TPM Series: No.10

TPM Deploying Guidebook

(Vol. 1)

The Key to Competitiveness and Profit-Producing

Oh-Woon Kwon ; Ph.d, P.E, TC

3rd Edition : October 15, 2016

www.atpm.co.kr

ATPM Consulting Inc.

Index

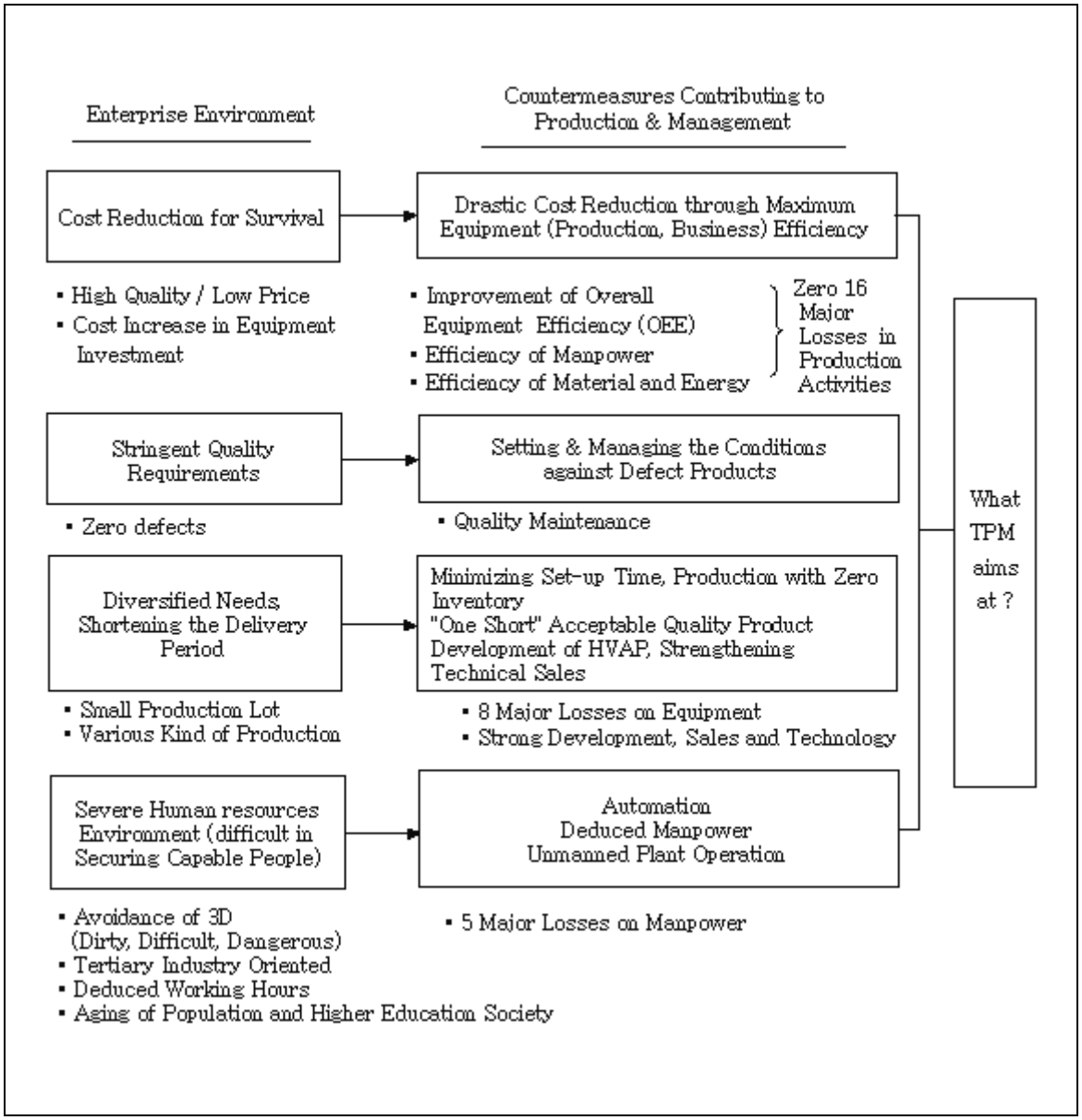
(Volume 1)

(Volume 2)

Chapter 1 Outline of TPM

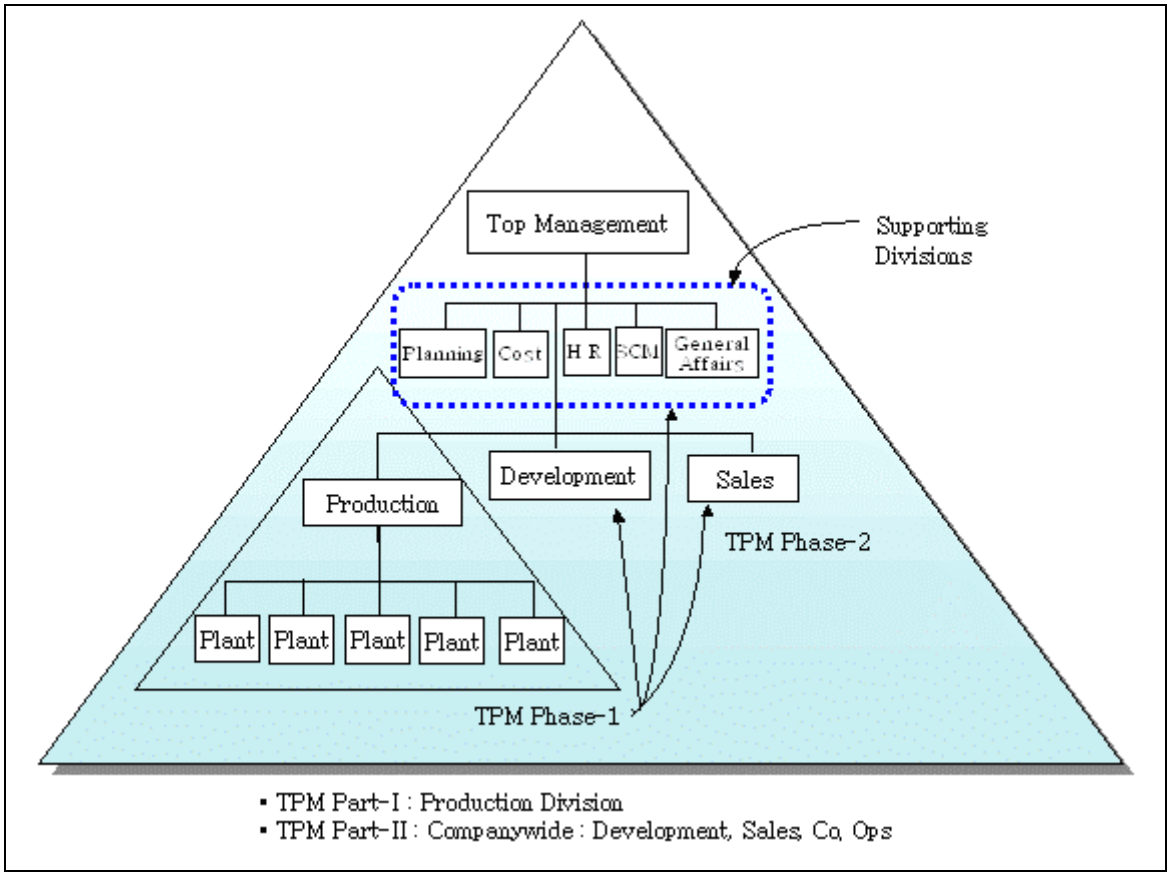
Contents

Figure 1-1 Severe Enterprise Environment and Necessity of TPM



Accordingly, the necessity of introducing TPM has been recognized so that the corporation can survive, with the sixteen major losses in material and energy, production activities, equipment and manpower reduced to zero.

Figure 1-13 From Production Division TPM to Companywide TPM



Making the loss level zero by "preventing losses" is the philosophy of TPM, and establishing a system to prevent losses at " the local site" is one of the TPM features.

④ All employees, involving from top management to front-line operators

The target is to change the people's mind or behavior to operate the equipment to its fullest capacity according to the purpose it was designed for, and to change the corporate structure. For achieving this end, it is indispensable that all employees at each level, especially the top management level, participate in the activities. Unless top management itself decides to introduce TPM by all means, the corporate structure change would not be possible at all. Another important point is the concept of "all the workers' participation" which means that the corporation is operated with all workers participating. TPM is an all worker-participation type operation, and priority is given to the human being.

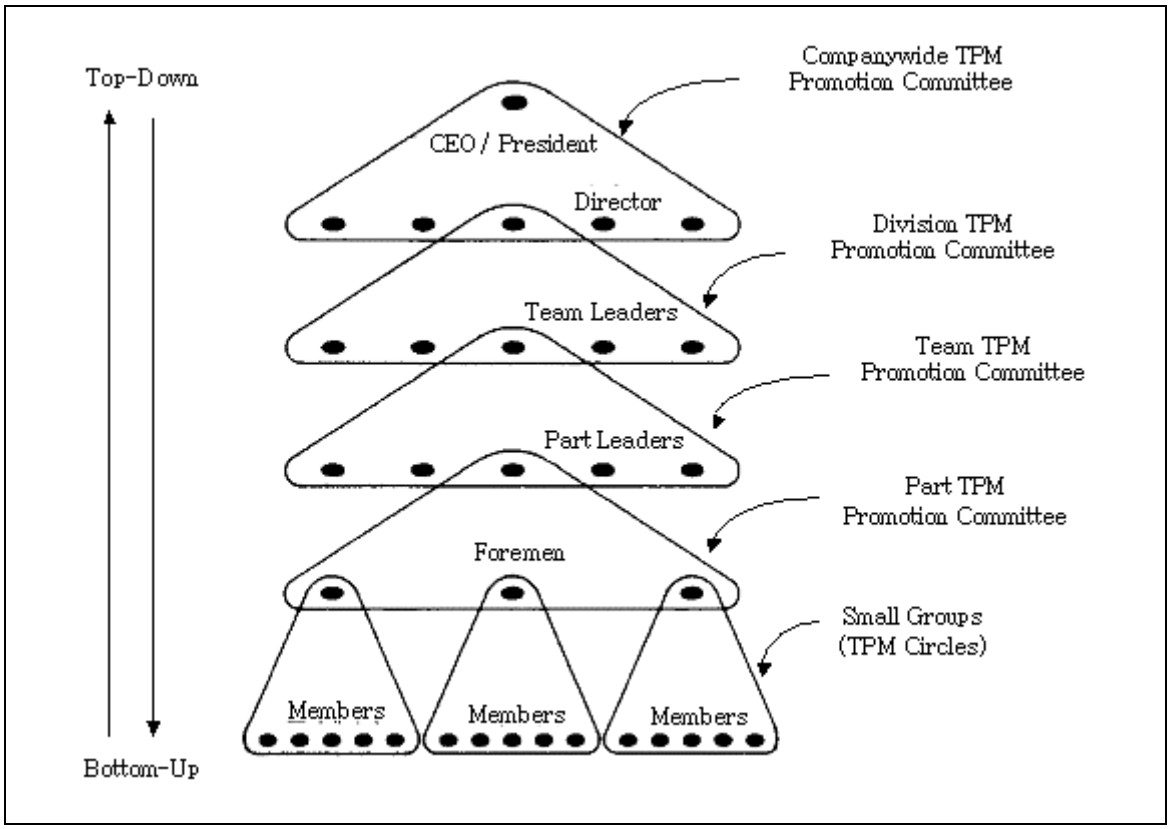
⑤ Achievement of zero-loss level through the activities of overlapping small groups

Figure 1-14 Comparison of Dictator Type Management and All-worker-participation Type Management

Category	Characteristics	Effect
Dictator type	Management based on order and control	* High productivity can be achieved within a short period. * Lack of reliability * Productivity would be lowered over the long period of operation.
All-worker' participation type (small group activity)	Management based on self-decision and self-control 1. Operation based on the cooperative relationship and support principal 2. Decision making by consensus problem solution by the group approach. 3. Setting a higher target of performance to be achieved	* Solid reliability * Higher productivity assured over the long period

TPM should be performed as a job, and if small group activities can be conducted at each level in the company, and they can perform their own functions properly at each level, "zero-loss" might be successfully achieved.

Figure 1-15 Activities of overlapping small groups



The leader of each small group at each level must be the person in a managerial position of the company.

By developing those kinds of activities, the company policy or target would be transmitted to the lower level of small groups, namely the front-line of the company, by the top-down channel and can be fully understood by them. On the other hand, the opinions suggestions and proposals made by the front-line groups will be transferred to the top management, resulting in good communication between the top management and the front-line operators.

"T" of TPM stands for total :

① Total connotes the "total improvement of efficiency" set forth in the first clause of the definition.

② Total connotes the "total life cycle of production system" set forth in the second clause of the definition.

③ Total connotes the "total departments" set forth in the third clause and the "total workers participation" set forth in the fourth clause of the definition respectively.

1.3.3 Pillar Composition of TPM

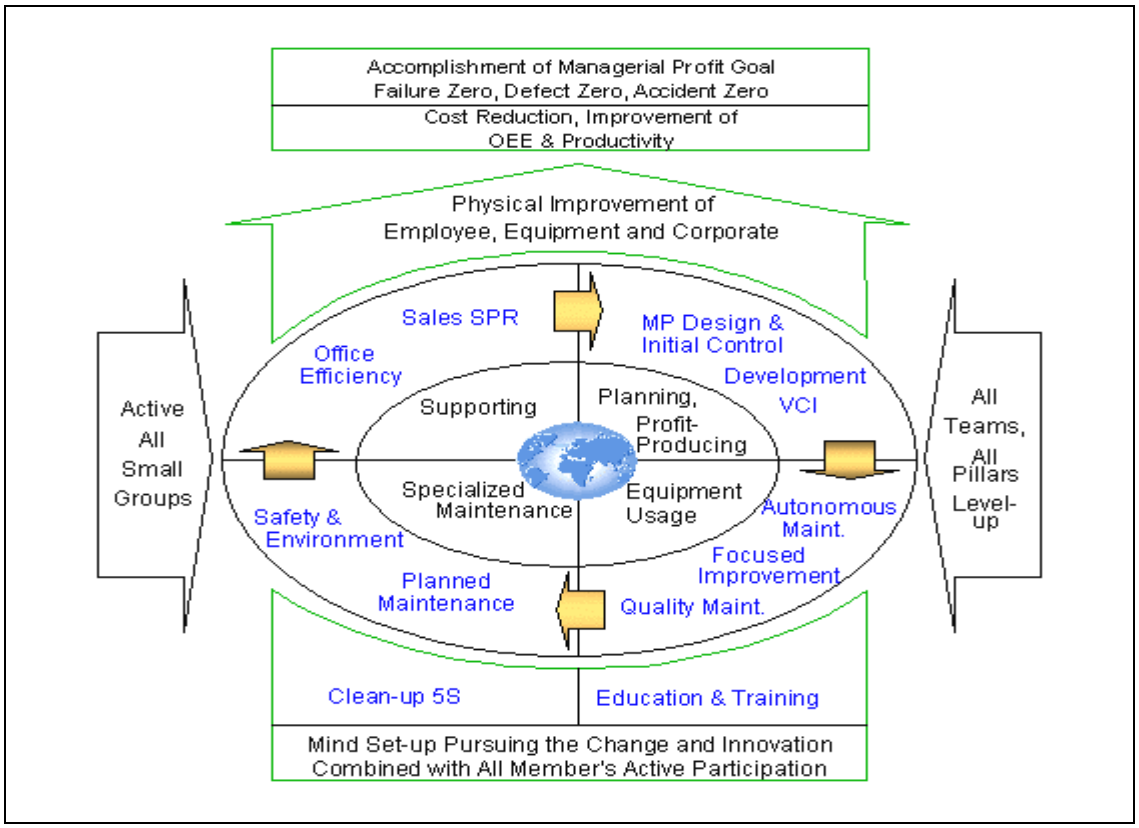
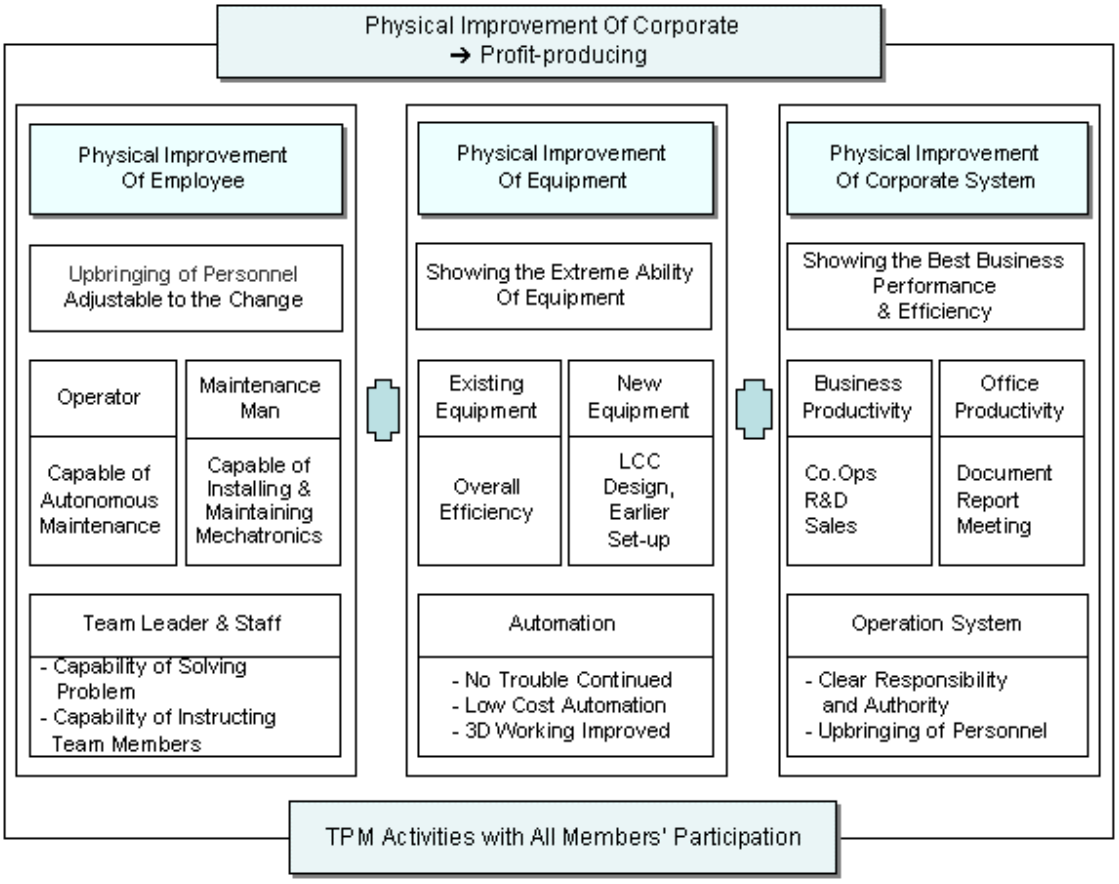


Figure 1-17 Purpose of TPM



1.4 Five Principles in TPM Deployment

① Establish the system to achieve production efficiency.
   1. Individua1 improvement
   2. Autonomous maintenance
   3. Planned maintenance
   4. Education and training to raise the skill levels for operation and maintenance

