations wheel. After adjustment of this backlash, process capability recovered and poved that there still was enough accuracy. As a result, "Measurement of backlash of feed screw of adjustment wheel" was added in the preventive maintenance items in the patrol of maintenance member.

(3) Research before and after machine overhaul

Based on maintenance performance result data (operation rate, frequency of equipment breakdown, degree of maloperation and maintenance cost, etc.) and also on process capability, number of products and the life of the machine, in October each year, we prepare overhaul plan on each machine. This is done within full cooperation with Process Design, Maintenance and Operation departments.

In practice, machine repair report is made for accuracy comparison before and after the repair.

An overhaul conducted report is also made for it is useful to confirm the recovery of accuracy and cost estimation for the next overhaul.

4. Maintenance improvement activities of process capacity (Machine operation rate)

As mentioned before, at Nihon Denso, in addition to retain the qualitative process capacity of machine is also maintaining and improving the process capability which is machine operation rate (MOR). This MOR is the primary index to PM performance. Maintenance improvement activities of machine operation rate at Nihon Denso is outlined in the following.

(1) Equation of machine operation rate (MOR)

(2) Data collection system on machine operation rate (MOR)

(3) Methods of maintenance improvement of machine operation rate (MOR)

(4) Cases of improvement methods for machine operation rate (MOR)

(1) Equation of machine operation rate

Machine operation rate is the ratio of net operation time and active time as shown below. Net operation time, in principle, is the number of good products expressed in terms of time.

$$\text{Machine operation rate (\%)} = \frac{\text{Operation time}}{\text{Active time}} \times 100 = \frac{\text{Net operation time}}{(\text{Net operation time}) + (\text{down-time})} \times 100 \quad \ldots (1)$$

Net operation time is generally figured out by equation (2) but in case of painting, plating and using general purpose pressing machine there are many materials waiting for process, making it difficult to calculate a unit cycle time, equation (3) is used.

In this case the net operation time = Cycle time in seconds stipulated at the point of its process design x number of good products x 1/3,600 ... (2) is used.

Net operation time = (active time) - (down-time**) ... (3)

** Down time = (set-up & adjusment time) + (routine maintenance, production preparation time) + (time producing bad products) + (machine regulating time) + (other allowance time) ... (4)

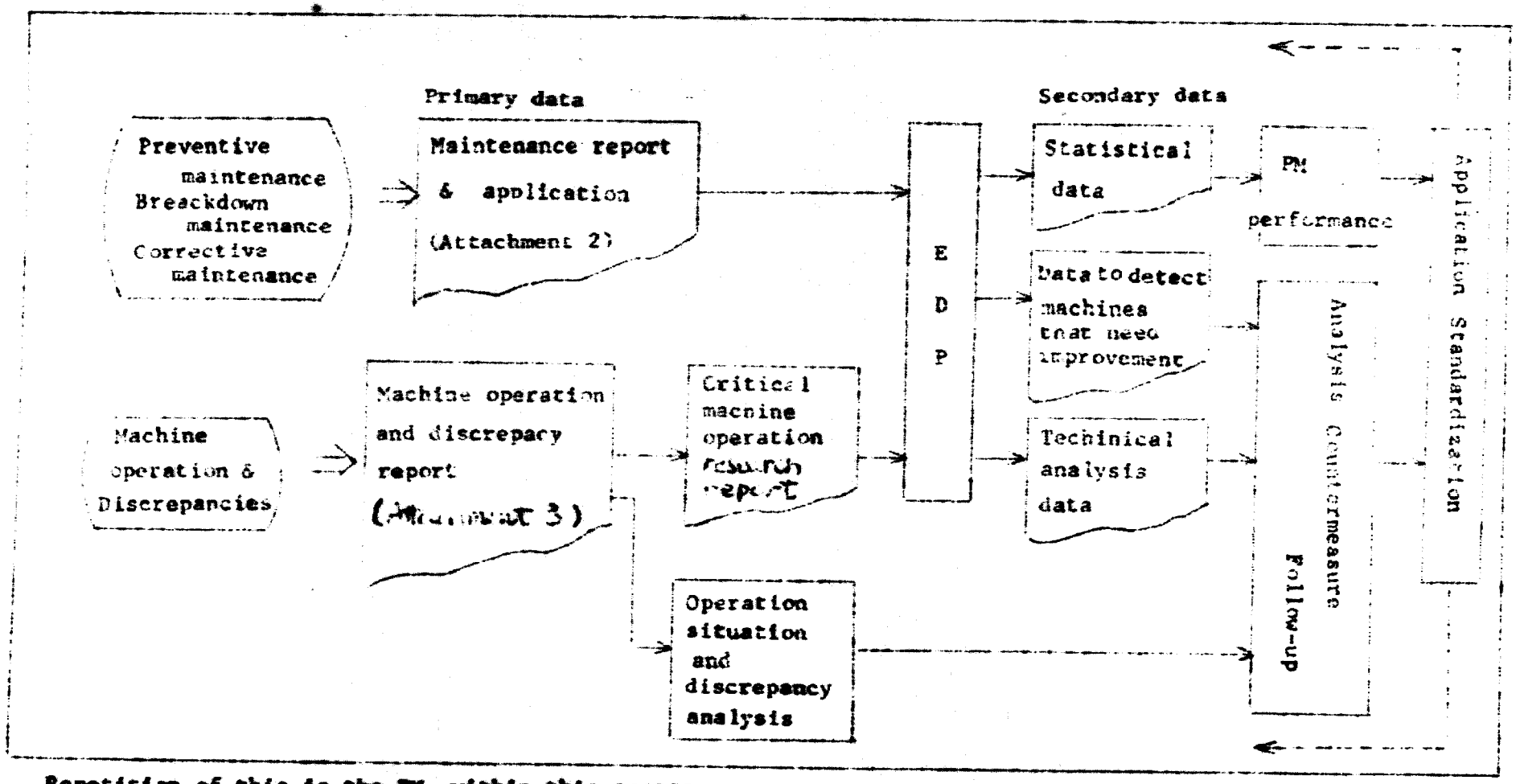
When figuring out machine operation rate, special attention should be needed: all terminologies relating to machine operation should have specific definitions to be clear and consistant among the people concerned; otherwise the reliability of original material declines and evaluation of PM performance among sections, facilities and departments become difficult.

"Calculation Guide of machine operation rate" (which is Attachment 1) is an except covering major subjects relating on machine operations describing existing equipments in the company to be distributed to the people concerned in operation in Production, Maintenance and Planning Departments.

4.2. Data collection system of machine operation

Data collection activities on currently existing machines are outlined in Chart 4-1:

Chart 4-1



Repetition of this is the PM within this company.

Data on failures more than 30 minutes and maintenance performance are individually filled by each failure in "Maintenance Report application" (Att. 2) and Maintenance Dept. file there reports under each machine type and input major items in EDP. While data on machine operation such as active time, number of products, number of rejections, down time with descriptions are daily recorded in "Machine operation and discrepancy report" (Att. 3) by Operation Dept. on PM critical machines (approx. 900 machines accounting for 8% of the total) are listed in order to keep normal operation by doing routine control.

In the beginning of the following month, operation rate, active time rate etc. are posted in "Critical machine operation situation research list" and imput to EDP.

Thus maintenance and operation situation are matched in EDP and comes out with various second data. These data are used for evaluation, countermeasure and application of PM performance.

