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**MAINTENANCE COSTING**

by

Seiichi Nakajima

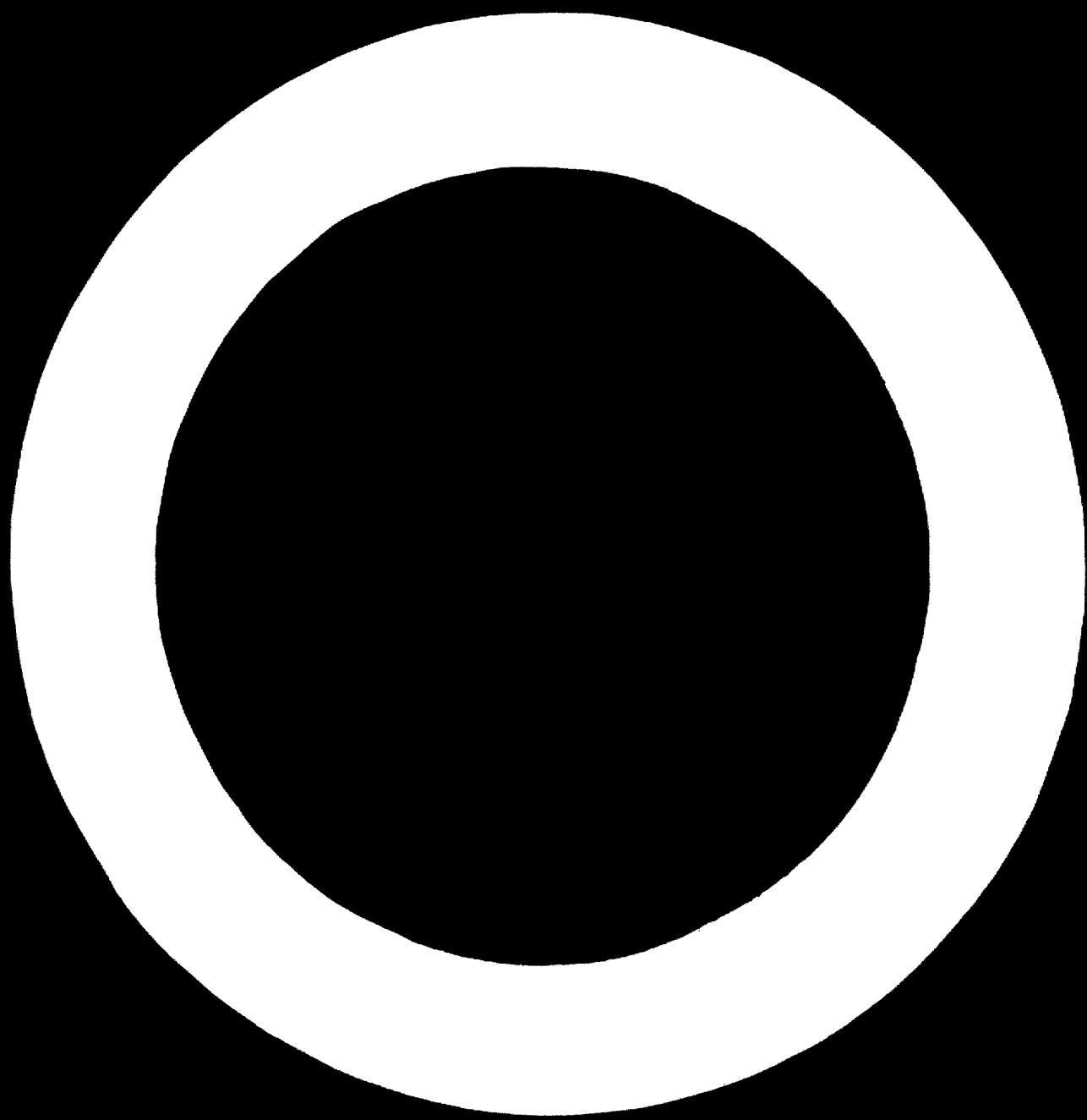
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## **Synopsis**

The objective of maintenance costing is two-fold. One is to insure proper bookkeeping, and the other is to provide the necessary information for internal control and performance evaluation in order to reduce the cost.

This thesis deals with the latter point, internal control and performance evaluation by placing a special emphasis on reduction in maintenance cost, and I would like to take up the subjects in the following order:

1. What is the maintenance cost?
2. How much is spent in maintenance cost?
3. What is the purpose of maintenance costing?
4. Classification of maintenance cost.
5. Total approach to the reduction in maintenance cost.
6. Budget and control system of maintenance cost.
7. Who controls maintenance cost?
8. How to make reduction in maintenance cost and its successful cases.

1. What is the maintenance cost?

First, I would like to give a clear definition of the maintenance cost.

1.1 Definition of the maintenance cost

Roughly speaking, maintenance cost means all the cost that is expended for the proper functioning of facilities. According to a British standard, the definition of maintenance cost is stated as follows: "Work undertaken in order to keep or restore every facility, i.e. every part of a site, building and contents, to an acceptable standard" (Glossary of general terms used in maintenance organization, B.S. 3,811, 1,964). Therefore, we might call all such costs expended for the above-mentioned type of maintenance work as the maintenance cost.

Also in the PM Glossary of Terms by JIPE (Japan Institute of Plant Engineers) defines the meaning of the maintenance cost as follows.

"In a broad sense, the maintenance cost means all the cost expended to maintain the performance of facilities, and the following three types of costs which are classified according to its purposes would be included.

o Routine maintenance cost

All such cost of labor and materials required for check, lubrication, clean-up, and adjustment in order to prevent the possible deterioration of facilities.

o Facilities inspection cost

All such cost of labor and materials expended for inspection of facilities in order to determine whether there are any abnormalities, and if such abnormalities are repairable or not.

o Repair cost

All such cost of labor and materials expended to repair deteriorated facilities.

In a narrow sense, only routine maintenance cost, or the routine maintenance cost plus facilities inspection cost would be defined as maintenance cost.

1.2 Distinction between capital expenditure and maintenance cost

Acquisition of the fixed assets such as newly installed and replaced facilities are amortized as the capital expenditure for a period of anticipated and legally prescribed life of such facilities, and the maintenance cost, in this case, would be incorporated into the general production cost for that particular fiscal year term under the present company accounting practices.

However, from the period of such fixed assets being procured up to the time of its replacement or disposal, we often encounter with the difficulties in identifying whether the said-fixed assets might be classified as capital expenditure, or the production related cost.

After the acquisition of the fixed assets, any cost thus incurred with regard to the facilities should be divided into the following items:

1. Maintenance cost

It means the maintenance cost which was explained earlier in the column of broad sense, that is, routine maintenance cost, facilities inspection cost and repair cost.

2. Facilities improvement cost

Its objective is not to maintain the capabilities, like that of the maintenance cost, but it is the cost required to increase the value of the fixed assets such as the augmented production capacities and renewal of facilities.

3. Added facilities cost

They are any costs required for increase of quantity such as those required by expansion and addition of facilities.

Of the above additional expenditure for fixed assets, it is understood that improvement and added costs are considered as capital expenditure items.

But, when the additional expenditure is involved, situation would be confusing to differentiate the capital expenditure from maintenance cost. For example, the situation where the facilities would be improved or expanded while they are in repair, or during the initial failure period, or immediately after the installation of facilities.



It is rather common to perform some minor adjustments since the facilities does not work as specified. There may occur a lot of discussion on the subject whether the cost required for such operation should be regarded as maintenance cost or the capital expenditure.

As for the division of such capital expenditure and maintenance cost, it is generally governed according to each country's tax system and its related rules, and they should be managed accordingly.

## 2. How much is spent in maintenance cost?

How much is the proper amount of maintenance cost?