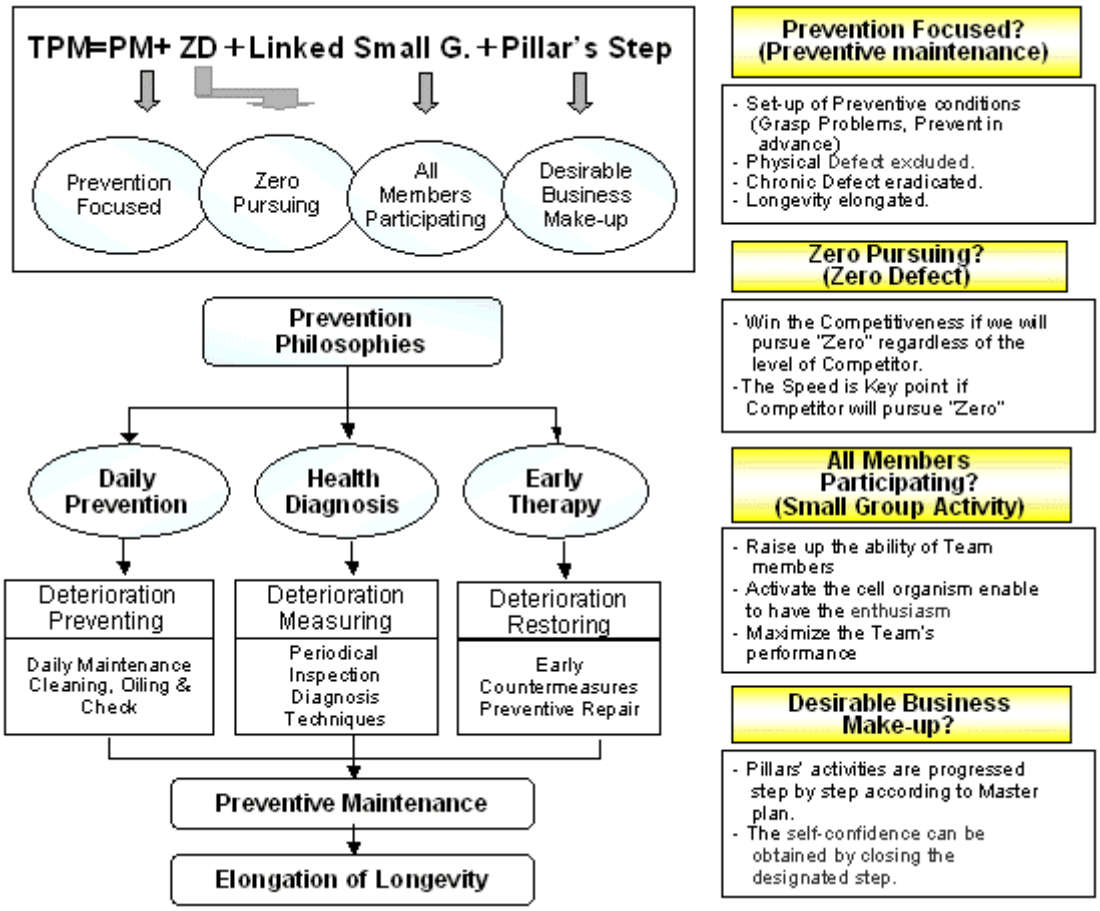
② Establish the system to perform initial control over new products and equipment.

③ Establish the quality maintenance system.

④ Establish the system to realize operation efficiency in the indirect administration departments.

⑤ Establish the administration system to control the safety, hygiene and environment protection.

1.5 Four Philosophies of TPM



1.6 Comparison between TQC and TPM

TQC is software-oriented. While TPM is hardware-oriented, that is, reforming the corporate culture so that it becomes what it should be.

In order to achieve the "high level of quality that TPM is aiming at in the production processes", it is necessary to implement thorough TPM activities by improving the workers behavior so that "high quality can be assured with well-maintained equipment."

Figure 1-20 Comparison of TQC and TPM

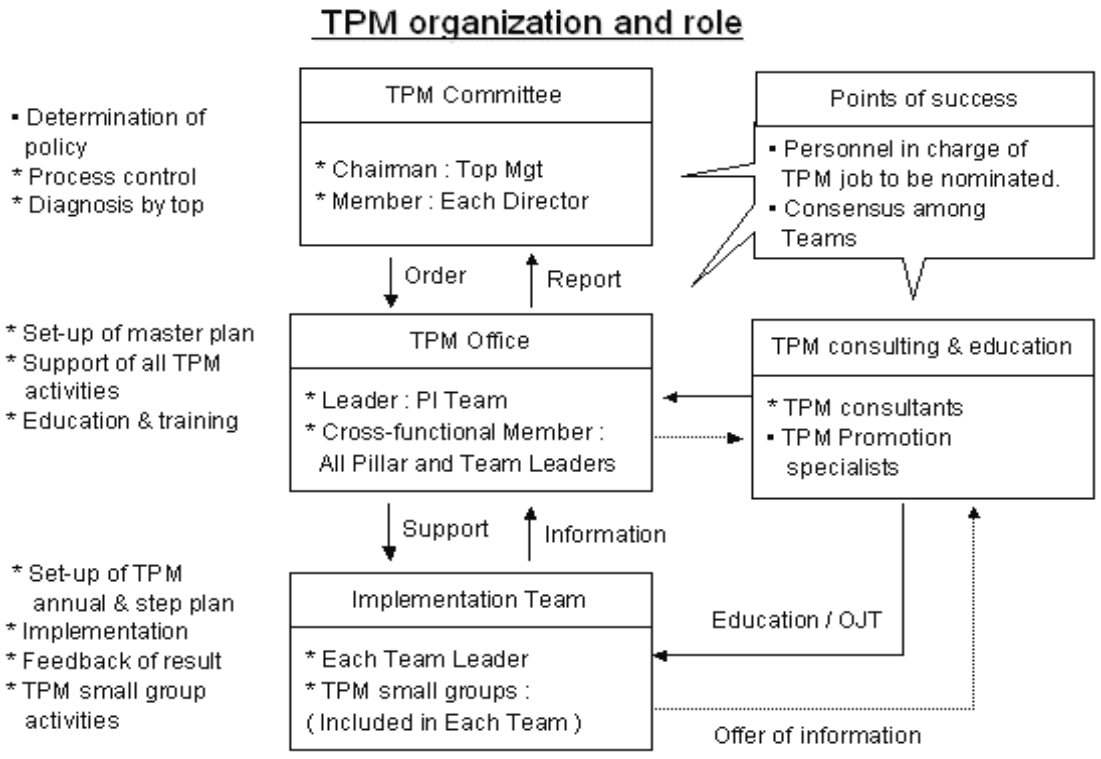
Category	TQC	TPM
Purpose	Improvement of corporate culture (Improvement in actual performance, Creating a cheerful working environment)	
Object	Quality (output side, Effect)	Equipment (Input side, Cause)

(5) Characteristics of Small Group Activities in TPM

	QC Circle		TPM Small Group
Position in organization	Indifferent from official organization. (Non official Organization)		Involved in official organization. (Official Organization)
Leader of Small Group	Selected from small circle member		Line leader or Foreman
Handling of the acting Hours	In duty hours	Not accepted	Accepted by permission of one's superior.
	Except duty hours	Not accepted	Accepted by permission of one's superior. (Overtime work allowance, Holiday work allowance, Etc.)
Selection of Theme Set-up of Target	Determine one's theme freely		Follow the Team's policy and target

(6) Organization of TPM Activities

Figure 1-24 Organization of TPM Activities



TPM is to be implemented after set-up of organization based on all members' participation and consensus, identification of departmental duties, responsibilities and roles.

(7) Organization and Functions for TPM

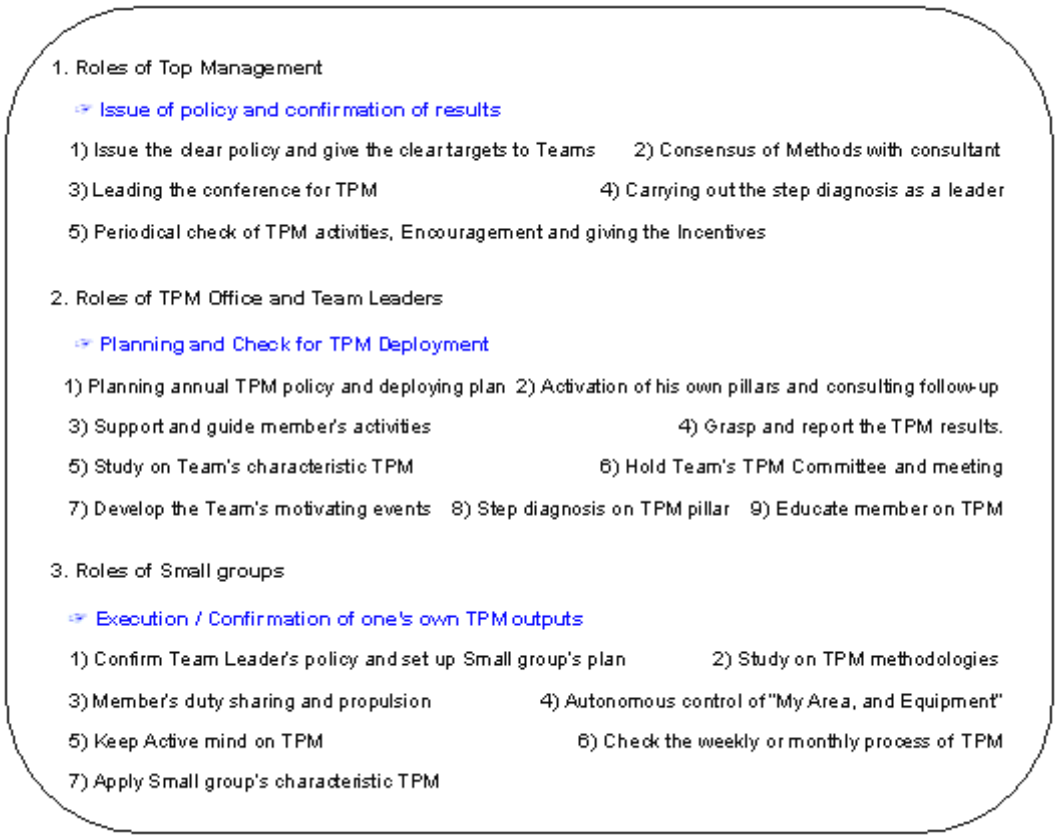
Promoting Organization	Composition	Functional Duty
CW TPM Committee	▪ Chairman ; CEO ▪ Organizer : SO / Director ▪ Member : Directors	▪ Determine CW TPM Policy and Target ▪ Diagnosis and instruct TPM
CW TPM Office	▪ PI Team ▪ CW TPM Office	▪ Set-up and Manage TPM Master Plan ▪ Diagnosis and instruct TPM ▪ Study on CW TPM Motivation and Event
Div TPM Committee	▪ Chairman ; Director ▪ Organizer ; Assigned Team Leader	▪ Determine Div TPM Policy and Target ▪ Diagnosis and instruct Div TPM
Div TPM Office	▪ Team assigned by Director ▪ Div TPM Office	▪ Operate Div TPM Master Plan ▪ Diagnosis and instruct Div TPM ▪ Study on Div TPM Motivation and Event
TPM Pillar Committee	▪ Chairman : Assigned Team Leader ▪ Organizer : TPM Leader ▪ Member : Assigned Team Leader	▪ Review Pillar Master Plan ▪ Set-up Pillar Deploying Methodology ▪ Manage and adjust pillar activity
Team TPM Committee	▪ Chairman ; Each Team Leader ▪ Member ; P/L, Foreman	▪ Review and instruct Team TPM ▪ Diagnosis and instruct Small Group TPM
TPM Small Group	▪ Small Group Leader ▪ Small Group Member	▪ Perform assigned TPM activities ▪ Review TPM activities before diagnosis

☞ CW : Companywide, Div : Division

(8) Roles of each Class on TPM Activities

Roles of each Class are very important for reaching to the successful results of TPM activities.

Figure 1-25 Roles of each Class on TPM Activities



1.7.4 Step 4 : Setting basic principles and target for TPM

(1) Purpose

To promote TPM as a part of policy and target management by clarifying the integration of the basic business policy and mid/long term business plan into TPM and by integrating the TPM target into the corporate business target for the fiscal year.

(2) Items to be implemented

① Clarify the TPM integration into the basic business policy or mid/long-term corporate business plan

② Clarify the goal (3 to 5 years to go) by each section level. It is important to set the major items to be realized (TPM 5 principles), and to obtain consensus throughout the corporation.

③ Predict the time needed for reaching the level needed for PM Excellent Plant Award screening and decide the TPM target at that time (target items and target values such

(4) Role of top management

① Thoroughly check that the master plan has been properly prepared by the promotion department.

② Prepare detailed schedules for each department, section and circle according to the master plan. Check if the development is being advanced as scheduled.

Table 1-3 TPM Master Plan (Example on Company TS)

Year		Y 2005 (Latter Half)		Y 2006	Y 2007	Y 2008
Stage		Basis Settlement Stage			Growth & Take-off Stage	
TPM Policy	Major Basic Policy	▪ TPM organization & system ▪ Set-up of TPM Base ▪ Preparation of Prod TPM		▪ Launching of Prod TPM ▪ Active Focused Improvement ▪ Closing TPM Phase 1	▪ Active R&D, sales TPM ▪ All pillars in TPM ▪ Profit-producing TPM	▪ Up-graded TPM pillars ▪ High productivity of All Teams ▪ Closing TPM Phase 2
Target	Product ivity	Present value	Y2005 4Q Kick -Off TPM Target Set-up	10% Up compared by BM	10% Up compared by Y 2006	10% Up compared by Y 2007
	OEE	Present value		20% Up of gap	20% up of gap	20% up of gap
	Equip failure	Present value		30% Down 20% of gap	30% down 20% of gap	30% down 20% of gap
	Q defect rate	Present value		50% Down of gap	50% down of gap	50% down of gap
	Mnauf cost	Present value		10% down compared by BM	10% down compared by Y 2006	10% down compared by Y 2007
	Theme done	100		130	150	150
	Accident	Present value		50% down of gap	50% down of gap	50% down of gap
TPM Organization and Master Plan		Set-up of TPM master plan		TPM & pillar's committees	Active TPM committees	Mature TPM committees
		Selection of TPM Leaders		Activities (FI, AM, PM, QM)	Activities (FI, AM, PM, QM + Office Efficiency + VCI + SPR)	
Consult & Diagnosis		(Top / Director Diagnosis: once per 1Q), (TPM leader Diagnosis : once per 1M, (Team L diagnosis : once per 1Q)				
TPM Manuals		General, FI, AM, PM, QM		OE, Sales SPR, R&D VCI	Phase 2 Step Manuals	Reference Manuals for pillars
E&T	Texts	General, FI, AM, PM, QM		OE, Sales SPR, R&D VCI	Texts for specialists	Reference texts for pillars
	E&T	Introduction, Step Approach		Internal specialists, Each Step	Small G Leader, Each Step	Internal specialists, Each Step
F I	Organ ization	Small Group, Project Model		Staff, Small Group, Project	Staff, Small Group, Project	Staff, Small Group, Project
	Activities	Improvement of work Base		Themes for equipment losses	Equip, & Energy Losses	Production & process losses
AM	Clean -up & E·S	6 Step (Assurance of work quality)		0 Step (5S Activities) 1 Step(Observance of house keeping)	2 Step (Prevention of work errors) 3 Step (Remedy of inadvertent work standard)	4 Step (Prevention of poor quality) 5 Step (Improvement of work quality)

Table 1-3 TPM Master Plan (Example on Company TS)

(Continued)

Year		Y 2007 (Latter Half)	Y 2008	Y 2009	Y 2010
Stage		Basis Settlement Stage`		Growth & Take-off Stage	
PM	System	6 Step (Overall appraisal of specialized Planned Maintenance)	0 Step(Set-up of basic maintenance system) 1 Step(Fundamental activities for efficient maintenance)	2 Step (Higher activities of efficient maintenance) 3 Step (Settlement of Maintenance information system)	4 Step (Settlement of Time-based Maintenance) 5 Step (Settlement of Condition-based Maintenance)
	Quick -fix	6 Step (Overall Appraisal of equipments)	0 Step (Grasping of essential maintenance conditions) 1 Step (Gap analysis between as-is and essential maintenance conditions)	2 Step (Reduction of gap between as-is and essential maintenance conditions) 3 Step (Set-up of fundamental maintenance requirements)	4 Step(Counter-measures on longevity elongation & weak points) 5 Step (Systemization of check and maintenance)
Quality Maintenance			1 Step (1st Improvement of worst process causing poor quality) 2 Step (2nd Improvement of worst process causing poor quality)	3 Step (Improvement of worst product causing poor quality) 4 Step(Improvement of worst modes causing poor quality)	5 Step (Reduction of chronic quality problems) 6 Step (Eradication of chronic quality problems)
Office Efficiency				0 Step (Preparation & 5S Activities) 1 Step (My Area & Machine Activities)	2 Step (Set-up of Business Conditions) 3 Step (Countermea-sures of Problems)
R&D VCI				1st year R&D VCI program based on EVE (Excellent VE)	2nd year R&D VCI program based on EVE(Excellent VE)
Sales SPR		4 Step (Effective Sales Activities) 5 Step (Efficiency of Sales Business)		0 Step(Prep & 5S Activities) 1 Step(Autonomous Improvement of Sales Office Area and Equipment)	2 Step(Standardization of Sales Business) 3 Step(Improvement of Sales Process)
Boom-up	Event	* TPM Promoting Event	* TPM Best Practice Contest * Promoting Events * Adequate Boom-up Contests	* TPM Best Practice Contest * Promoting Events * Adequate Boom-up Contests	* TPM Best Practice Contest * Promoting Events * Adequate Boom-up Contests
	Publi city	* Collection of Slogan & Poster	* Collection of Slogan & Poster * Issue of TPM News	* Collection of Slogan & Poster * Issue of TPM News	* Collection of Slogan & Poster * Issue of TPM News

1.7.6 Step 6 : TPM Kick-off

(1) Purpose

The preparation for TPM implementation is through and announcement of TPM introduction to all employees is ready, that is, the starting date of challenging the achievement to reduce 8 major losses on equipment to zero has come. The purpose here is to create a situation where every employee agrees with top management policy

(3) Notes

① Steps 1 through 4 are the basic steps which are mostly associated with reforming the physical constitution of the people and equipment, and if strictly observed and patiently maintained, the satisfactory effect could be brought about as expected.

② Absolutely avoid painting on passages and equipment with unattended dust, stains, rust and oil leaks.

(4) Role of top management

① Confirm if the trouble shooting of the malfunction areas and the preparation of measures against the sources of outbreaks are properly carried out.

