TPM Series: No.11

TPM Deploying Guidebook

(Vol. 2)

The Key to Competitiveness and Profit-Producing

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Chapter 5 Planned Maintenance System

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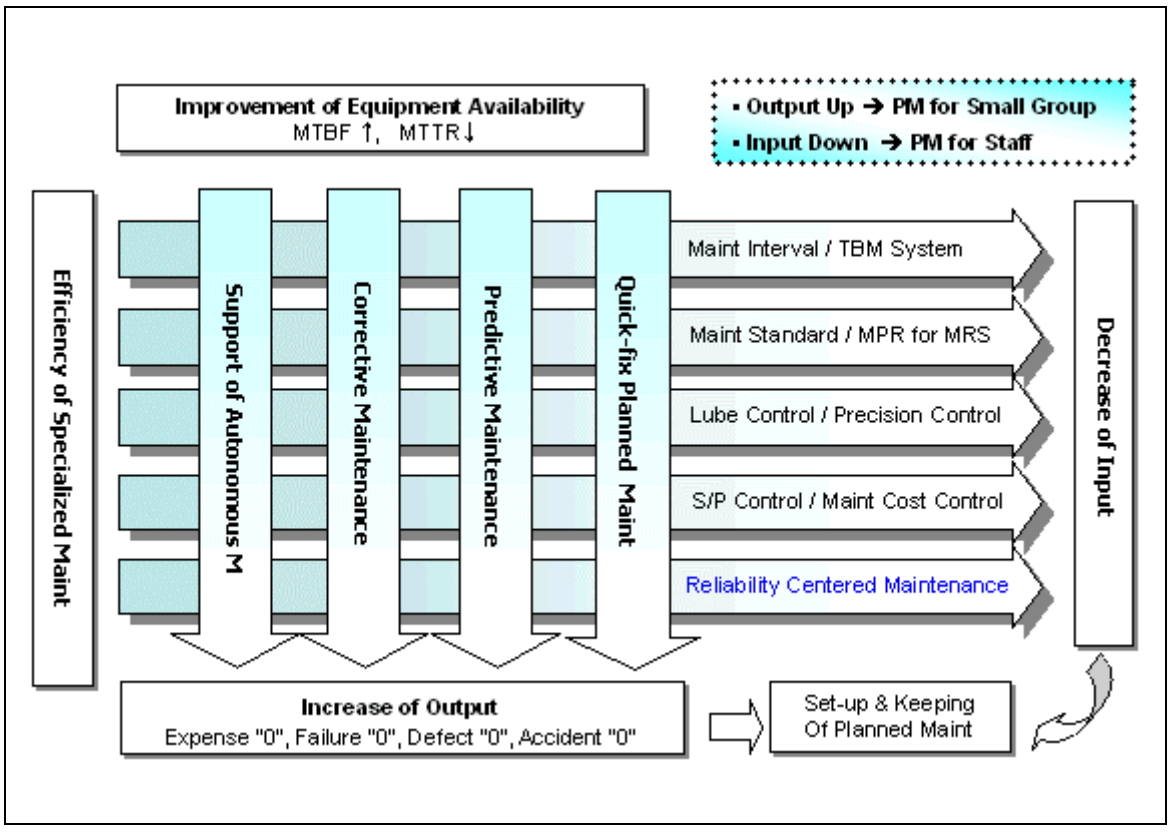
5.1 Basic Concept of Planned Maintenance

5.1.1 Purpose of Planned maintenance

Planned maintenance is the specialized maintenance for the staffs and small groups of Equipment Engineering Teams to secure the improvement of equipment availability, the decrease of maintenance cost, and the elongation of equipment longevity by the systematic planned maintenance, predictive maintenance, and planned breakdown maintenance as the maintaining activities, and also the corrective maintenance as the improvement activity.

Planned maintenance is composed of activities for increasing the output and decreasing the input as shown in the Figure 5-1.

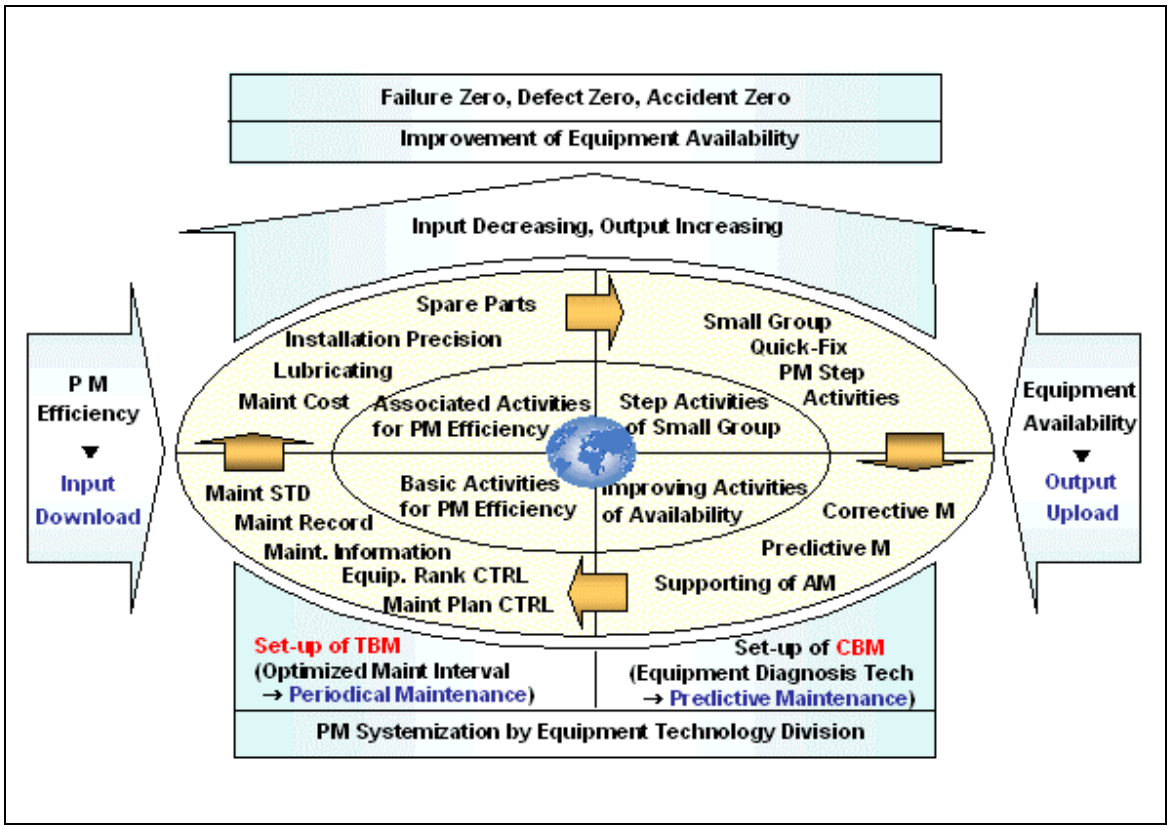
Figure 5-1 Composition of Planned maintenance



5.1.2 Elemental Constitution System of Planned Maintenance

Planned maintenance is composed of functional activities for specialized maintenance as shown in the Figure 5-2.

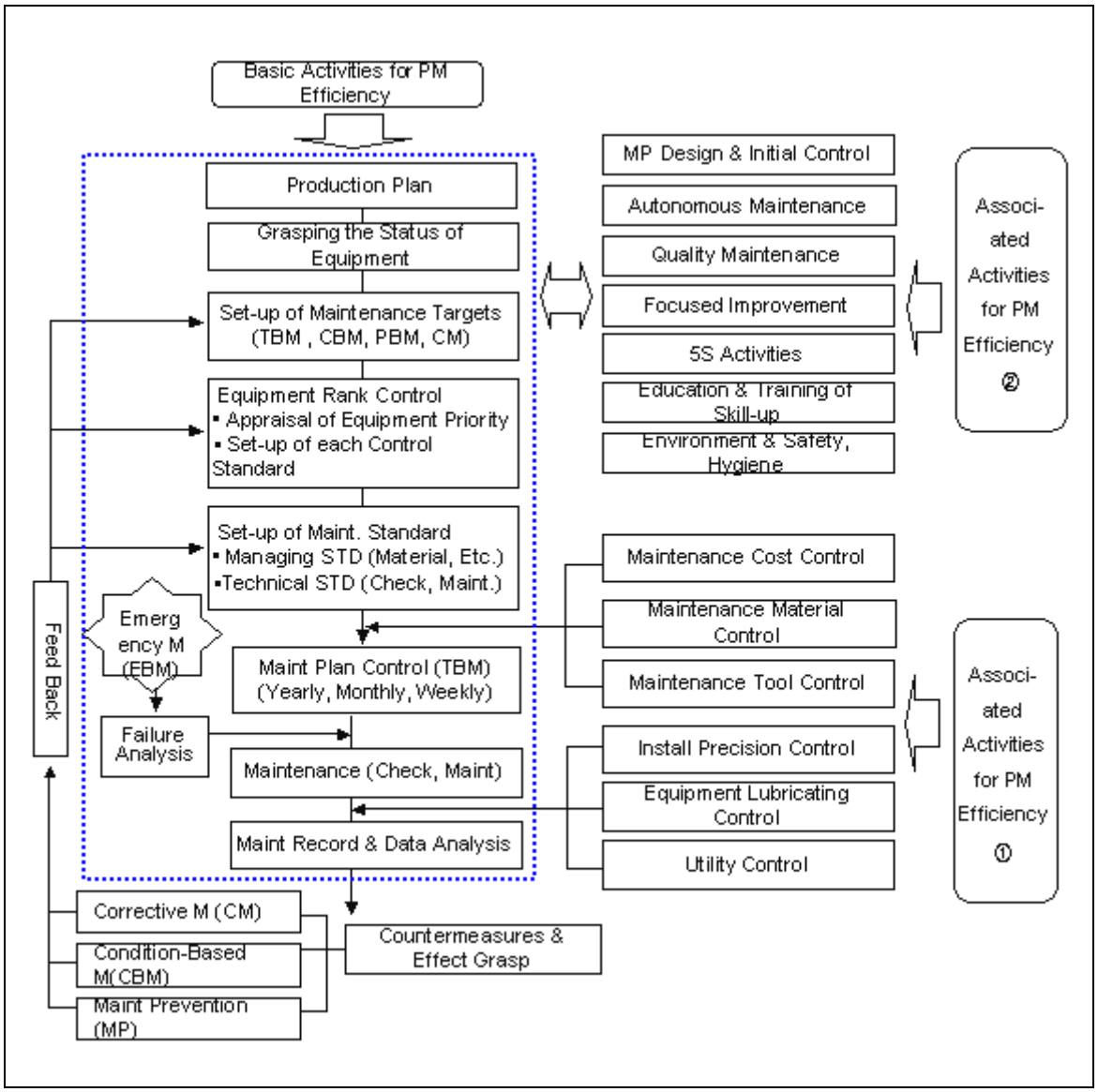
Figure 5-2 Elemental Constitution System of Planned Maintenance



5.1.3 Flow and Composition of Planned Maintenance Activities

Specialized maintenance is composed of functional activities according to maintenance work flow for specialized maintenance as shown in the Figure 5-3.

