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MEASUREMENT OF MAINTENANCE EFFICIENCY

by

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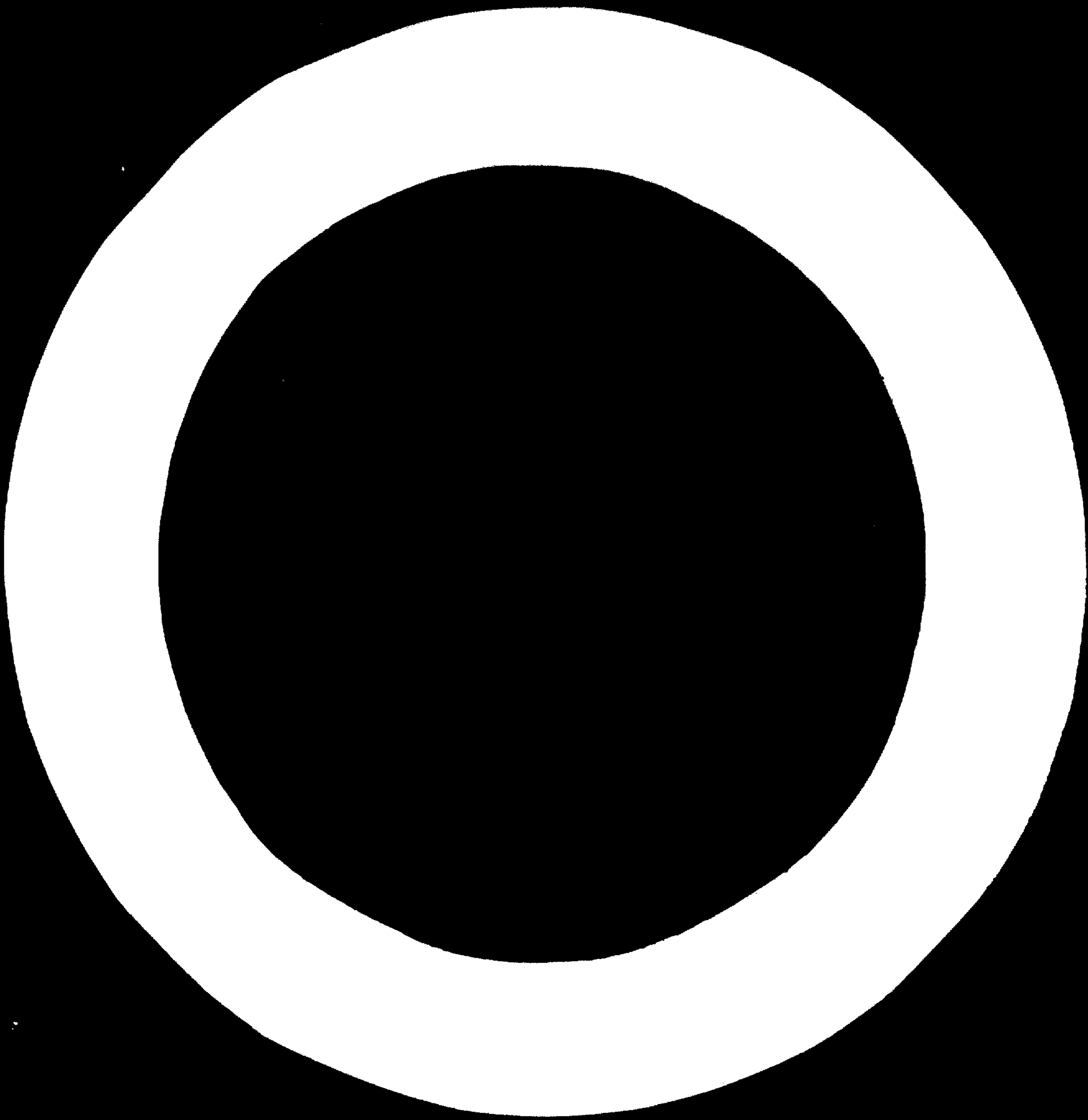


- Hibi System -

Measurement of maintenance performance is that part of See in the Plan - Do - See cycle of equipment maintenance and the results are shown in pecuniary values. It also aims at improved productivity through effective maintenance of equipment by feeding back such results to Plan-Phase or Do-Phase. Measurement of maintenance performance, therefore, is indispensable to performance of equipment maintenance and the positive attitude can be expected in various activities of equipment maintenance only when they are backed by measurement of maintenance performance.

The objectives of maintenance performance measurement include:

(1) To clearly indicate what the equipment maintenance department aims at, and to evaluate the results of the operation by measuring its achievement toward such goals.

(2) To locate points that most need technical improvement to be obtained in the course of or in the various resultant values of maintenance performance measurement, and to afford more effective maintenance activities by taking timely actions as required, and

(3) To raise will to work of those engaged in maintenance activities through enforcement of maintenance performance measurement.

The following items have long been pointed out as reasons for delayed establishment of a maintenance performance measurement system:

(1) Because of the maintenance department being a supplementary organization, the performance measurement system was not made much of.

(2) In measuring performance of the maintenance department, other factors have an unavoidable effect--- such as operation, production conditions, or equipment; therefore it was difficult to measure maintenance performance without being affected by these alien factors.

(3) Performance measurement has to be conducted finally on the pecuniary scale, in which case, however, there were too many diversified problems to be solved that were related to various other departments within an enterprise. It was thought too complicated to solve these problems.

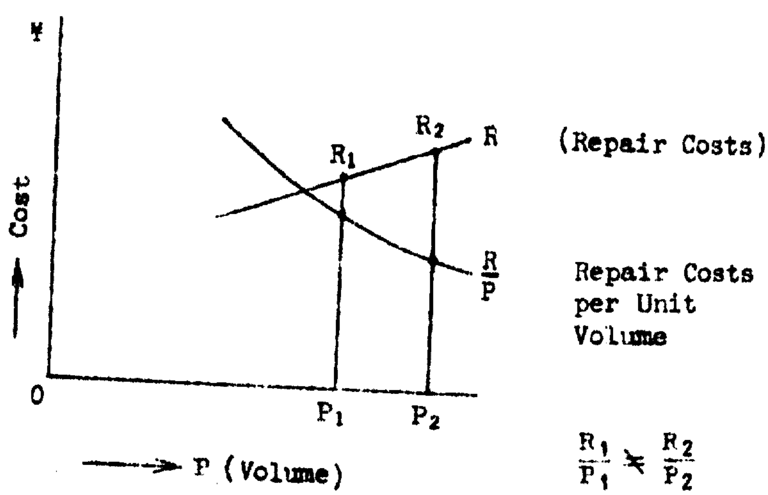
For these reasons most of the prevailing measurement methods of maintenance performance are only partial or quantitative and extremely unsatisfactory.