4.3. Methods of maintenance improvement for machine operation rate

Operation situations of productive machine facilities used in the company are shown in Chart 4-2. Approximately 80% of down-time accounts for repair of failure, routine maintenance operations (which is directly related to PM) and set-up and adjustment (which is related to PM) on machine technique and skill.

In order to improve this approx. 80% of down-time, not only the efforts of Maintenance Dept. as shown in Fig. 4-2 and moreover with the cooperation of the three departments are indispensable.

Fig. 4-2 Down-time factors

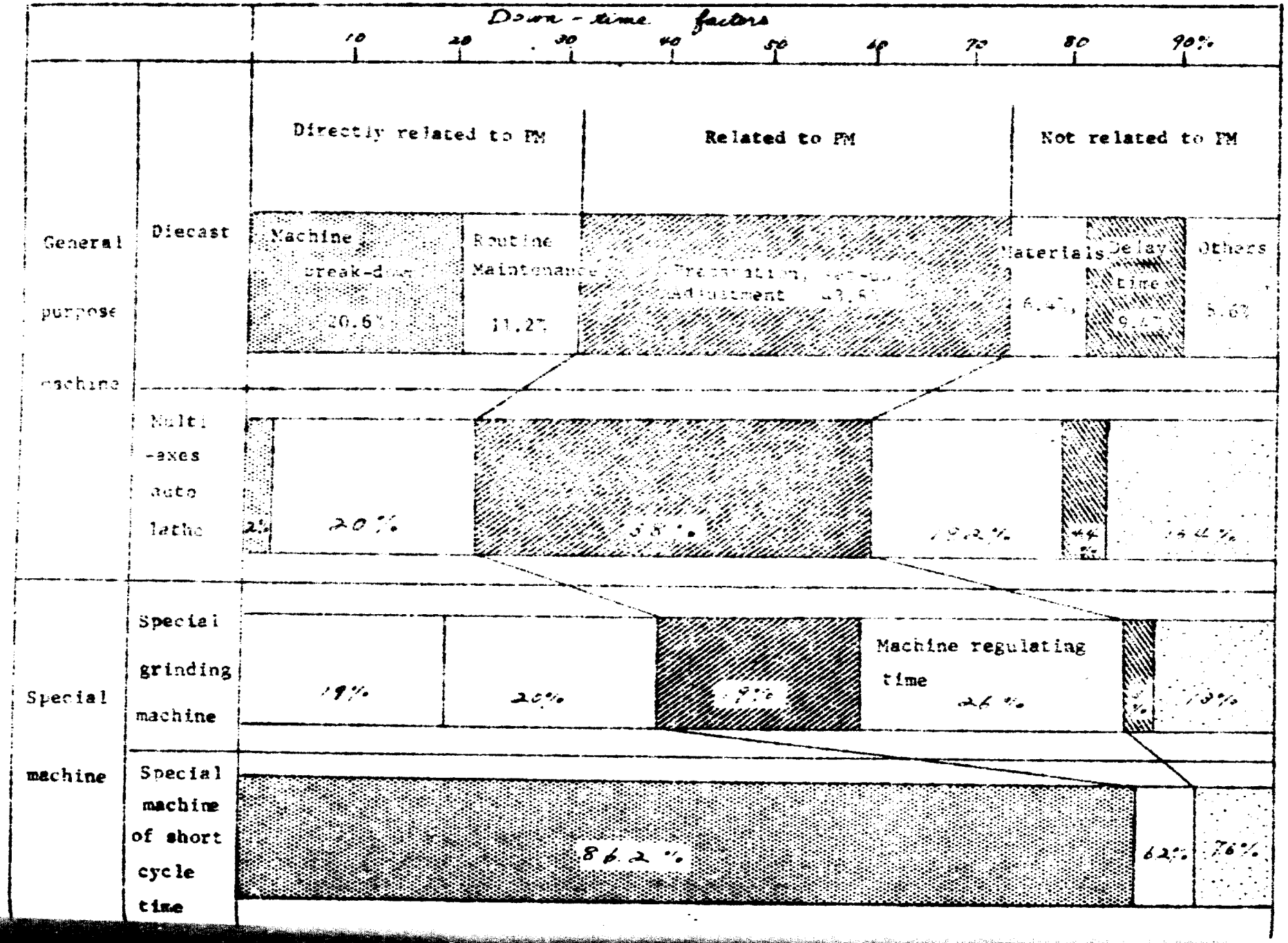


Fig. 4-2. Departmental Activities for MOR Improvement

Dept. / Function / Activities	Planning	Maintenance	Operation
	Deliver to Operation machines which can operate the stipulated function with minimum cost and no failure (installation, remodel & renewal)	At the requests of Operation Dept. and also at the recommendations to operation Dept., check up, adjustment and repair should be made to achieve the stipulated function with minimum cost and no failure.	To achieve production plan by fully operating the stimulated function with minimum cost and without failure
Reduction in Breakdown (Reliability improvement)	Apply countermeasures to prevent further failures to next machine and to similar machines, process design, machine design, machine manufacture for machine inspection standards.	o Conducting accurate & efficient check-up & adjustment o Routine maintenance guidance o Conducting corrective maintenance to reduce failures o Feed back of good information to planning Dept.	o Enforcement of normal operation and accurate routine maintenance o Good communication & prompt feed-back to maintenance o Revisions of all routine maintenance standards (Selection of routine maintenance items directly connected to prevent break-down) o To prevent minor failures
Shorten Maintenance time (Maintenability improvement)	Designing, manufacturing and erection of machines that require easy maintenance	o Conduct corrective maintenance to improve maintenability o Feed back of good information to planning Dept.	o Shortening routine maintenance time by improving routine check-up procedures and lubrication o Lengthening check-up cycle based on break-down and deduction in check-up time
Shorten set-up & adjustment time	o Design and manufacture of machines that are easy for set-up and adjustment o Lengthen life span of bites and molds with new materials and processing methods	o Support activities of planning and Operation Dept.	o By improving skill workers to reduce unit set-up & adjustment time. o Conduct minor improvements to expand life span of molds and bites.

In order to improve equipment efficiency, maintenance improvement of MOR should primarily be improved. In order to accomplish this goal, each department should fully corporate discharging its responsibility. In other words, at Nippon Denso, machine operation rate (MOR) is considered to be most appropriate for measurement of joint PM activities. And this MOR is the subject to our control as most important index.