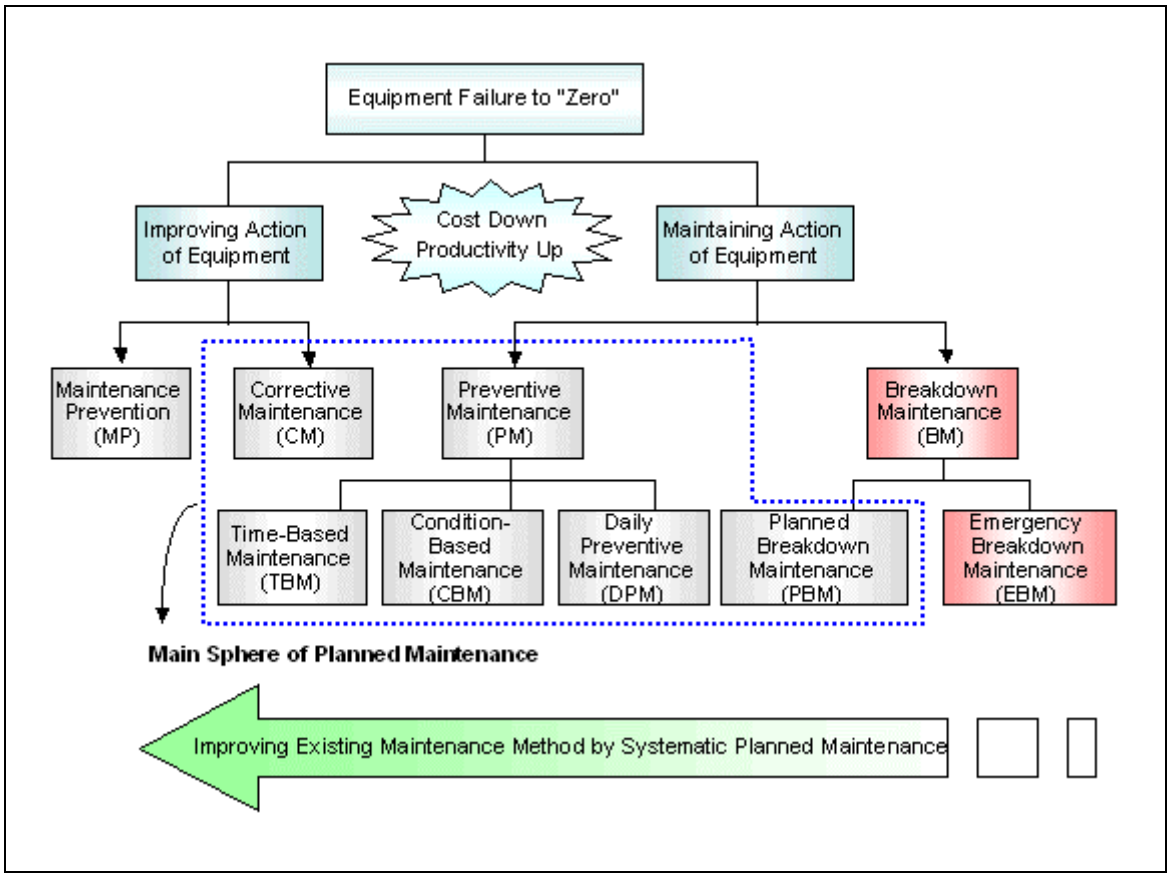
Figure 5-3 Flow and Composition of Planned Maintenance Activities



5.1.4 Specialized Maintenance for Reducing the Equipment Failures

Planned Maintenance is pursuing the improvement and maintenance of equipment for the prevention of unexpected line stoppage and equipment failure loss to zero as shown in the Figure 5-4.

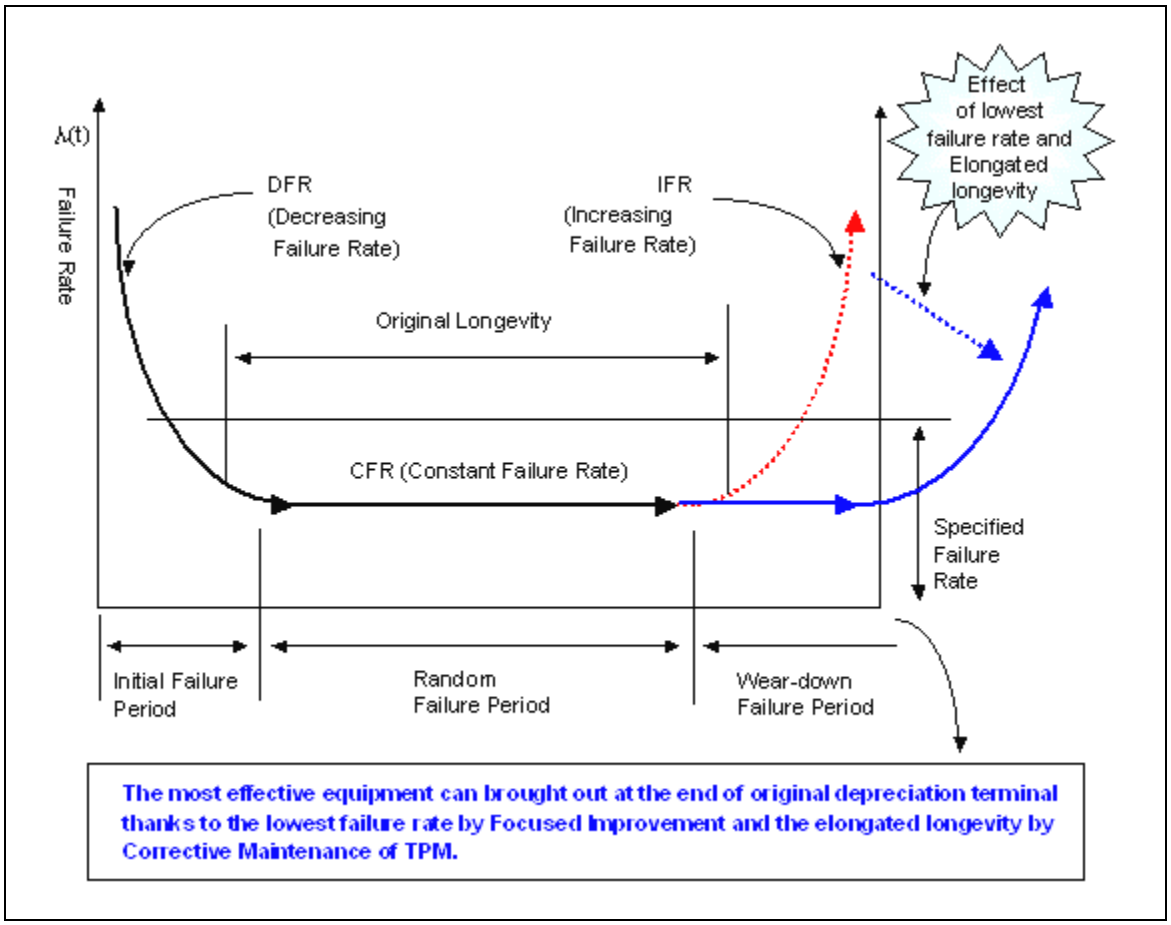
Figure 5-4. Specialized Maintenance for Reducing the Equipment Failures



5.1.5 Typical Patterns on Equipment Failure Rates (Bathtub Curve)

Planned Maintenance is pursuing the lowest failure rate and elongated longevity of equipment as shown in the Figure 5-5 by the Step activities of Planned Maintenance and Focused Improvement in TPM.

Figure 5-5 Typical Patterns on Equipment Failure Rates (Bathtub Curve)



5.2 Classification of Maintenance Activities

There are mainly the following two classifications of maintenance measures used to realize maintenance goals, and they should be implemented simultaneously.

* Upkeep activities : to prevent failures, to fix failures
* Improvement activities : to extend life span, to shorten maintenance time, to avoid maintenance.

The above four items are the autonomous maintenance activities of the operation division

On the other hand, the principles for the maintenance division are as follows :

① Autonomous maintenance activities of the operation division should be technically supported.

Figure 5-8 Allotment and Classification of Maintenance

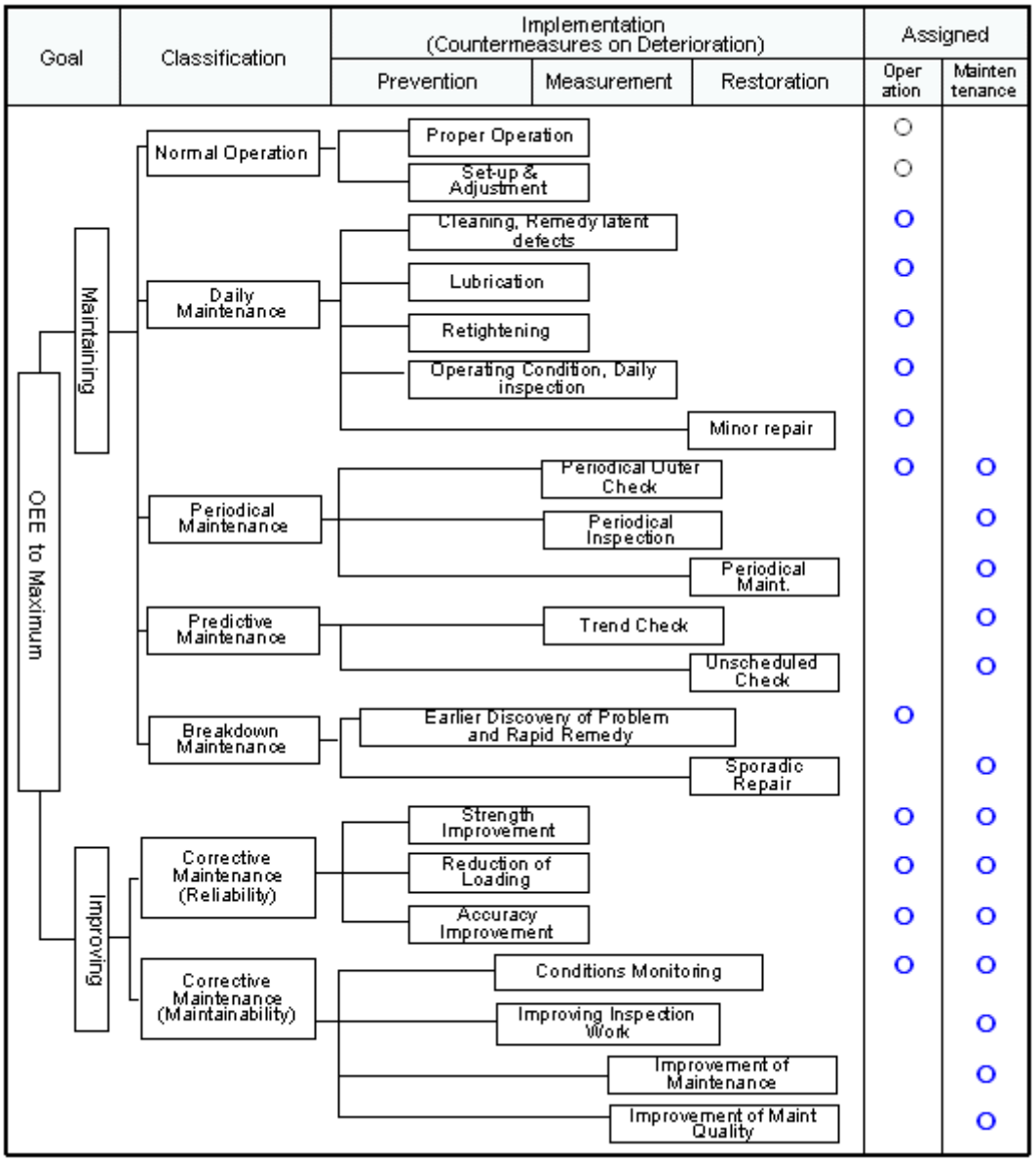
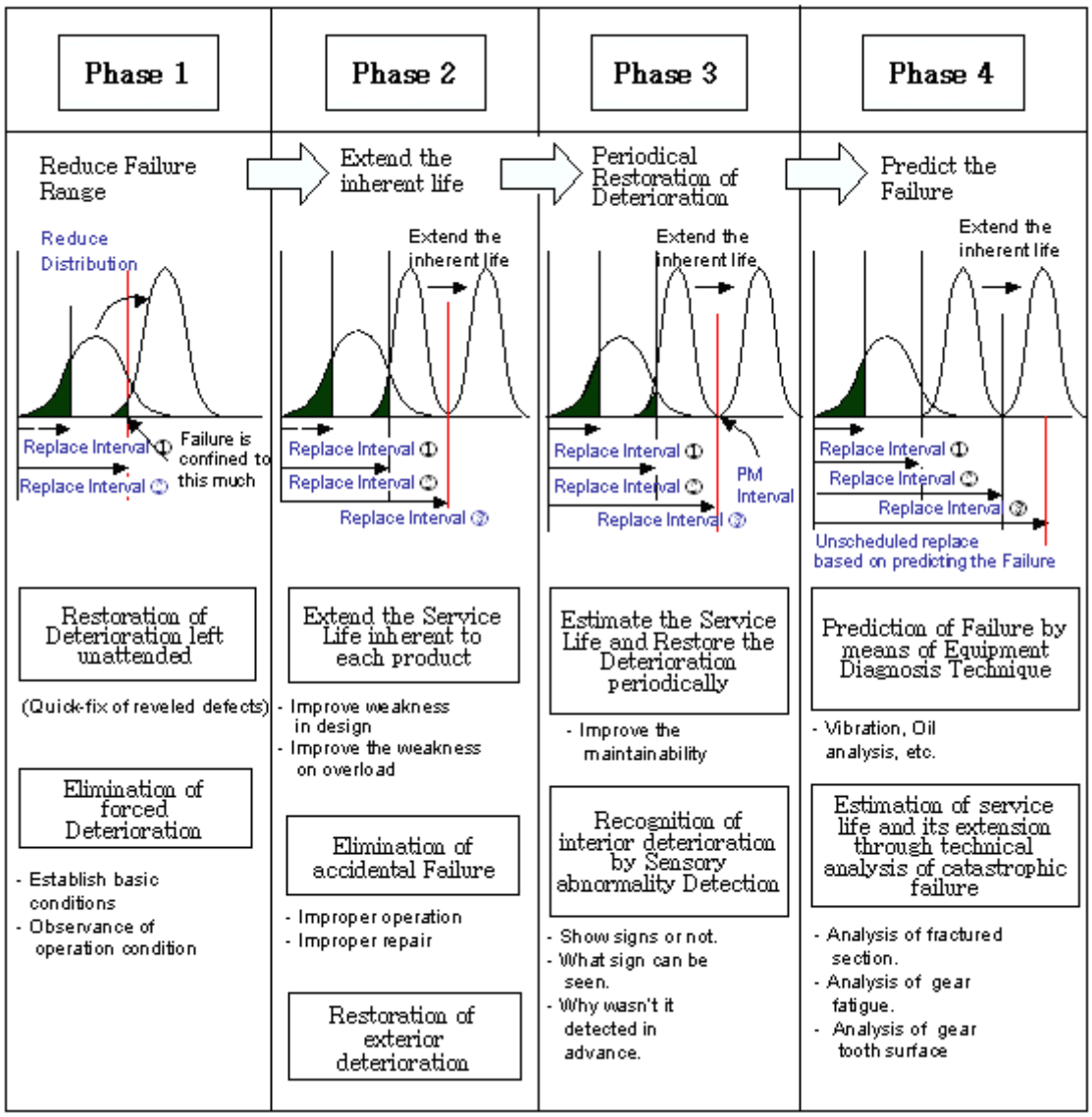