2. Maintenance Performance Measurement Methods Currently in General Use and Problems Thereof

Most of the maintenance performance measurement methods currently in general use are an individual elementary measurement method for such item as frequency of equipment breakdown, degree of maloperation, material cost per repairman, rate of planned work, or repair cost per ton of work. They have in general the following defects or difficulties:

(1) In each of these measured elements a good many factors exist to affect the results of measurement, therefore, it is difficult to conduct long term comparison of measured values and to locate where specific responsibilities exist. In other words, it is not clear who should use the measured values for what purposes.

(2) There is no clear-cut relationship between maintenance effect and volume of operation itself.



$\frac{R_1}{P_1} \neq \frac{R_2}{P_2}$

(3) **The repair cost of a certain period of time does not always correspond to the control scale of the period.**

R (Repair Costs) { F_o ..... come out within 6 months
{ F_n ..... come out exceeding 6 months

P (Volume of Operation) ... sum of 6 months

(4) **Repair costs and loss of failures are isolated and not figured synthetically.**

R (Repair Costs) → pecuniary unit

L (Loss of Failures) → physical unit

(5) **Loss of failures is not computed in the practical manner.**

Methods in general use:-

L { 1 Fixed Cost per Hour .... F/Hr
{ 2 Marginal Income per Hour ... M/Hr

In summary, the measurement methods generally used at the present time are either good only for a part, off the point, or of self satisfactory type.

3. Characteristics of Synthetic Maintenance Performance Measurement System (HIBI SYSTEM)

Contrary to the old individual elementary measurement methods aiming at fragmentary or physical effect only, the most important characteristic of this measurement system is that it conducts measurement from a synthetic, pecuniary standpoint.

Another characteristic of the new method as a synthetic management system is that by adopting the"newest period based method" for computation it enables pecuniary computation always at the newest period so as to be able to use the results in other management areas as well than in repair cost management. Distinguishing features are listed as follows:

(1) The new system will furnish with such information as maintenance result of the business term, trend of long-term results, results of individual equipments, sum of results on all equipments, results in repair costs and loss of failures, results by each supervisor and manager, and causes affecting these results.

(2) A synthetic result measurement is conducted from the pecuniary standpoint combining the two phases of repair cost (R) and loss of failure (L) as one (R + L) entity.

(3) As the standards for repair cost and for loss of failures by equipment are established at the start of each business term, the objectives of activities of the maintenance department become clear. Further, where is the bottleneck in the process and which equipment is over-loaded or has more chances of causing loss of short production becomes known in the early days of a month. Thus, it becomes clear where to place emphasis in planning monthly maintenance schedule or overall improvement plan.

(4) The standard repair costs established at the start of business term may be used as the repair cost estimates and also as cost planning data.

(5) The variance analysis conducted in each business term in comparing values on the synthetic efficiency scale (referred to as U later) can be used in various planning activities as it gives various information such as price variance, process utilization variance, or effects of operation or equipment changes.

(6) Since a prescribed method is used in performance measurement, economy in maintenance cost management is guaranteed.

(7) Top management may delegate to subordinates the responsibility and authority regarding equipment maintenance without any concern.

(8) To conduct performance measurement by the authorized company method will contribute much to raise the morale of maintenance people.

4. Basic Formulas of HIBI System

The HIBI System contain the following six basic formulas:

$$U_i = \frac{(R+L)_i}{P_i} = \frac{(R+l_1+l_2)_i}{P_i} = \frac{(R+l_{41}+l_{42}+l_d)_i}{P_i} \quad \cdots\cdots (1)$$

$$\eta_i = \frac{U_{ist}}{U_{iAc}} = \frac{\dfrac{(R+L)_{ist}}{P_{iAc}}}{\dfrac{(R+L)_{iAc}}{P_{iAc}}} = \frac{(R+L)_{ist}}{(R+L)_{iAc}} \quad \cdots\cdots (2)$$

$$R_{st} = R_{i-1 \cdot Ac}\left(1 + \frac{P_i - P_{i-1}}{P_{i-1}} \cdot \omega_i\right) \quad \cdots\cdots (3)$$

$$\omega_i = f\,(k,\ P_{i-1}) \quad \cdots\cdots (4)$$

$$L_{st} = (L_a + l_e)_{i-1 \to i} \quad \cdots\cdots (5)$$

$$\left.\begin{aligned} U'_{i-1} &= U_i \cdot \eta_i \\ U'_{i-2} &= U_i \cdot \eta_i \cdot \eta_{i-1} \\ &\vdots \\ U'_{i-n} &= U_i \cdot \eta_i \cdot \eta_{i-1} \cdots\cdots \eta_{i-n+1} \end{aligned}\right\} \cdots\cdots (6)$$

$$\left.\begin{aligned} U'_{i-1} &= U_i \cdot \eta_i \cdot \frac{\eta_{i-1 \cdot N}}{\eta_{i-1}} \\ U'_{i-2} &= U_i \cdot \eta_i \cdot \frac{\eta_{i-1 \cdot N}}{\eta_{i-1}} \cdot \eta_{i-1} \cdot \frac{\eta_{i-2 \cdot N}}{\eta_{i-2}} \\ &\vdots \\ U'_{i-n} &= U_i \cdot \eta_i \cdot \frac{\eta_{i-1 \cdot N}}{\eta_{i-1}} \cdot \eta_{i-1} \cdot \frac{\eta_{i-2 \cdot N}}{\eta_{i-2}} \cdots\cdots \eta_{i-n+1} \cdot \frac{\eta_{i-n \cdot N}}{\eta_{i-n}} \end{aligned}\right\} \cdots\cdots (6)'$$

Formula I

where U_i = Synthetic efficiency scale at period i

R = Repair cost

L = Loss of failure
- L_1 = Short production loss
  - L_{11} = Recovery loss for short production
  - L_{12} = Actual short production loss
- L_2 = Loss of various cost items

P_i = Period i value of repair cost control scale (Consumption amount of electric power is used.)