Do we spend more or less maintenance cost than the average standard compared to other companies? These are the problems in which manager of maintenance department as well as maintenance staff show their great interest. In order to answer such demands, I would introduce the results of surveys both done in U.S.A. and Japan.

### 2.1 Results of the surveys

In U.S.A., the survey on the maintenance cost was made in 1957, and its result was published as a following chart 2.1.

(Reference: Maintenance Cost Guide, Factory Magazine, February 1957, Total of 687 companies)

By using almost same method of the survey done in U.S.A., I led the survey in Japan for three times in 1961, 1966, and 1969. Chart 2.2 is the result of 1961, chart 2.3 shows that of 1966, and chart 2.4 shows that of 1969.

(Reference: Management, June 1961. Maintenance Guide Book, Oct., 1966, Plant Engineer, Oct. 1969).

Chart 2.1 to 2.4, types of industries pertaining to the types of factories are shown in the footnote of chart 2.1. As of the types of factories, bench work is included in the light assembly in the survey of 1966, and 1969. In the survey of 1969, I omitted the maintenance cost ratio to the total sales.

. Any of these numerical values are summarized by classifying the types of industries, and scales of companies, degree of automation of their facilities, and other conditions are also included, so the numbers are much scattered. Therefore, by comparing these numerical values and the values of one's company, it is dangerous to make a comparison in size. But by considering one of the mean number as one yardstick, it would be better to examine whether you are using too much maintenance cost or reducing them too much.

Chart 2.1 Survey on maintenance cost in U.S.A.

Types of factor-ies	Yearly maintenance cost against total sales					Yearly maint. cost a- gainst manufacturing			Yearly maint. cost against fixed assets		
	minim-um	lower 1/4	mean no.	higher 1/4	maxim.	lower 1/4	mean no.	higher 1/4	lower 1/4	mean no.	higher 1/4
Heavy process	0.83	3.39	5.01	7.65	15.92	4.76	7.25	10.87	3.95	5.80	7.90
Light process	0.04	0.99	1.84	3.08	10.38	1.45	2.56	4.37	3.44	5.05	7.20
Heavy assembly	0.34	1.46	2.08	3.24	17.46	1.83	2.60	4.14	5.10	6.97	10.25
Light assembly	0.12	1.35	2.09	3.25	8.62	1.88	2.75	4.29	4.37	6.46	9.43
Bench- work	0.19	0.89	1.49	2.74	8.48	1.06	1.98	3.68	3.40	5.34	10.50
All the factor-ies	0.04	1.37	2.45	4.25	17.46	1.91	3.18	5.74	3.97	5.89	8.53

Notice: Lower 1/4 means 1/4 of corporations' maintenance cost is under the said value.

Higher 1/4 means 1/4 of the corporations' maintenance cost is above the said value.

Types of industries pertaining to the types of factories are as follows:

- o Heavy process (iron & steel, paper pulps, vinyl (chloride, soda rayon, purified sugar, (petroleum etc.
- o Light process (spinning, electric wire and cables, (oil & fat, foodstuffs, brewings, etc.
- o Heavy assembly (industrial machineries, machine- (tools, automobiles, ship buildings, (etc.

- o Light assembly (light electric machines, automobile  
(  
(parts, rubber products, plastics &  
(  
(resin, bearings, etc.
- o Bench-works (instruments, watches, cameras,  
(  
(exchanges, radio sets, etc.

Chart 2.2 Survey of Maintenance Costs in Japan

Types of factories	Yearly maintenance cost against total sales					Yearly maint. cost against manufacturing			Yearly maint. cost against fixed assets		
	minimum	lower 1/4	mean no.	higher 1/4	maximum	lower 1/4	mean no.	higher 1/4	lower 1/4	mean no.	higher 1/4
Heavy process	0.41	1.54	2.93	4.00	8.94	1.83	3.46	5.40	4.27	7.08	10.48
Light process	0.34	0.79	1.38	2.04	8.05	1.05	1.85	3.09	4.22	7.50	10.90
Heavy assembly	0.04	0.47	0.84	1.38	3.48	0.54	0.97	1.47	1.73	2.93	5.45
Light assembly	0.20	0.79	1.07	1.66	3.21	1.03	1.37	2.37	3.29	4.05	8.66
Bench work	0.15	0.66	0.85	1.23	2.82	0.58	0.89	1.45	2.00	4.00	7.57
All the factories	0.04	0.73	1.33	2.33	8.94	0.80	1.39	2.15	2.98	5.09	9.30

Since the time of research varies between Japan and U.S.A., to compare these numerical value is quite rough, but if we compare the numerical value of Japan of 1961 to that of U.S.A. of 1957, the tendency of the types of factories are quite similar to each other, and the tendency of 1966 and 1969 in Japan also show their similarities.

## 2.2 Maintenance cost comparison according to the types of industries

In the survey of the last clause, the types of factories are roughly divided into four to five types, so due to such a rough division, the speciality of each type of industries are not fully presented. So, from the surveys done in Japan, I selected ten types of industries which are relatively well answered, and tried the comparison according to the types of industries.

(Reference: PM Journal, December 1966)

Between the labor-equipment ratio and the maintenance cost ratio according to the types of industries, it was judged that there is a co-relation, so I decided to draw a chart of co-relation.

The labor-equipment ratio was worked out by the following formula:

$$\text{Labor-equipment ratio} = \frac{\text{Total amount of tangible fixed assets}}{\text{All the numbers of employees of company}}$$

But in this case, the numerator, the total amount of tangible fixed assets is the total of the book value of the tangible fixed assets without the real estate.

On the labor-equipment ratio, if the mean number of each type of industries are arranged in order of size, the results came out as diagram 2.1.

According to the diagram 2.1, oil and fat, petroleum refining, iron & steel, and other so-called process type of industry has a high labor-equipment ratio, and light electric machine, machine tools, industrial machineries, and other assembly type of industry had low labor-equipment ratio, and it was exactly following our expectation.

When the mean number of each type of industries on the maintenance cost ratio to the fixed assets are arranged in order of those mean numbers, the result such as one shown on the diagram 2.2 was achieved.

Diagram 2.2 Maintenance cost ratio to the fixed assets

If you see diagram 2.2, soda came out to the top, and its maintenance cost ratio to the fixed assets is 7%. If the labor-equipment ratio of diagram 2.1 and maintenance cost ratio of diagram 2.2 are compared, there is a little difference in the order of the types of industries, but on the whole, the order of both diagrams is quite similar.

So, when I drew a diagram of co-relations of labor equipment ratio and maintenance cost ratio, diagram 2.3 would come out.

Diagram 2.3

### 3. What is the Objective of Maintenance Costing

In the Maintenance Engineering Hand Book, Mr. C. H. Knight of Monsanto Company states as follows:

(see Maintenance Engineering Hand Book, 2nd ed. 1966, p. 5-3)

"there are two general goals of any cost system. One is to provide an accounting activity with information required for proper bookkeeping; the other is to provide the operating department with information required for its internal control and performance evaluation."

In the Plant Engineering Hand Book, Mr. H.W. Shockley of E.I. du Pont de Nemours & Co., Inc. notes as follows: (See Plant Engineering Hand Book, 2nd ed., 1959, p.9-32)

"The objective of the cost control plan is low maintenance costs."

As Mr. C. H. Knight states, there are two general goals in maintenance cost system like any other cost system. One is for proper bookkeeping, and the other is to provide information for the operation department which it requires for its internal control and performance evaluation.

That is to say, the purpose of maintenance costing is:

1) Information for proper bookkeeping

Cost data of labor cost, material cost, contracting cost, and others for maintenance which occur within the maintenance department and other areas should be accurately recorded. The information would be sent to accounting department, and within



the department, they would be summarized and arranged according to the cost price, the cost center, and others. They would serve as fundamental data for a statement of profit and loss, and for the cost accounting record according to the department or to the products.