Figure 5-11 4 Phase to Failure Zero



5.6 Approach toward Maintenance Planning

Even if we are going to execute maintenance as planned and economically, if failures occur constantly and intervals of failures are scattered, it is impossible to make a plan. Therefore, measures against failures should be implemented in accordance with the four phases indicated at the left.

(4) Breakdown Maintenance

This is a method to be applied when the restoration after failure is economically better. It is important to note that there are lot of places for breakdown maintenance and to increase this item by corrective maintenance and others.

5.8 Maintenance Management System

Figure 5-13 An Example of Maintenance System

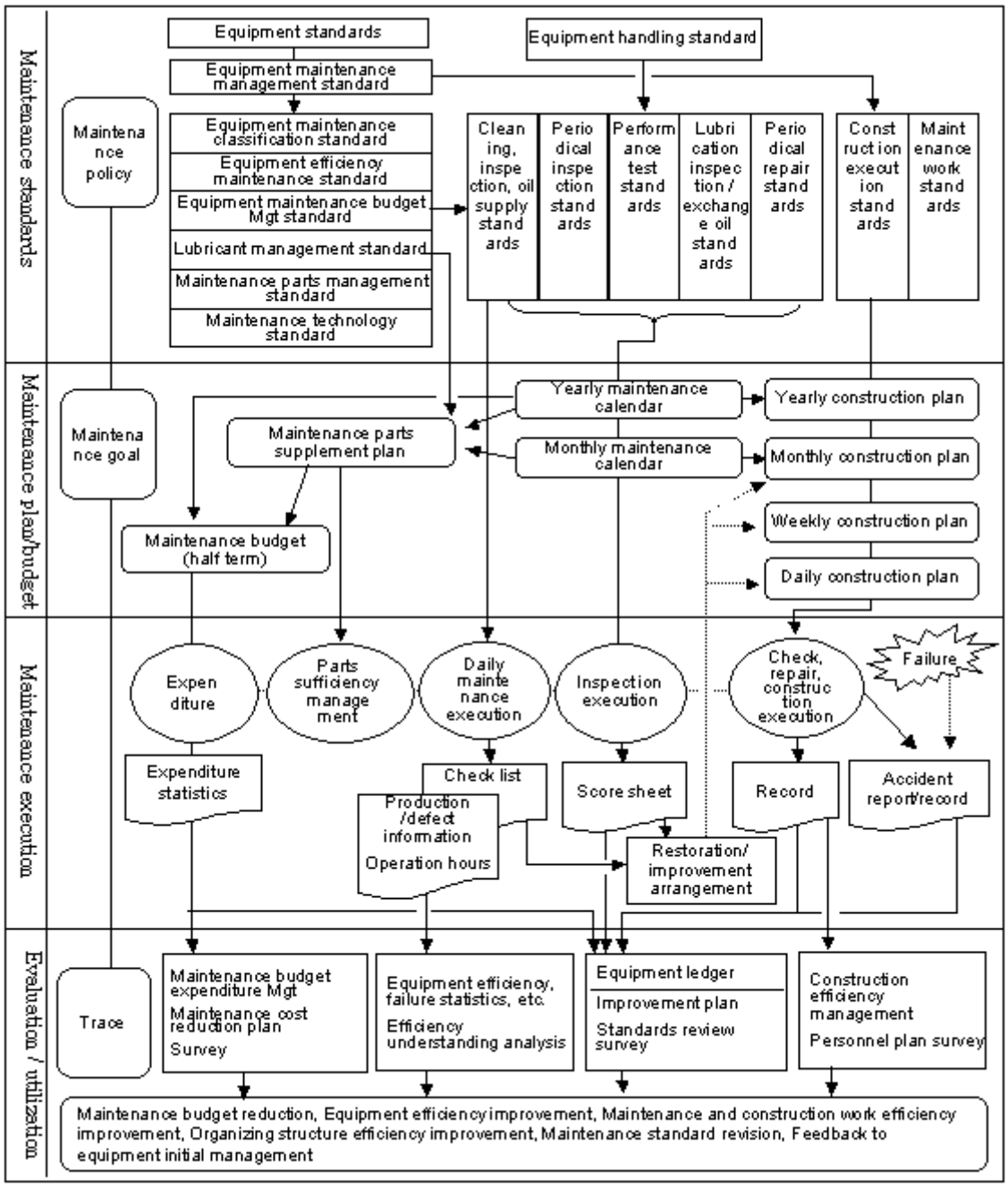


Figure 5-19 Flow Chart for Maintenance Records

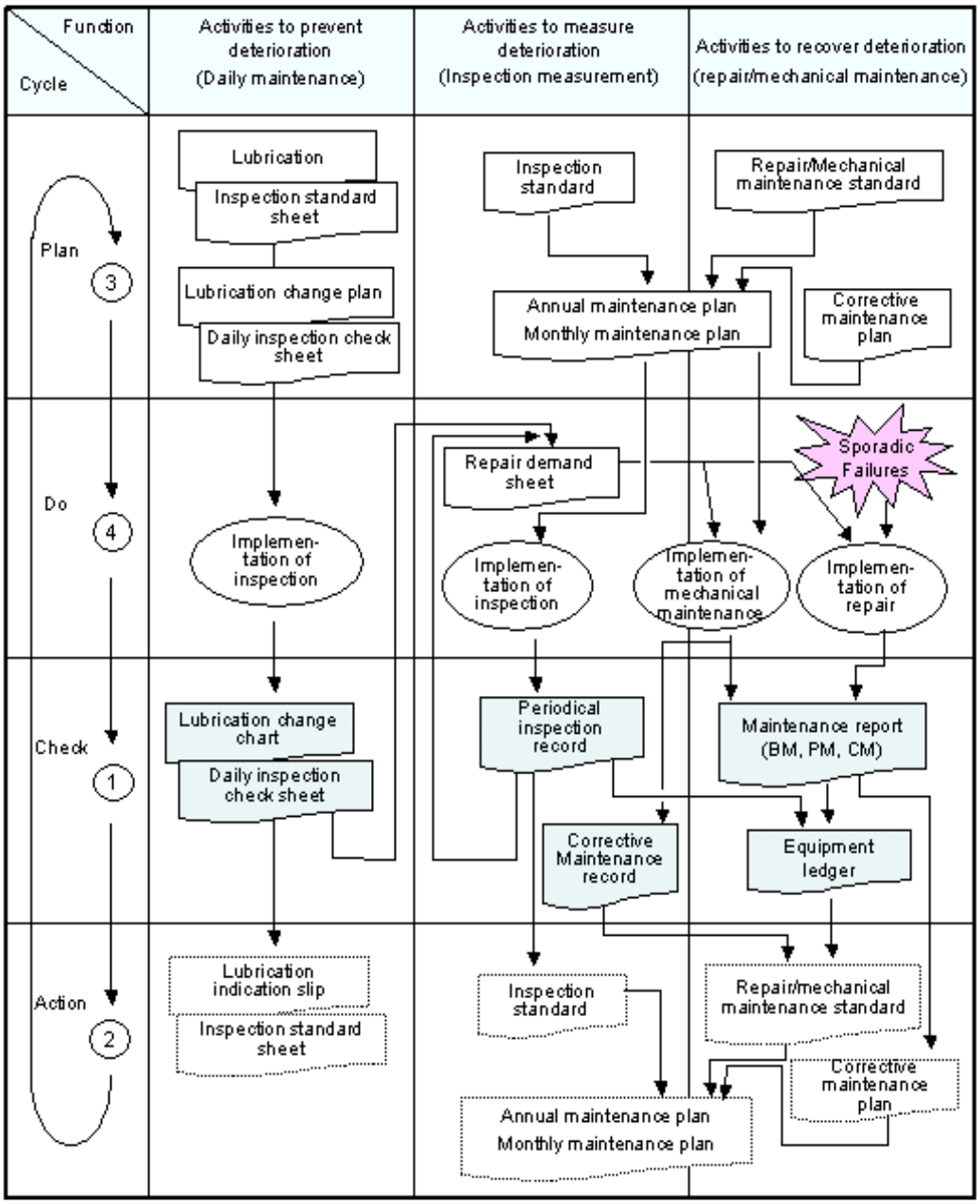


Table 5-05 Overview on Diagnosis Equipment

No.	Diagnosis equipment	Outline of diagnosis
1	Machine checker	From the amount of vibration generated by the machine, diagnosis as good or bad the imbalance of gears, bearings and rotors.
2	Rotating machine diagnosis equipment	By the analysis of vibration waveform or vibration mode, degree, position and cause of deterioration of gear, bearings and rotating mechanisms should be judged.
3	Machine signal measuring device	Single of vibration, pressure, etc. should be processed and disposed for easy analysis.
4	Wide use signal analysis device	As frequency resolving power Is very strong, the vibration waveform is an analysis for the ultra precision diagnosis and deteriorating place and cause of bearings and gears should be judged.
5	Crack monitor	By detecting the sound generated at the development of crack, degree and level of danger of crack development should be diagnosed
6	Ferrography analysis device	By the shape or size of abrasive power in lubricant abrasion of sliding surface should be judged.
7	Super megar (DC high voltage method)	By the changes of insulation resistance during the time, humidity and pollution should be judged.