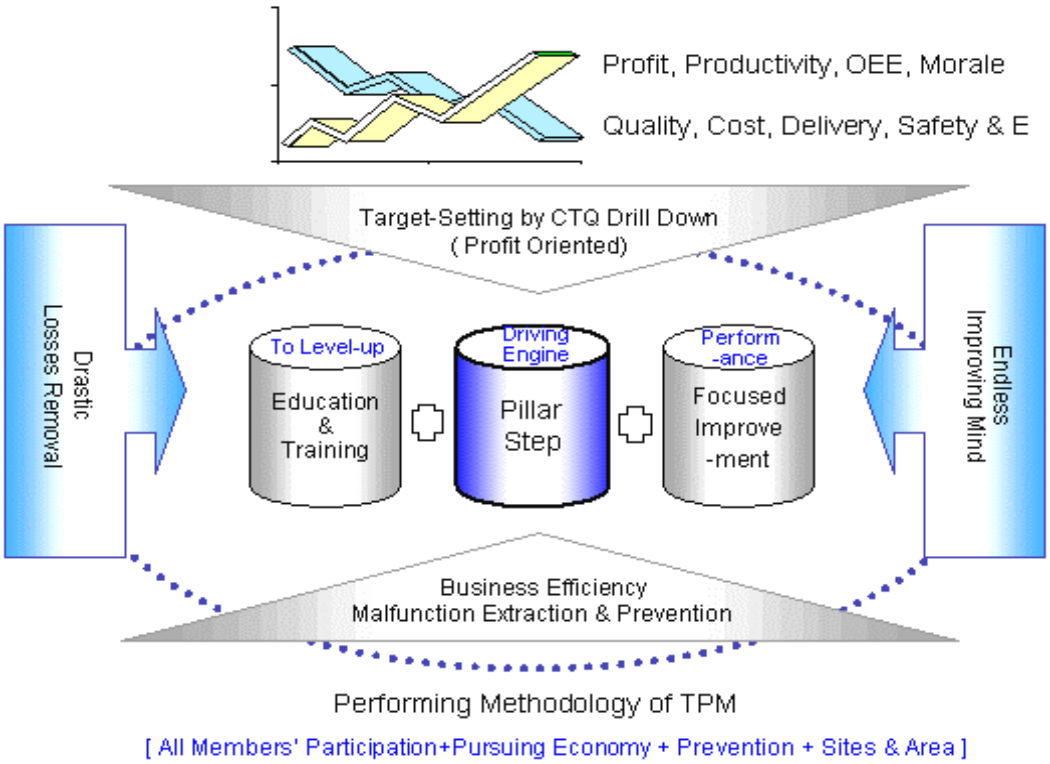
② Give unstinted praise to those who submitted good idea and recommendations

③ Carry out top management auditing over the autonomous maintenance regularly (not an all-round audition for each step).

The remaining major activities will be explained in each corresponding chapter.

1.8 Deploying Methodology of TPM

1.8.1 Deploying Concept on TPM



Performing Methodology of TPM

[All Members' Participation+Pursuing Economy + Prevention + Sites & Area]

1.8.2 Correlation Matrix between Organization and TPM activities

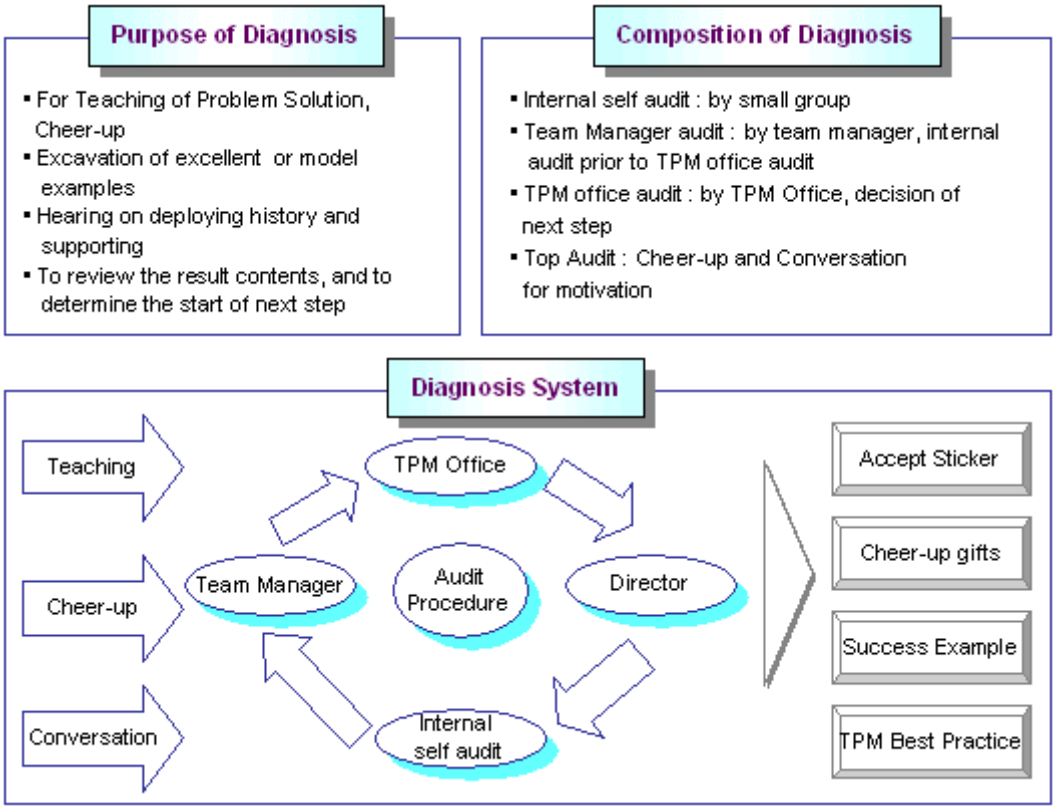
● Strong O Weak

Organization / TPM Pillars		Production		Equipment		Proc. Engineering	E&S		QC	Test	Prod. Development	PE	Company Operations					R&D		Sales
		Staff	Operator	Engineer	Maint man.		Sys	Env. Equipment	Insp.	Func. Test			General Affairs	Logistics	Inspection	Purchasing	Subcontract	Proc. Dev.	Design	Sales /MKT
TPM General		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Focused improvement		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Autonomous Maint.	Clean-up & Safety	●							●	●					●					
	UT Maint							●												
Planned Maint.	System			●																
	Quick-fix				●															
Quality Maintenance						●														
Office Efficiency													●	●		●	●			
R&D VCI																		●	●	
Sales SPR																				●
Initial Control						●					●									
Environment & Safety							●													
Education & Training		O		O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O

1.8.3 Annual Deploying Program of TPM Activities

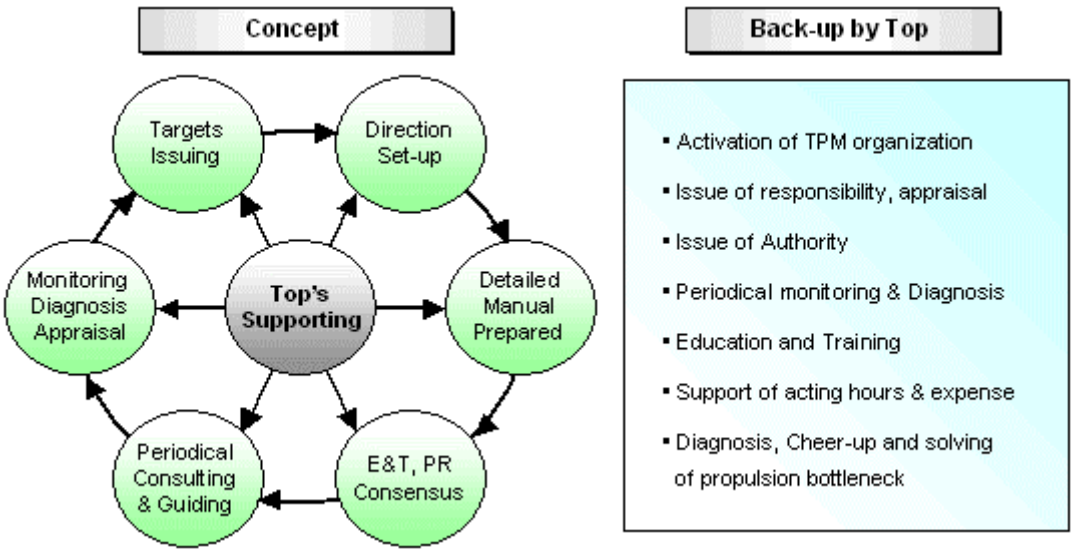
No	TPM Procedure	TPM Activity Contents	TPM Activity Method
1	Recognition and grasp of losses	■ Grasp of losses hindering the cost, efficiency & productivity - Management : Sales, Profit, Production output - Productivity: OEE, Productivity per person, Failure intensity rate, Failure time, Failure times, Failure frequency rate, etc. - Q: Defect ratio of process & product, Customer claims - Cost: Manufacture cost, Maintenance cost per product - Delivery: Delivery observance	■ Refer to effect evaluation indices in TPM general manual & Focused Improvement manual for MC ■ Refer to the detailed check list for improvement theme finding of each organization in focused improvement ■ Refer to loss

Figure 1-28 Diagnosis System on TPM Step Activities



1.10 Success Factors of TPM

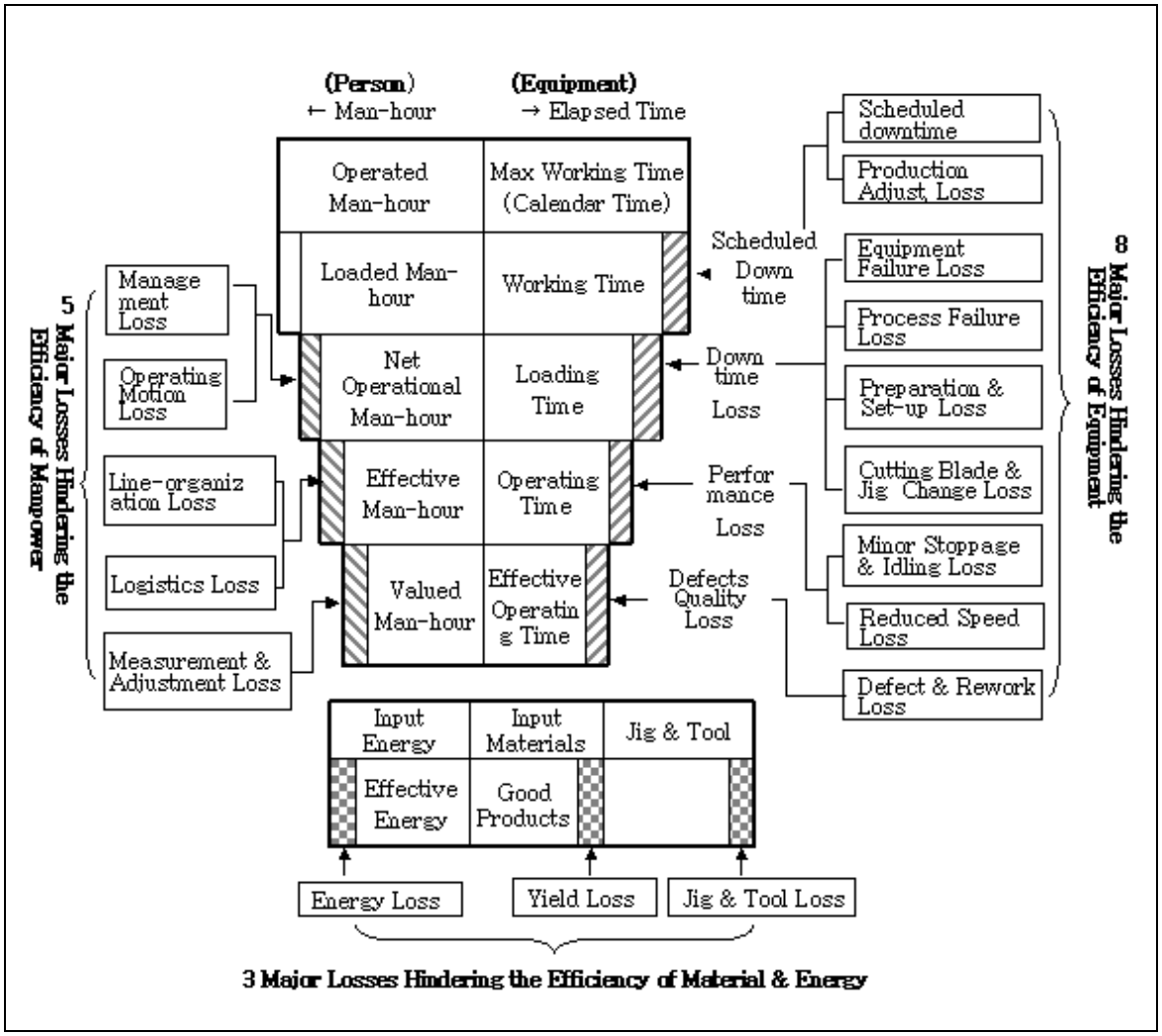
1.10.1 Concept for the settlement of TPM Deploymen



Chapter 2 Production Efficiency and OEE

Contents

Figure 2-1 Loss structure during production activities (16 major losses)



(3) Cutting blade & jig change loss

The cutting blade & jig change loss is caused by the line shutdown for replacing the grinding wheel, cutter bite etc. which might be broken or worn due to long service.

(4) Start-up loss

The start-up loss is the one which has to be considered until the start-up, running-in and machining conditions of the equipment have been stabilized.

(5) Minor stoppage & idling loss

The minor stoppage loss differs from the other losses and is the one in which temporary trouble causes the equipment to stop or idle. It might be called a "minor trouble" (frequent trouble).

Idling of a line caused by a low supply of work in the chute due to clogging, and temporary line stops caused when the sensor detects a non-conforming product are examples of minor stoppage loss. These losses can be eliminated and the line returned to the normal operation so long as the clogged work is removed. The losses are quite different from natural equipment failure losses.

(6) Reduced speed loss

The reduced speed loss is the loss caused by the difference between the designed speed and the actual working speed.

For example, when the line was operated at the designed speed, it was found that the line caused poor quality trouble or mechanical trouble in the line. In that case, the line had to be run at a slower speed than the designed one. This situation is called the reduced speed loss.

(7) Defects & rework loss

This is the loss caused when defects are found and have to be reworked.

In general, the defects are likely to be considered as waste which should be disposed of. But since even the reworked products need waste manpower to repair them, this must be considered as the loss.

2.1.2 Loss which hinders the equipment loading time

(8) SD loss

This 1oss is referred to as line shutdown loss which is caused by stopping the equipment for periodical maintenance/inspection, and for scheduled shutdown for legal inspection during the production stage.

2.2 How to Calculate the Overall Equipment Efficiency

The re1ationship between 7 major losses and overall equipment efficiency, as well as how to calculate the equipment loss are explained here.

minutes for adjustment, totaling 60 minutes, the total availability are 400 minutes. In this case, the availability is.

$$\text{Availability} = \frac{400}{460} \times 100 = 87\%$$

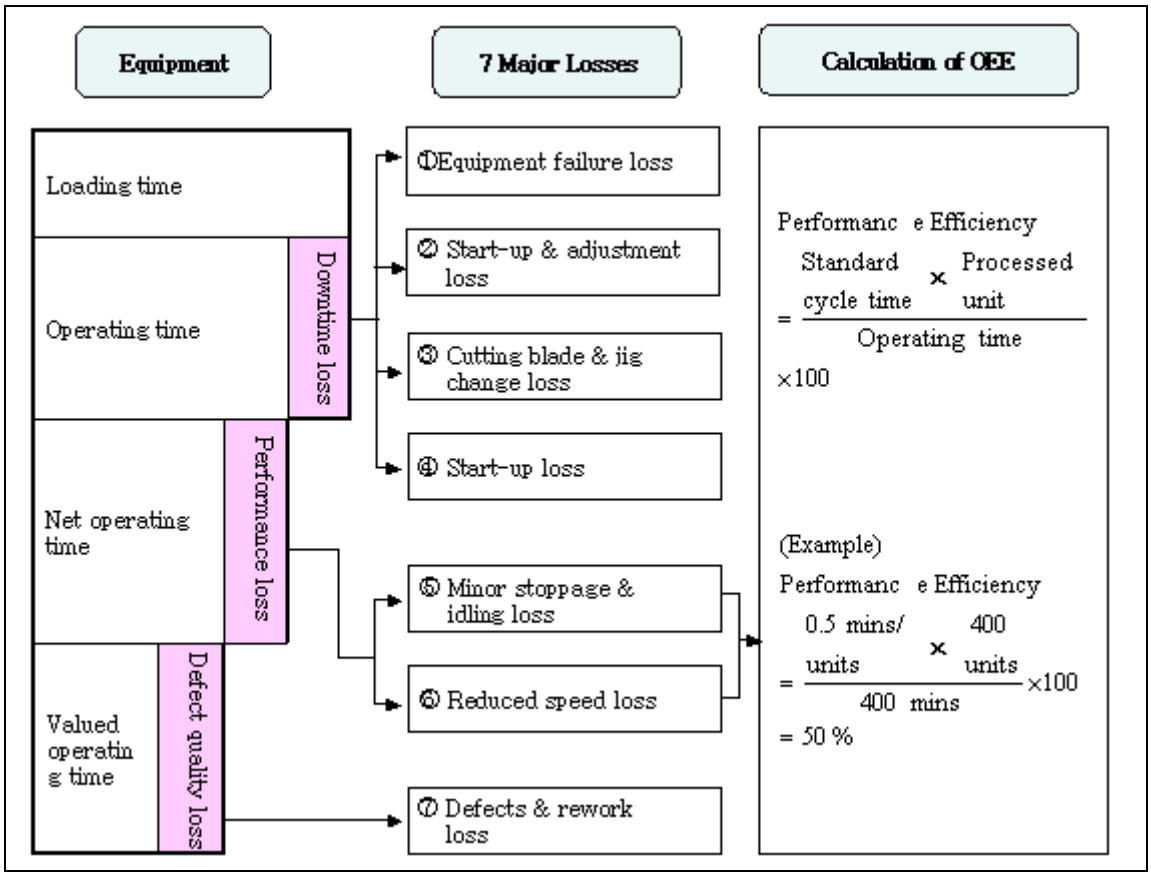
That is to say, the availability is approximately 87%.

2.2.2 What is performance efficiency

The performance efficiency consists of the speed operating rate and the net operating rate.

The speed operating rate means the difference between various speeds and is the ratio of the actual speed to the capacity (cycle time) the equipment inherently has.