2) Information for internal control and performance evaluation

By using Mr. H. W. Shockley's words, internal control and performance evaluation which are used by Mr. C. H. Knight means a control plan, and its purpose is to reduce the maintenance costs.

In this thesis, I would like to treat the problem of maintenance costing from the point of maintenance management. Therefore, the emphasis would be placed on the subject of internal control and evaluation, namely, the problem of reducing the maintenance cost through cost control, rather than the problem of bookkeeping which was mentioned in column 1.

#### 4. Classification of Maintenance Cost

Maintenance cost on accounting's needs is generally classified as follows:

o Classification by the cost price

Repair material cost (material cost such as the necessary parts for maintenance, general materials, oil & grease, and tools and fixtures.)

Internal labor cost

Repair payment (expenditure paid for contractor)

o Classification by cost centers

They are classified according to every cost center such as machine, line, and department, and others.

But, making a discovery of problems from the viewpoint of cost control for taking an improvement

action, this classification on accounting's needs

is rather insufficient, therefore, we should try

to acquire beneficial information for management

controls by making a classification as follows:

o Classification by maintenance purposes

As mentioned in the statement of the maintenance

cost definition, the classification will be as

follows:

Routine maintenance cost (Prevention of degradation)

Facility inspection cost (Measurement of degradation)

Repair cost (Recovery of degradation)

o Classification by planning

Planned maintenance

Unplanned maintenance

Emergency maintenance

o Classification by maintenance methods

Preventive maintenance

Breakdown maintenance

Corrective maintenance

Besides above, several other classification are done, such as:

- o Classification by maintenance areas (mechanical, electrical, piping and plumbing, civil engineering, measuring instruments, vehicles, ships, etc.)
- o Classification by the size of maintenance works (large repair, medium, small, or specified work and miscellaneous work)
- o Classification by the maintenance periods (regular maintenance, routing maintenance)
- o Classification by on-work or off-work (on-stream repair, on-stream inspection, or shutdown work)

At E.I. du Pont Nemours & Inc., maintenance cost is classified by direct, indirect, and general as follows.

(Ref.: Plant Engineering Hand Book, 9-32, 1959, or Maintenance Engineering Hand Book, 1-63, 1966)

Direct maintenance covers repairs to operating equipment or auxiliary equipment attached to it. It also includes miscellaneous repairs, such as oiling machinery, packing pumps, inspections, etc. Direct maintenance should be in proportion to production. Figure 4.1 is a chart for establishing monthly budgets based on direct, indirect, and general maintenance costs.

Indirect maintenance covers repairs or replacement of parts (such parts being not entirely worn out) with parts of improved design, additions (when not capitalized), replacements (when they reflect changes in design), materials and methods only, rearrangements, and service to operations.

General maintenance covers repairs to buildings, outside lines, storage tanks, roads, main power, steam, air, or process lines, and structural supports of buildings but not that supporting equipment. General maintenance covers any type of repair that does not vary with production.

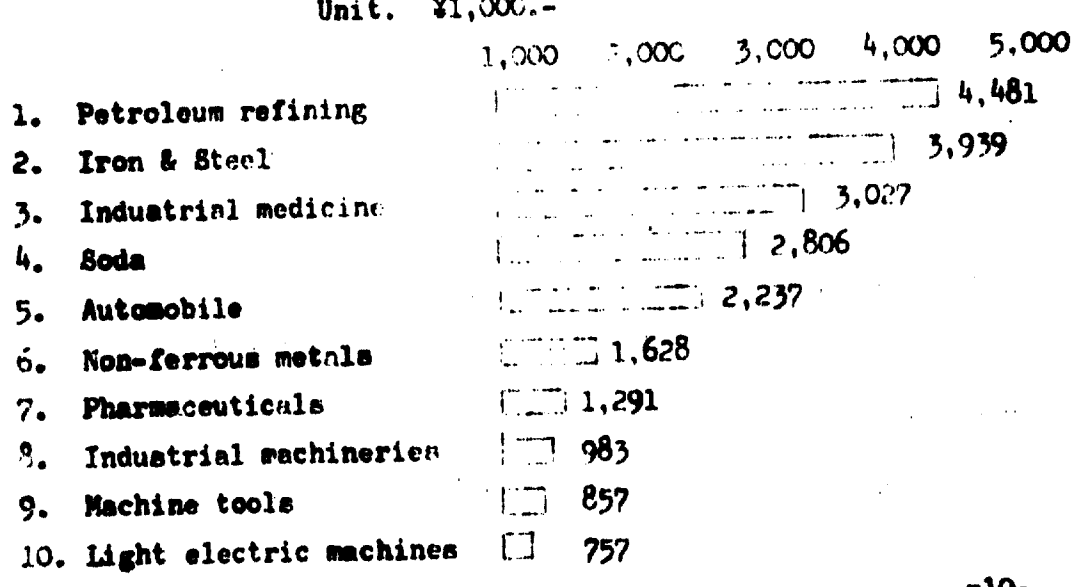
Chart 2.3 Percentile of yearly maintenance cost against  
manufactured cost and fixed assets and total sales (1966)

Types of factor-ies	Ratio against total sales			Ratio against manufacturing cost			ratio against fixed assets		
	lower %	mean no.	higher %	lower %	mean no.	higher %	lower %	mean NO.	higher %
Heavy process	1.4%	2.5%	3.5%	1.64%	3.4%	5.0%	2.0%	4.2%	5.23%
Light process	0.52	1.0	2.2	1.0	1.4	2.6	2.12	3.3	7.0
Heavy assembly	0.5	0.75	1.6	0.5	1.0	1.5	0.9	2.0	3.93
Light assembly	0.15	0.7	1.0	0.55	1.0	1.5	0.4	1.0	4.3
All the factor-ies	1.2	2.4	3.1	1.4	3.1	4.6	1.9	3.9	4.9

Chart 2.4 Percentile of yearly maintenance cost against  
manufactured cost and fixed assets (1969)

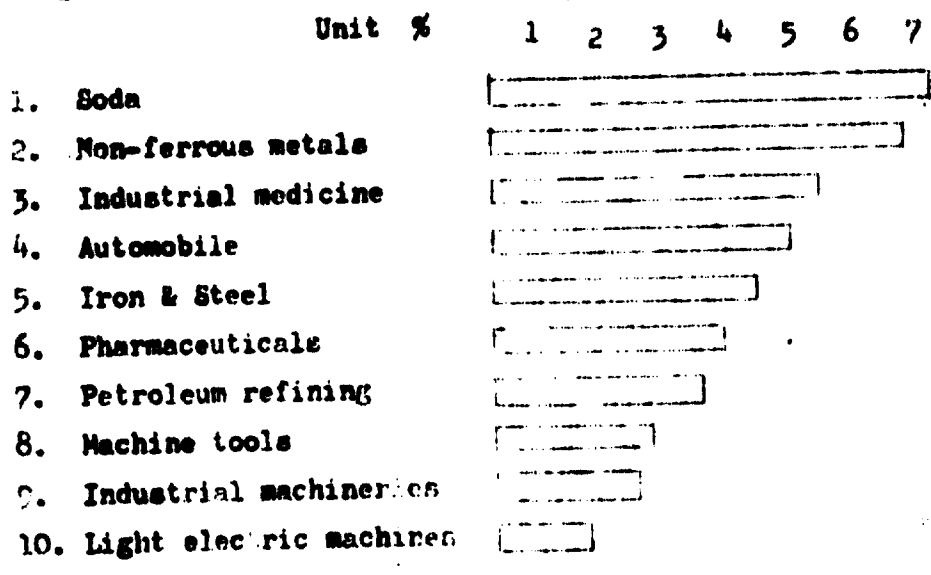
Types of factor-ies	Ratio against manufactured cost			Ratio against fixed assets		
	lower %	median no.	higher %	lower %	median no.	higher %
Heavy process	2%	3.8%	6%	2.6%	3.9%	7.6%
Light process	0.6	1.74	2.1	1.5	4.4	6.2
Heavy assembly	0.35	0.67	1	1.4	2.1	4
Light assembly	1	1.2	2.5	3.0	4.5	7.1
All the factor-ies	1	1.9	5	2	3.9	7.1