4.4 Cases of MOR improvement countermeasures

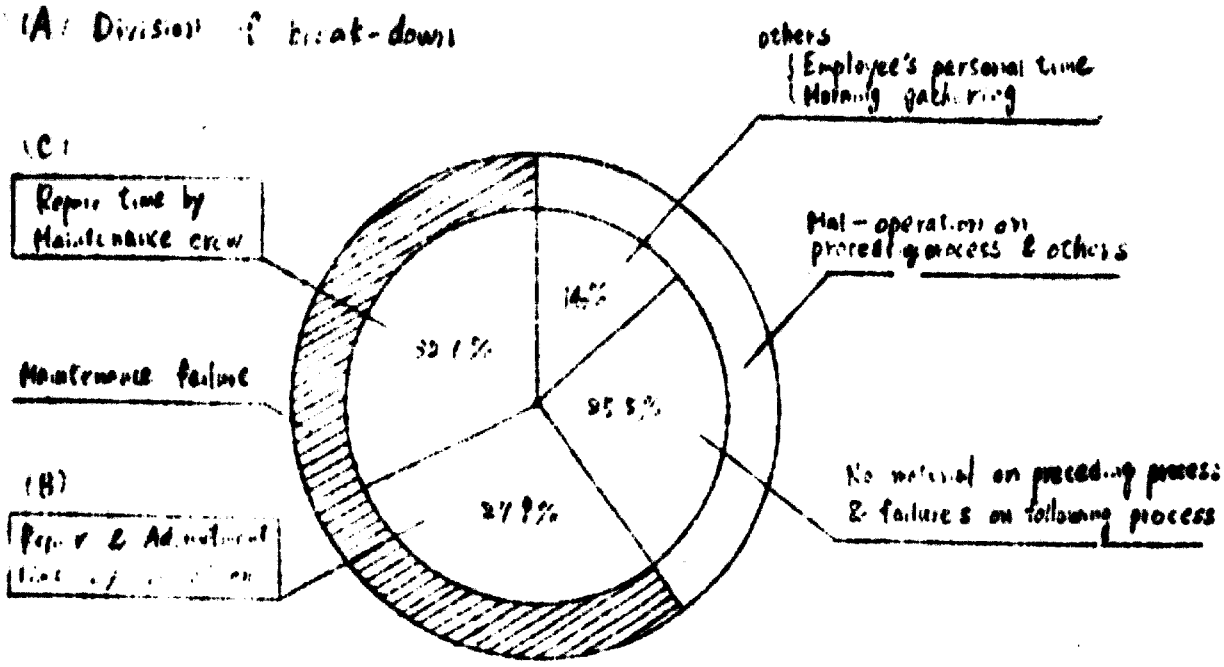
One example each of designing, Maintenance and Operation Departments is shown here.

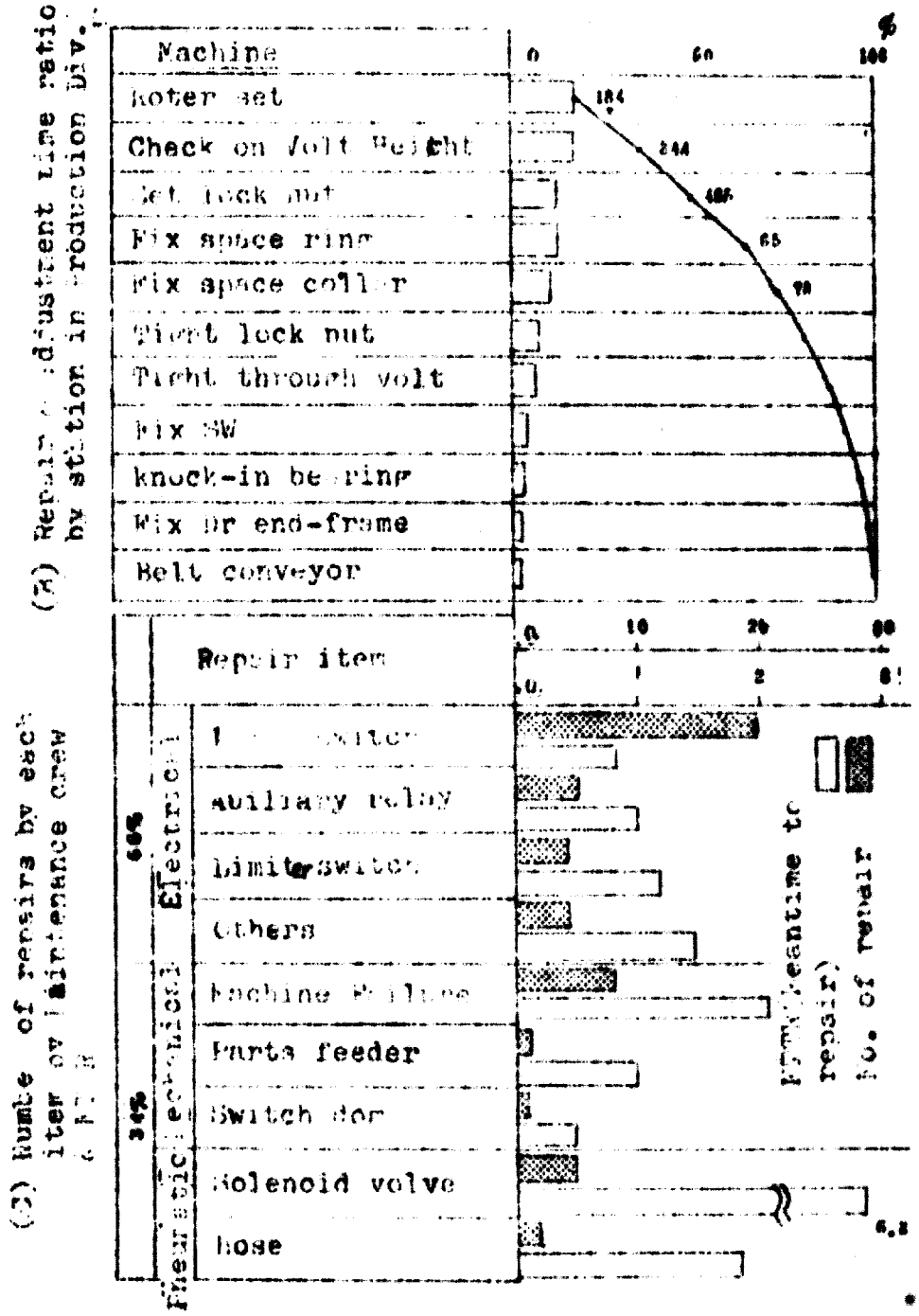
(1) Case of Machine Designing Department

Product A-1 is expected to drastically increase its volume in the near future. If we achieve this increase using the conventional belt conveyor line, the number of manual assembly operators who are fully skilled should increase proportionately.

Therefore, we discussed various problems resulting from the similar existing line A-2, we have determined to design another production line with improved assembly speed of 50%, with reduced number of workers by 50% and with improved M.S of 10%, having a total of 1.9 times increase in productivity when compared to production line for A-2.

Chart 4-5 Review and analysis of rationalized assembly line





Results of A-2 line down-time analysis are shown in Chart 4-3 (A) (B)(C). Adding technical analysis on each problem and applying them to A-1 line results in Fig.4-2 as one example. It consists of evaluations of reliability, maintainability, characteristics in operation and safety.