Figure 2-3 Relationship between 7 Major Losses of Overall Equipment Efficiency and Performance Efficiency



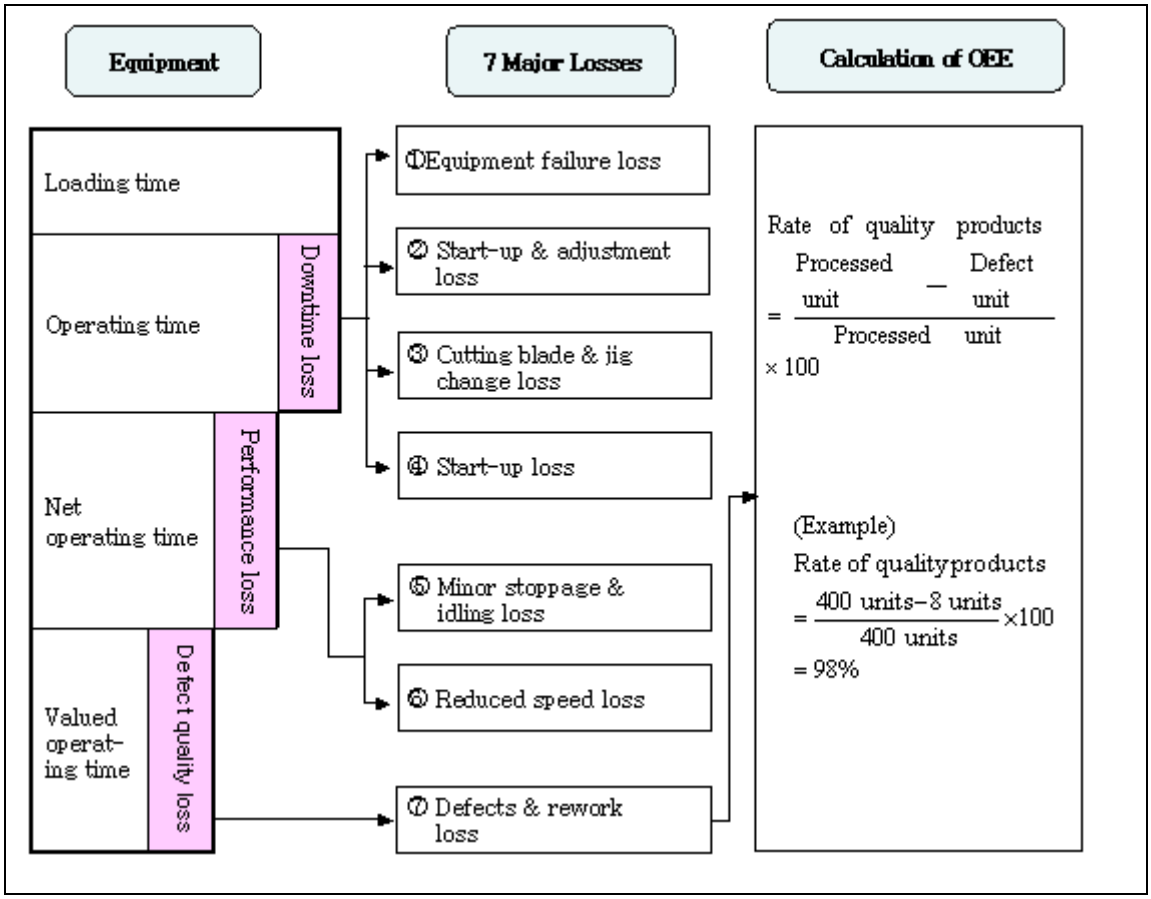
2.2.3 What is the rate of quality products

The rate of quality products is the ratio of the quantity (material and energy) to be machined or loaded for machining to the actual quantity of quality products produced.

$$\text{Rate of quality products} = \frac{\text{Processed unit} \times \text{defect unit}}{\text{Processed unit}} = \frac{392}{400} \times 100 = 98\%$$

Defect products include not only the waste, but also the rework.

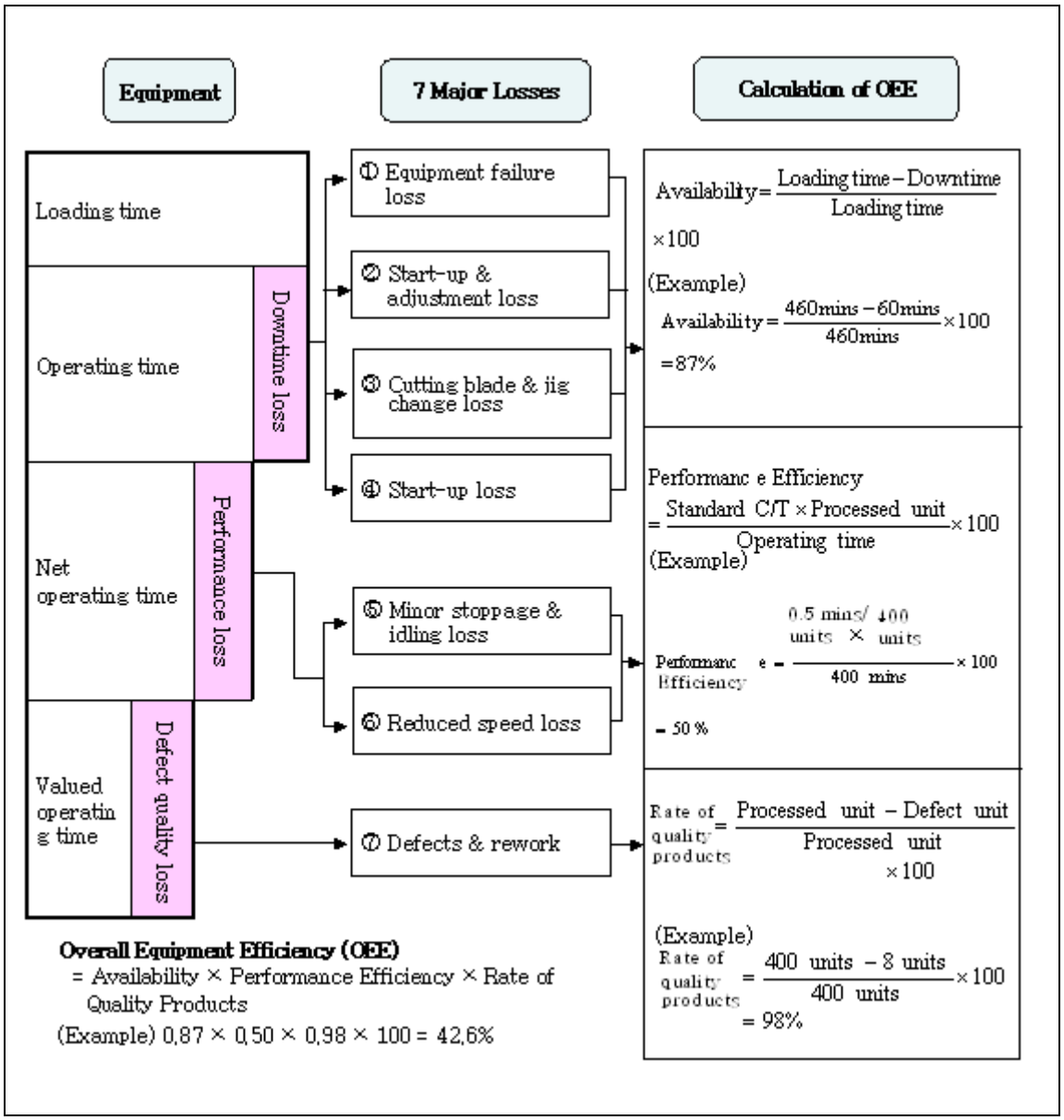
Figure 2-4 Relationship between 7 Major Losses of Overall Equipment Efficiency and Rate of Quality Products



2.2.4 Overall equipment efficiency (OEE)

As mentioned above, various equipment losses can be quantitatively calculated. With the results of those calculations put together, we can measure the equipment operating state and judge if the equipment is utilized to its fullest. To express the equipment utilization, the following equation should be used.

Figure 2-5 Relationship between 7 Major Losses on Equipment and Overall Equipment Efficiency



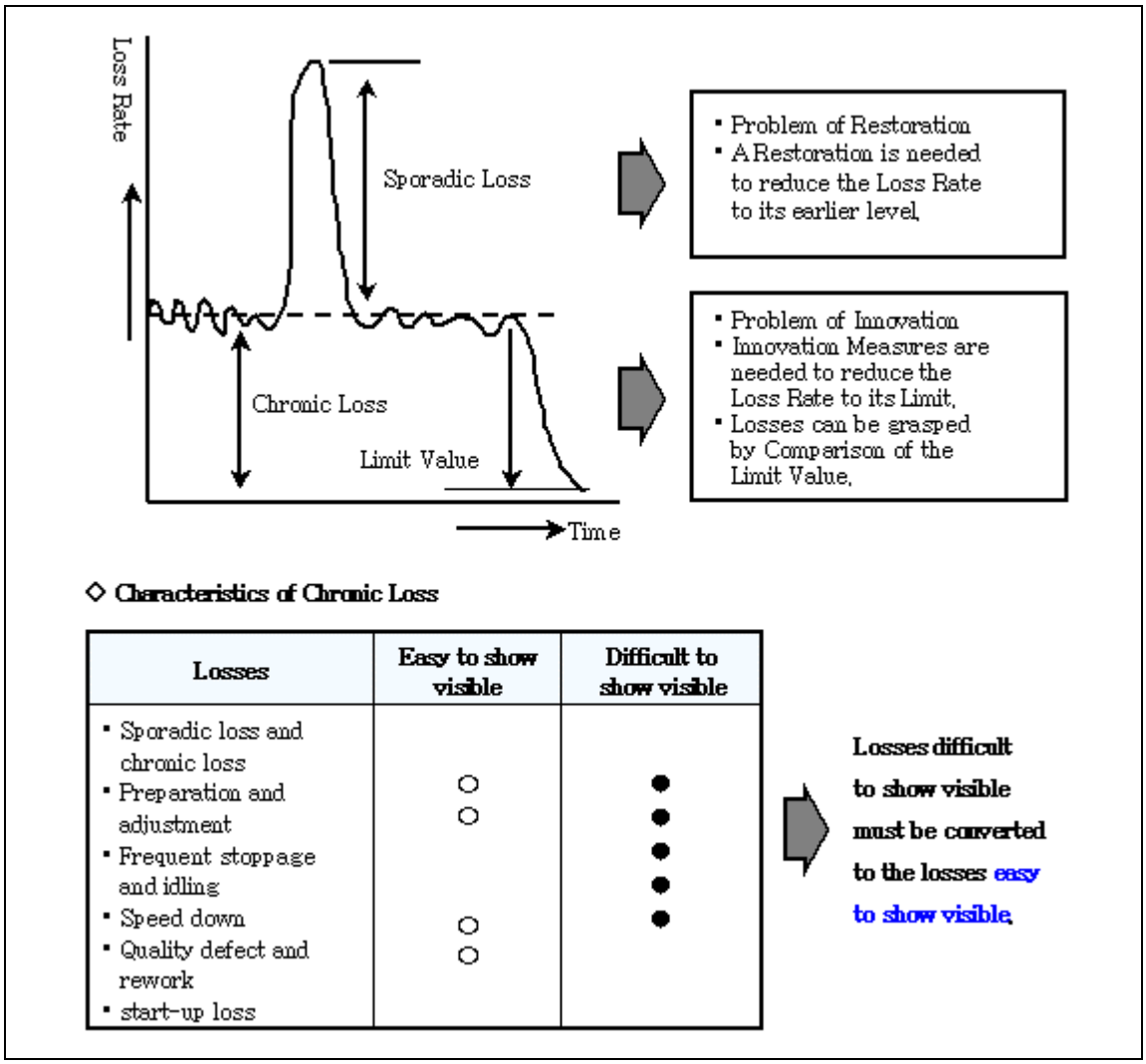
As a countermeasure, plant manager Aoki is considering TPM introduction so he can make the most use of existing equipment and perform the production within regular working hours to achieve the cost reduction.

2.7 Chronic Loss

2.7.1 Sporadic loss and chronic loss

The types of failure or defect generation can be classified into two. Sporadic and chronic ones.

Figure 2-7 Sporadic Loss and Chronic Loss



As the causes for sporadic failure or defect can usually be traced easily, and the relationship between cause and effect is rather clear in most cases, it is easy to establish remedial measures. Therefore, most of the sporadic failures or defects can be solved so long as the remedial measures, such as restoration of changing conditions or factors to the original proper status, are taken.

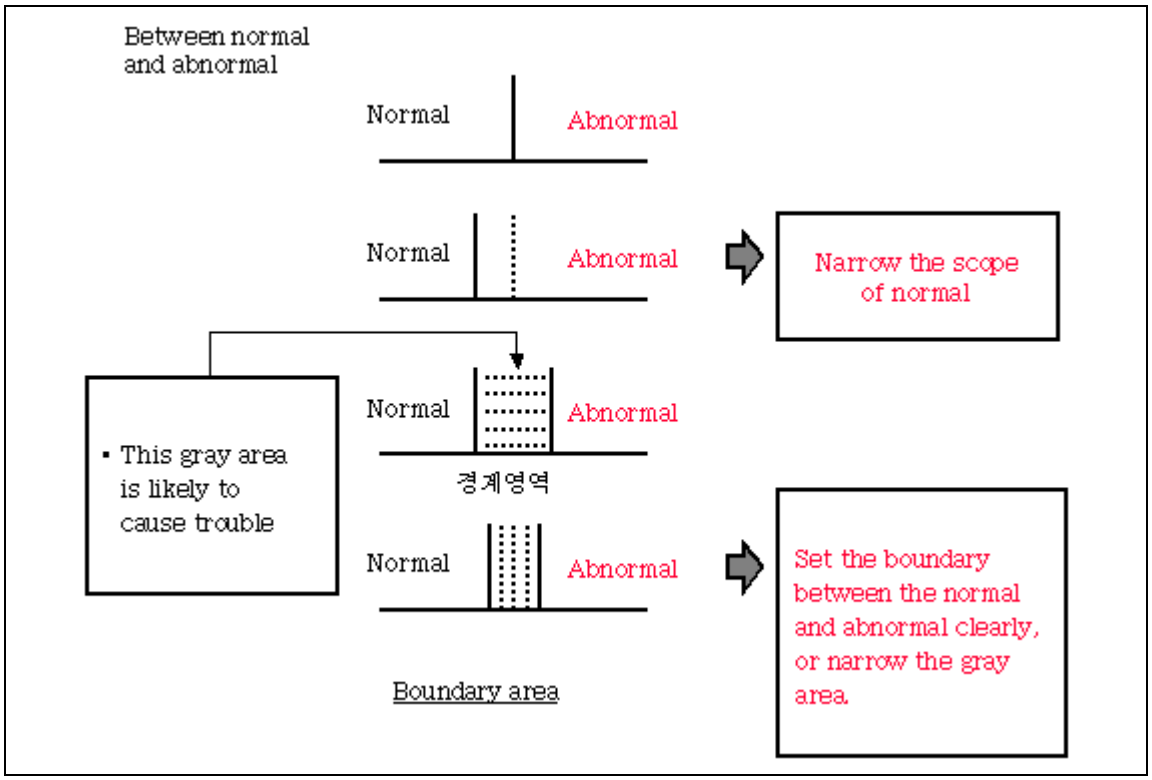
* Necessary conditions are complete, but it cannot be fully understood what the adequate conditions are.
* Only the necessary conditions won't help eliminate the chronic losses.

(3) How to find 8 optimal conditions

* Extema1 appearance * Installation accuracy
* Dimensional accuracy * Function
* Assembly accuracy * Usage environment
* Usage condition * Materia1 strength

(Machining accuracy of machine tool :
Level of machine → Vibration → Is it possible to stand a coin on its edge?)

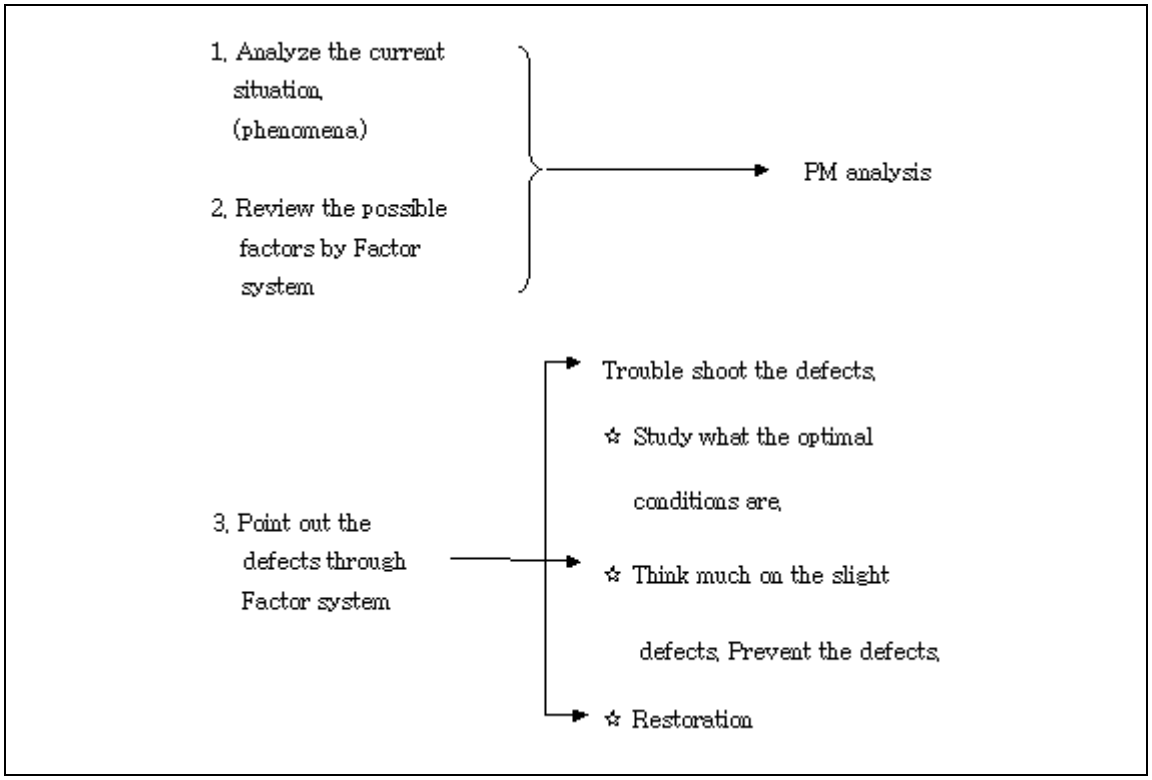
Figure 2-12 Discrimination of Normal and Abnormal



2.8.2 Boundary between Normal and Abnormal

What you have to take note of when considering optimal conditions is the situation where boundary between normal and abnormal is not clear. In an extreme case, there

Figure 2-17 Elimination of Chronic Losses



It is very important to completely point out all of the slight defects which are barely visible.

2.8.8 Considerations needed when picking out slight defects.

(1) Review the analysis, referring to the principles or rules.

It is necessary to review the symptom analysis from the standpoint of engineering principles or basic rules, and at that same time, to review its relationship to equipment. Without sticking to the difficult theoretical analysis, all of the symptoms and factors which might be related to the symptom should be picked out through the application of fundamental analysis principles. That is to say, it is important to pay much attention to not overlook or ignore slight defects without being influenced too much by the symptom.