Diagram 2.1 Labor equipment ratio (median no. arranged by the types of industries)



-p10-

Diagram 2.2 Maintenance cost ratio to fixed assets



-p11-

Diagram 2.3 Co-relations of labor equipment ratio and maintenance cost ratio

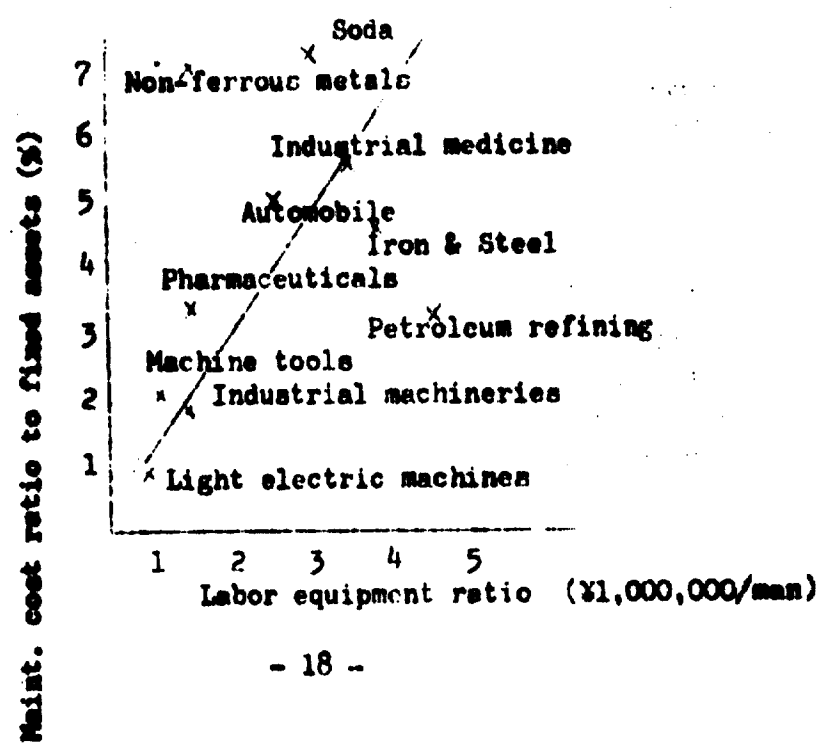
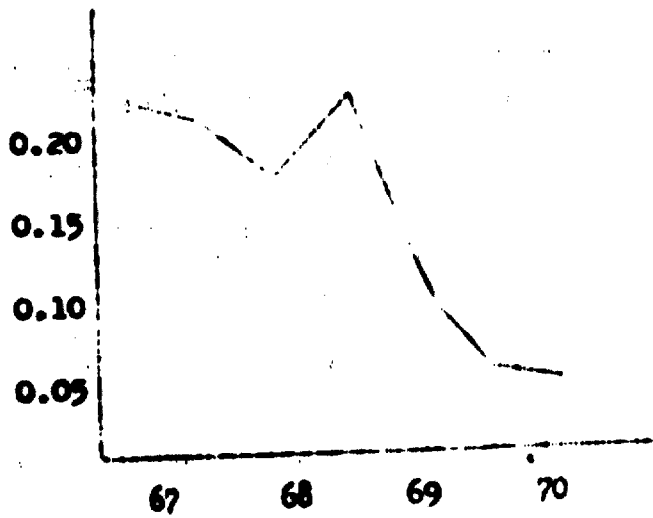


Diagram 6.5 Example of work order form

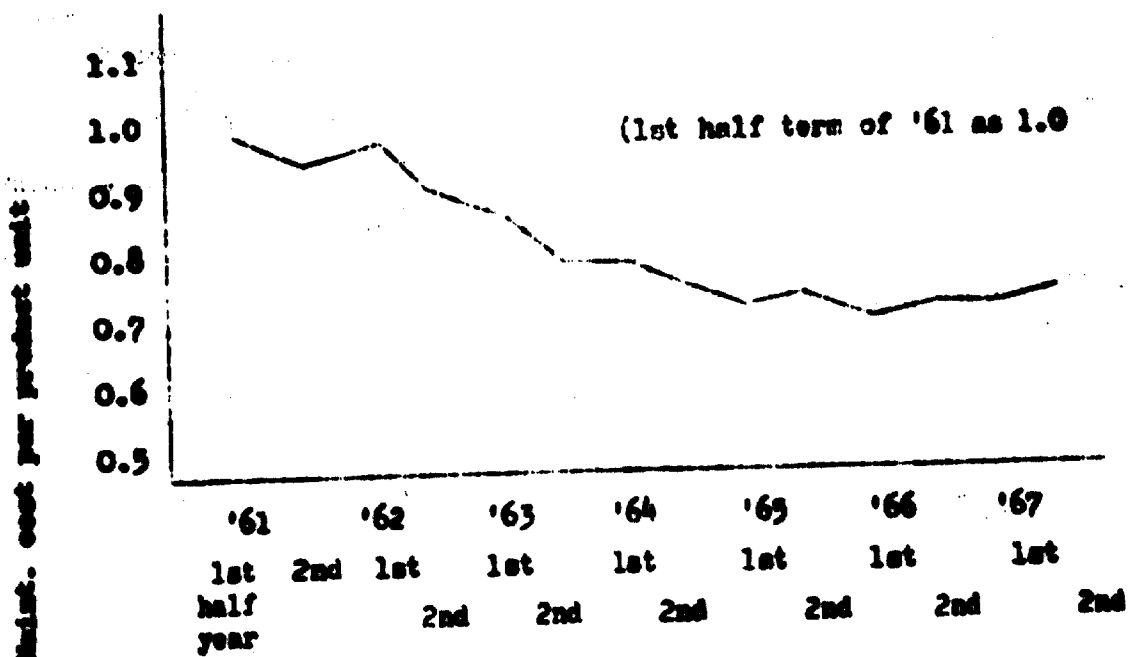
<u>Work order form</u>								
Issued				yr. mths. day		No. issued: Issued: Section		
<b>Specified work</b>					Fixed assets no.			
					Facilities name			
<b>Work Specification</b>					Blue print no.			
					Work classification			
					Prospective time for delivery			
					Planned starting date ( mths. day)			
					Planned completing date ( mths. day)			
<b>Utilized materials</b>	<b>Materials name</b>	<b>standard</b>	<b>No.</b>	<b>Unit price</b>	<b>Amount of money</b>	<b>Estimated man-hour</b>	<b>Completion</b>	
				¥	¥		mth. day	
						<b>Actual man-hour</b>	<b>Inspection stamp</b>	
							mths. day	
						<b>Actual work cost</b>	Material cost ¥	
							Labor cost ¥	
							Expense of sub-contractor ¥	
							Total:	
	<b>Issued:</b>			<b>Receipt No.</b>		<b>Received:</b>		
	<b>Person in charge</b>			<b>Work no.</b>		<b>Person in charge</b>		

Diagram 8.2 Maintenance cost ratio  
(Kojima Press Co.)



- p39 -

Diagram 8.3 Transition of maintenance cost ratio  
(Kobe Steel Ltd.)