The synthetic efficiency scale in the Formula I shows the total of repair cost and loss of failure per unit of the control scale.

Formula II

where η_i = Performance index of period i

U_{ist} = Value of Standard value of U at the period i

U_{iAC} = Actual value of U at the period i

P_{iAC} = Actual value of control scale for the period i

$(R+L)_{ist}$ = Sum of the standard values of R and L for the period i

$(R+L)_{iac}$ = Sum of the actual values of R and L for the period i

If η_i = 100%, the results are the same as the preceding period; if exceding 100%, better, and if short of 100%, worse than the preceding period.

Formula III

where

R_{ist} = Standard repair cost for the period i

R_{i-1AC} = Actual repair cost of the period i-1

P_i = Planned volume for the period i (Planned value of the control scale)

P_{i-1} = Actual volume for the period i-1 (Actual value of the control scale)

ω_i = A coefficient of amended consumption of repair cost

Formula IV

where k = A coefficient of consumption of repair cost

Formula IV shows that a coefficient of amended consumption is a function of coefficient of repair cost consumption and the actual volume for the preceding period.

Formula V

where L_{ist} = Standard loss of failure for the period i (Standard value of loss of failure)

$(L_1 + L_2)P_{i-1} \rightarrow P_i$ = Standard value of loss of failure can be obtained in pecuniary amount from the planned volume of operation for the period i by using as basis the actual loss of failure in the volume of operation for the period i-1.

Formula VI and VI'

where U'_{i-1} = Value of U obtained as the comparative record of the period i-1 based on the actual value U for the latest period i

U_{i-2} = Value of U obtained as the comparative record of the period i-2 on the same base as above

U'_{i-n} = Value of U obtained as the comparative record of the period i-n

η_i = Performance index of the period i

η_{i-1} = Performance index of the period i-1

η_{i-n} = Performance index of the period i-n

η_{i-n+1} = Performance index of the period i-n+1

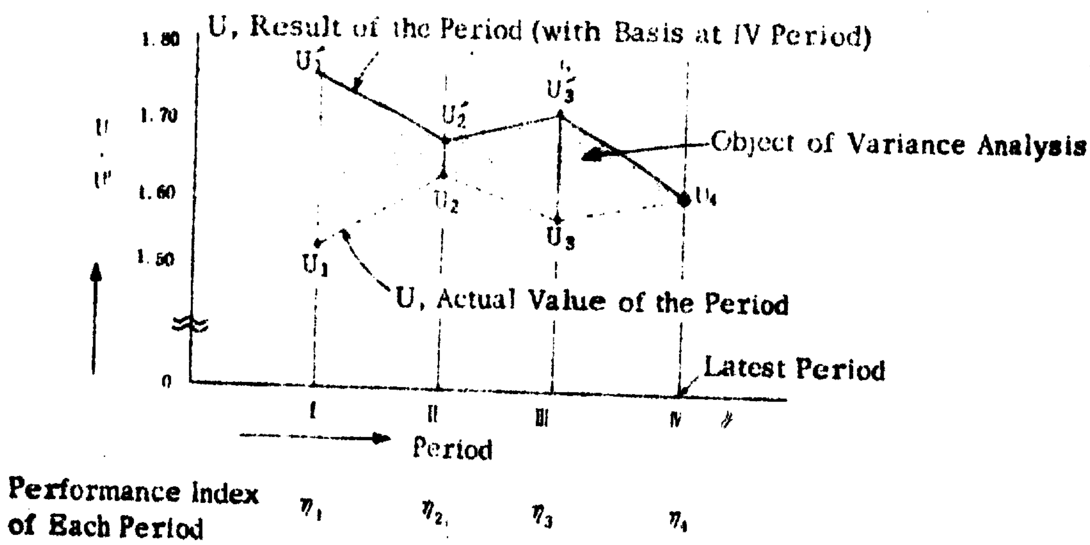
η_{i-1N} = Performance index of the period i-1 as computed using only normal values, excending abnormal values, from the actual results during the period i-1. (The same goes with the following.)

Formula VI and IV' are the equations to obtain long-term values of synthetic maintenance performance of each period using the performance index for each period on the basis of U_i for the period i. Formula VI is used in the case where no abnormal values are found in actual results, and Formula VI' is used where abnormal values are included.

Fig. 1 Long-term Results Computed by Performance Index

期 / 区分	I (St / Ac)	II (St / Ac)	III (St / Ac)	IV (St / Ac)	Variance Analysis
Actual Value of U of Each Period	$U_1' = 1.53$	$U_2' = 1.65$	$U_3' = 1.57$	$U_4' = 1.62$	
Performance Index of Each Period	$\eta_1 = \frac{St}{Ac} = 0.980$	$\eta_2 = 1.069$	$\eta_3 = 0.977$	$\eta_4 = 1.074$	1 Price 2 Volume 3 Equipment change 4 Production Condition 5 Process Use Ratio
Result of the Period (Long-term Results)	$U_1' = U_4 \times \eta_4 \times \eta_3 \times \eta_2 = 1.70 \times 1.069 = 1.80$	$U_2' = U_4 \times \eta_4 \times \eta_3 = 1.74 \times 0.977 = 1.70$	$U_3' = U_4 \times \eta_4 = 1.62 \times 1.074 = 1.74$	$U_4 = 1.62$	

Fig. 2. Relationship Chart of U, Actual Value and U', Result of Each Period



5. Classification of Repair Cost

In order to establish the standard repair costs, the "Usage Classification" and "Frequency Classification" of repair costs will be used as shown on Chart 3.

Chart 3 Standard Classifications of Usage and Frequency of Repair Costs

No.	Usage \ Frequency Symbol	Maintenance frequency is within 6 months F_o	Maintenance frequency is exceeding 6 months F_n
1	Cost of Replacement Parts	o Cost for short cycle o One serial number made one unit	o Cost for long cycle F_1 = frequency 6 - 12 months F_2 = 1 - 2 yrs F_3 = 2 - 3 yrs F_4 = 3 yrs ~ o Same to all F_n Usage
2	Cost of Parts Regeneration Processing	o For welding, grinding, lathing, etc. o Control unit is same as above	
3	Labor Cost for Inspection, Adjustment, Replacement, Repairing	o Work number made one unit.	
4	Cost for Oil	o Lubricant and hydraulic oil o Oil number in equipment made one unit	
5	Miscellaneous Cost	o For steel plate, paint, rag, cleaning oil, jigs & tools, etc. o Each equipment made one unit	
6	Cost for Maintenance Improvement	o Minor improvement cost for maintenance.	
7	Cost for Production Improvement	o Minor improvement cost for production control by work order number	
8	Supplementary Cost	o Minor improvement cost for maintenance and production to be given within 6 months of operation started on newly installed equipment.	