8	Automatic insulation diagnosis device (AC high voltage method)	By the side, phase, degree of change of leakage current (current in ground wire) in the case that AC high voltage is added, the degree of deterioration of insulation should be judged.
9	Electric coil diagnosis device	By the side, duration, changes of vibration frequency when big current surge is added in the coil and vibrated, the loosening of coil by the deterioration of insulation should be judged.
10	Rectification characteristic measurement device	By measuring rectification flux distribution at neutral point and contact characteristic of brush, the cause of rectification defects should be analyzed by the comparison with normal situation.
11	Frequency characteristics measurement device	A signal which does not affect the product quality is added to the operative control device, and the frequency characteristic including electric and mechanical characteristics should be measured.
12	Thyristor fail tracer	The waveform at each part during the irregularity of thyristor control device (mainly gate pulse) should be automatically recorded and reused.
13	High voltage cable insulation diagnosis device	By the size and changes during the time of leakage current with the addition of a DC current addition, deterioration should be judged.
14	Analyzer of gas in oil.	By analyzing flammable gas composition in oil, the destruction of insulation or local heating should be judged

Figure 5-31 Concept and Responsibility in Planned Maintenance

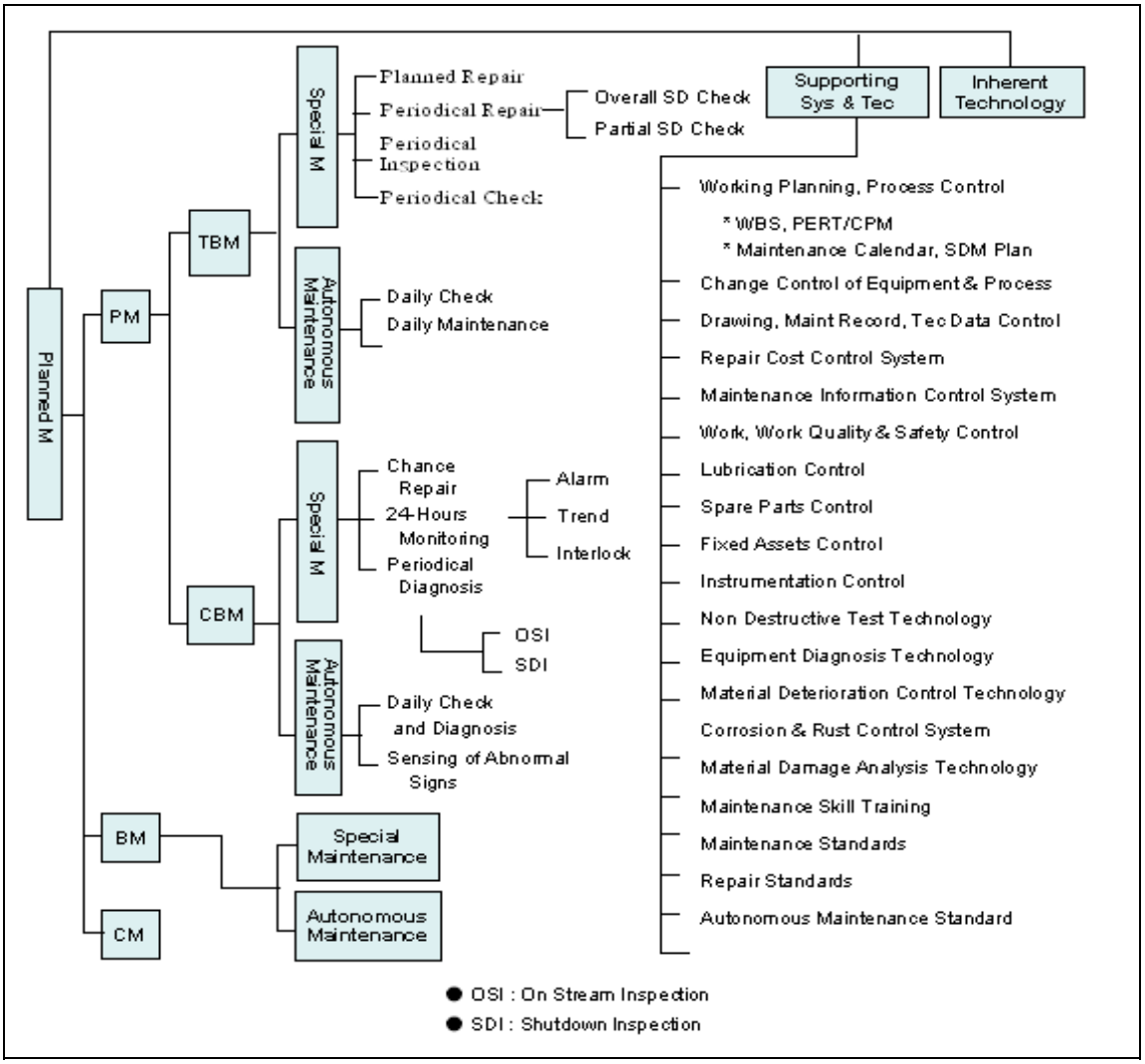
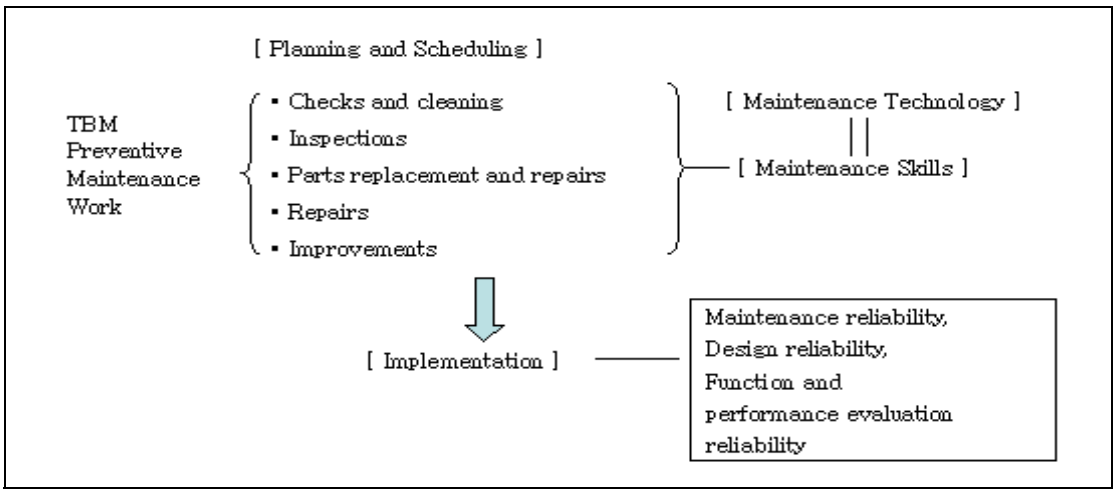


Figure 5-32 Preventive Maintenance by TBM



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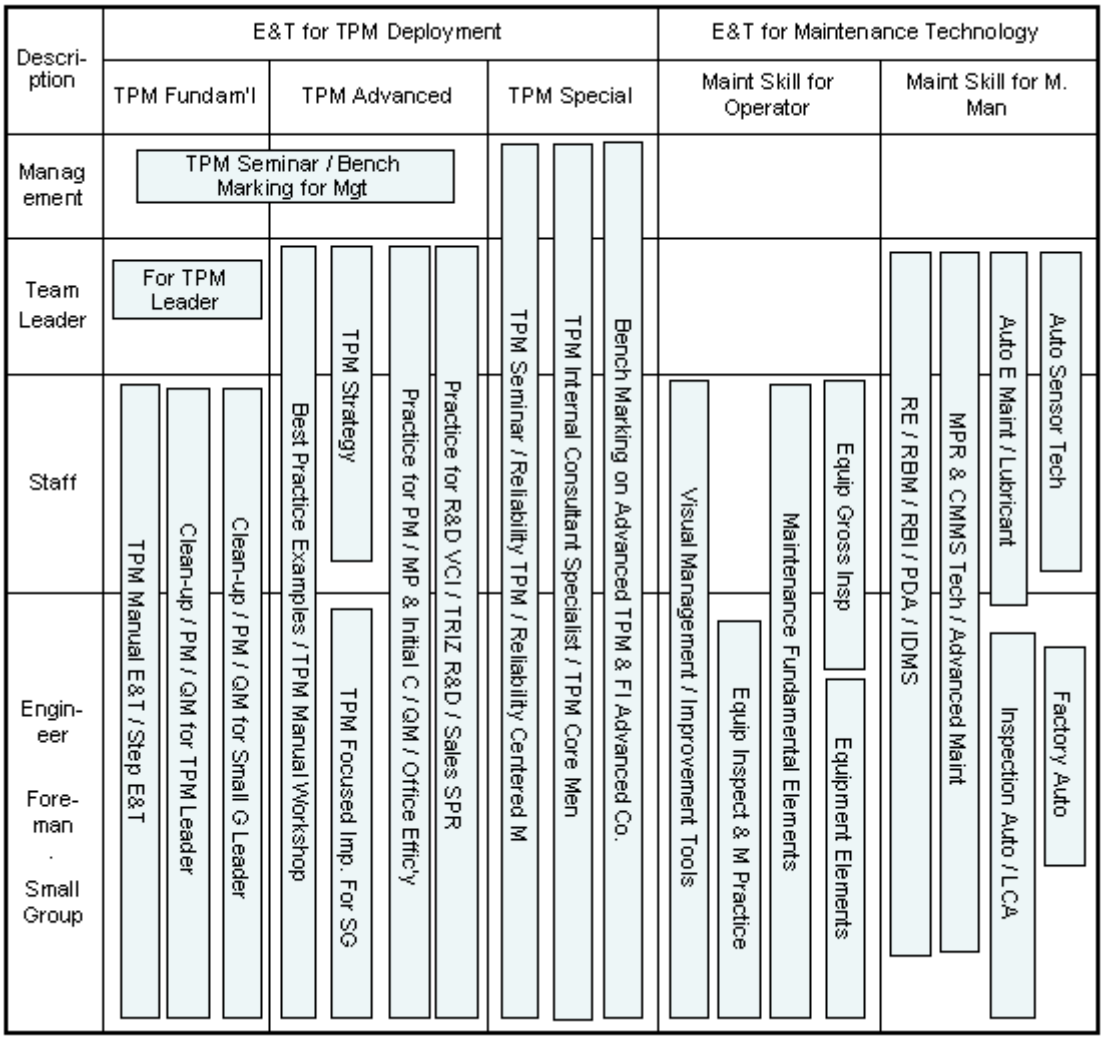
6.7 Education and Training System of Each Class for TPM



6.8 Profile of MP Design

(1) What is MP Design?

MP(maintenance prevention) design is activities to design equipment that does not fail and generate defects when introducing new equipment.

The activities study weaknesses of present equipment and feed them back to design to enhance equipment reliability. The ultimate dream is to design equipment which is maintenance-free.