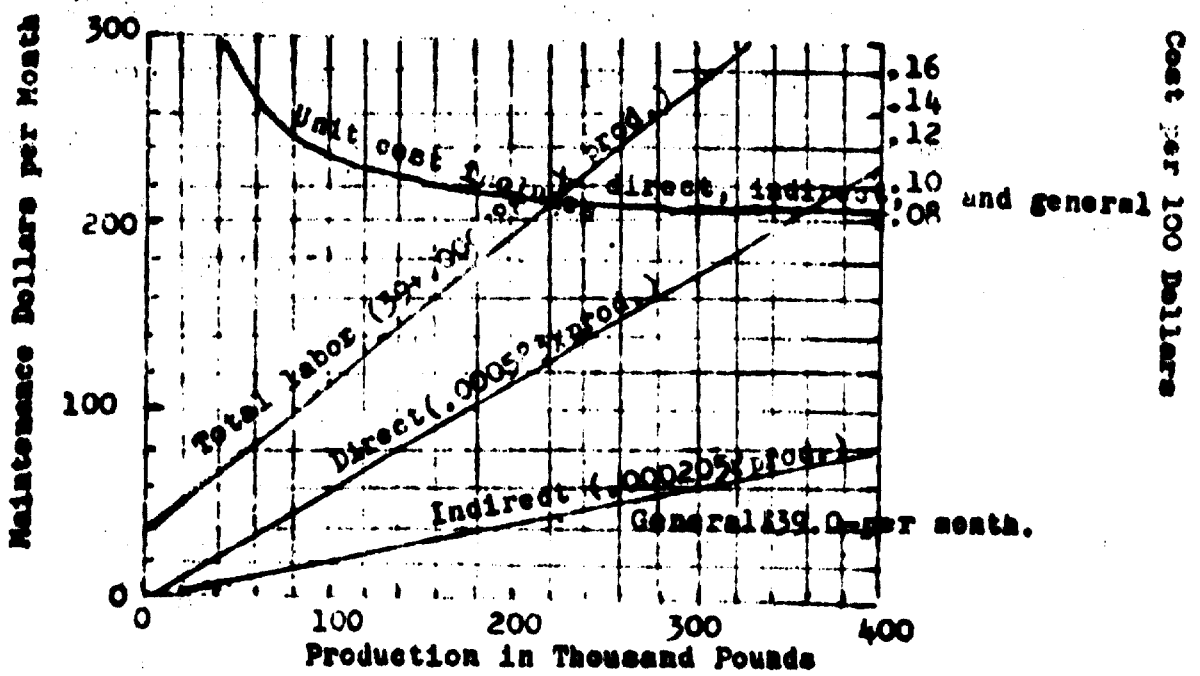


Fig. 4.1 Chart for establishing monthly budgets based on direct, indirect, and general maintenance costs.

5. Total approach to the reduction of maintenance cost

Here is a quite natural, yet quite important idea: the real meaning of "low maintenance cost" does not simply mean reducing the maintenance cost. That is, assuming that full and necessary maintenance activities should be performed in order to execute the prescribed function of any facility without mishap, the words "low maintenance cost" actually means reducing the cost which is required for the above mentioned, necessary maintenance activities.

It is possible to curtail the maintenance cost in unilateral manner, without being based on the above ideas. But as a result, the facility may not be fully kept in good condition, failures may occur in succession, and expected function may not be performed. Then the quality of the products may deteriorate, and that may even cause a loss to corporation.

We could say that the pursuit of real economy is to consider both the loss caused by the facts of undoing the maintenance, and at the same time the expense of maintenance, and I would like to note on this point a little more in detail.

If the maintenance cost is spent on the facilities to keep them in a satisfactory condition, then the productive loss which could have been avoided is called opportunity cost, and we call the loss resulted from the degradation of facilities as "degradation loss".

As for corporation, it is most economical to minimize the total of the necessary maintenance cost which is to maintain the function of the facilities plus degradation loss caused by the said-degradation of facilities, and JIPE decided to call this total of the maintenance cost and the degradation loss as "total maintenance cost".

Generally, if the maintenance cost is not fully spent, the degradation loss of the facilities will grow, and in contrast with this, it would require much maintenance cost to reduce the degradation loss of the facilities, and the best answer (the least cost point) could be acquired by combining these two essential elements which tends to be contrary to each other.

(see fig. 5.1)

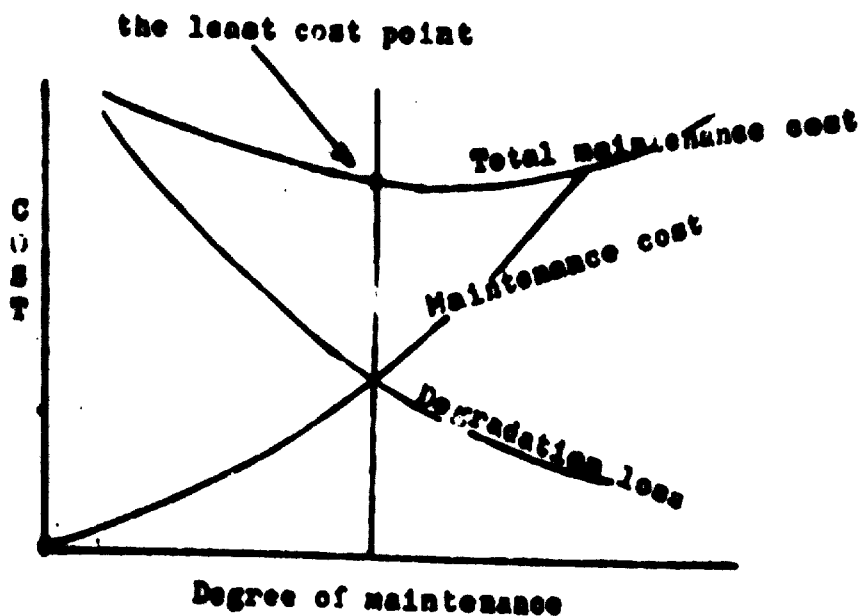


Fig. 5.1 Idea of low total maintenance cost

There is an idea of maintenance which pursuists what may be the most economical way after all through the entire management system of the above total approach.

We call such an idea as "productive maintenance" These words, productive maintenance; themselves were first used by General Electric Company of U.S.A. in 1954, and the idea was sympathized also in Japan, and the idea was so much sympathized that if anyone says PM nowadays, it would even mean productive maintenance rather than preventive maintenance.

In case the low maintenance cost may be argued later on, please take its meaning as stated here, for it signifies the low total maintenance cost.