(2) Don't think too much of the contribution rate

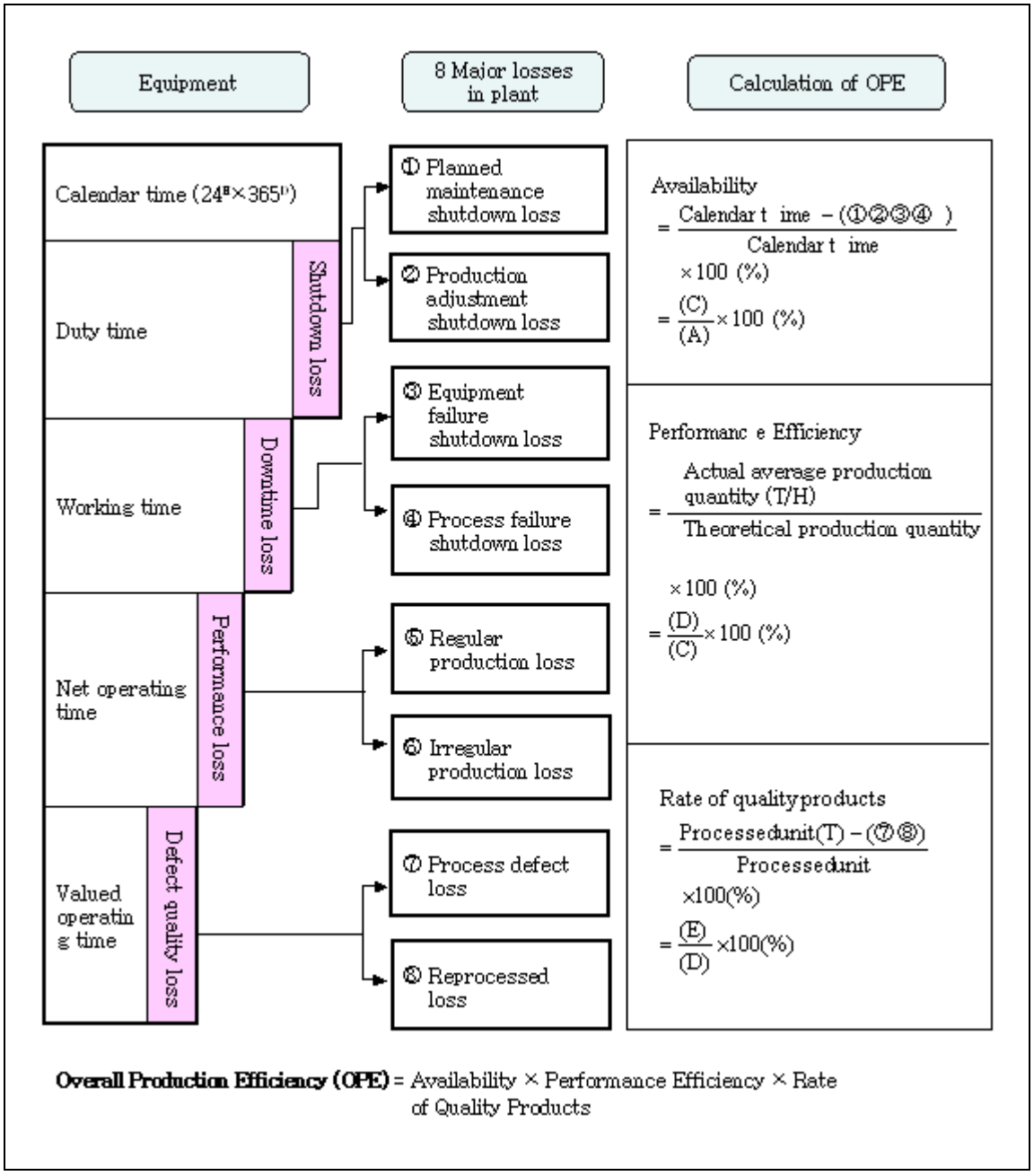
The most important thing in picking out slight defects is not to think too much about their contribution rate, which indicates how far the results would be affected by the slight defects. If too much consideration is given to the contribution rate, the trend

2.9 Production Efficiency and Overall Production Efficiency

Table 2-1 8 Major Losses in Plant

8 major losses	Definition of losses
① Planned maintenance loss	Shutdown loss, which is caused by the shutdown of the plant for its planned annual maintenance and periodic plant adjustment
② Production adjustment loss	Adjustment time loss, which is caused by the production plan to adjust the supply and demand balance
③ Equipment failure loss	Loss which is caused by sporadic shutdown of the facility or equipment due to malfunctions
④ Process failure loss	Loss which is generated in the process by plant shutdown due to improper chemical or physical properties of the substances to be handled, some other improper equipment operation or external factors
⑤ Regular production loss	Loss which is caused by set-up and adjustment at the time of start-up, shutdown and/or die or jig changes
⑥ Irregular production loss	Hour and loss which is caused by reducing the production rate due to plant malfunction or abnormality
⑦ Process defect loss	Hour and material losses which are generated by producing defective products or imperfection Loss, Which is defined as a loss deserving 2 rank down-grading
⑧ Reprocessed loss	Loss which is caused by reworking

Figure 2-20 Overall Production Efficiency(OPE) of Plant

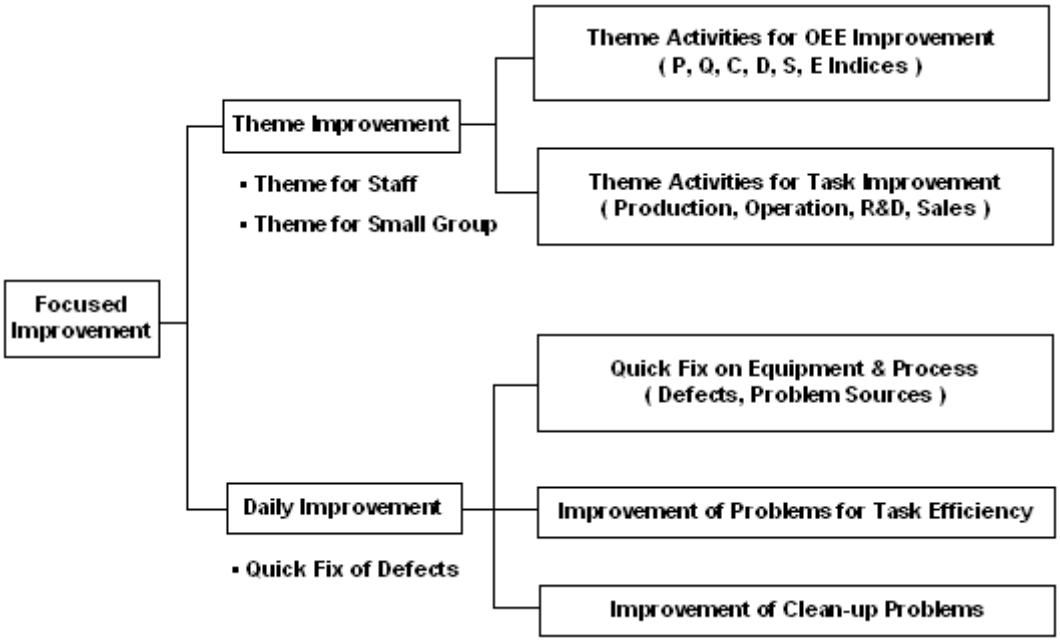


Chapter 3 Practice for Focused Improvement

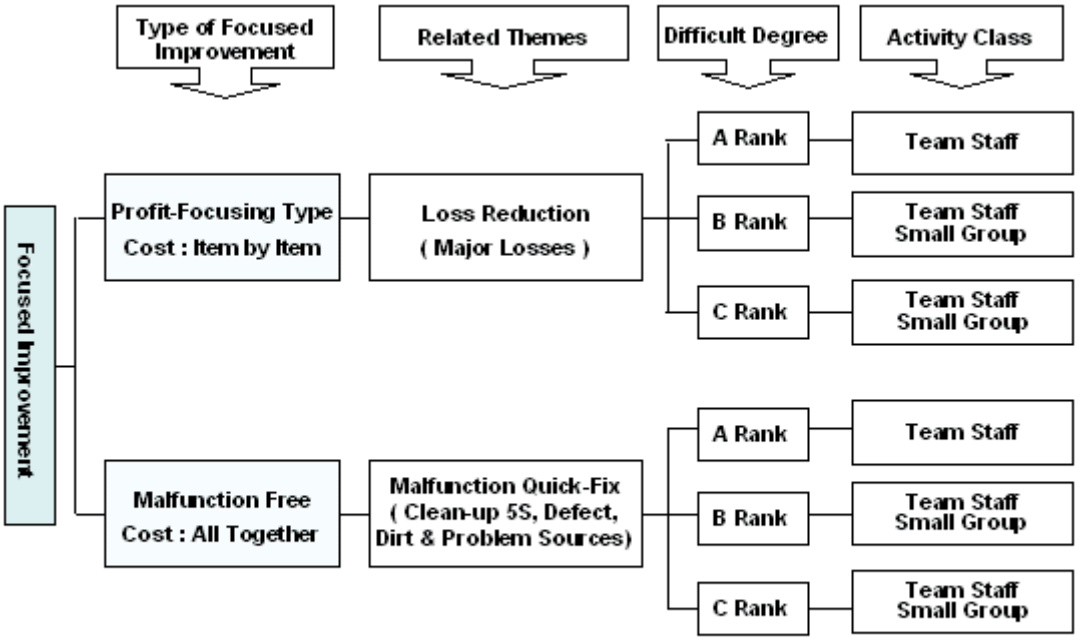
Contents

3.1 Basic Concept of Focused Improvement

3.1.1 Definition and Activities of Focused Improvement



3.1.2 Type and Difficult Degree of Theme Improvement Activities



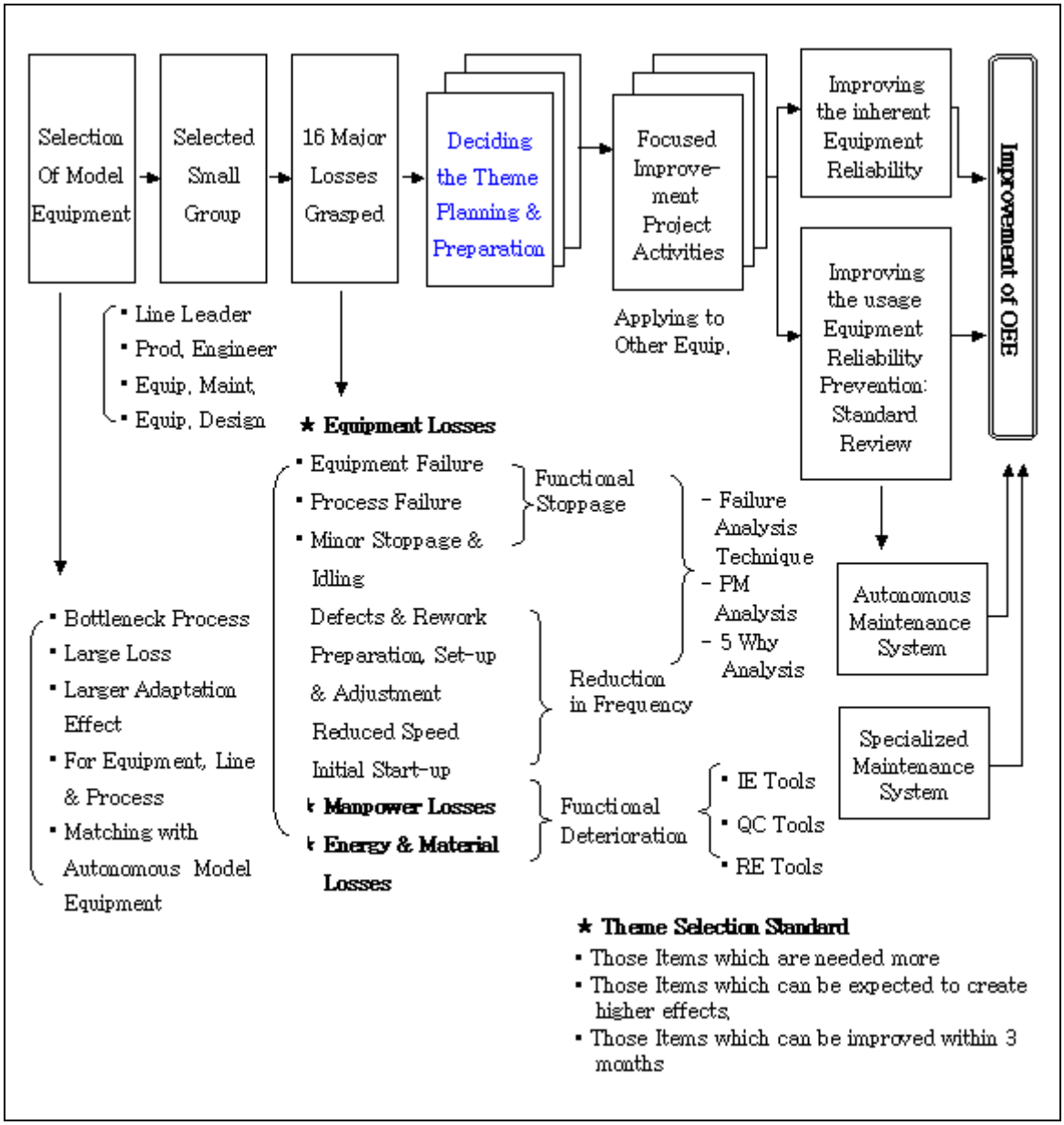
☛ Weight Value :

A Rank 1 Theme = B Rank 2 Themes, C Rank 6 Themes, B Rank 1 Theme = C Rank 3 Themes

3.2 How to Advance Focused improvements

As one of the pillars of TPM activities, focused improvements pursue efficient equipment, worker and material and energy, that is, extremes of productivity, and aim at achieving substantial effects. Focused improvement activities try to thoroughly eliminate 16 major losses. The basis of these activities is to enhance and demonstrate the technological, analytical and improvement powers of the worker engaged in them.

Figure 3-1 How to advance Focused Improvement



(2) Medium theme				(3) Minor theme				Promotion			Progress	Accomplishment Rate(%)
Case	B.M	Goal	Current	Case (Loss)	B.M	Goal	Current	Charge	Start	End		
Improve raw material yield				Cutting loss								
Improve cutting blade material & energy				Cutting blade cost loss								
Energy saving				Waste heat loss								
Overall efficiency	%	"	"	Operation monitoring loss	Hours /shift							
				Carrying loss	"							
				Labor saving substitution loss	"							

Yellow : Being implemented. Blue : Completed. Red : Accomplished ↑

3.2.2 How to Advance Focused Improvement Activities

Focused improvement activities can be implemented efficiently after kicking off by setting models in departments, sections or groups and by implementing activities in a planned manner in accordance with focused improvement plans.

The step-by-step implementation shown below is recommended to implement these activities. The focused improvement work group or implementation office must monitor and control the implementation of activities. Table 3.2 and 3.3 show examples of implementation control (monthly plan tracing score) and of expansion to other places for focused improvement plans.

Table 3-2 Focused Improvement 10-Step Development

Step	Activity
Step 1 Select model equipment/line/process	* Lines, processes and equipment in focused improvement plans that produce many losses. * Possibilities of expanding to other places are large. * Synchronize with lines, processes and equipment in autonomous maintenance activities and advance Steps 1 to 3.
Step 2 Organize Project	* Manager of department is the leader (e.g., department manager for department model and section manager for section

factors without carrying on the symptom analysis thoroughly, and sometime tends to list unrelated matters, which results in not achieving a noticeable loss reduction in spite of various countermeasures taken. To avoid this kind of situation, the PM technique is the best solution.

Figure 3-6 What is PM Analysis ?

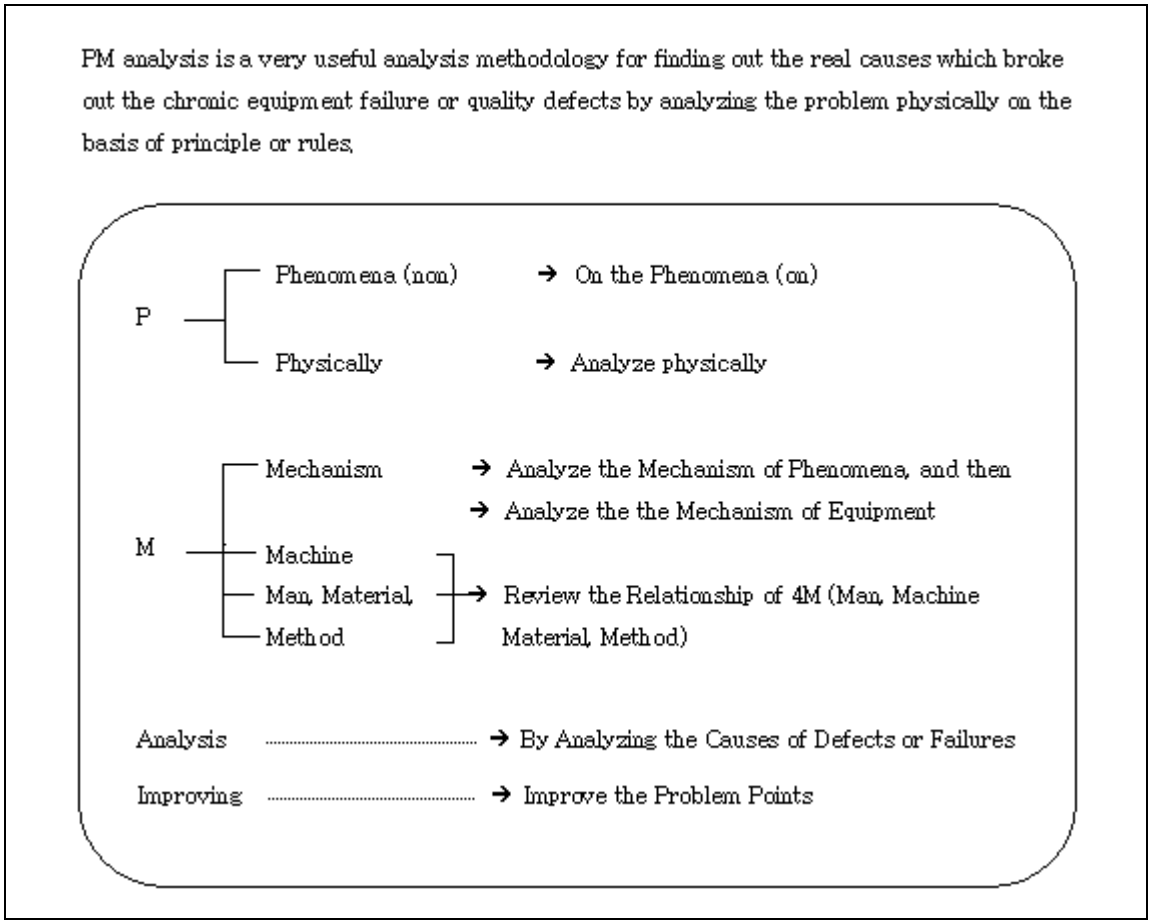


Table 3-4 Steps for PM Analysis

1. Clarification of phenomenon	Classify the pattern of the phenomenon thoroughly.
2. Analyze the phenomenon physically	Analyze the phenomena from the physical point of view and present them by referring to the theory or the principle.
3. Conditions which contribute to phenomenon	Pick every case which might contribute to the symptom if the conditions are met.
4. Understand the relation between equipment, man, material and method	Study the relationship between equipment, tools/jigs and the creation of conditions which

7) Step 7 : Point out the malfunction

Utilizing the investigation method selected in the step mentioned above, pick the malfunction for each factor, when performing this step, you have to take care so that you will proceed in picking the malfunction and incidental defects from the standpoint of looking for "what is optimal conditions", or "incidental defects", without sticking to conventional concepts or judgment practices

8) Step 8 : Work out the improvement plan

Work out the improvement plan for the items which are pointed out as having malfunctions.