Fig.4-2 Application List

Function	Review	Problems of presently used ... line	Cause	Application to new ... line	
Reliability	Improve reliability of parts, reduce down-time ratio and improve machine operation rate.	1) Many electrical parts failure	• Short life span of timer • Short life span of stalling electronic relay	• Change to C (cathode ray) type timer • Change to DC relay	○
			• Unstable fixing of limit switch	• Standardize fixing methods and specify limit switch	△
		2) Inconsistency of cylinder speed	• Loose [illegible] valve	• Adopt air flow control valve	○
		[illegible] failures	• set-[illegible]	• [illegible] shape of [illegible] it will be sustained [illegible] end	○
		4) Switch dog breakdown	• Shock at cylinder's [illegible]	• [illegible] of fixing set- it	○
Maintenability	Improve maintenance, reduce [illegible] and improve [illegible]	1) Replacement of limit switch takes time	Unable to change limit switch without taking off the cover	• Change diecast [illegible] small limit s[illegible]	[illegible]
		2) Lengthy MTTR of neumatic parts	• [illegible] valves [illegible] plate	• Change to manif[illegible] magnetic valve [illegible] changing metho[illegible]	
			Complicated piping system	• Change to [illegible]	
		3) Valve fixing space too large		• Change to manifold [illegible] magnetic valve [illegible] reduce fix space	[illegible]
		4) Rusting cylinder preventing smooth operation	• Incorrect draining in air [illegible]	• Change to automatic drain type air limit lubricator	○
		5) Lengthy MTTR with machinery	• Difficulty in changing spare parts	• Simplify changing met[illegible]	○
Operational	Improve operational functions of machines for easy handling	1) Fixing place for Valve not appropriate	• Fixing space of valve too large	• Change to manifold type electro-magnetic valve and reduce fixing space	○
		2) Unstable operation board		• Stabilize operation board in certain specified direction	○
		3) Incapable successive operation by each station		• Enable successive operation through automation and individual operation	○
Safety (Environment)	Abate noise and improve working environment	1) Noisy air ventilation	• Unable to fix silenser [illegible] control	• Change [illegible] cock to flow control and fix silenser at [illegible] port	○
		2) Noisy parts feeder		• Install anti-noise	△

As a result of the above countermeasures, (1) improved 15% against 10% as we have originally planned and could acquire over 1.5 times of productivity increase which was set in the stage of designing. Among these countermeasures which are considered to have wide application were standardized into design Machine Standard Index (DMSI).

(2) Case in Maintenance Department
(Establishment of Corrective Maintenance and Preventive Maintenance Cycle)

Constant temperature furnace of diecast:
The structure of the furnace is shown in Chart 4-4. It consists of firebrick, heat insulating materials and melting pot. Heat generator is in the shape of chrysanthemum flower.

Before establishing inspection cycle, improvement items shown in fig.4-3 were experimented on 15 furnaces after analyzing the present situation of heat generator by Maintenance Dept. and related Departments.

Then result the above EDP as output plotted in Weibull Probability Sheet.

As shown in Chart 4-5 "mean time between failure" (MTBF) improved from 5.5 months to 15 months and distribution of failures changed from index distribution type (m=1.0) to wear-out distribution type (m=1.6) and now capable to apply preventive maintenance and practice regular changing of heat generator.

Regular Changing Cycle (shown in Chart 4-6) is established at the point when the sum of down-time loss and total preventive maintenance cost becomes minimum. That is, most economical changing cycle is at 9 month's time and change the generator. This was standardized as Regular Machine Standards (DM S-4).

Result: As set-up time cycle lengthened and catastrophic failure drastically reduced, machine operation rate of Diecast machine improved.

Fig. 4-3 Problems and improvements

Problem	Suggested Improvements
1.Many generator failures 2. Along with machine automation, brought increase in aluminum hot-solution use and increase of throw-in of ingot. (Increase work-load of furnace)	1. Increase generator capacity to 55 KW from 46KW 2. Change sectional size of generator from 1.8 x 13 to 2.0 x 16

Chart 4-4 Constant temperature furnace structure

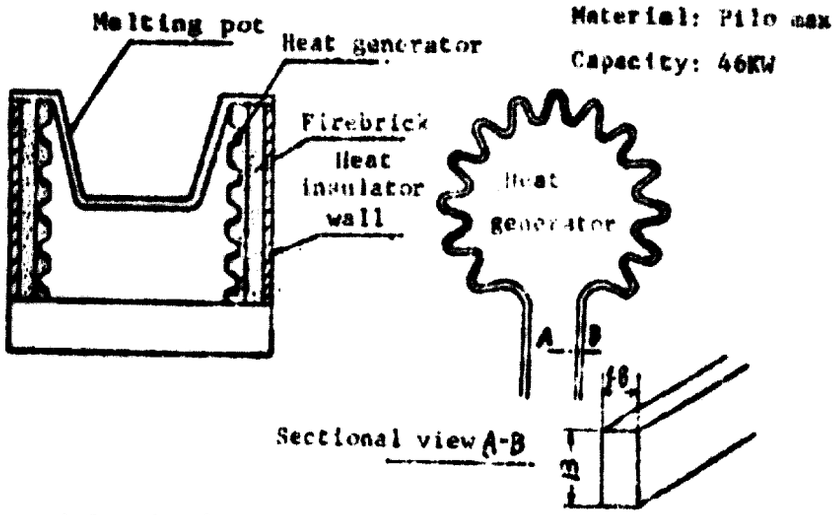
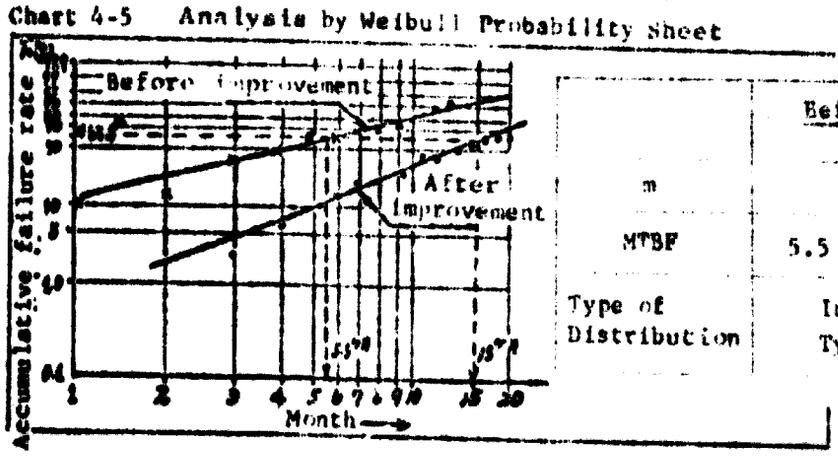


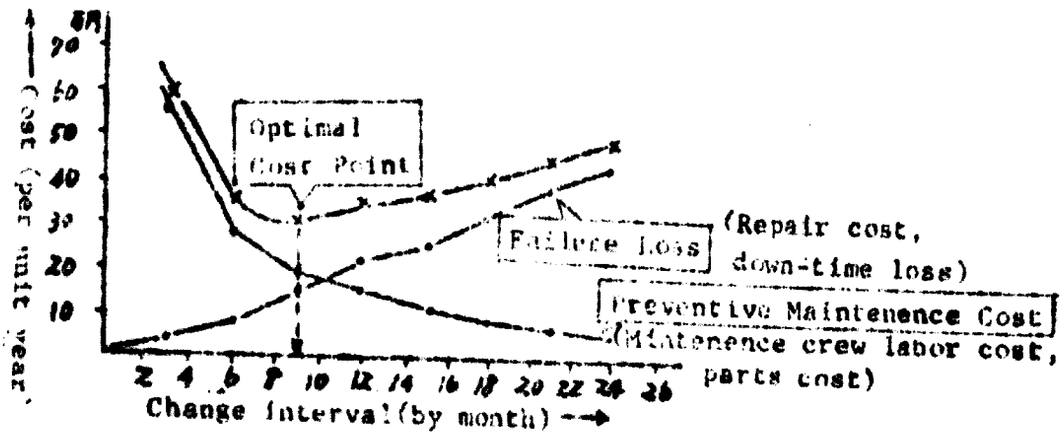
Chart 4-5 Analysis by Weibull Probability Sheet



	Before Improvement	After
m	1.0	1.6
MTBF	5.5 months	15 months
Type of Distribution	Index Type	Logarithmic regular type