Note: 1. F_o in Item 1-6 are the subject area of control
2. F_n, Cost for Production Improvement and Supplementary cost are excluded.

6. <u>Definition and Roles of the Control Scale</u>

When R + L is viewed in terms of volume of operation, the sliding scale of R + L is called the Control Scale (=P).

The roles of the control scale are---

(1) To use as a scale to establish appropriate standard. values of R + L for use against the volume of operation in each period.

(2) In showing result of maintenance performance, standard values and actual values of R + L will be indicated as per unit of P.

(3) Comparison of U values of each period or variance analysis of U values of each period will be made easy and understandable by the use of P.

The following four conditions are considerd necessary in selecting a control scale:

(1) There exists a closer correlationship with the repair cost actually spent.

(2) There is a common applicability for groups of equipments.

(3) It must be easy to grasp on the individual equipments.

(4) It must be something having easy access to any one.

The dynamic scale, or the static scale may be used as a control scale. However, the amount of electric power consumption is in the practical and theoretical sense the most recommendable for the scale.

7. Definition of Coefficient of Consumption (k) and How to Figure It

In this system the result of the preceding period is used as the basis for figuring out how much would be the repair cost for the current period with its volume of operation, and the result of this computation is used as the standard for the current period. Taking parts cost for exampe: Parts Cost = Unit Price x Amount. And the coefficient of consumption of parts (k) is the practical basis to apply to the volume of operation of succeeding period derived from the result of the preceding period.

k is individually fixed for elements of repair costs such as parts, materials, oil, or man-hours. k is determined for each of the repair cost elements in consideration of theoretical coefficient of consumption for change in operational volume and practical factors that give deviation to it.

Major factors that give deviation to theoretical coefficient of consumption are:

(1) Length of parts life, and length of maintenance operation cycle.

(2) Restraint of maintenance date

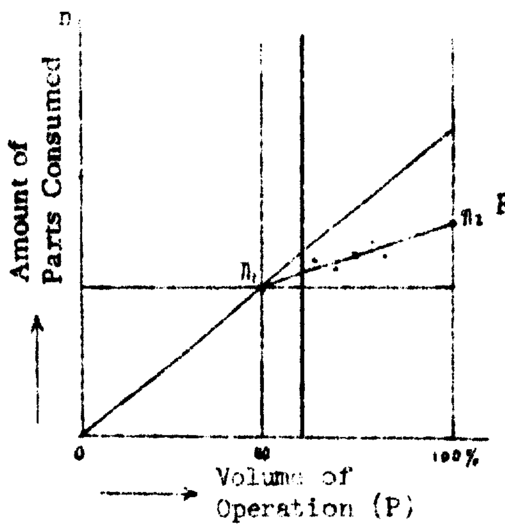
(3) How a failure occurred, frequency of change at production kind and stability of quality of parts and materials.

(4) Degree of correspondence between the selected control scale and parts or operation.

In summary a coefficient of consumption k is an index showing actual consumption of material n against changing P. This shows degree of deviation as it changes in proportion to P.

K is determined for each element of repair costs on the basis of actual consumption analysis (analysis on actual materials and statistical analysis). As a supplementary method "Table of Estimate Standard for Consumption Coefficient" may be used.

Fig. 4. How to Find Coefficient of Consumption (Graphic Method)



P = n_1 is for n when P = 50%

P = n_2 is for n when P = 100%

Coefficient of Consumption

Range of this K is $1 \geq K \geq 0$

$$K = \frac{n_2 - n_1}{n_1}$$

Ex. $K = \frac{14 - 10}{10} = 0.4$

II-3-14

Chart 5 Table of Estimate Standard for Coefficient of Consumption (K)

$(k = k_1 \times k_2 \times k_3 \times k_4)$

Factor	Description of Evaluation Factors and Range of the Scale
Dynamics K_1	1. The degree of [illegible] dynamic degeneration, which causes consumption of materials or need for remedial work, such as abrasion, vibration or impact. 2. Anything degenerated or work required because of dynamic reason, degree of dynamics is larger, so $K_1 = 1$. 3. When the cause is static such as corrosion, it is small, so $K_1 = 0$. 4. When both dynamic and static causes work, depending on the rate of [illegible], $1 > K > 0$
Sensitivity K_2	1. When life or parts of materials or cycle of operation shown in the maintenance control scale (like [illegible] electric power) are to be adjusted in a [illegible] as the result of change in volume of operation [illegible] that period, the degree of sensitivity to make such change in number of items, times or hours of work [illegible] is called "Sensitivity K_2". 2. [illegible] or work may be changed or replaced during the given period. (1) [illegible] shorter life or cycle are liable to be affected by changes in operation either in quantity, times [illegible] of work. [illegible] of high sensitivity $K_2 = 1$. (2) [illegible] longer life or cycle are [illegible] affected by changes in operation. Their quantity, times or hours of work needed will not easily be changed. For such case $K_2 = 0$. 3. [illegible] parts, materials or work [illegible] regular adjustment date [illegible] the [illegible] replacement is made only on a periodical adjustment [illegible] original sensitivity is lowered on account of the restraint [illegible] The rate of lowered sensitivity [illegible] material's life or work cycle. [illegible] is evaluated in [illegible] rate of material life or cycle. 4. [illegible] materials, or work to receive restraint of fixed adjustment date and those that do not receive [illegible] are evaluated separately using the different evaluating scale prepared independently.
Stability K_3	1. When [illegible] of parts or materials or time or hours of work are affected according to the change in [illegible] as the result of degree of stability of the following items, the degree of such relationship is called "Stability K_3". (1) [illegible] will be occurred. (2) Degree of requirement in equipment to obtain desired quality. (3) [illegible] in size or kinds required by production plan. (4) [illegible] of parts or material. (5) Adequacy of the control scale. a. Whether overall scale or partial scale. b. Kinds of scale. (6) Others 2. Stability will be [illegible] of $1 > K > 0$ depending on degree of correlationship (or size of stability)
Others	When [illegible] factor exists other than above dynamics, sensitivity or stability, such factors will be evaluated as K_4