(3) Structure of PM Analysis Sheet

Appraisal : A B C D Re-Analysis		PM Analysis Table [Physical Analysis of Failure or Defect based on Mechanical Principles]	Team L Comment	
Serial No :			P/L Comment	
Member :			Foreman Comment	
Date:	Leader:	OPL Required : Yes / No	Reflect on Maint STD : Yes / No	Applying to Others : Yes / No

Clarification of Phenomenon (Select one problem pattern)						Analyze the Phenomenon Physically (Form as in "C of A and B is characterized to D".)								
				Result		Grasp the Relation Among 4M								
Condition Contributing to Phenomenon	Tolerance	Effect Degree	Investigation Method	Measured Value	Judge	1st List-up of 4M Causes	Judge	2nd List-up of 4M Causes	Investi-gated Result	Judge	Countermeasures	In Charge	Improving Plan	Result

Of course, a wider conception besides a related wide range of knowledge and technologies are required as well as thorough knowledge about the products, process, raw material, manufacturing method, manufacturing conditions and equipment.

Table 3-5 Procedures and Consideration of PM Analysis

Step	Name	Procedures	Considerations
Step 1	Phenomenon (Phenomenon means which can actually be seen)	Observe phenomenon carefully at the local site ↓ Classify the phenomenon into details as much as possible - Appearance - Change-over time - Location of trouble - Difference in the location of trouble by equipment or machine - Process of generation ↓ Grasp the phenomenon exactly	* Don't stick to the conventional way of expression * Describe precisely * Tracer to the smallest possible unit of the phenomenon (such expressions as flows, dent, broken or malfunction are not enough) * Errors can often be observed due to insufficient classification of phenomenon * Don't guess the phenomenon, confirm them visually
Step 2	Physical point of view (Physical is the subject to study the truth or nature of things)	Present the phenomenon physically ↓ Describe the phenomenon with a generation mechanism	* Experience, perception, sensuous judgment should be avoided definitely. * When it is difficult to find a way to see the matter physically, the way to observe the phenomenon is wrong, or there is insufficient understanding about equipment, material and method. * Review the phenomenon theoretically * The way to pick the element differs, depending on how they are physically analyzed. * Understand the physical principle and theory. * Understand the function and mechanism of equipment and operation manuals.
Step 3	Conditions (Conditions mean the things which limit the phenomenon)	Pick all the possible causes which might contribute to the trouble generation	* Always try to develop the activities wondering if every element involved (so that no missing of causes occurs.) * Don't stick much to the rate of contribution. Rough recognition of conditions would fail to proceed to the next steps. In that case, take the conditions as the phenomenon. * Experience, perception and sensuous judgment should

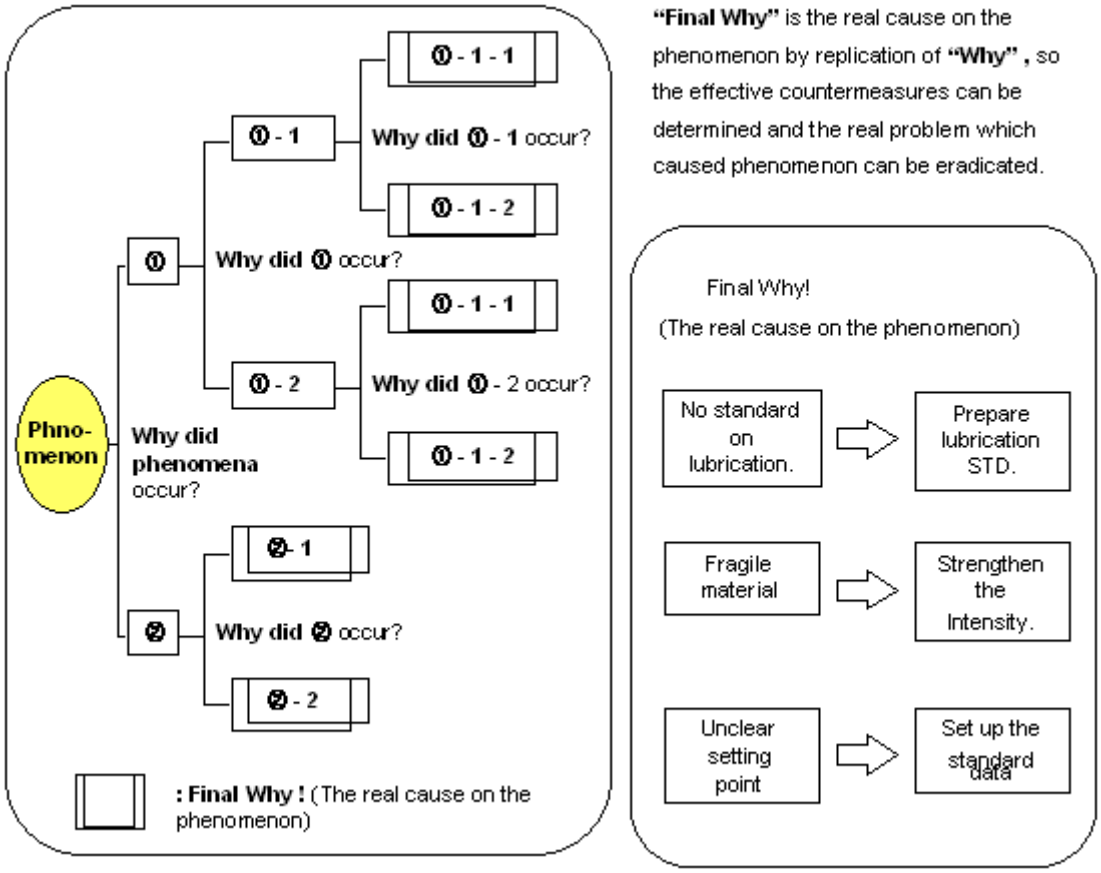
Step	Name	Procedures	Considerations
		Confirmation of results ↓ Standardization	employed carefully, the one to conduct everything at one time or the one to perform actions one by one.

3.3.3 5 Why Analysis for Extracting the Real Causes of Malfunction

(1) What is 5 Why (Know-why, Why-Why) Analysis ?

5 Why analysis is a commonly used analysis methodology for finding out the real cause which broke out the equipment failure or quality defects by repeating the "Why" until the real causes can be found.

Figure 3-8 Concept of 5 Why Analysis



(2) 5 Why Analysis Sheet

a) (Type on Pursuing the Desirable Appearance) Structure of 5 Why Analysis Sheet

Appraisal : A B C D Re-Analysis		5 Why (Know-Why) Analysis [Analysis Pursuing the Desirable Appearance]		Team L Comment	
Serial No :				P/L Comment	
Member :				Foreman Comment	
Date:	Leader:	OPL Required : Yes / No	Reflect on Maint STD : Yes / No		Applying to Others: Yes / No

Malfunction Phenomenon	Check Items	Result	Why (1 Round)	Why (2 Round)	Why (3 Round)	Why (4 Round)	Why (5 Round)	Result	Counter measures	In Charge	Improving Plan	Result
Problem Diagram												

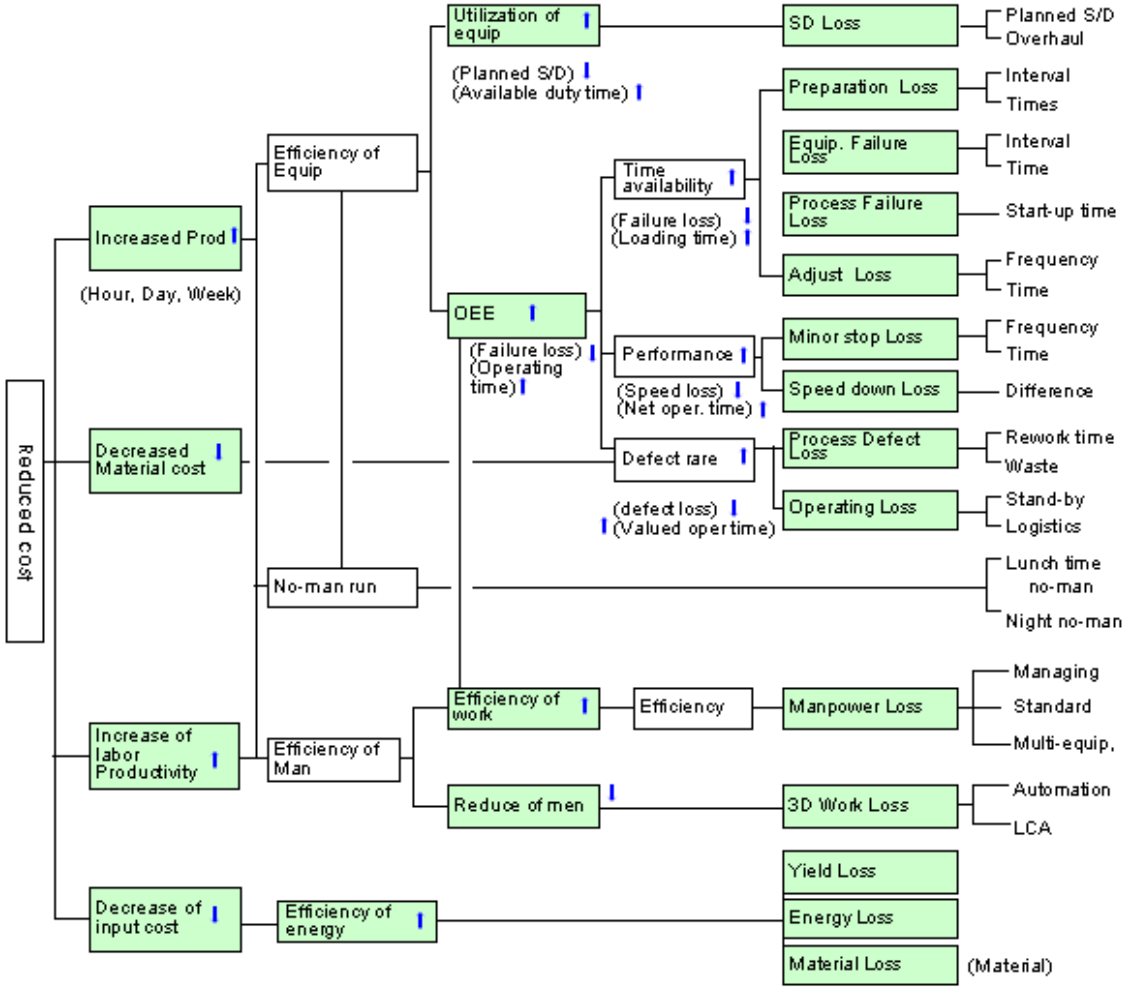
b) (Type on Pursuing the Principle & Rule) Structure of 5 Why Analysis Sheet

Appraisal : A B C D Re-Analysis		5 Why (Know-Why) Analysis [Analysis Pursuing the Principle & Rule]		Team L Comment	
Serial No :				P/L Comment	
Member :				Foreman Comment	
Date:	Leader:	OPL Required : Yes / No	Reflect on Maint STD : Yes / No		Applying to Others: Yes / No

Malfunction Phenomenon	Why (1 Round)	Why (2 Round)	Why (3 Round)	Why (4 Round)	Why (5 Round)	Result	Counter measures	In Charge	Improving Plan	Result
Problem Diagram										

3.4 Loss Removal for contributing to manufacture cost

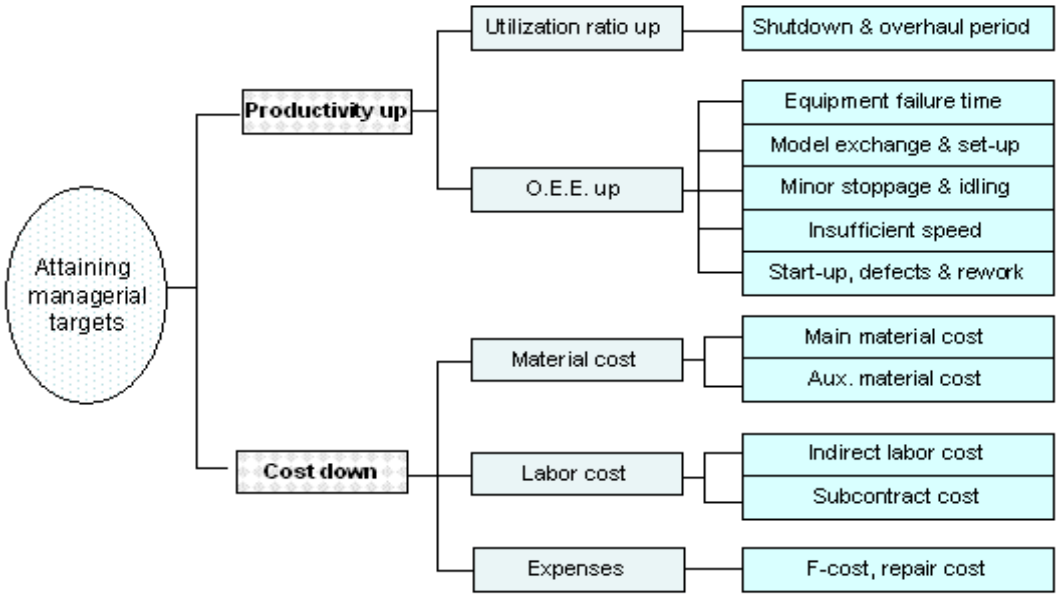
3.4.1 How Can the Loss Removal be contributed to manufacture cost ?



3.4.2 Points on the Removal of Losses hindering the Equipment Efficiency

Losses	Improvement Points	Countermeasures on improving the indices
Shutdown Loss	Reduction of shutdown loss	Design and countermeasures on curtailed Shutdown overhaul period
Production Adjustment Loss	Reduction of unplanned loss	Set-up of emergency control system in case of stoppage of power supply, water shortage, fire, and unavoidable events

Figure 3-9 . Direction of TPM Activities for Increasing Profit



3.5.2 Countermeasures for Profit-producing TPM

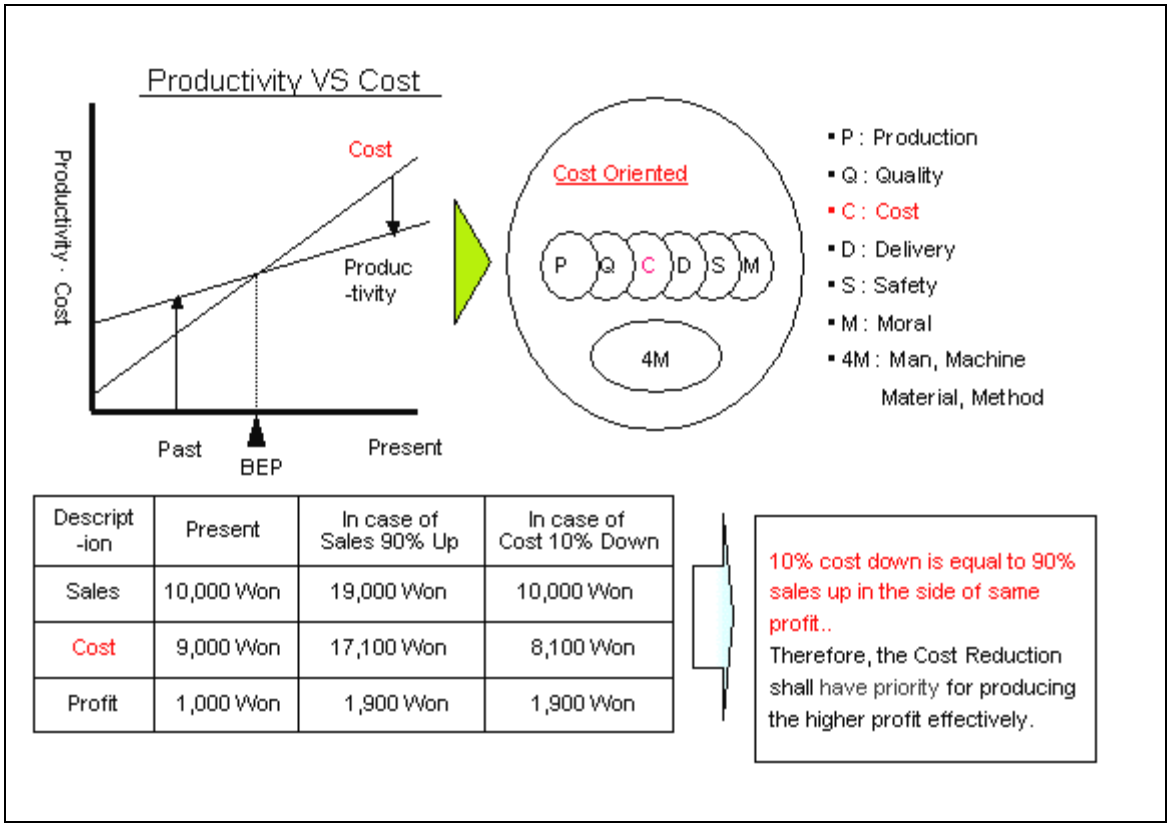
Descript-ion	Contents	Countermeasures ◁ Profit ↑ = Sales ↑ × (Unit Price ↑ - Unit Cost ↓)
Quantit-ative Phase	Increase of Sales Amount	▪ Sales division contribute to the elongation of sales and shall the priority on the timely sale of the additional products raised by Production efficiency. For this purpose, Sales division deploys SPR (Sales Process Reengineering) of TPM. ☞ Sales division's key indices linking with Production division' TPM ① Lack-of-order shutdown loss among " Planned shutdown losses" ① Excess retain rate of product stock
	Increase of Production Amount	▪ Increase of OEE by removal of equipment losses with Focused Improvement. ▪ Increase of production amount by Focused Improvement, Planned Maintenance, Quality Maintenance and Autonomous Maintenance.
Sales Price Phase	Increase of Sale Price	▪ Raise-up of product function and cost reduction by quality and technology innovation. ▪ R&D Division deploys VCI (Value Cost Innovation) of TPM for activating development activities of high valve-added product .
Cost Reduction Phase	Cost Reduction 7 Elements	▪ Cost saving activities of all divisions such as ① For decrease of material cost, Countermeasures on purchasing process, stock & inventory, Production phase ② Adequate low purchasing price, ③ Reduction of resources & energy, ④ Logistics cost, ⑤ Reduction of expense, ⑥ Efficiency of direct division, ⑦ Adequate equipment invest, etc.
	Cost Reduction by TPM	▪ Decrease of 16 losses hindering production efficiency such as ① Equipment loss, ② Manpower loss, ③ Material and energy loss

3.5.3 Importance of Cost Reduction in the side of Manufacturing Competitiveness

The Speed of improving productivity cannot catch up the one of uprising cost in the time of now market-in circumstance different from the past product-out time.

The Cost Reduction shall have priority for producing the higher profit effectively as in the below.