Fig. 4-6 Study of most economical changing cycle

(Unit period: two years)



(3) Case in Operating Department

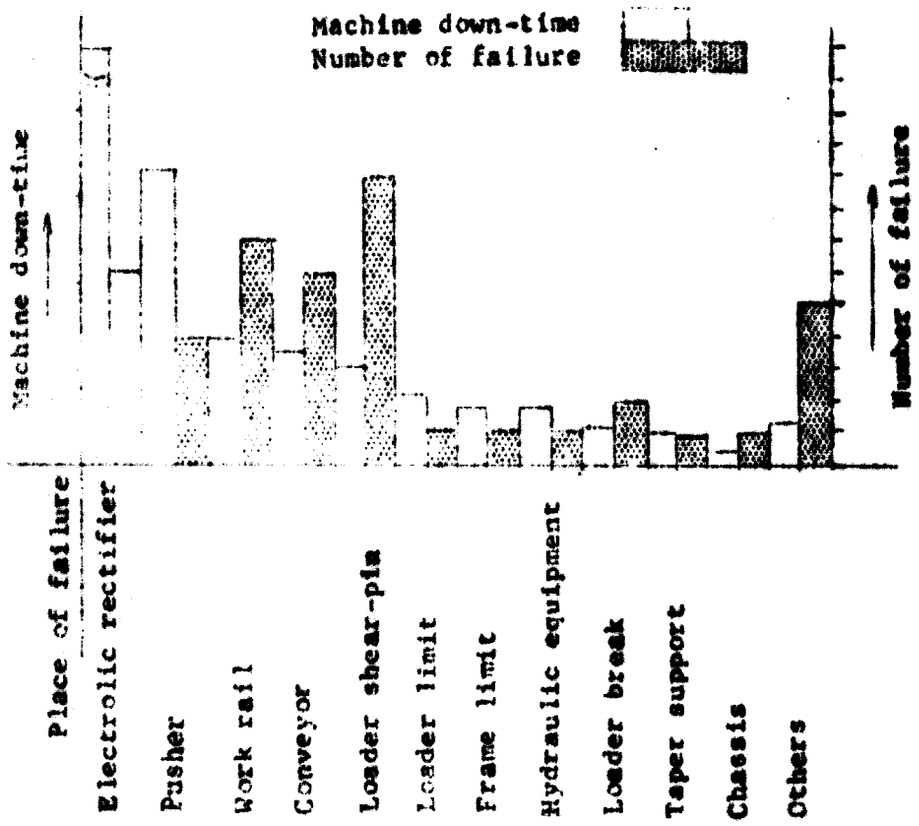
(Preparation of PM operation manual by PM circle activities to reduce machine failures)

Automatic zinc plating equipment is a large equipment and has series of closely related functions. It is very important for an operator to know the occurance of abnormality in the equipment and give "promet" treatment to maintain a smooth operation. As a role of machine operators, to provide on-the-spot action and to standadize the items of routine maintenance for prevention of abnormality; the following was reviewed by PM circle.

Chart 4-7 shows the accumulation of failures. taken from past abnormality records, both on "Maintenance Report - Application" and minor abnormality not recorded in this report but recorded by circle memebers. Along with technical education and improvement of morale, this problem was reviewed by examining each items of causes, emergency actions, routine maintenance items and spare parts control within 6 months; including 58 of newly brought abnormality problems, 132 failure countermeasures were established and, furthermore, machine structure check-up, operation methods were added to prepare the Manual of PM operations.

Chart 4-8 is a part of this Manual where machine itself and its supplimental conveyor are explained and also the emergency actions for movable loader which were standadized.

Chart.4-7 Failure Results



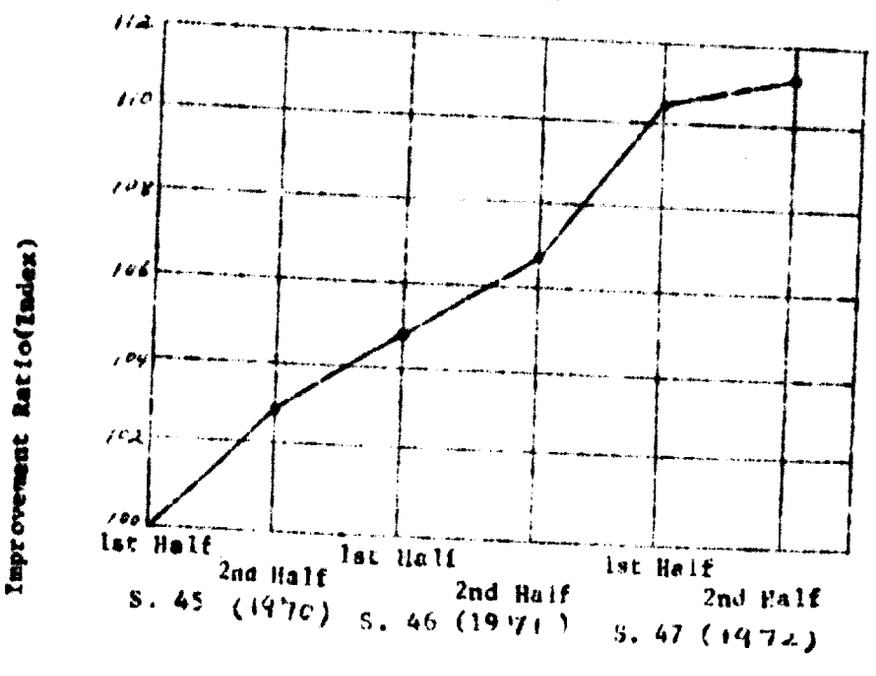
This PM operation Manual has brought such intangible effects as improvements in technical knowledge and morale for the circle members. As tangible effects, over 50% decrease in failures, machine down-time, repair and adjustment time thus improving of MOR.

Chart 4-8 Causes of Failure and emergency actions

Name of Parts Structure	Abnormality	Causes	Emergency actions	Routine Maintenance Items	FRequency	Life	Remarks
		related to [illegible]					

The effects of departmental improvement activities mentioned above has made approx. 11% increase in machine operation rate of the company in three years shown in Chart 4-9. This has brought a great saving in equipment investment.

Chart 4-9 Transition of MOR



5. Some important considerations on PM system

So far in this report I have explained how to improve and maintain availability from the standpoint of, first acquiring process capabilities and then to improve and maintain Machine Operation Rate by illustrating actual cases pertaining to policies and methods in Nihon Denso Company.

I would like to close this report by outlining some of the points which should be taken into consideration for coordinating PM activities.

To do this, the following three items should be emphasized.

(1) PM activities that fit into the degree of automation of the company

(2) Develop training programs and enhance morale of the employees

(3) Clearly define share of responsibilities among PM related departments and establish a total PM sytem

5.1. PM activities that fit into the degree of automation of the company

As shown in Fig5-1, machine and equipment become more and more complicated adding extra functions in accordance with the developmental steps in automation. Thus, maintenance system corresponding to each of the added functions in respective automation steps should be strengthened.