Chapter 7 MP Activities and Initial Control

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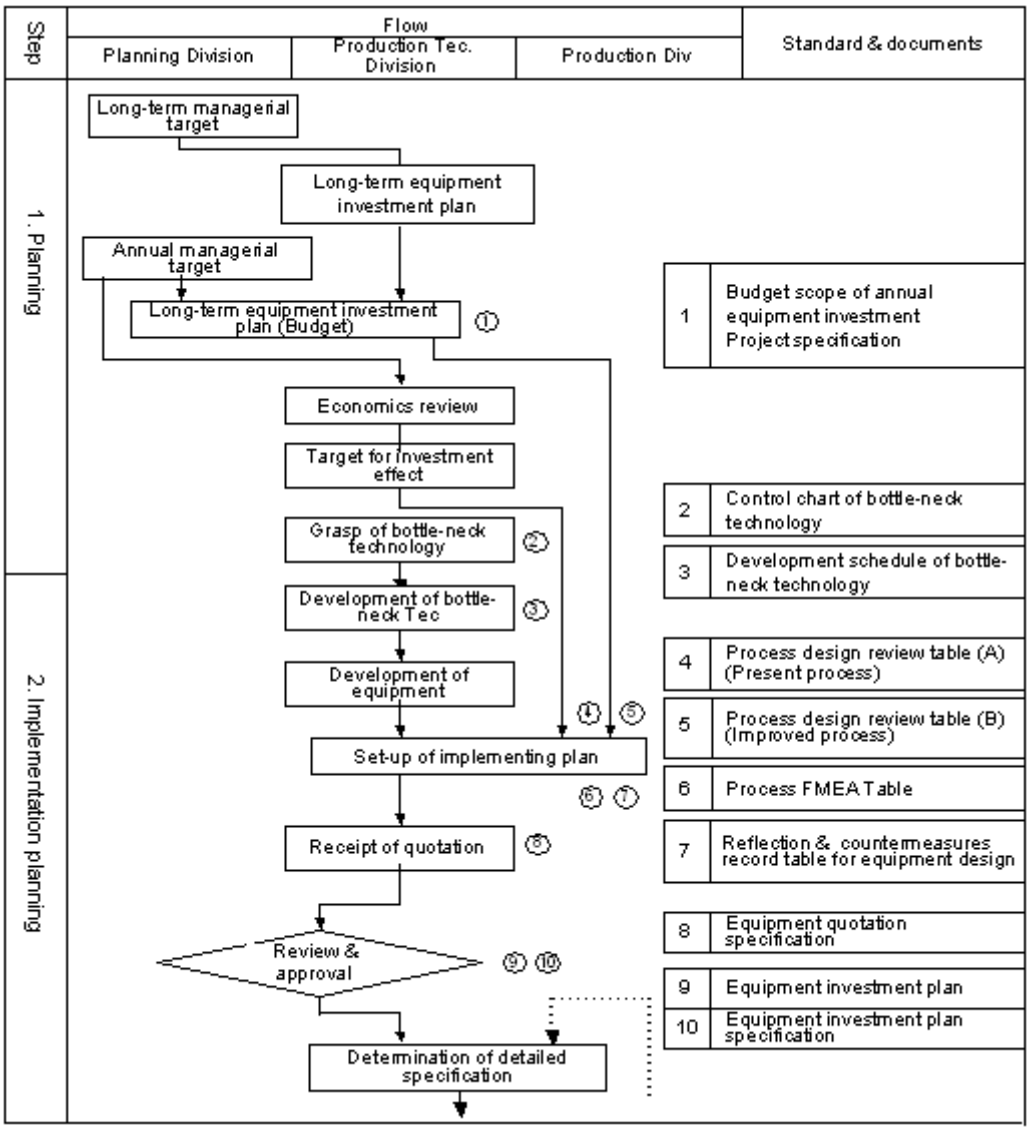
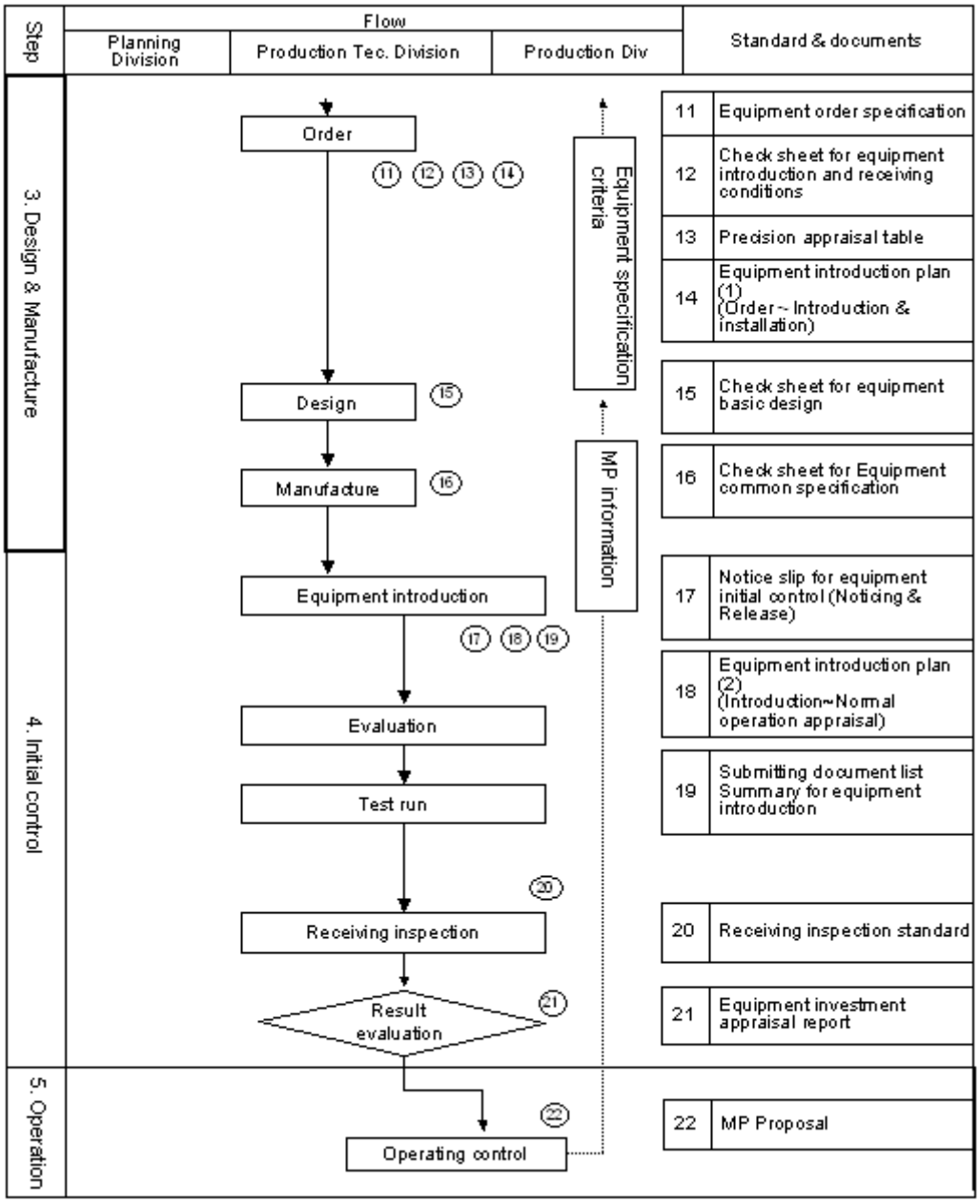
Figure 7-2 Example of MP Activities System (2)





7.3 Basic Characters Which Equipment Must Possess

Basic concepts of equipment design can be divided as follows based on the standpoint of effective utilization of equipment mentioned above.

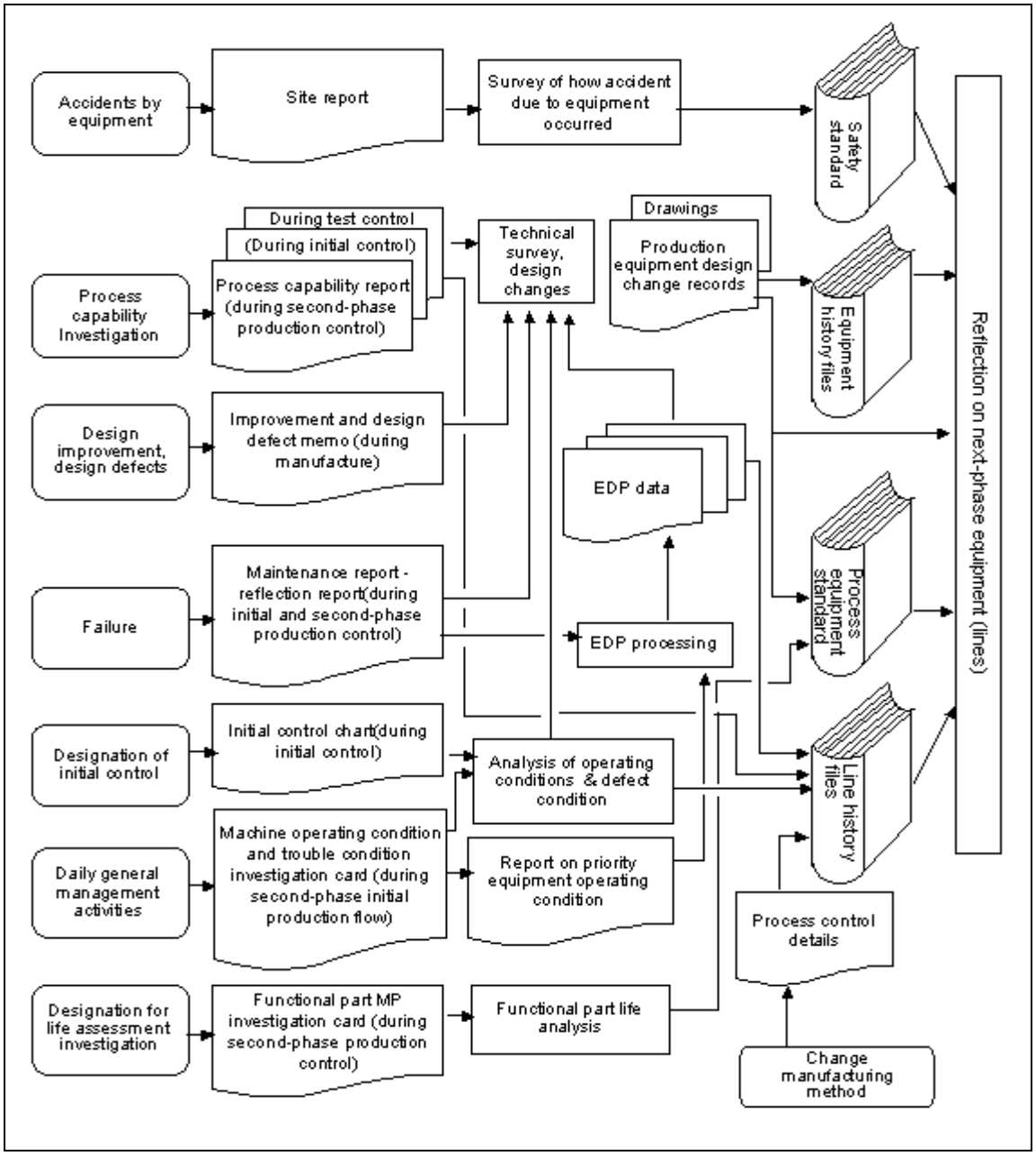
In many cases, equipment designed to accomplish the above purposes does not necessarily demonstrate the required functions.

7.5.2 Design Standard Based on MP Information

Table 7-3 is excerpts of a standard which is based on MP information.