## 6. Budgeting and cost control system for Maintenance

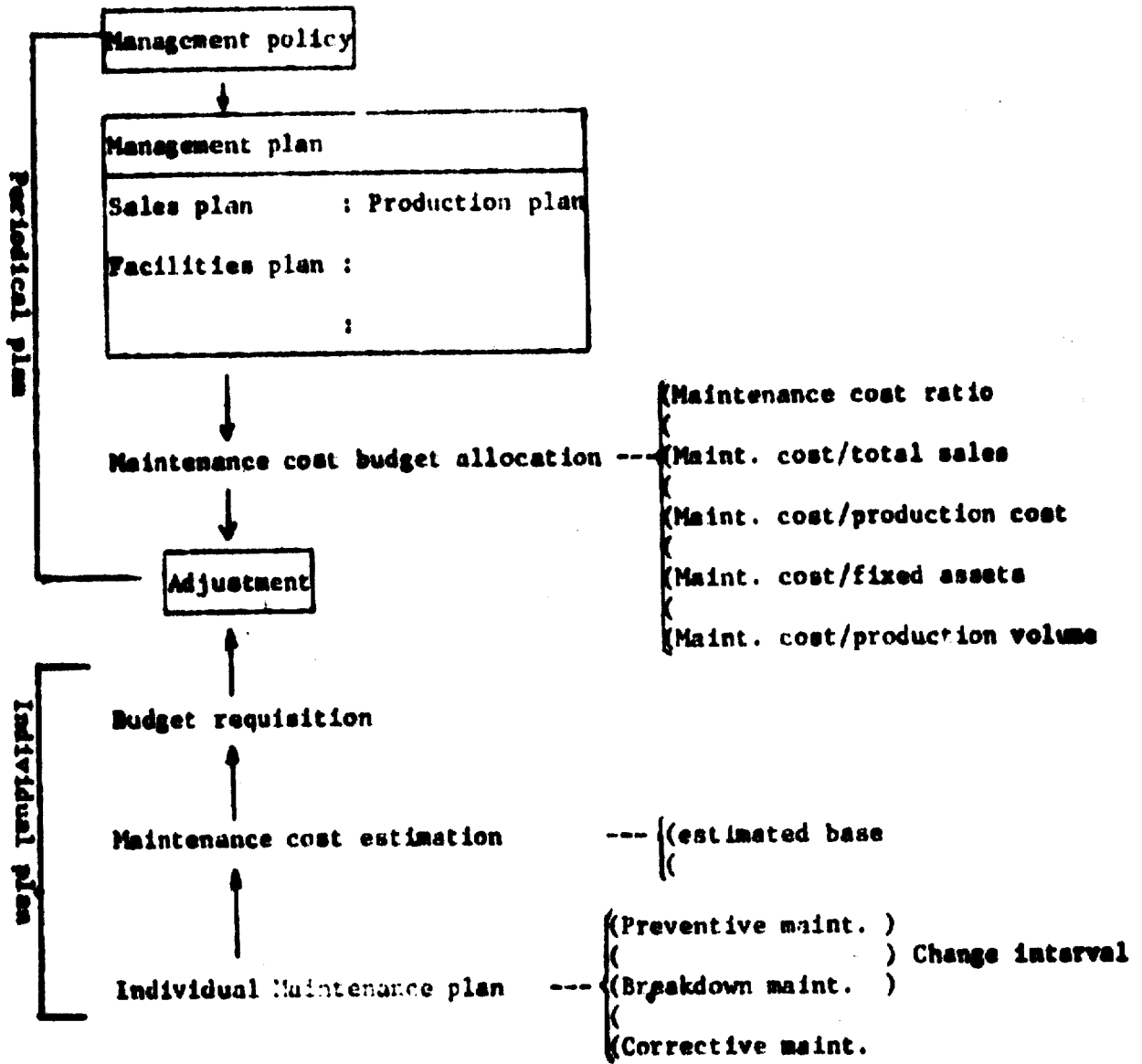
### 6.1 Budget preparation for the maintenance cost

Generally corporations prepare their yearly or half year budget in every fiscal year or half year, and as for the maintenance, the budget preparation is often done as one of the expense budgets.

When the budget preparation of the maintenance cost is simplified, it would be like diagram 6.1. From the point of management policies and plans of the subject year, finance department or budget secretariat calculate the budget allocation to each department. On the other hand, from each department, the budget requisition calculated from the regular accumulations of the maintenance plan would be submitted. This budget requisition generally exceeds the budget allocation plan, so, the adjustment of both budgets would be required, and many corporation have a budget meeting in order to do such adjustment.

Besides each department, budget preparations are often arranged according to the maintenance purposes, plans, methods, objects, size of construction works, maintenance cycles, and other classifications as said in the paragraph of the maintenance cost classification.

**Diagram 6.1 Budget preparation of the maintenance cost**



As for the standard to decide the budget allocation, it is up to each corporation to decide what is to be utilized. According to the survey I made in 1966 and 1969 in Japan, as it is drawn on diagram 6.1, tendencies of both years were almost the same and "previous term performance" is mostly used for measuring the standard, and fixed ratio which slides with of production volume, total sales, or production cost budget is also in use.

Diagram 6.1 Standard to determine maintenance cost total budget (numerical value shows % of numbers of factories)

	<u>1966</u>	<u>1969</u>
Previous term performance	77	80
Accumulation of repair programs	64	54
Productive volume slide	28	27
Fixed ratio to total sales or production budget	28	14
Others	13	6
Without any standard	3	4

I would show an example of forms for the budget preparation used in Japan on diagram 6.2 and 6.3. Diagram 6.2 is a form for each budget requisition, and diagram 6.3 is the budget diagram arranged by each department.

## 6.2 Budgetary control and its performance check

On the occasion of the budget execution, person in charge of the budget execution ought to endeavor that the actual expenditure should not exceed the budget amount. For this purpose, it is necessary to systematize the way to grasp the execution state in every moment. That is, to make a system which sums up repair material cost, repair payment, internal labor cost according to each work-number.

In order to grasp cost data, there are three opportunities such as points to determine order amount, receiving amount, and payment amount. Most efficient way to stop the exceeding of the budget is to grasp the cost data at the order point.

The meetings, such as so-called budget committee or cost review committee would be held regularly to compare and examine the maintenance cost budget and performance. The finance department who is in charge of the matter should promptly report the balance of budget to the managers of each cost center, and the managers of each department should regulate the expenditure by themselves in order to keep their budget within limit.

Diagram 6.4 is an example of the report sheet which shows the amount of budget, balance, and its state of progress according to each department and its purpose.









It would be fine if the budget would work out as it was planned, but by meeting the needs of later situation, and by making it possible to rationalize budget supplement, reduction and revision, we would be able to perform a real control.

### 6.3 Recording of the cost data

I would like to show an example of a work order system for recording the said cost data.

Diagram 6.5 is an example of work order form for the repair construction work. This slip would be used consistently for the construction work request and planning, construction work instruction, progress control, and for performance record. (This is so-called one writing system).

In case of a large scale construction work, several slips would be issued for each unit of construction work.

Diagram 6.5 An example of construction work slip form

As for the contracted construction work, the repair payment could be estimated by the construction work order sheet, or by an invoice submitted by contract worker after the work is completed, or by a payment slip.

The repair material cost could be estimated by materials shipment slips and others.

## 7. Who Controls the Maintenance Cost

### 7.1 Share of responsibilities among maintenance cost related departments

The department related to the maintenance cost control could be roughly divided into three main departments such as operation department, maintenance department, and finance department.

Corporations with high level of maintenance technics and controls in those three departments generally classify the maintenance cost control responsibilities as follows:

#### Finance department

In time of budget preparation of the maintenance cost, the department would calculate the budget allocation on the basis of management policies and plans. The maintenance cost budget of each department would be decided by coordinating the budget requisitions which are submitted by each department with the budget allocations. This adjustment is often done at the budget meeting.

On execution stage of the budget, the department would sum up the maintenance cost control performances of each department and report the balance to the related managers, and would held a budget meeting in order to give advices to managers of each department not to exceed the budgetary limits.

## Maintenance department

In time of the budget preparation, each department would make lists of maintenance work required for that particular fiscal year, and would estimate the maintenance cost of each and every maintenance work. They would also formulate the original plan of the budget requisition according to each department. They would consult with operation department on the original plan they had made in order to decide the final budget requisition, which they would submit to the finance department.

The representative of the maintenance department would participate in the budget meeting which will do the adjustment of their budget requisitions, and the maintenance cost budget allocations calculated by the finance department, and from the corporate and divisional standpoints, the representative would state their opinions for the budget as maintenance specialists.

On the execution stage of the budget, maintenance labor cost, material cost and other cost data would be recorded according to the work order, and the record would be sent to the finance department as the primary data for summation of the maintenance cost performance during that particular term.

The representatives would also participate in the budget meeting to examine the performance, and from the standpoint of the maintenance specialist, they would explain the progressive condition of the maintenance work, and would give advices for not to exceed the budgetary limit to related departments.

#### Operation department

In time of the budget preparation, based on each department's original plan of the budget requisition which is submitted by the maintenance department, the representatives of this department would decide the total budget requisitions by making some necessary modifications to meet their from their standpoint of production to meet their plan.

On the execution stage of the budget, they would request the construction work according to their budget, and endeavor not to exceed the budgetary limit by checking the report of balance on the maintenance cost performance provided from the finance department.