Chart 5-1 PM Points according to automation steps

	1	2	3	4	5	6	7
Automation Steps	.Tools . Manual work with certain supplimental power	. Power machine with manual control	Machine with single function	Automated machine (only one cycle process automated)	Automatic machine (loading is automated)	Group of automatic machines (Transfer lines, synchronization, group control)	Unattendance (Line, Factory)
Added functions		Mechanical, electrical, and instrumental function	Mechanical, hydraulic, pneumatic (incl. electronics), highly sophisticated instrumental measurement.	Control of the items on left	Panel control (Monitoring)	Computer control	
Objects of PM-MP target		Component parts	Structure of machine and its related factors	Hydraulic & Neumatic Electrical equipment	Loading & Control equipment	Means to take care of carrier mechanism, control mechanism, automatic instrumental control	Control system
Request of Reliability and Maintainability			The need will be increasing taking curve of quadratic equation.				
PM aiming point			Reduce down-time ---> Maintain availability · Improvement (Systematization)				

The more the automation progresses, the more reliabilty, maintenability and safety of machine facilities are required. So not only maintenance system but also MP system by project engineers should be strengthened.
also, the goal of M activities should not only be the reduction in failure breakdown but also to maintain and improve availability is needed.
For this purpose, along with acquisition of specific techniques and control techniques, training of people and total system of machine control are very important.

4.2. Education and training and methods for morale enhancement
Assembly type industry has its ultimate goal in automation and unattended facilities. But at present, it is in labor intensive industry and its facilities and machines are complicated; so as to fully utilize the existing facilities, positive methods of education and training and also morale improvement are required.

The aim in education and training differs according to the production systems: In case of small volume production, generally, as degree of automation is very low and dependence on skill of operators is high, emphasis is on specific technique trainings. While in the case of mass production, the degree of automation is high and seemingly there are numerous monotonous operations conducted by unskilled operators. Therefore, not only improvement on operators' skill but also morale improvement and systematic and various types of training programsshould be established for promoting employ- voluntary control activi

The followings are some elements of training programs for middle management PM members by each department in mass production assembly type industry.

(1) Training of operators

1) Step one (Fundamental course) The following subjects will be taken up chiefly for OJT (on the job training) program.

(a) Relation of 4M (four elements for process - man, machine, material & method) to the function of processed product.

(b) Safe and appropriate operation and routine maintenance methods based on critical and understandable standards

(c) Discrepancies caused by not observing operational standard

(d) Knowledge of fundamental actions

Next step is to check whether operations are taken place in accordance with the operation standards and give eveluation and guidance.

(2) Step two (Intermediate course) The following is taught in a combination of classroom and OJT program.

(a) Knowledge on machine construction and functions in order to find machine abnormality in the early stage of operation.

(b) Next is knowledge on simple repair and a little complicated set-up and adjustment operations.

(c) Further, to be capable to teach how to train unskilled workers in fundamental steps.

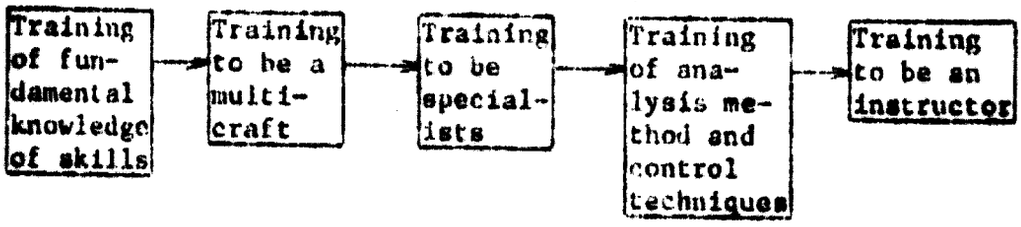
3) Positive promotion of various countermeasuces to be active in voluntary control activities and improvement activities such as circle activities, presentation meeting for actual results, improvement suggestion system, send to off-the company training and etc. Especially as circle activities are done in small groups, the leaders of first line workers' circles should be given the knowledge offered in this intermediate level training.

(2) Training of Machine Maintenance Workers

The aim for this training program should be to educate workers to be skilled maintenance technicians. Skilled maintenance technicians are experts those who are very good in check-up and repair skill and those who have acquired analysis methods and forecast techniques of breakdown.

The following is the recommended education steps.

Chart 5-2. Training steps of skilled maintenance technitians



(3) Education and training for Planning Dept.

Referring to the following procedure of general training methods, training program should be specifically designed in accordance to the type of industry and kind of duties in this department.

(a) Specific technique, control technique, operation procedures should be standardized as much as possible and be taught in classroom, reading circles and OJT course. It is important to make it a habit to actually confirm and check the collected information items and analysis with the trainee's own eyes.

(b) Train in order to acquire higher professional techniques.

(c) Cultivate self-development and creative thinking and ability to apply those thinkings.

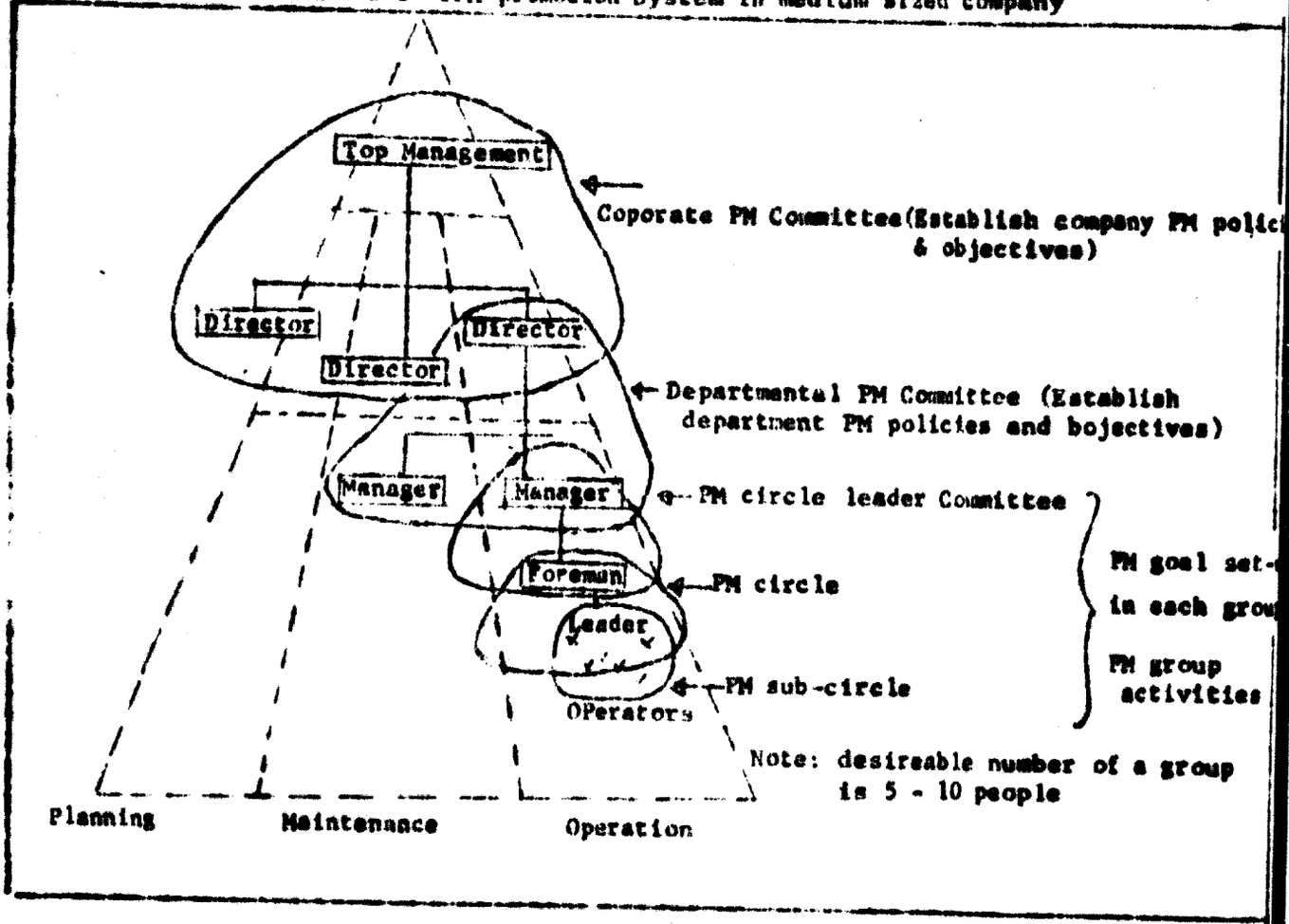
So far, I have explained elements of training middle class PM members by Operation, Maintenance and Planning departments. These departmental trainings should be systematically conducted parallel with basic training which is conducted at each organizational level.