This standard has a realness that vividly describes failures in daily PM activities and work difficulties. The information is concrete and is detailed incorporating line information from the standpoint of "know why.

Figure 7-5 MP Information Feedback and Standardization (Example)
(Source : Nippon Denso Co., Ltd.)

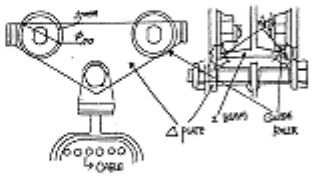
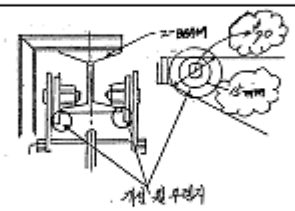


(3) Streamlining route for MP suggestions

Figure 7-7 shows an example of routing for MP suggestions.

Figure 7-7 Example of MP Suggestion

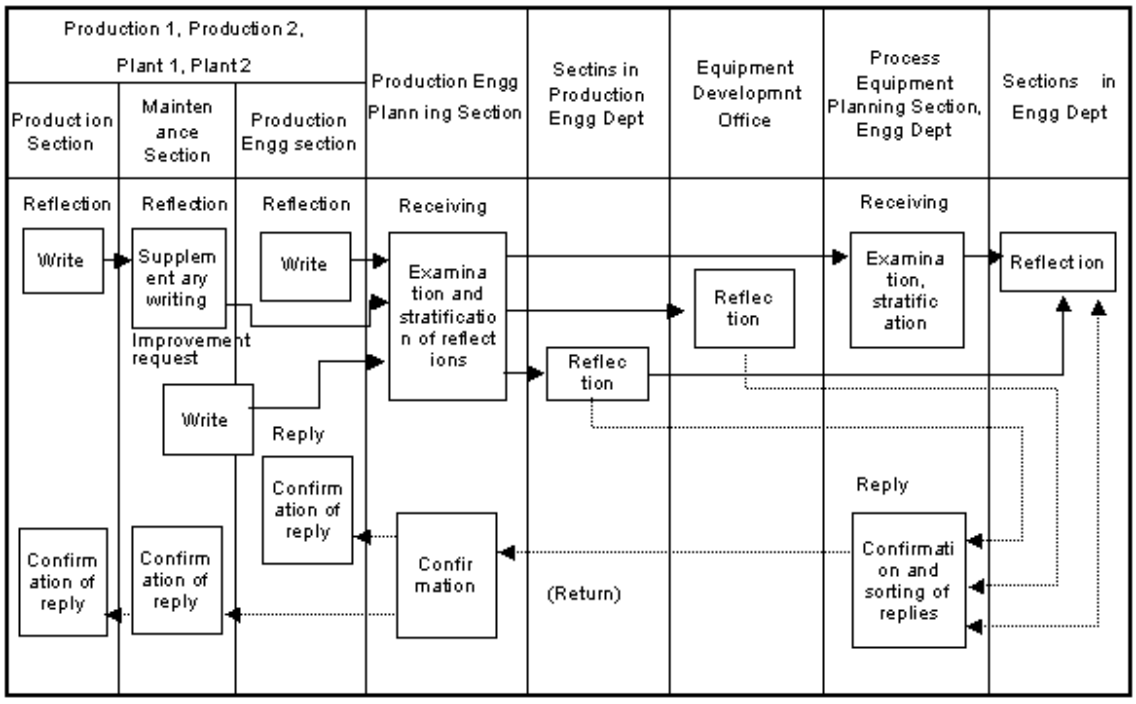
MP Proposal	Prepared by	Foreman	Part Leader	Team Leader
No. Small Group :				

Department	Maintenance team, Energy Part		Process name	Crane	
Date	2006.10.1		Equipment name	Crane	
Control No.	Energy-06MP016		Item No.	C-06	
Subject	Improvement of C-06 Crane guide roller			Type of MP Information	
				Elements	MP Type
Phenomena & Problems	Because C-06 Crane is running with high speed, The frequent troubles have been occurred on account of the shocking force with the wheel flange derailed.	Before indices	① Failure times ( ) ② Failure intensity rate ( )	① Mechanical	① Reliability
				2 Driving	2 Maintainability
				3 Lubrication	3 Autonomous Maintainability
		Improved indices	① Failure times ( ) ② Failure intensity rate ( )	4 Pneumatic & Hydraulic	4 Operability
				5 Electrical	5 Economics
				6 Instrument	⑥ Safety
				7 Others	7 Others
Proposal contents	Before improvement(Drawing, Data)			After improvement (Drawing, Data)	
					
Reviewed results	Proposed Department (1.Accepted 2,Holding 3.Not accepted) Rejected reason :			Maintenance Department (1. Accepted 2, Holding 3. Not accepted) Rejected reason :	
Horizontal deploying	Able to adapt to the same type of cranes.				

Only one section receives suggestions to distinguish the flow for suggestions and to enhance utilization of them in design. This section also follows up how replies are written and implemented to quantitatively and qualitatively activate MP information.

The continuation of these activities further enhances harmony and cooperation between the maintenance and equipment design sectors to give birth to equipment that is born sound and easily.

Figure 7-8 Example of MP Suggestion Routing and Role Sharing (Source : Asmo)



Division	Department /Section	Roles	Description
Draft Section	Production ↓ sections Maintenance section	Reflections drafted by production sections must be submitted to maintenance sections. Maintenance Section checks reflections from various sections and supplements what needs to be supplemented. Maintenance Section stratifies reflections and sends to Production Engg Planning Section.	Equipment name line Equipment No., process name Installation, person prepared Contact address Writing contents
	Maintenance section, Production Engg section	Writing improvements and requests (problems) Reflections are sent directly to Reduction Engg Planning Section	
Receiving Counter	Production Engg Planning section	Receives, examines and stratifies by reflection recipients from drafted sections and submitted to departments and sections Sections in Reduction Enaa Dept. Equipment Development Office Process Equipment Planning Section	Reflection No.

technology. What is important is how to extract problems in the before stages and the value in use of this before study and control chart is high in making these analyses.

Analysis of items which could not be found in the initial control stage must be made to develop new debugging techniques and technologies.