However, their duty is not only to keep down the execution of budget within its limit, but to strive to reduce the maintenance costs with the assistance of maintenance department.

As for the control of the maintenance cost, the said departments such as operation, maintenance, and finance department ought to fulfil their share of responsibilities

as mentioned. This is quite an important idea to realize that controlling the budget within its limit and reducing the yearly maintenance cost are the duties of operation department. Maintenance department and finance department are in a position to cooperate with operation department as specialists for effective cost control.

Here in this thesis, the budget preparation and performance summation are categorized under the share of responsibility of the finance department, but with the recent rapid progress of EDPS, the summation is getting to be done by computer department.

## 7.2 The relation between the maintenance level and the maintenance cost control

The share of responsibilities by the above-mentioned three departments only applies to the corporations with high technical and control level of the maintenance.

If the maintenance level would vary, then the share of responsibility of the maintenance cost control would also be different from the above. The reason would be clearly understood by looking back the history of maintenance progress in Japan.

History of our maintenance progress may be roughly divided into four stages. The fact may denote the general transition of the whole country, and these four stages may also be applied to each corporation as well.



First stage: Breakdown maintenance age, before 1950's

This stage was consisted of an idea that facilities are something that will be repaired after they break down, and this was the condition of pre-preventive maintenance. At this stage, inspection on routine maintenance and preventive maintenance were not yet done, and instead of maintenance department there were repair shops to do the breakdown repairs which were based on the request of operation department.

From the lack of the information which otherwise could have been accumulated on each maintenance plan, the maintenance cost control of this stage could prepare the budget only in a rough manner even if they wished to have a close budget preparation.

The maintenance cost control of this age was the responsibility assigned to the operation department, but since catastrophic failures or unplanned repairs were frequent, satisfactory cost control was not often done during this stage.

Second stage: Preventive maintenance age, after 1950's

American type of preventive maintenance was introduced to Japan around 1951, and with the introduction of preventive maintenance, the share of responsibilities of the maintenance cost control made a drastic change in our country.

While there were only repair shops in the breakdown maintenance age, inspectors who were in charge of inspection professionally appeared to carry out the preventive maintenance, and the special maintenance department was established by combining the inspector and the repair shop.

To achieve the new preventive maintenance functions completely, authorizing the maintenance department on the matter of cost expenditure became of its utmost necessity, because if the operation department were to keep their power over the expense of the maintenance cost, the old concept of the breakdown maintenance age would remain, for even if the maintenance department wished to inspect facilities, or perform the regular repair, the operation department might not shut down the facilities out of their short-sighted anxiety of production loss caused by the shut down for the inspection and the preventive repair.

Therefore, in order to establish preventive maintenance, the authority of the maintenance cost expenditure for preventive maintenance was decided to be given to maintenance department.

Third stage: .Productive maintenance age, after 1960's

Concept of productive maintenance started to expand in Japan in the 1950's, but it was popularized only in process type industry in the beginning, and during the 1960's, the productive maintenance began to spread in fabrication industry especially among the automobile

industry and electric home appliances industry, and if the word PM is mentioned at present, it signifies the productive maintenance. This productive maintenance aims at the totally reduced maintenance cost which is the sum of the maintenance cost and degradation loss, and in order to achieve the purpose of the productive maintenance:

At the stage of facilities ... Maintenance prevention planning and installation

At the stage of facilities ... Preventive maintenance operation

At the stage where the ... Corrective maintenance failures occur

Thus, idea of getting the effective maintenance resulting from these MP, PM, CM as its three main supports began to permeate.

Maintenance cost control of this stage was still a continuation of preventive maintenance age, and maintenance department had the power on the maintenance cost expenditure at most of the corporations, but as PM concept began to spread even in the operation department, a new idea that the maintenance cost control should primary be the responsibility of the operation department began to appear.

Fourth stage: Total productive maintenance age, after 1970

As the concept of MP-PM-CM began to expand itself, facilities maintenance was thought to be done not only by the maintenance department, but also by the planning, operation, and other departments related to facilities.

By the participation of all these departments, a total maintenance system covering entire life-span of the facilities was considered necessary.

#### Operation department

The routine inspection, lubrication, and clean-up and other necessary jobs would be done by the facilities operation department, and the repairs which this department is not able to do by itself would be requested to the maintenance department, and operation department would also be responsible for the maintenance cost control.

#### Facilities maintenance department

As maintenance specialists, this department would do the overhaul, adjustment, and repairs at the requests and recommendation of the operation department, and would also give advice and guidance to the operation department regarding the actual method of maintenance and operation.

As for the maintenance cost control, this department would give their aid and cooperation to the operation and finance departments on their budget preparation, and records of data and performance.

#### Planning department

This department is responsible to hand over the facilities with high reliability, maintainability, and economy to the operation department.

If the functional specialization in the field of operation and maintenance goes too far during the preventive maintenance and productive maintenance ages, the attention

towards the facilities by the operation department would be weaker, and as a result, early detection of failure and routine maintenance would go only half way, and they would lead to the breakdown of the facilities, and bring about the increase of the maintenance cost.

The relation between the operation department and maintenance department resembles that of car driving and maintenance. Driver would do his routine check and clean-up of his car by himself, and would ask the regular maintenance and overhaul to auto-repair factory. The relation between the operation and maintenance is much the same. Operation corresponds to the driver, and maintenance is equivalent to the auto-repair shop.

As each department realizes their part in above manner, and try their best to reduce the maintenance cost with their very best, it would obviously bring a great effect rather than sole effort of maintenance department.

In Great Britain, a new word "Terotechnology" was coined in 1970, and this word advocates the total system for the whole life-span of facilities as the objective of maintenance minimization. Source of this word "tero" is derived from a Greek root "tereo" which means "to take care of." The terotechnology places its point on what we call as Maintenance Prevention, and its aim is quite alike to total PM which we at JIFE advocate.

8. How to make reduction in maintenance cost, and its successful cases.

### 8.1 Variable factors of maintenance cost

In order to reduce the maintenance cost, we ought to review what are variable factors of the maintenance cost, and what sort of factors have a great influence on, and then take an effective action.

Professor Hibi states "the factors to affect maintenance cost" in his book. If we enumerate the variable factors of maintenance cost by referring to the above mentioned subject, it would be as follows:

(Reference: Hibi Shohei: How to measure maintenance efficiency, 1971)

- o Facilities itself:  
Types and classes of facilities, its age, quality of design etc.
- o Method to operate facilities:  
Degree of operation, quality standard, application of load, how to operate etc.
- o Method of maintenance:  
PM or BM, degree of upkeep and care, repair techniques, organization of maintenance, inhouse or contracted outside etc.
- o Environmental condition:  
Temperature, humidity, pressure, chemical atmosphere, vibration, etc.

Besides these, motivation of top management, middle management, and the first line worker, management system of accounting and purchasing and warehouse, level of budget preparation, and fluctuation of price etc. could be stated.

#### 8.2 Reducing the total maintenance cost by TPM

In order to reduce the total maintenance cost which is the sum of maintenance cost and degradation loss, JIPE advocates TPM in Japan after 1971, and much increase in number of corporations which induced TPM has been seen.

This TPM is the abbreviation of Total PM which means productive maintenance participated by all employees.

JIPE defines TPM as follows:

- 1) To maximize equipment efficiency (to achieve synthesized optimization of equipment use ... to minimize maintenance cost + degradation loss)
- 2) To establish the total system of PM for the whole life of the facilities.
- 3) All the way through planning, operation, and maintenance departments of the facilities.
- 4) The participation of all the employees from the top management to the first line workers.
- 5) Management by motivation, that is, to promote the PM by small voluntary group activities.

There are three meanings contained in the word, "total" of TPM. First meaning is derived from the total participation of all the employees. Next one is derived from "total system" is total, and the last one is derived from "totally synthesized optimization".