5.3. Share of responsibilities by related departments and Total PM System

Referring to share of responsibilities among Planning, Maintenance and Operation departments shown in Fig 4-2 of "Departmental activities for MOR improvement" an appropriate organization should be adapted in accordance with the type of the compay.

Based on this principle, Fig.5-3 shows the established PM promotion system and it is desireable to build-up cooperative system.

Chart 5-3 TPM promotion System in medium sized company

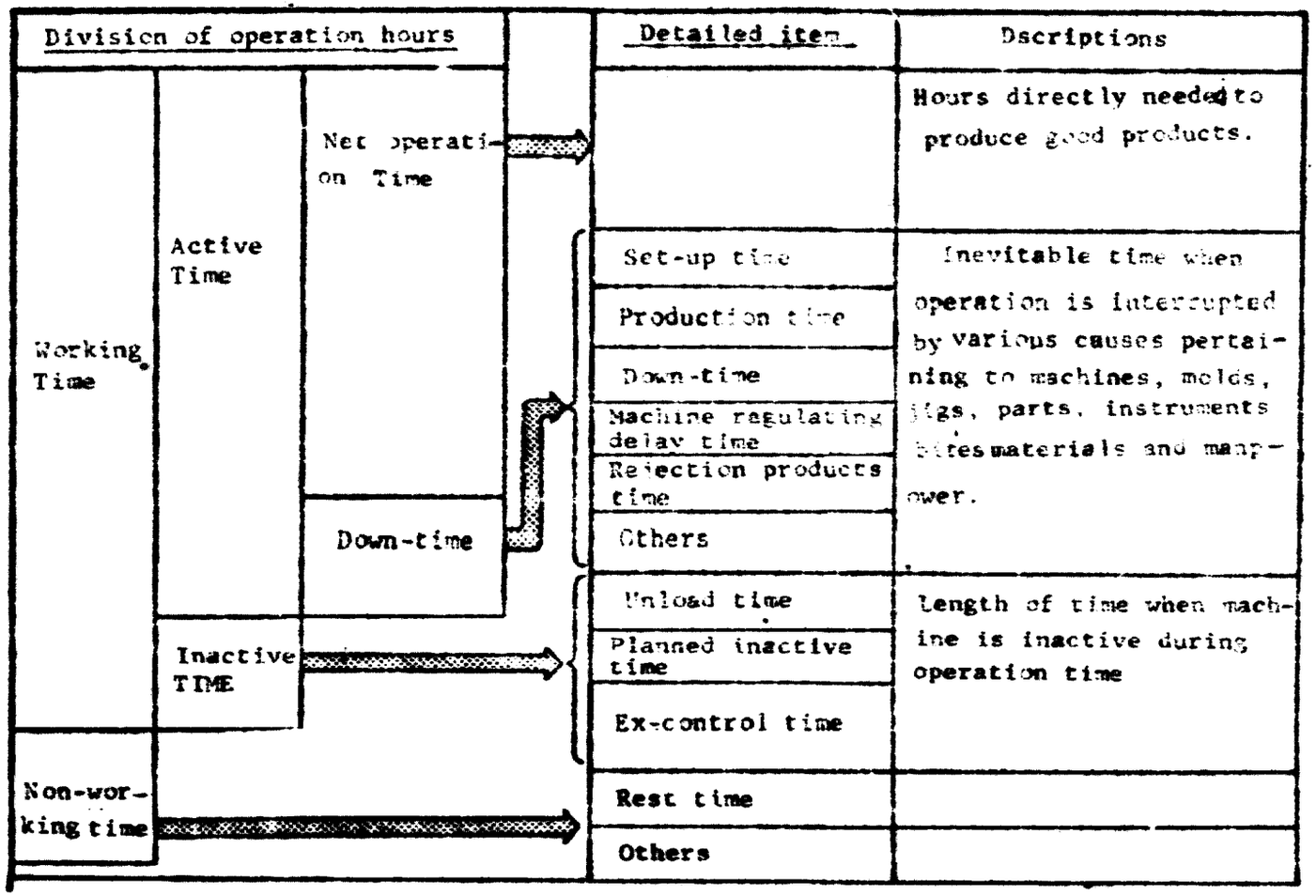


based on PM policies and objectives determined by coporate level PM Committee, departmental managers, executives and group leaders should work on management by objectives. It is important to make clear the corporate wide evaluation methods of PM performance and to have systematic co-relation between management by objectives and actual PM result evaluation.

PM evaluation does not merely include such hard figures as MDR and maintenance cost byt it also includes the evaluation of situation or atmosphere where coporate level PM policies set-out by top management should be deceminating among the first class workers and practice to prevent further failures and standardizations are observed.

In order also to promote this TPM activities through this TPM system, understanding and enthusiasm of top management and zeal, ideas and persuation of the members of the Corporate PM committe are greatly needed and their continuous efforts are a must for success.