Evaluation Scale

Dynamics K_1:

Extra Large	Large	Medium	Small	Extra Small
1.0	0.9 ~ 0.7	0.6 ~ 0.4	0.3 ~ 0.1	0

Sensitivity K_2 — Table of Frequency (f) by Group of Equipments Corresponding to Different Values of K_2

Restraint of Adjustment Date	Group of Equipments \ K_2	1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0
not receive	①	≥70	19~13	12~10	9		8	7	6	5	4	3~1
not receive	②	≥25	24~12	11~[illegible]	7. 6	5	4			3		2. 1
not receive	③	≥64	63~32	31~18	17~12	11~8	7. 6	5	4		3	2. 1
not receive	④	≥43	42~[illegible]	[illegible]	15~[illegible]	12. 11	10. 9	8		5	5~3	2. 1
receive	①							2. 12		6	4	1. 2. 3. 24
receive	②						6. 8	4. 12				1. 2. 24
receive	③							6. 12	8		3	1. 2. 24
receive	④								12	8	3. 4. 6	1. 2. 24

Stability K_3:

Extra Large	Large	Medium	Small	Extra Small
1.0	0.9~0.7	0.6~0.4	0.3~0.1	0

Others:

1. Evaluation will follow that for the stability scale
2. When K_4 is not needed, $K_4 = 1$.

(Note) (f) under the table of the evaluation scale means the frequency of replacement as figured out on the bais of original life of parts (which does not receive restraint of adjustment date) under normal operation of equipment. The same goes with materials in general and maintenance work also.

Table 6 Sample Table of Coefficient of Comsumption for Parts and Works

Line	Item Number of work Number	Equipment	Parts or Works	K Coefficient of consumption	K_1 Pyramids	K_2 sensitivity	K_3 stability	K_4 Otheys
Pickling	100	Intake Conveyor	Conveyor Roller	0.2	1	0.7	0.3	-
	192	Uncoiler	Leveler Joint Slipper	0.3	1	0.4	0.8	-
	180	Flash Trimmer	Cutter	0.7	1	1	0.7	-
	548	Oiler	Oiler Pump Bearing	0.2	1	0.2	0.8	-
	841	Wringer	Wringer Roll Rubber change	0.4	1	1	0.4	-
Cold Strip Mill	067	Entry Guide	Bridle, upper & lower	0.8	1	1	0.8	-
	116	Work Roll	Fastener Bolt for wave Roll collar	0.3	1	1	0.3	-
	810	"	3" Plunger Packing Washer	0.1	1	0.1	0.6	-
	877	Coil Car	Broke Shoes	0.3	1	0.4	0.8	-
Cleaning	025	Seam Welder	Electrode Wheel	0.8	1	1	0.3	-
	111	Payoff Reel	Drum Liner	0.1	1	0.1	0.8	-
	138	10" Roll Wringer	Seal C B 4 x $5\frac{1}{8}$ x $\frac{1}{2}$	0.3	1	0.4	0.8	-
	109	Helper	Big 6208 for 16" Deflector	0.1	1	0.2	0.7	-
	304	12" Brush Roll	Neck Adjustment	0.1	1	0.4	0.3	-
Pickling	161	Flash Trimmer	Cutter Adjustment	0.7	1	1	0.7	-
	191	Processor	Bending Roll Replacement	0.2	1	0.2	0.8	-
	330	No.4 Pickling	Wringer Role Replacement	0.2	1	0.2	0.3	-
Cold Strip Mill	616	WR-Chock	Chock Assembly	0.5	1	1	0.5	-
	162	Tension Reel	Drum Setting	0.2	1	0.4	0.6	-
	402	Boum Oil	Stand Repair Plumbing	0.1	1	0.3	0.3	-
	584	BR chock	Chock Metal Sealing	0.5	1	1	0.5	-

Table 7 Sample Table of Mean Coefficient of Consumption for Maintenance Element and Equipment

Equipment \ Element	Parts	Works	Oil	Mean
Pickling Line	0.38	0.25	0.19	0.33
Cleaning Line	0.38	0.15	0.17	0.32
Electrolytic Tinning Line	0.16	0.07	0.18	0.14
Standem Cold Mill	0.73	0.38	0.14	0.47
2 Tandem Skinpass Mill	0.25	0.30	0.12	0.26
Single Stand Skinpass Mill	0.29	0.42	0.16	0.34
Shearing Machine for Thin Plate	0.50	0.07	0.17	0.25
Shearing Machine for Thick Plate	0.20	0.08	0.20	0.18
Rotary Shear	0.53	0.06	0.22	0.35
Batch Annealing Furnace	0.04	0.04	0.13	0.05
Hot Dip Tinning Machine	0.10	0.08	0.10	0.09
Mean	0.31	0.20	0.15	0.26

(Note) Mean Coefficient of Consumption on this Table calculated as an Aggravative Mean with cost for parts, works and oil etc, of each Equipment on an average volume.

8. <u>Definition of Coefficient of Amended Consumption (ω) and How to Figure It.</u>

In determining standard repair cost of a period based on actual performance of the preceding period and to meet the change of volume in a given period, ω in <u>Formula III</u> replaced with K will not give correct standard repair cost. (Because repair cost is not proportional to volume.) Therefore, if a corrected value of K based on actual preceding volume is made the coefficient of amended consumption ω , actual repair costs will always be on the line of actual consumption trend, as long as the same amount of effort is given by the maintenance people.