The first company in Japan to put TPM into practice was Nippon Denso Co., Ltd. and this is considered as the model company of TPM. Since admitted that they made a great effect on reducing the total maintenance cost by TPM, they received PM Prize of 1971 from JMA and JIPE. (This PM Prize was inaugurated in 1964 to raise the maintenance level of corporations, and is offered every year). In 1972, Toray Ltd., Okazaki Plant received PM Prize also on TPM.

Small voluntary group activity signifies the independent, self-controlled activities by all the employees in such small groups as QC circles or ZD groups, and these small groups take up PM with QC and ZD and will carry routine lubrication, inspection, care, and other jobs which they could do voluntarily or independently. At the special department such as project engineering and maintenance, by showing high level of technics and skills, their aim is to reduce the total maintenance cost drastically by MP and CP. This TPM is especially pursued by highly skilled operators and maintenance crew, and its absolute condition for success is fully motivated, voluntary activities of those employees.



American way of preventive maintenance was introduced in Japan in 1951, and twenty years has passed since then, and during the time, technique, skill, and philosophy of management have developed, and finally reached to TPM, so PM is more like that of Japanese way of PM.

In the developing countries, I wish you to study the developing history of PM in Japan, yet not to imitate PM Japanese way wholly, and reduce the total maintenance cost by these methods which suit best to each country's condition.

### 3 Examples of reducing maintenance cost

I would like to introduce some examples which made a great effect for reducing the maintenance cost.

From above-mentioned PM prize winner's plant, I chose several types of industries. Diagram 8.1 shows the production of the repair cost of Toray Co., Ltd. Okazaki Plant. In recent six years, in spite of the fact that the productive volume increased twice, the repair cost was reduced about 30%. (B of the diagram), and if you see the repair cost by the productive unit, it was reduced by about 60% you may see the curve A in the diagram.

Diagram 8.2 shows Kojima Press Co. which received PM in 1970, and its maintenance cost ratio to the manufacture cost decreased to a quarter within four years.

Diagram 8.3 shows Kobe Iron and Steel Industries which received PM Prize in 1968, and within the recent seven years, maintenance cost per unit product shows a 30% decrease.

Diagram 8.1 Transition in repair cost

- (A) o—o Repair cost (B/C)
- (B) --- Repair expense (repair payment + factory expendables cost)
- (C) --- Productive volume

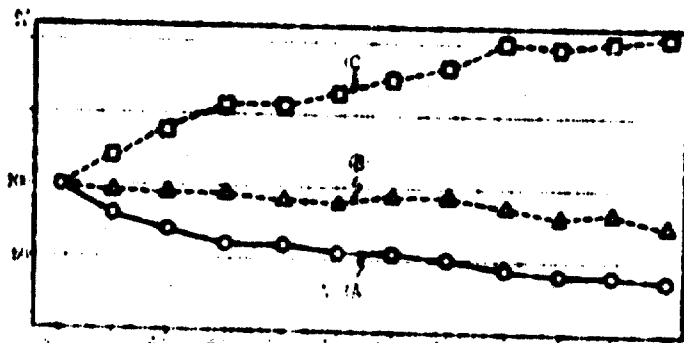
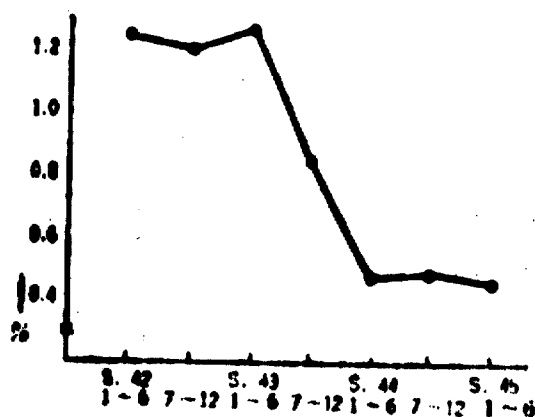
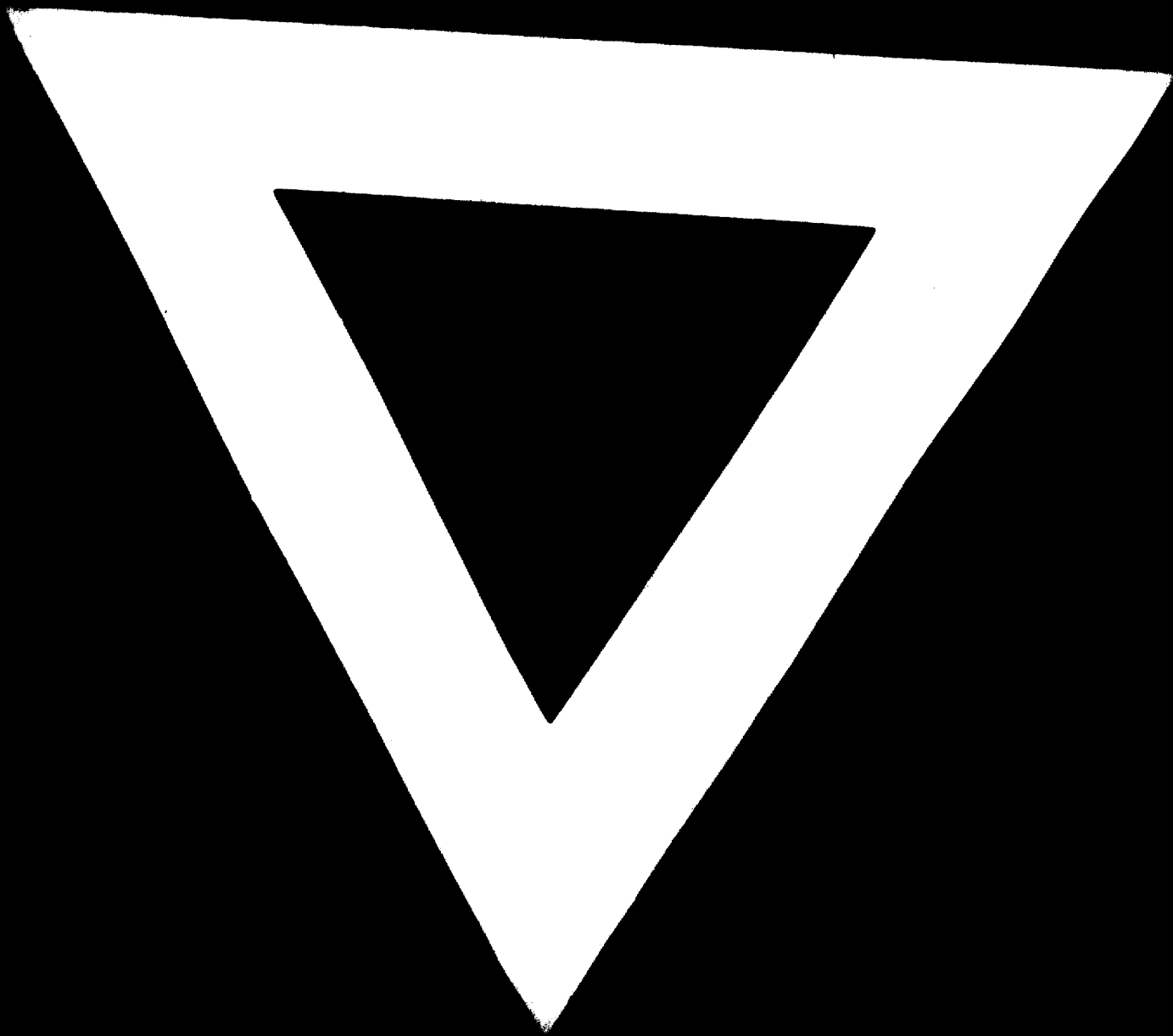


Diagram 8.2 Degree of catastrophic failure intensity (Pressing equipment)





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