Figure 7-10 Design Review and Start-up Period

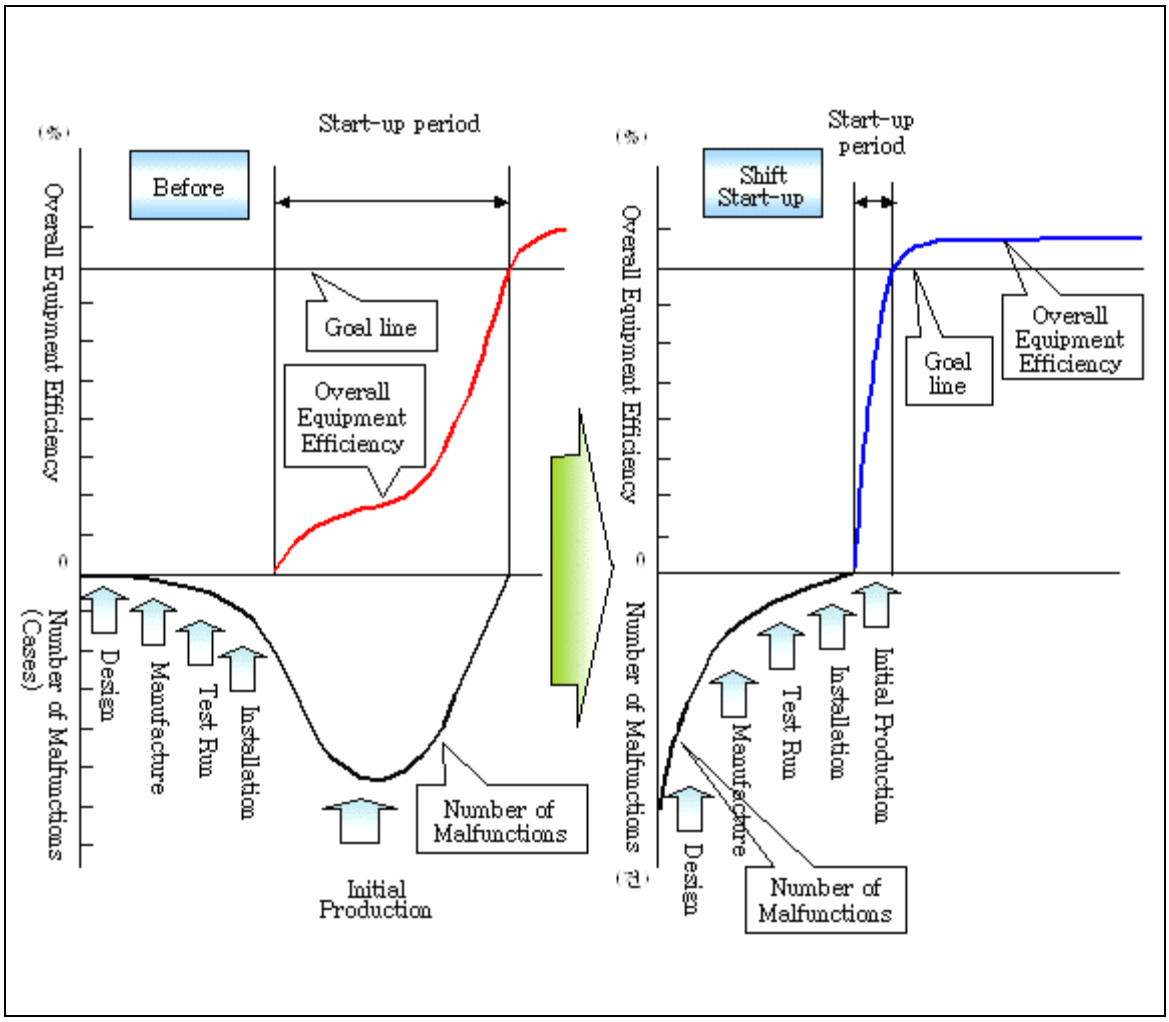


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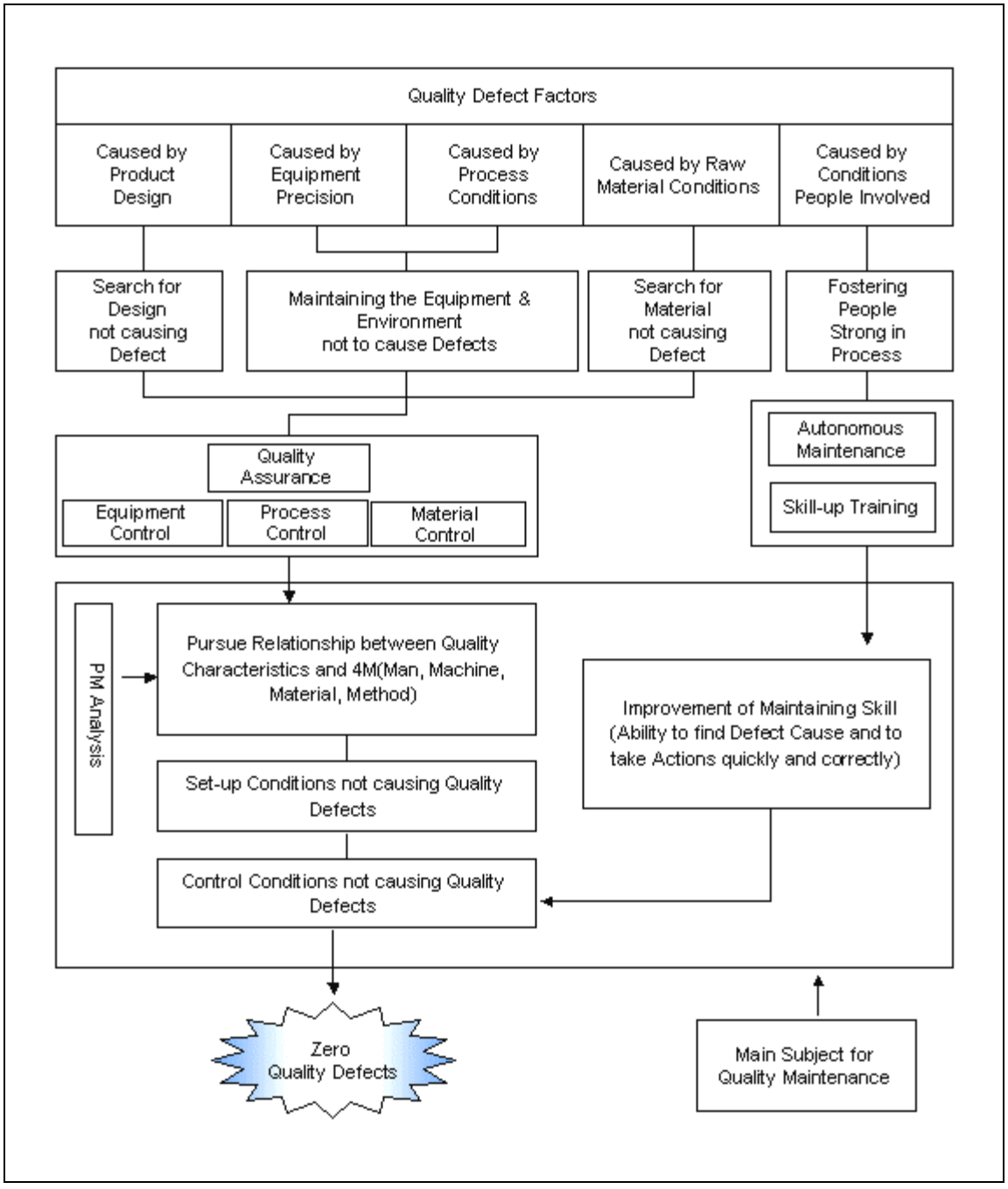
Figure 8-1 Basic Approach to Quality Maintenance



	Step			Description	Precautions
	Survey and Analysis	2	Survey process which generated defects	Prepare QA matrix based on process survey * Survey each process which caused defect mode	* Survey relationship between unit process and failure mode.
		3	Survey and analyze 3M conditions	(1) Survey 3M conditions for each process (2) Survey lines and extract defective points	* Survey 3M conditions by drawings, standards, instructions, etc. * Pursue proper approach to 3M conditions by processing principles, equipment mechanisms and functions, etc. * Survey lines and analyze defects in 3M condition setting and maintenance.
	Survey and Analysis	4	Survey malfunction countermeasures	(1) Prepare malfunction list and study countermeasures (2) Check and restore equipment condition, equipment improvements	* Check maintenance status in autonomous maintenance activities, survey processing conditions and set-up methods and restore malfunctions. * Improvement of equipment that does not meet equipment conditions.
		5	Analyze conditions for non-defective units that are not confirmed	(1) Analyze conditions to build in non-defective units that re not confirmed, Set proper approach by experiments. (2) Evaluate	* Thoroughly pursue relationship between quality characteristics and processing conditions/equipment precision based on processing principles and rules. * Examine which quality characteristics are affected by each member of equipment if several quality characteristics become problems in the same equipment. * Pursue relationship between defect factors and 3M by PM analysis, FMEA and design of experiments and set 3M conditions for incorporating quality in products and process. * Decide tentative tolerances (tentative standard values) for equipment precision and processing conditions to confine quality characteristic values inside the standard.

1) Step 1 : Verifying present status

The present status is surveyed in this step to set bench marks (BMs) and goal values for quality maintenance activities to prepare an implementation program to smoothly conduct activities.

Figure 8-4 Deploying Procedure of Quality Maintenance Focused 4 Ms

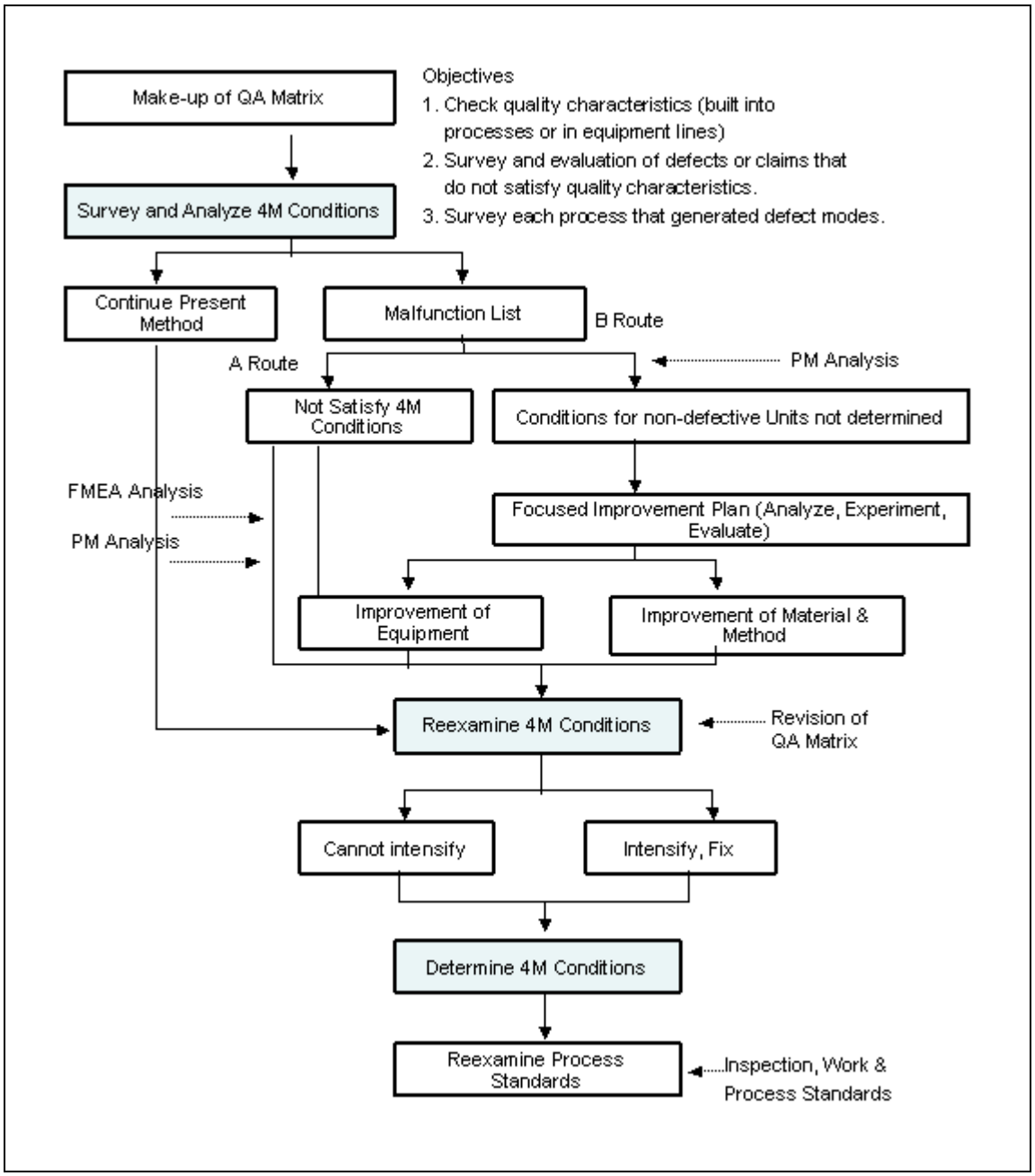
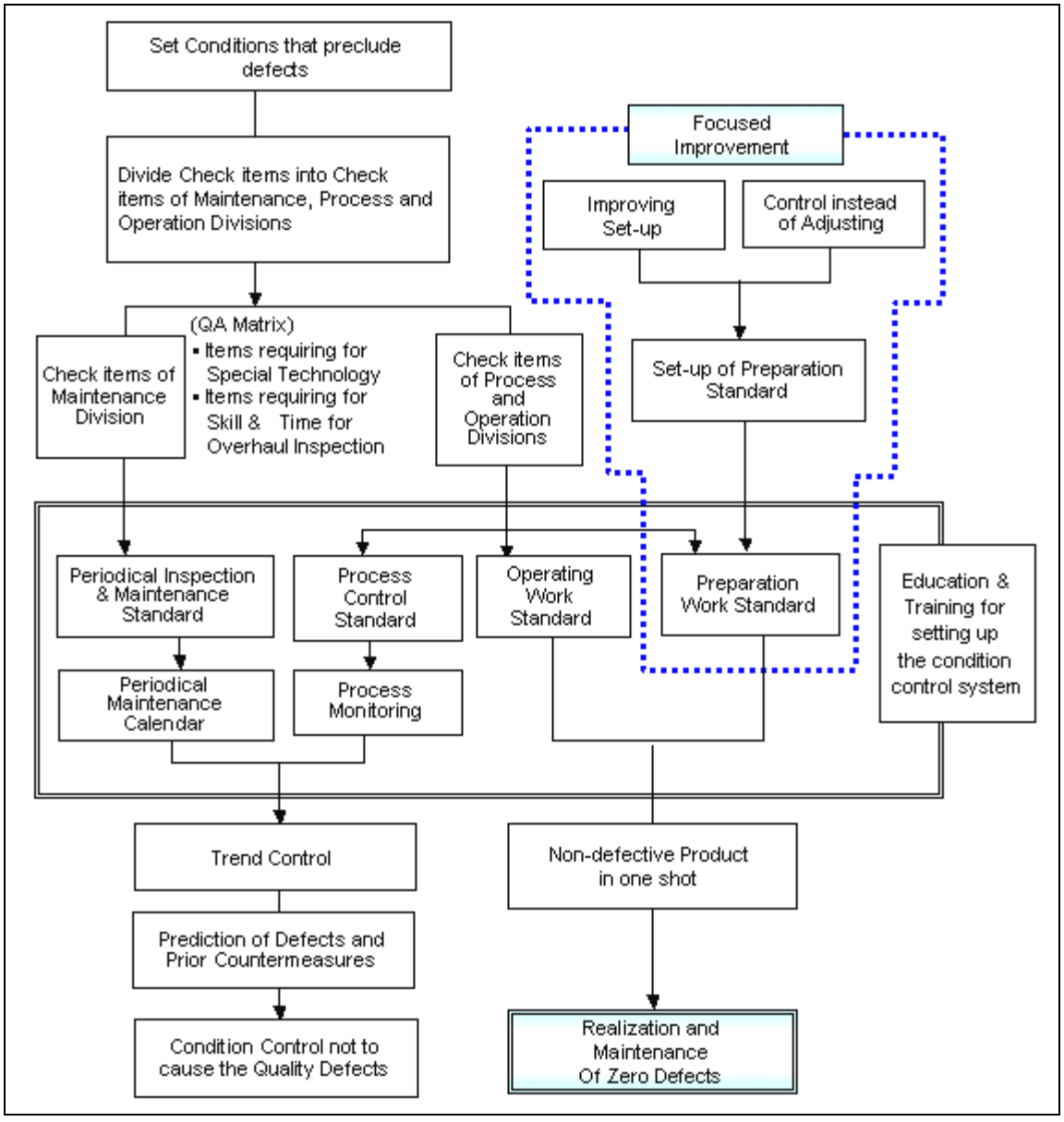


chart at the applicable members of the equipment and accomplish trend control to achieve zero defects.

Figure 8-6 Concept on Standardization



11) Results of Activities

There have been many examples where process defects and rework have been reduced to zero by thorough implementation of quality maintenance activities on model products of model lines (equipment) and by spreading these activities to other sectors. These activities lead to reductions in inspection and claims.