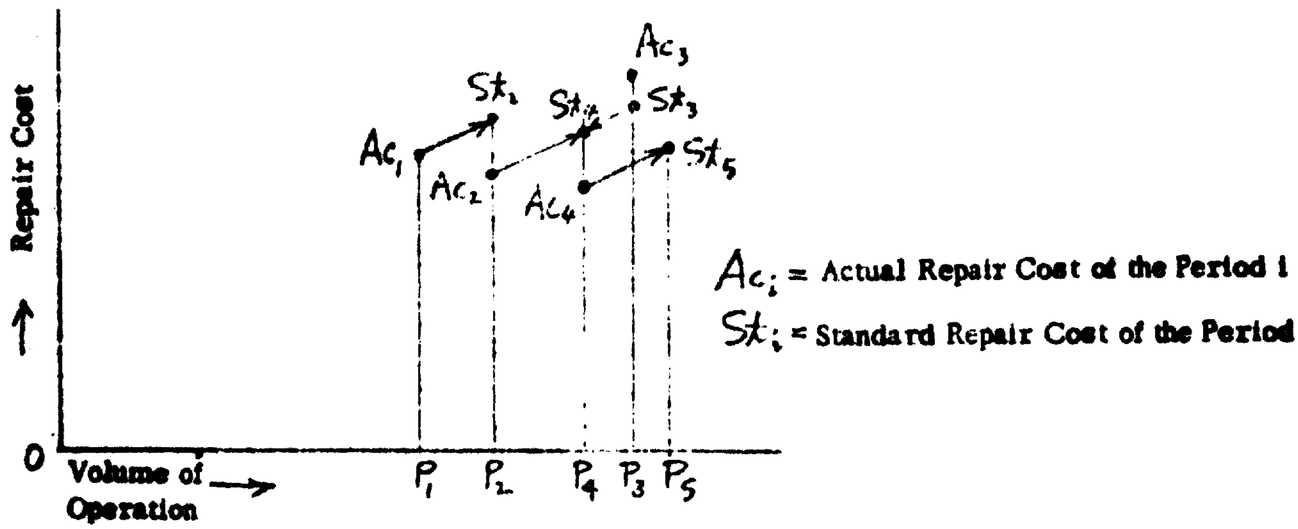
Table 8 Table of Coefficient of Amended Consumption

K \ P_{t-1}	50	55	60	65	70	75	80	85	90	95	100
1.0	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.9	0.900	0.908	0.915	0.921	0.926	0.931	0.935	0.939	0.942	0.945	0.947
0.8	0.800	0.814	0.827	0.839	0.849	0.857	0.864	0.872	0.878	0.884	0.889
0.7	0.700	0.720	0.736	0.752	0.766	0.778	0.789	0.799	0.808	0.815	0.824
0.6	0.600	0.623	0.642	0.661	0.677	0.692	0.706	0.718	0.730	0.740	0.750
0.5	0.500	0.524	0.545	0.565	0.583	0.600	0.615	0.630	0.642	0.655	0.667
0.4	0.400	0.423	0.444	0.464	0.483	0.500	0.516	0.531	0.545	0.558	0.571
0.3	0.300	0.320	0.340	0.358	0.375	0.391	0.407	0.421	0.435	0.448	0.461
0.2	0.200	0.216	0.231	0.245	0.259	0.273	0.286	0.298	0.310	0.322	0.333
0.1	0.100	0.108	0.118	0.126	0.135	0.142	0.150	0.158	0.167	0.174	0.182
0.0	0	0	0	0	0	0	0	0	0	0	0

9. <u>Method to establish Standard Repair Cost</u>

The management system of planning progress may be used by establishing standards successively for each period and by placing ratchets on those having brought favorable results.

Fig. 9 Relationship Chart of Standard Value and Actual Value of Repair Cost



Major steps for establishment of the standard repair cost are as follows:

		(in thousand yen)
a.	Actual value for the preceding period--	7,228
b.	Abnormal value for the preceding period + repair cost due to special circumstances for the preceding period --	355 (-
c.	Normal actual value for the preceding period --	6,873
d.	Correction of price --	— 184 (+
e.	Normal actual value after correction of the price for the preceding period --	6,689
f.	Normal actual value for the preceding period for operation of the current period --	• 6,494

g. Repair cost due to special circumstances of the current period -- 0 (+

h. Standard repair cost for the current period -- 6,454

$$= 6689\ (1 + \frac{1175-1262}{1262} \times 0.51) = 6,454$$

10. Loss of Failure

Following points are to be considered in conducting pecuniary evaluation of loss of failure:

(1) Computation must be based on actual data.

(2) Computation of loss must be made as close to actual loss as possible.

(3) It must be the sort of accounting for line management which under the present situation should be able to convince the people concerned in that the principle and method of computation are most adequate for the given loss.

(4) The methods of collecting data or of computation should be ones that are applicable for a long time without frequent correction, when long range successive collection is made.

(5) Information produced should be of the kind that would work as an appropriate stimulant to the people concerned, not hurt them unnecessarily.

The loss of failure L will be classified and defined as follows:

$L = L_1 + L_2 = L_{11} + L_{12} + L_2$

where L_1 = Loss of short production

This is the "loss in production caused by not being able to achieve planned amount of production" resulting from either stoppage or slowdown by equipment breakdown. The loss in such a case is basically the minus of the profit which should have been obtained from the production, if the maloperation of the equipment had not happened.

L_{11} = Various countermeasures taken to cover short production due to failure.

These are the incremental costs needed, for example, for holiday work, change in kinds of products or in the order of process, or increased temporary workers, etc. (This is called the first step loss).

L_{12} = The loss of profit which would have been gained if no short production had occurred due to failure and products were produced and sold. These are such as loss of marginal profit or loss of interest. (This is called the second step loss.)

L_2 = Loss that is incurred by failure such as in yield rate, expendables, energy, quality, labor cost or any other loss generally sustained in cost.

Fig. 10 Three Patterns of Equipment Load

← Total Hours of Total Calender days of the Month →			Pattern
Scheduled Work Hours Required to Achieve Planned Production of the Month	Allowance Time	Non Work Hours Anticipated at the time of drawing Production Plan	A (Light Load)
L_{12}	L_{11}	0	
Scheduled Work Hours	All. Time	Non Work Hours	B (Medium Load)
L_{12}	L_{11}	0	
Scheduled Work Hours		Non Work Hours	C (Heavy Load)
L_{12}		0	

Following are the samples of the specific method of evaluation of loss of failure:

(A) Sample Computation of L_1 on a Model

a. Total hours of calendar days of the month = 8H x 3S x 30D = 720H

b. Scheduled work hours required to carry out production plan of the month = 560H

c. Non-work hours as scheduled at the time of drawing production plan = 120H

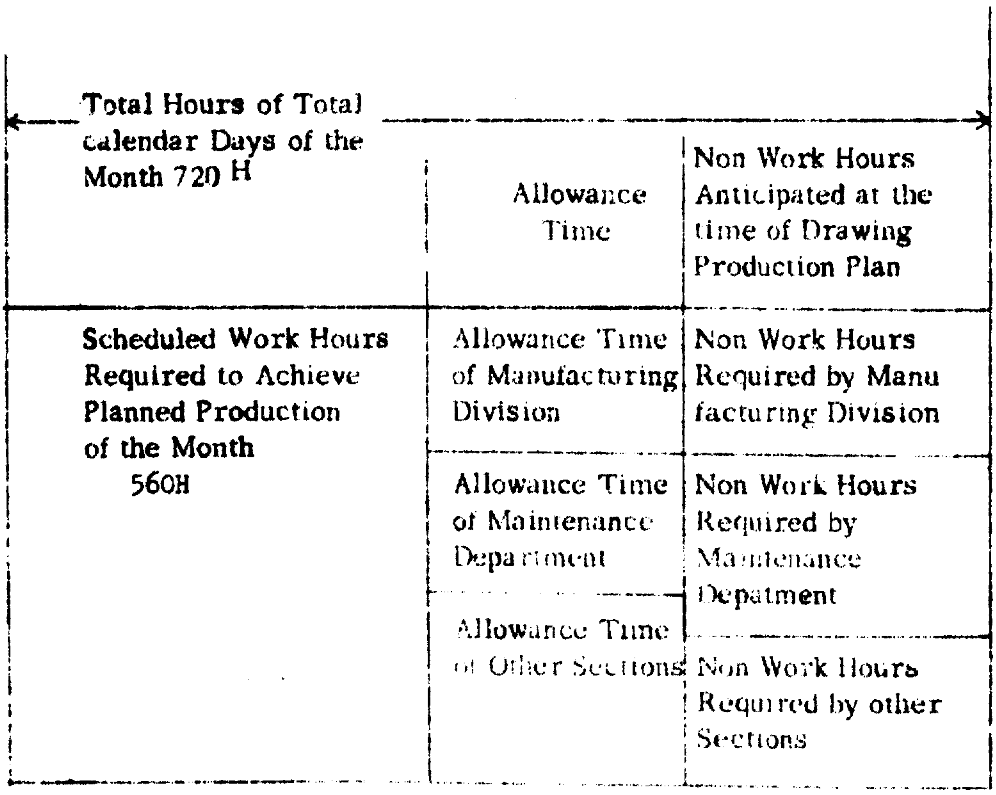
d. Total allowance time of the month = a-b-c = 40H

	(Non-work hours required by individual departments)		(An objective time which should not distribute the allowance time)		(An objective time which should distribute the allowance time)
Manufacturing Division (Preparation, clearance work, setup change, lunch, etc.)	45H	=	28	+	17H
Maintenance Department (Schedule maintenance)	16	=	16	+	0
(Stoppage by failure)	15	=	0	+	15
Other Departments	44	=	20	+	24
Total	120	=	64	+	56

e. Allowance time to be distributed per non-work hour to the total objective time of distribution of the month is --

$$40H \div (17 + 15 + 24) = 0.714H/H$$

Fig. 11 Explanation of Loss of Short Production



8. Allowance time to be distributed to the maintenance department for stoppage due to failure is --

$$0.714H \times 15 = 10.7 \fallingdotseq 11H$$

As the result of the above computation, the standard table of L_1 for the month will be --

No.	Title of Loss	Time of stoppage due to failure	Unit price of short production
0	-	Less than 15H	-
1	First step loss L_{11}	15H – 26H	¥5,000/H
2	Second step loss L_{12}	More than 26H	¥45,000/H

The actual amount computation of L_1 of the maintenance department for a given month will be as follows:

(Actual time of stoppage due to failure of the month) = 27H = 15 + 11 + 1 (No. 0, No. 1, No. 2)

$$L_1 = ¥5,000 \times 11H + ¥45,000 \times 1H$$

$$= ¥°00,000/Month$$

The characteristics of this computation are:

i The degree of effort required of the maintenance people is made known for each equipment according to the size of monthly production plan. In other words, directions are given at the beginning of a month regarding emphasis to be placed in maintenance so that maintenance activities are made more effectively.

ii The maintenance department does not suffer from unjustified blame for short production caused by other sections.

iii It is possible to conduct relatively close-to-the-fact loss accounting without much trouble.

iv In case scheduled non-work hours is saved at bottleneck processes, computation is made with increased production and profit, which gives favorable effects on the morale of the maintenance people.

(B) Sample Computation of L_2 on a Model

As for loss in costs, preliminary technical survey will be conducted to find what degree of loss results in what cost item from stoppage due to failure of different equipment and a table of standard losses by hours of stoppage will be prepared.

Hours of Stoppage	Unit Cost of Loss		Number of Cases		Amount of Loss
0.5h	¥1,630	x	8	=	¥13,040
1.0	2,130	x	6	=	12,780
2.0	3,140	x	5	=	15,700
3.0	2,410	x	1	=	2,410
4.0	2,840	x	1	=	2,840
		Total	21	=	¥46,770

(C) Loss of Failure on the Preceding Model

$$L = L_1 + L_2$$
$$= ¥100,000 + 47,000$$
$$= ¥147,000$$

11. Sample Long Range Results of Maintenance Performance Measurement

Long range results of maintenance performance measurement under this system will be shown as in Fig. 12.

Fig. 12

Chart of Synthetic Maintenance Performance

In Fig. 12,

i. The heavy line U' is the long range results of each period shown on the basis of every condition in the sixthe period.