Attachment 1 Calculation Guide of M O R



Attachment 2

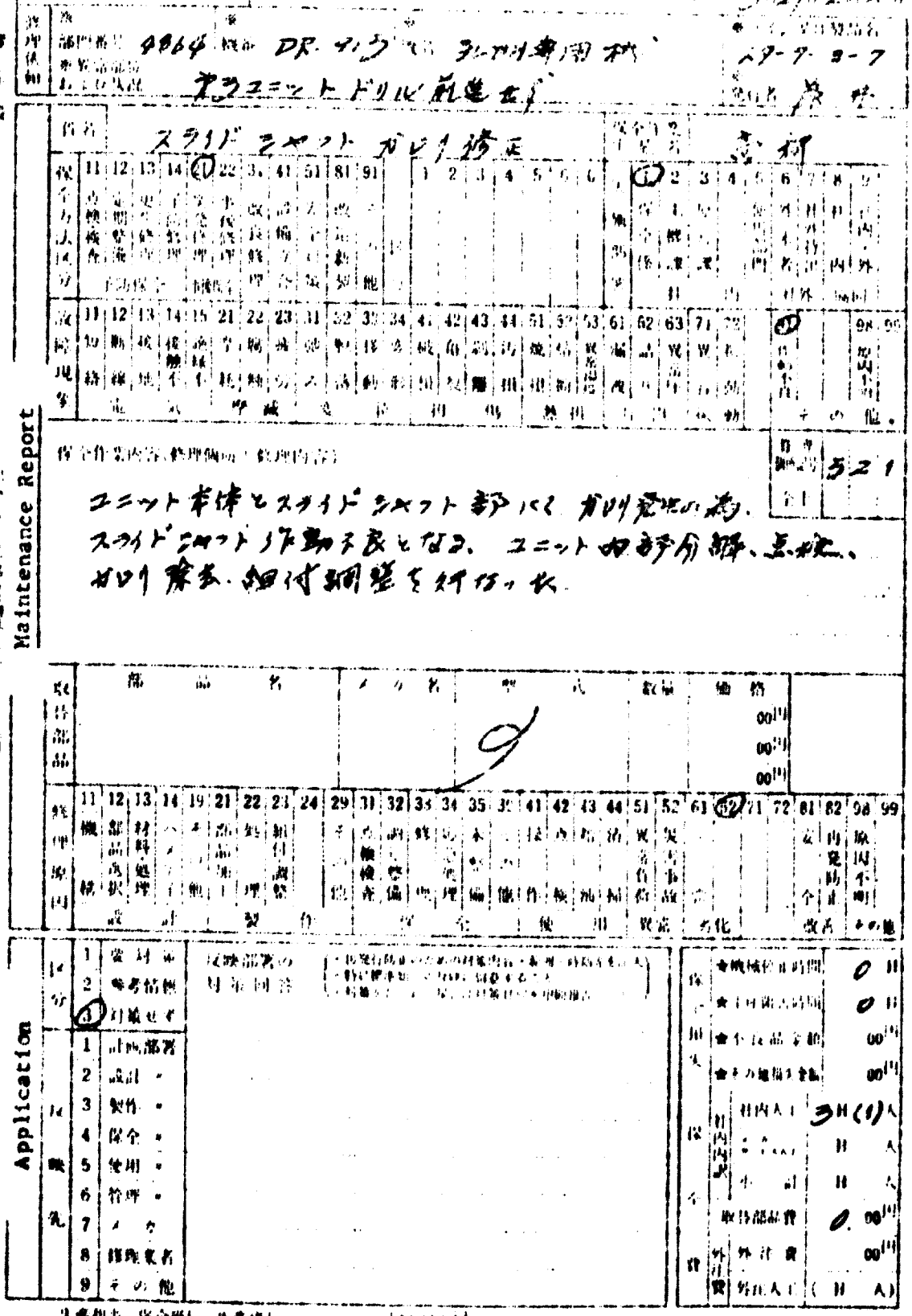
4－1－3 保全報告 ― 反映書

Maintenance Report - Application

(Machine Repair Request-Report-Application)

Maintenance Report

Application



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Attachment 3

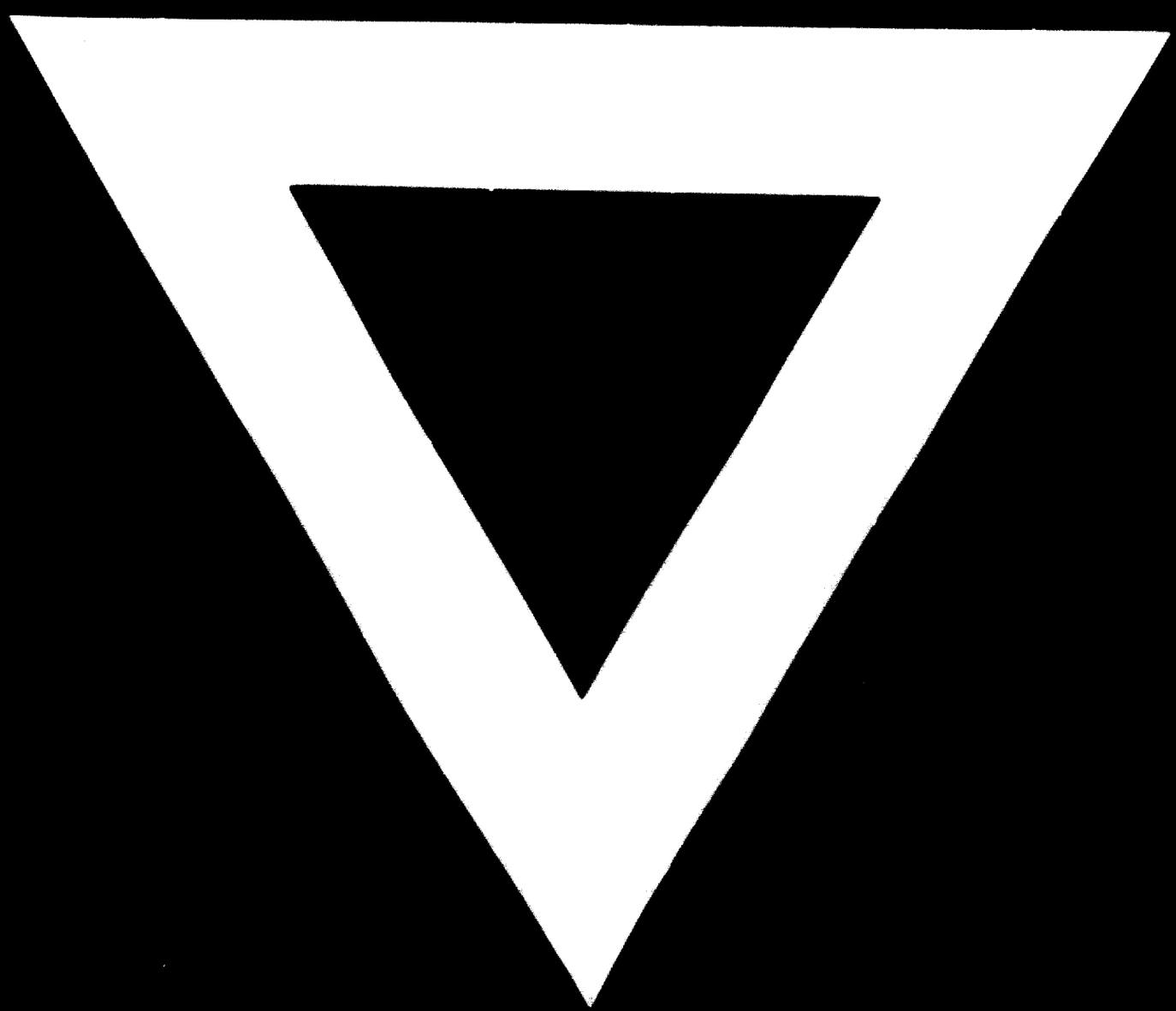
Machine Operation Report and Research List

Line	No. of product	Machine No.	Monthly Machine Operation & Discrepancy report	Organizational Unit	Manager:
Operation/Process	Name of product	Machine name		Section Squad Group	Foreman: Recorder:

DATE	Discrepancy Descriptions	Number of Productive Machines: Number of rejections	Number of Productive Machines: Number of good products	Machine Operation: Machine load (Min.)	Machine Operation: Machine production process in seconds	Production Process Number: Total operation process number (Total man hours)	Production Process Number: Production process number in seconds	Inactive time	Content of inactive time	1 Routine maintenance (oiling, check-up, cleaning-up)	4 Regular change & set-up	3 Regular change of jigs & tools	Operation rate Load Rat. Efficiency Mal-operation rate % Frequency of machine breakdown (1) Production process Number (2) Machine production process in seconds → Graph
1													
2													
3													

Rejection Rate %	

Attachment [illegible] Machine operation & discrepancy report



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