Figure 3-10 Importance of Cost Reduction in the side of Manufacturing Competitiveness

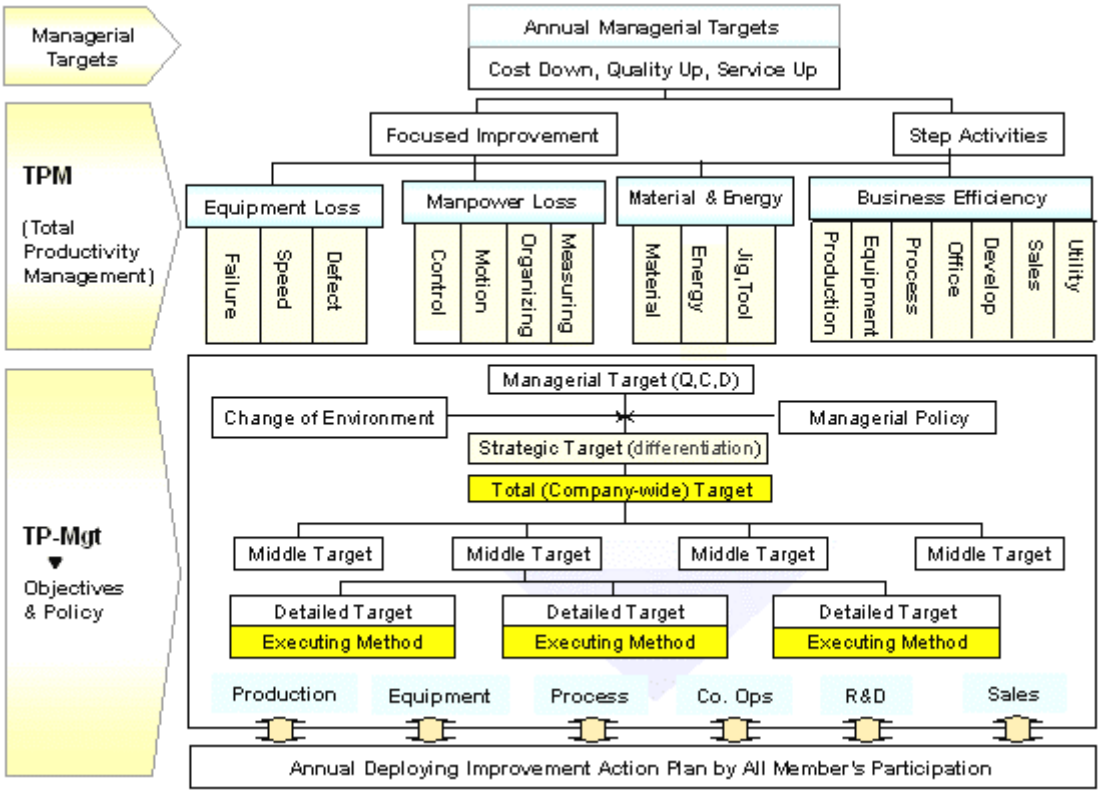


Descript -ion	Present	In case of Sales 90% Up	In case of Cost 10% Down
Sales	10,000 Won	19,000 Won	10,000 Won
Cost	9,000 Won	17,100 Won	8,100 Won
Profit	1,000 Won	1,900 Won	1,900 Won

3.6 Set-up of Annual Managerial Targets in TPM

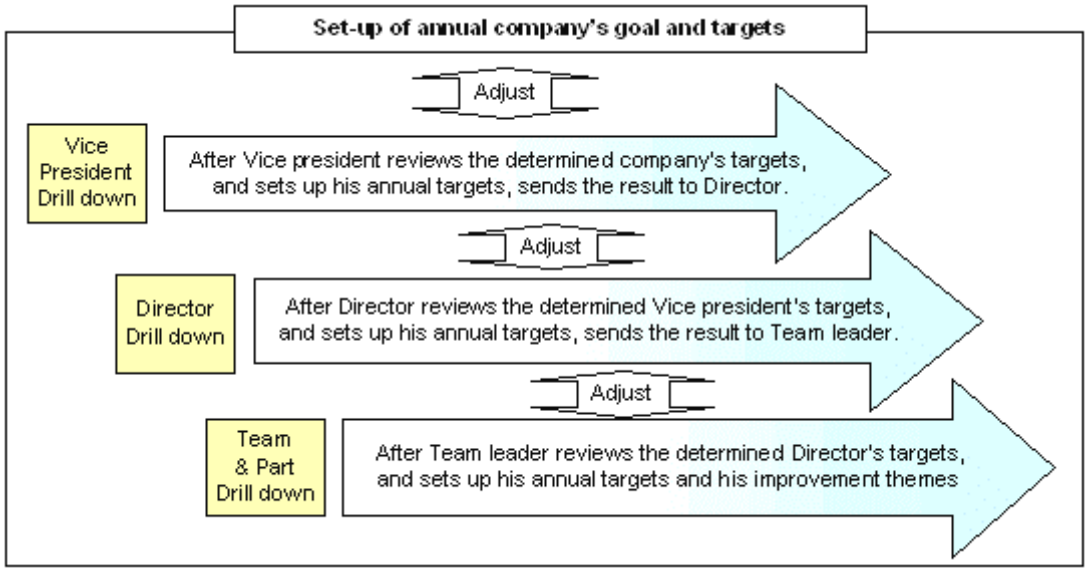
3.6.1 Set-up Structure of Annual Managerial Targets in TPM

Figure 3-11 Set-up Structure of Annual Managerial Targets



3.6.2 CTQ Drill down Logic of each Class

Targets of each class – Division, Director and team – are drilled down and the improving themes are set up to attain the annual company's goals and objectives.

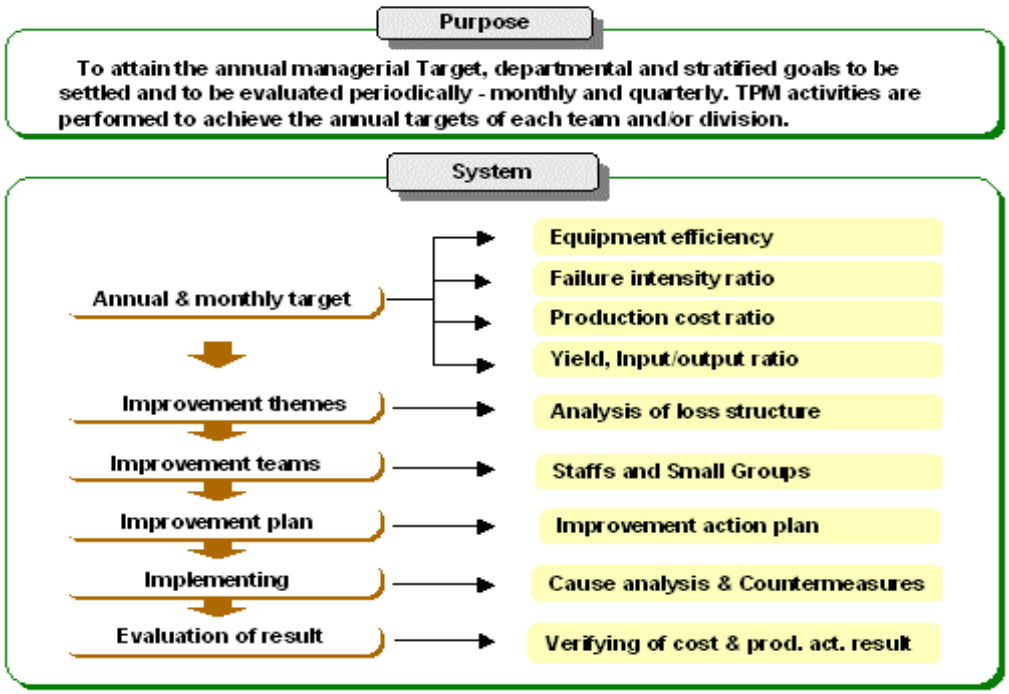


3.6.3 Target-setting Guidelines for Major Indices

Fields	Major Indices		Unit	B / M	Recommending Annual Targets	
				Y 2007	Y 2008	Y 2009
P (Productivity)	Productivity per man		Ea/Person	Present value	10% Up compared by BM	10% Up compared by Y2008
	Valued added productivity		Won/Person	Present value	10% Up compared by BM	10% Up compared by Y2008
	OEE (Overall Equipment Efficiency)		%	Present value	20% Up of gap	20% Up of gap
	Failure Intensity rate		%	Present value	30% Down 20% of gap	30% Down of gap
Q (Quality)	Product defect ratio		PPM	Present value	50% Down of gap	50% Down of gap
	Yield		%	Present value	20% Up of gap	20% Up of gap
	Customer complaints		Items/Year	Present value	50% Down of gap	50% Down of gap
C (Cost)	Product stocks		Won/Year	Present value	30% Down of gap	30% Down of gap
	Manufacturing cost		Won/Year	Present value	10% Down compared by BM	10% Down compared by Y2008
D (Delivery)	Preparation & replacing time		Min/Year	Present value	30% Down of gap	30% Down of gap
S (Safety)	Accident		Times/Year	Present value	50% Down of gap	50% Down of gap
M (Morale)	Proposal	Send-out	Items/M,Year	100	130	150
		Accept ratio	%	100	130	150
	Small groups	Improvement theme	Items/Small group,Year	100	130	150
		Self-learning (OPL*)	Items/Small group,Year	100	200	400
	Clean-up	Improvement Items	Items/Small group,Year	100	200	300

3.7 Activity Procedure for Focused Improvement

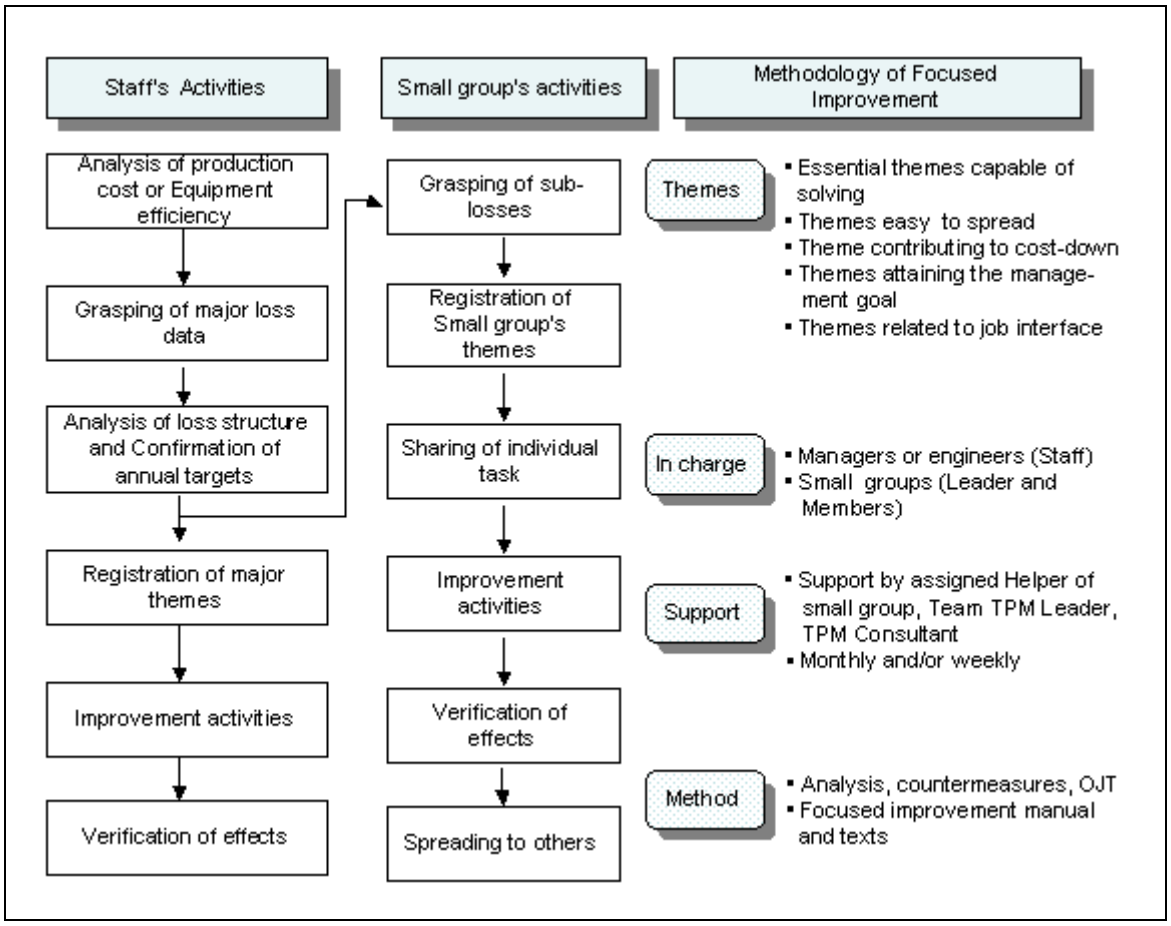
3.7.1 Methodology for Achieving Annual TPM Targets



3.7.2 Progressing Methodology of Focused Improvement

Focused improvement is to be performed by Team staffs and TPM small groups to attain the annual managerial targets such as production cost ratio, labor productivity after the loss analysis of production cost and equipment efficiency.

Figure 3-12 Progressing Methodology of Focused Improvement



3.8 Annual Deploying Procedure for Focused Improvement Activities

No	Activity Procedure	Focused Improvement Activity Contents	Activity Method
1	Recognition and grasp of losses	* Grasp of losses hindering the cost, efficiency & productivity - Management : Sales, Profit, Production output - Productivity: OEE, Productivity per person, Failure intensity rate, Failure time, Failure times, Failure frequency rate, etc. - Q: Defect ratio of process & product,	* Refer to effect evaluation indices in TPM general manual & focused Improvement manual. * Refer to the detailed check list for improvement theme finding of each organization in focused

Theme Step	Activity Contents	Recommended Tools
Background analysis of theme	* Recognition of losses and analysis of problem. (Equipment overall efficiency, Failure intensity rate, Failure frequency rate, Failure times, Etc.) * Analysis of reliability and maintainability (MTBF, MTTR, Etc.).	* Pareto analysis * Graph analysis
Determination of theme	* Selection of improvement theme : Poor efficiency and equipment and/or process capable of applying to others easily. * Criteria on selecting the process or equipment to be improved as below. - Process with low efficiency. - Process capable of applying to others easily. - Bottleneck process, process with big losses. - Theme corresponding to Model Equipment helped by Team leader. - Process corresponding to Team leader's policy or annual targets.	* Matrix diagram * Brain storming
Set-up of step plan	* Organize the improvement team and share the small group's duties. * Set-up the detailed implementing plan of improvement theme	* Graphs
Collecting data	* Survey the parts to cause the problems. - Capability analysis and confirmation of bottleneck process. * Extraction of malfunctions and list-up of them. * Grasp the fundamental conditions and eight big losses.	* New QC 7 tools * QC 7 tools * IE Tools * OEE and Subordinates
Cause analysis	* Cause analysis of malfunction or problem. - Use of PM analysis and 5-Why analysis tools. * Utilization of inherent manufacturing technology.	* PM analysis * FMEA / FTA * 5 Why analysis
Set-up of target	* Set-up of improvement targets - Grasp the level which shall be attained. Set the target to challenge the "Zero" level with the active mind * Set-up the attainable target reasonably.	* Bar Graph
Set-up of countermeasures	* Set-up the countermeasures for improving the problem or malfunctions.	* PM analysis * FMEA * 5 Why analysis
Implementation of countermeasures	* Implement the improvement plan after determining the Implementing priority.	* PDCA cycle
Grasping effects	* Analyze the gap, that is, the difference between target and result.	* QC 7 Tools
Standardization & on-going control	* Standardize the improved results into the related business standards.	* Control chart * Graphs
Reflection & next plan	* Reflect the step-by-step process of theme and review the application to others.	

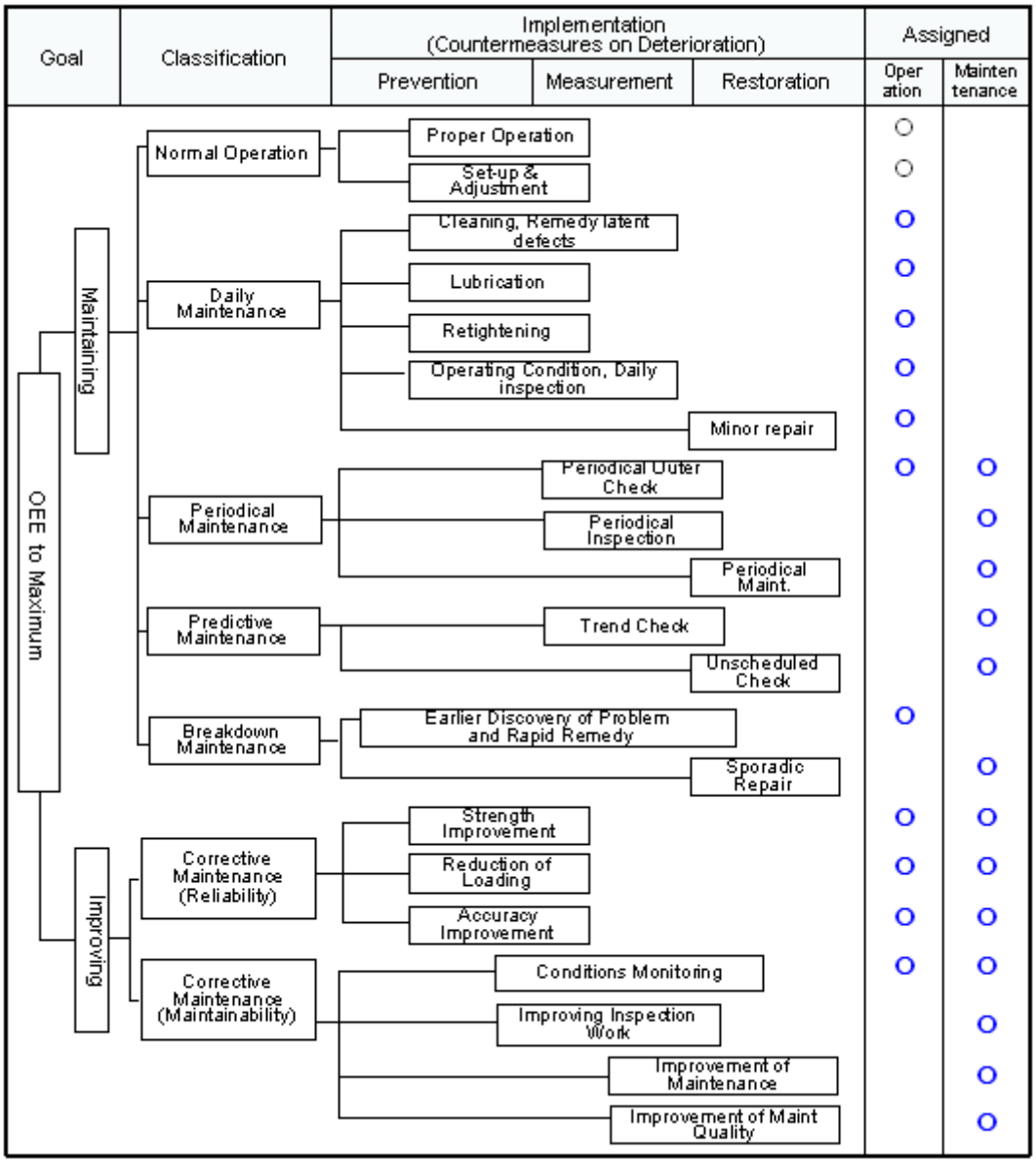
Chapter 4 Practice for Autonomous Maintenance