Chapter 9 Implementation of Office Efficiency

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9.4.2 Autonomous Maintenance for Office Efficiency

(1) Improvements of clerical environment

Clerical environment improvements must be tackled from the following 3 aspects :

a) Improvements of desks, lockers and office supplies and equipment.
b) Appropriate utilities such as temperature, humidity, ventilation, day lighting, lighting and sound isolation.
c) Layout improvements to accomplish a bright workplace environment for a high office work efficiency.

(a) Step 1 : Initial clean-up and inventory

In this step, elements such as desks, lockers, office equipment and passages are inspected, cleaned and maintained so that anyone can use them anytime.

Figure 9-1 Examples of Initial clean-up and inventory

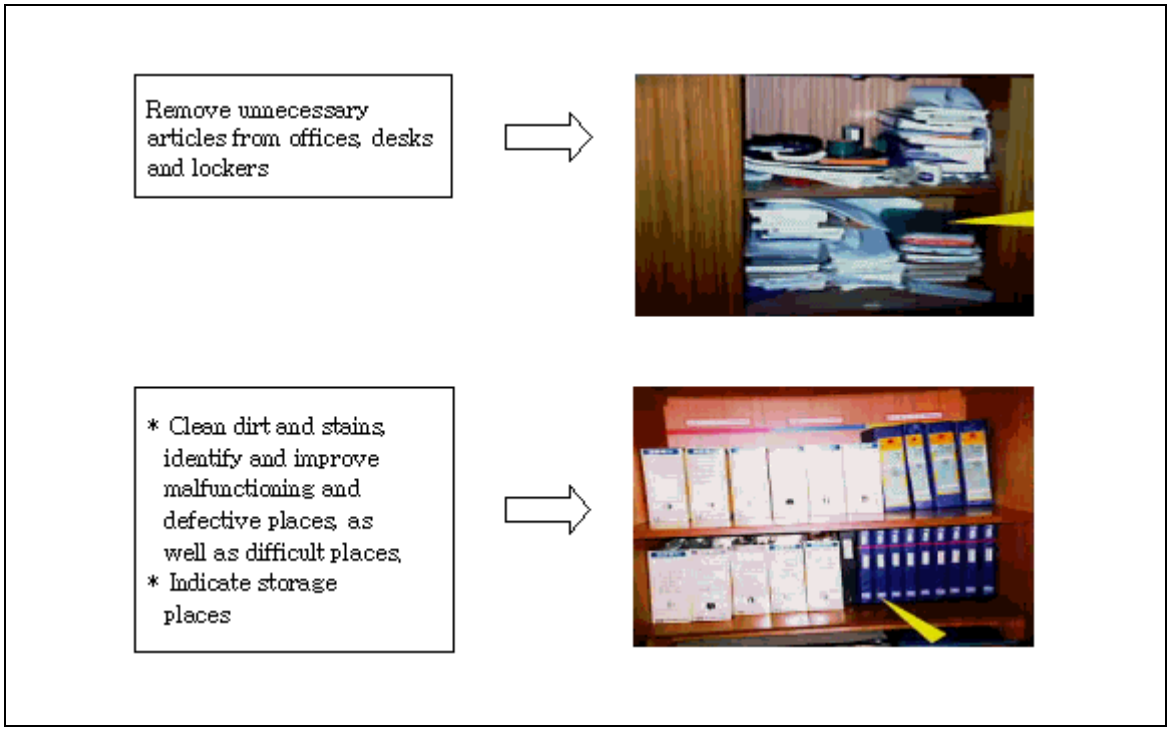
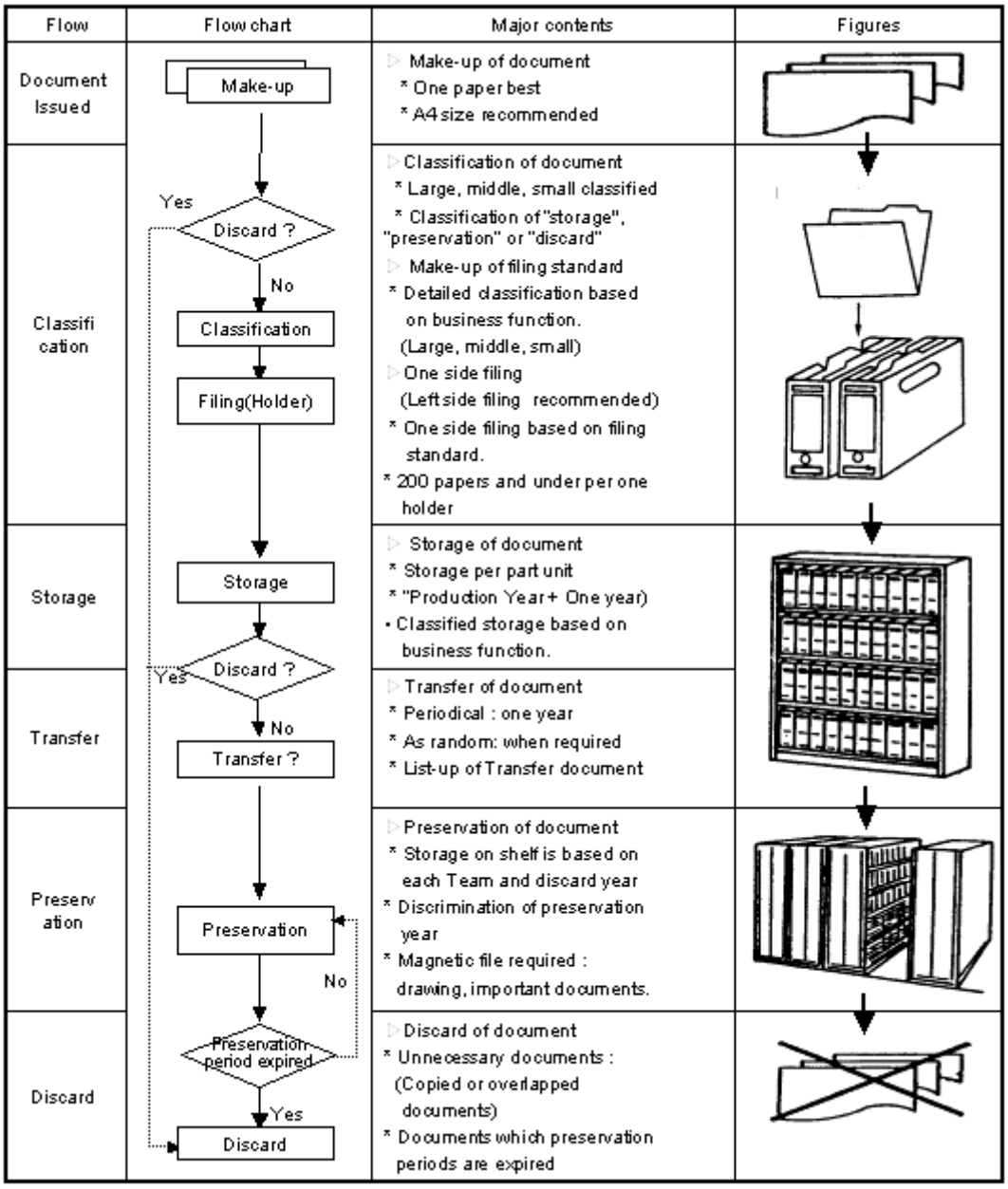


Figure 9-3 Procedure of Filing System



2) Implement layout planning

a) Objectives of layout planning

* Meet future qualitative and quantitative changes in business.
* Achieve results in quality, cost, lead time and work environment.
* Plan installation places and spaces for office facilities and equipment to be installed.
* Smooth execution of the foregoing items.

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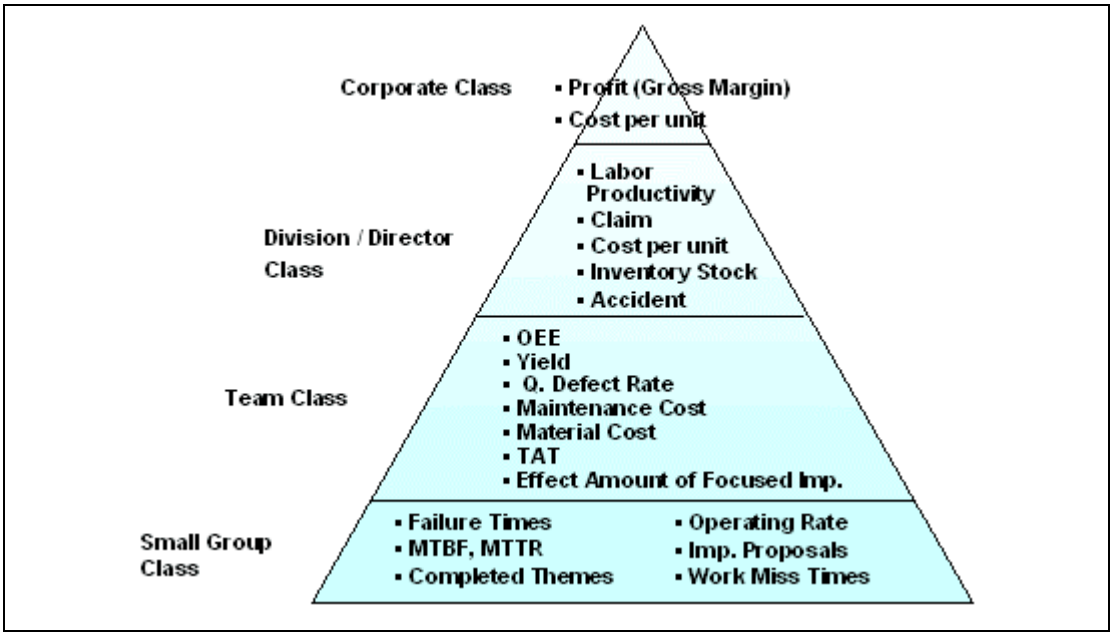
10.2 TPM Effect Measuring Indices for Each Class



10.3 Correlation Matrix between Organization and TPM Indices

● Strong O Weak

Organization / TPM Indices		Prod.	Equipment		Proc. Eng	E & S		QC	Test		Prod. Dev	PE	Company Operations					R&D		Sal-es
		Prod.	Eng	Maint		Sys	Env. Equ-ipm	Insp.	Func. Test				Gen Affairs	Logistics	Inspection	Purchasing	Subcontract	Proc. Dev.	Des-ign	Sal-es
Profit	Sales amount																	O		●
	Added Value																	●	●	
Productivity	Volume	●			●						●									
	Labor Productivity	●			●							●								
	OEE*	●	●	●	●			●	●			●								
	Equipment breakdown	●	●	●	●			●	●											
Quality	Defect Ratio	●		●	●			●	●		●						●			
	Claim	●						●	●						●		●			
Cost	Maint. Cost			●																
	Energy Cost	O	O	O	O	O	O	O	O		O	O	O	O	O	O	O	O	O	O
	Cost of MFG	●	●	●	●	O	O	O	O		●	O	O	O	O	O	O	O	O	O
Safety	Safety Index	O	O	O	O	●	O	O	O		O	O	O	O	O	O	O	O	O	O
Envirt	Environment Index	O		O	O	O	●	O	O		O	O	O	O	O	O	O	O	O	O
Morale	Suggestion Count	O	O	O	O	O	O	O	O		O	O	O	O	O	O	O	O	O	O
	Theme Count	O	O	O	O	O	O	O	O		O	O	O	O	O	O	O	O	O	O
	OPL Count	O		O			O	O	O					O	O					
	Improvement Count	O	O	O	O	O	O	O	O		O	O	O	O	O	O	O	O	O	O

10.4 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

* OPL : One Point Lesson

TPM Deploying Guidebook (Vol. 2)

The Key to Competitiveness and Profit-Producing

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