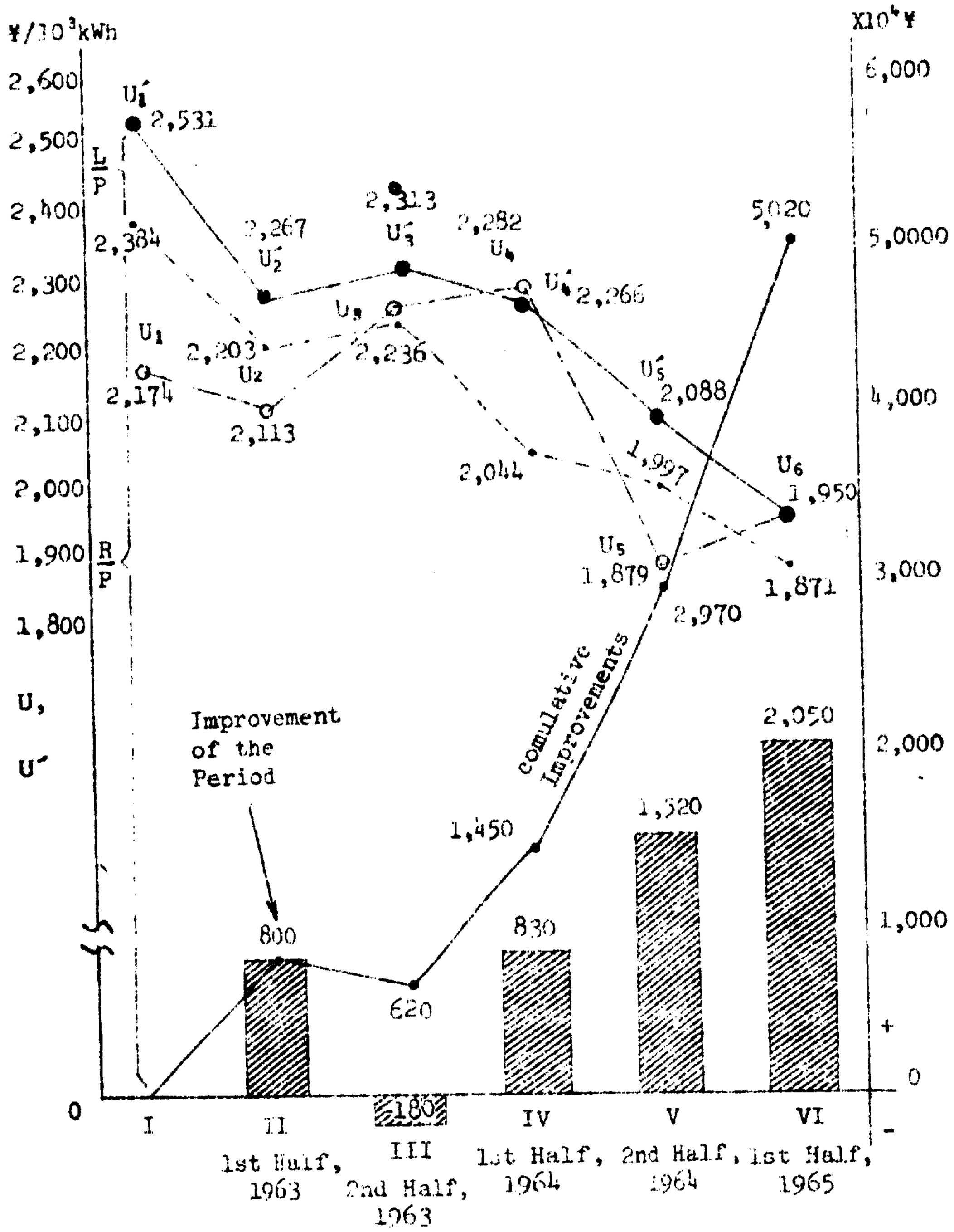
ii The height between the dotted line and the heavy line shows the degree of loss due to failure in the results of each period. Below the dotted line is the result of repair costs.

iii The bar graphs indicate pecuniary amount of absolute improvement brought about to the management by the effort of the maintenance people during respective periods. Its cumulative amount of improvement is shown with a line that goes up toward right upper side of the chart.

iv The chained line indicates U (synthetic performance scale) as obtained for each period under every condition (volume, unit price, equipment, etc.).

Fig. 12 Chart of Synthetic Maintenence Performance

(Results of based on the first half, 1965)



$$U = \frac{\Sigma(R+L)}{\Sigma P} = \frac{\text{Sum of (R+L) on all equipments}}{\text{Sum of Consumption amount of electric power on all equipments}}$$

U'_L = Synthetic efficiency scale as a result of each period

U_L = Loss due to Failure

R_R = Repair Cost

Amount of Improvement $= \frac{2,531-1,950}{2,531} \times \frac{2}{5} = 0.092 \rightarrow 9.2\%$

12. Conclusion

As the result of seven years of experience with the Hibi System the following effectiveness of this system has been proved.

(1) As the result of maintenance performance can be clearly figured out, the maintenance people may make effort to achieve established goals, thus making their daily work purposeful and more effective.

(2) As the effort of the maintenance people can justly be evaluated and propagated, they ceased to feel that their work is only of the supporting role and started to realize that they are on the equal standing to those of the manufacturing divisions.

(3) Since the repair costs or standard values of loss due to failure alternate as the volume of operation changes, the maintenance section is able to carry out reasonable, autonomous type of activities.

(4) As the results of repair costs and loss due to failure actually sustained are shown every month in appropriate classification, the data became easy to access and useful.

(5) As the system allows costs for maintenance improvement to be spent unlimitedly so long as they pay, the maintenance section has now become able to use the system without restraint in consideration of effectiveness articipated.

(6) When any of the changes in production conditions such as quality of products is made, consequent increase in repair costs is also made as due to a change in condition. Accordingly, demarkation of responsibility between the manufacturing division and the maintenance department becomes clear-cut, improving cooperative relationship between the two.

(7) As difficult processes are known in advance, it became easy for maintenance personnel to plan for the lower repair costs or the reduced loss due to failure.

(8) As the system prescribes systematic management of repair cost and of loss due to failure on the basis of all the equipment used in manufacturing process, the maintenance department has become able to consider equipment maintenance from the standpoint of increasing productivity of the company as a whole.

(9) Since the accounting of performance effectiveness is performed in terms of opportunity cost accounting, it is easy for engineers and technicians to understand, and their cost consciousness has been raised.

(10) Budgeting for each period can automatically be made by using results of the previous period, coefficient of consumption (k) and planned volume

of operation (in estimated amount of consumption of electricity), and hands of specialists in the maintenance department are no more required for this purpose. (In about three days a budget for 100 odd million yen can be drawn up.)

(11) No company management will talk of high repair costs without concrete data. As a result, maintenance personnel had more desire for autonomous control of work.

(12) The company management has become able to know through consolidated monthly or quarterly reports the economy of activitities of maintenance personnel and give favorable recognition to them as data so warrant.

[redacted]

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