Contents

(2) Support to autonomous maintenance activities by operating division

The importance of autonomous maintenance activities centering on activities to prevent deterioration has been mentioned earlier. This can be accomplished only if the maintenance division provides precise guidance and support. The operating division looks to the maintenance division for the following concerning equipment maintenance :

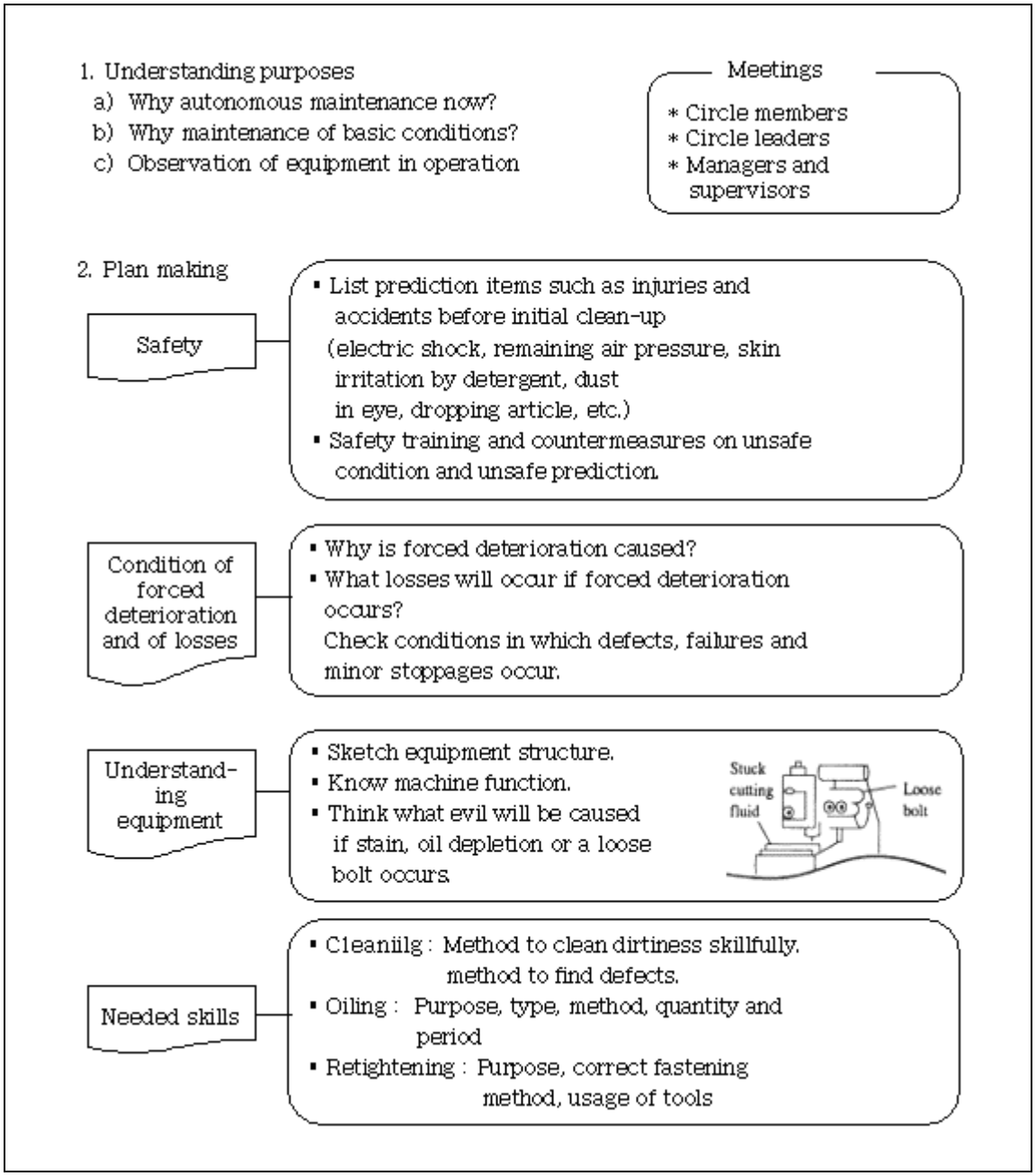
Figure 4-3 Classification of Maintenance and Responsibility



a. Support contained in Steps 1 to 3 of autonomous maintenance.

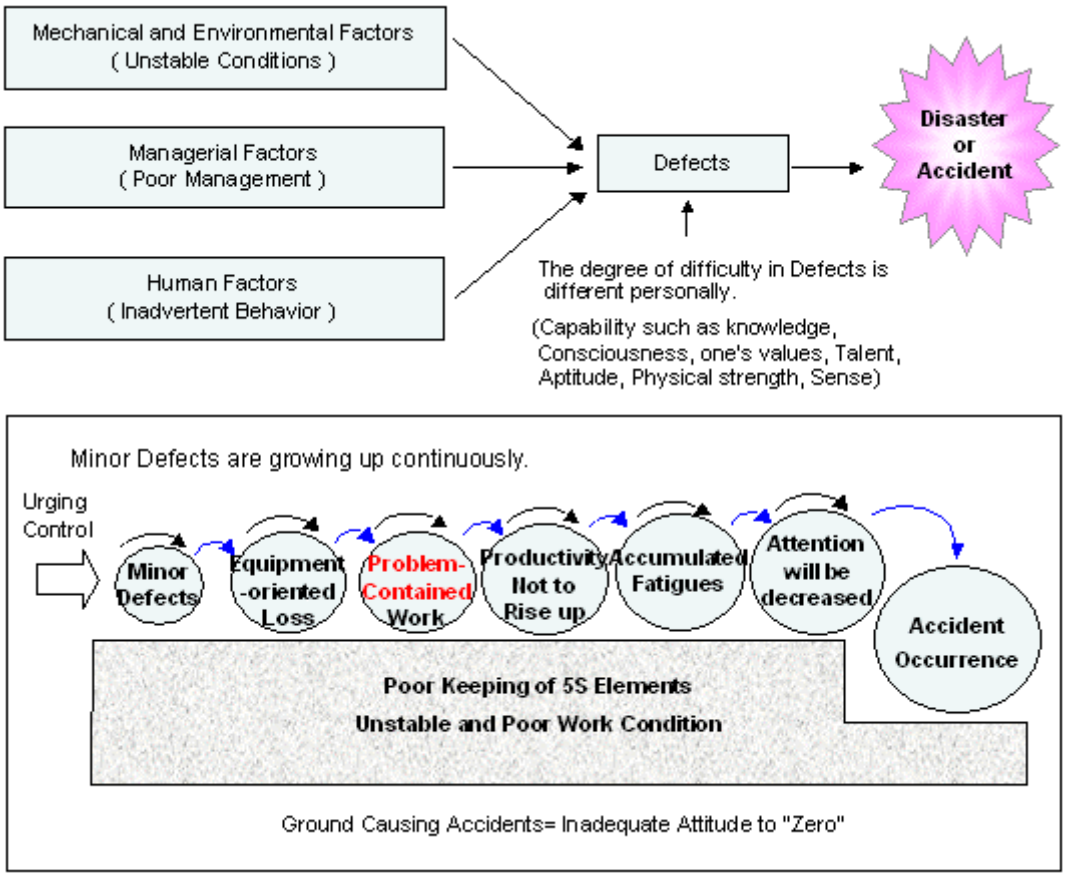
* Training and guidance of equipment structures and functions, names of parts

Figure 4-4 Outline of Step 0 (Preparation)



c. Draw a simple illustration of equipment for which you have responsibility, to identify its mechanism and to understand the types of possible trouble if the equipment is poorly maintained, as well as to remember each component of the equipment.

e. Safety Consideration for preventing Accident



(2) 7 steps for evolving autonomous maintenance

Basic composition of the 7 autonomous maintenance development steps consists of the following 3 stages.

▶ 1st stage : This stage consists of completion of the basic conditions of equipment and establishment of the system to maintain the conditions during the step 1 through step 3, which are mainly equipment cleaning and inspection.

As a process to change the equips8ent through autonomous maintenance development, the following requisites :

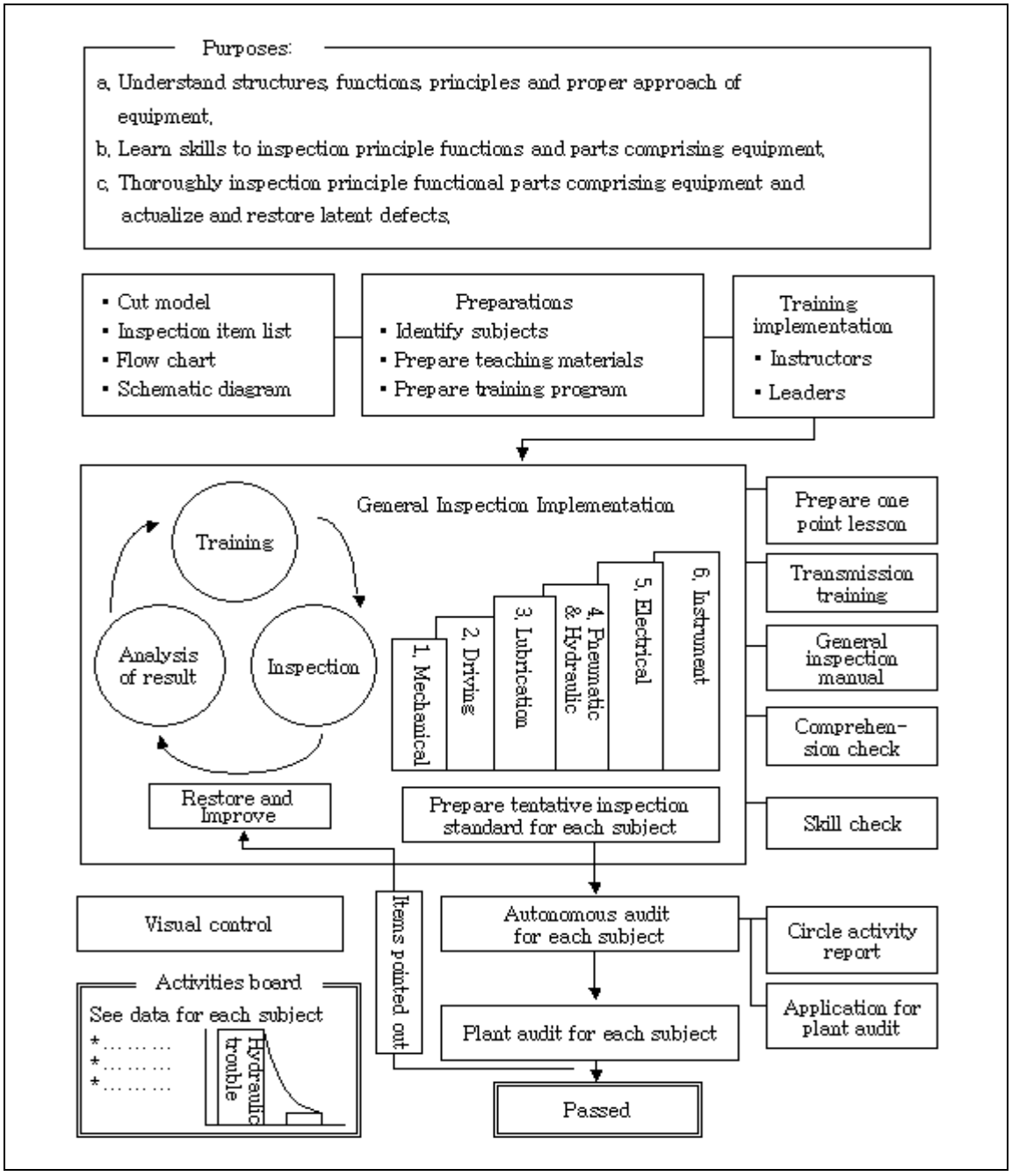
* Cleaning is inspection
* Inspection is performed to find defects
* Defects are to be restored and then improved, shou1d be understood, and this process is also important to thoroughly understand the concept "to make efforts, to devise, and to think."

Step	Activities	Target		Guidance and promotion
		Equipment	Operator	
	implementation of MTBF analysis and recording (Recording failures by visual control) and equipment improvement	data analysis * Keeping overall equipment efficiency at its best	skill to perform minor repair by oneself * Acquisition of data recording and analyzing technique and improvement technology	training in repair skills

Table 4-2 Deployment of Autonomous Maintenance (Assembly)

Step	Activity	Description	Purpose	Gudline and implementation
1	Initial Clean-up	* Remove all unnecessary articles from work areas and other p1aces. * Ordering and tidiness of jigs, tools and parts. * Clean dust and dirt in work areas.	* To think of the proper approach to work areas by tidying and cleaning work areas by one's self. * Recognize importance of 5S.	* Guide on decision as to which are unnecessary articles, approach to tidiness and importance of 5S. * Prepare diagnosis sheet. * Responsibility sharing and operation
2	Countermeasure for the causes of dirty equipment and improving access to hard to clean areas*	* Implementation of source control measures for unnecessary articles. * Source control measures for dirt, stains and blemishes. * Measures to control splashing of dirt stains. * Measures to control attaching of dirt and stains.	* Pursuit of ease of orderliness and tidiness. * Think of what generation sources, viewed from 5S, blocking quality in assembling products are.	* Arousing consciousness as to problems. * Approach to and implementation of process improvement. * Implementation and new ideas on visual control.
3	Prepare tentative 5S standard	* Preparation standard to correctly maintain orderliness, tidiness, cleanliness and cleaning in a short Lime. * New ideas and improvements in ease of checking and visual control.	* Set standard, taking method to maintain process provided in Steps l and 2 and thorough observation of rule into consideration.	Guidance of role consciousness resolutely decided and strictly Followed by ones' self. * Method used to write standards. * Prevention of wrong and missing parts.
4	General inspection	* Acquire knowledge and skills by check manual.* * Extraction and restoration of minor defects by general inspection.	* Understand product structures and functions. * Understand quality guarantee rules. * Define proper approach to tools, jig's, meters	* Preparation and creation of teaching materials for general inspection training. * Map out training schedules.

Figure 4-13 Outline of Step 4 (General Inspection),



(5) Step 5 : Autonomous Inspection

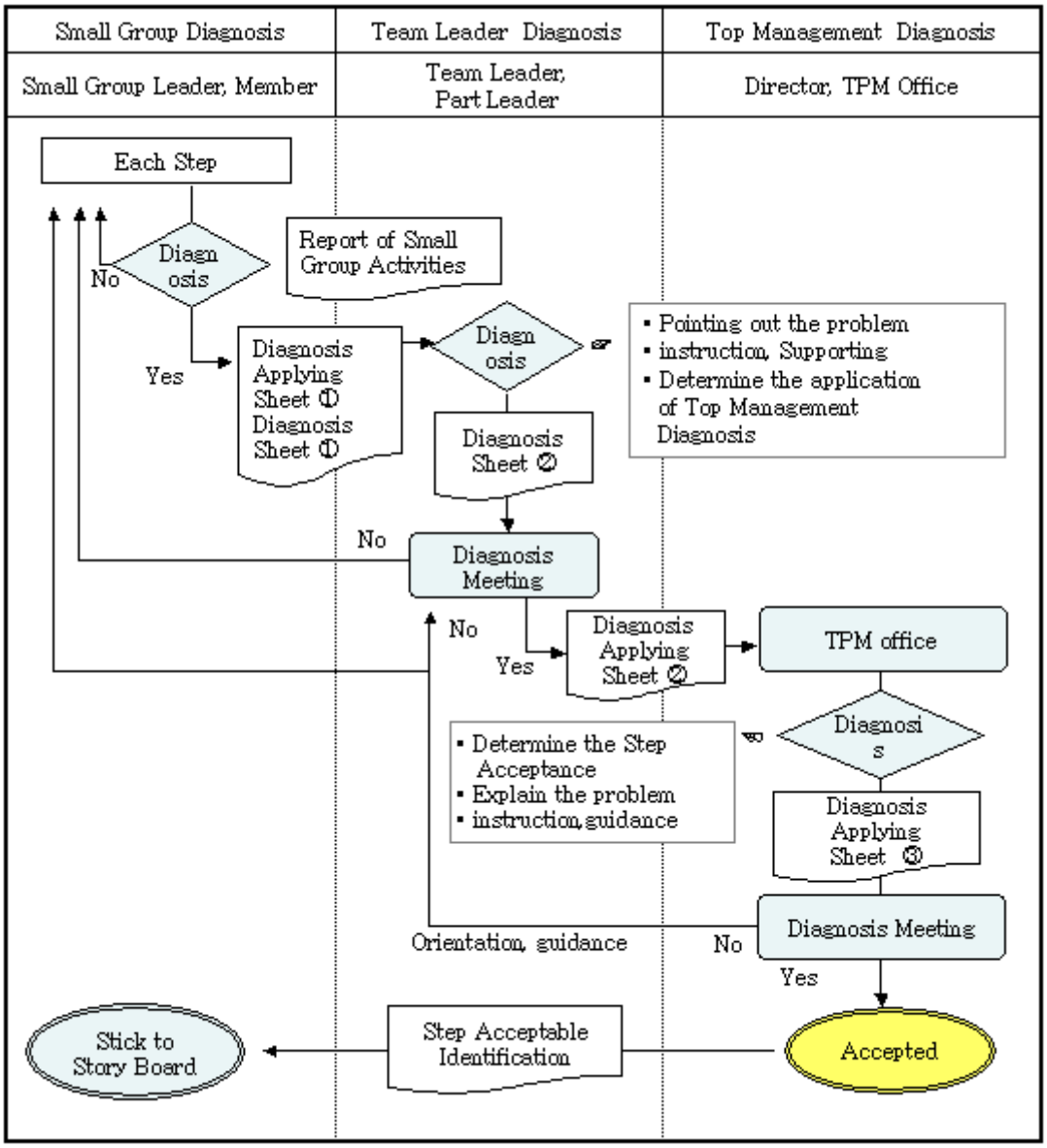
(a) Purposes of activities

Equipment deterioration and restoration condition accomplished in Steps 1 to 4 must be maintained and improved to further enhance equipment reliability, maintainability and

Therefore, instead of mere judgment of acceptance or rejection, it is important for the diagnosing group to clarify the future challenges to not only the cire1e members, but also the person who has responsibility for diagnosis should address it through discussion with the circle members.

Mere pointing out of the trouble points which need further improvement to the cire1e members should be avoided. Instead, it is important to try to discover the excellent points in the circle members to make the most of their characteristics.

Figure 4-19 Diagnosis Flow



TPM Deploying Guidebook (Vol. 1)

The Key to Competitiveness and Profit-Producing

Author	Kwon Oh-Woon
Author's Certificate	Ph. D (Industrial Engineering) P.E (Quality Control) T.C (Production Control)
Author's Career	28 Years (TPM Consulting & Education)
Publisher	ATPM Consulting Inc.
Revised Status	First Edition : January 6, 2008 3rd Edition : October 15, 2016
ISBN	978-89-93219-10-4-98500
Purpose	TPM Deploying Practice