

# **An Introduction to Total Productive Maintenance (TPM)**

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In today's industrial scenario huge losses/wastage occur in the manufacturing shop floor. This waste is due to operators, maintenance personal, process, tooling problems and non-availability of components in time etc. Other forms of waste includes idle machines, idle manpower, break down machine, rejected parts etc are all examples of waste. The quality related waste are of significant importance as they matter the company in terms of time, material and the hard earned reputation of the company. There are also other invisible wastes like operating the machines below the rated speed, start up loss, break down of the machines and bottle necks in process. Zero oriented concepts such as zero tolerance for waste, defects, break down and zero accidents are becoming a pre-requisite in the manufacturing and assembly industry. In this situation, a revolutionary concept of TPM has been adopted in many industries across the world to address the above said problems. This chapter deals in length about this TPM.

## **What is Total Productive Maintenance (TPM)?**

*It can be considered as the medical science of machines.* Total Productive Maintenance (TPM) is a maintenance program, which involves a newly defined concept for maintaining plants and equipment. The goal of the TPM program is to markedly increase production while, at the same time, increasing employee morale and job satisfaction.

TPM brings maintenance into focus as a necessary and vitally important part of the business. It is no longer regarded as a non-profit activity. Down time for maintenance is scheduled as a part of the manufacturing day and, in some cases, as an integral part of the manufacturing process. The goal is to hold emergency and unscheduled maintenance to a minimum.

## **Why TPM?**

TPM was introduced to achieve the following objectives. The important ones are listed below.

- Avoid wastage in a quickly changing economic environment.
- Producing goods without reducing product quality.
- Reduce cost.
- Produce a low batch quantity at the earliest possible time.
- Goods send to the customers must be non-defective.

## **Similarities and differences between TQM and TPM:**

The TPM program closely resembles the popular Total Quality Management (TQM) program. Many of the tools such as employee empowerment, benchmarking, documentation, etc. used in TQM are used to implement and optimize TPM. Following are the similarities between the two.

1. Total commitment to the program by upper level management is required in both programmes

2. Employees must be empowered to initiate corrective action, and
3. A long-range outlook must be accepted as TPM may take a year or more to implement and is an on-going process. Changes in employee mind-set toward their job responsibilities must take place as well.

The *differences* between TQM and TPM are summarized below.

<b>Category</b>	<b>TQM</b>	<b>TPM</b>
<i>Object</i>	Quality (Output and effects)	Equipment (Input and cause)
<i>Mains of attaining goal</i>	Systematize the management. It is software oriented	Employees participation and it is hardware oriented
<i>Target</i>	Quality for PPM	Elimination of losses and wastes.

## **Types of maintenance:**

### **1. Breakdown maintenance:**

In this type of maintenance, no care is taken for the machine, until equipment fails. Repair is then undertaken. This type of maintenance could be used when the equipment failure does not significantly affect the operation or production or generate any significant loss other than repair cost. However, an important aspect is that the failure of a component from a big machine may be injurious to the operator. Hence breakdown maintenance should be avoided.

### **2. Preventive maintenance (1951):**

It is a daily maintenance (cleaning, inspection, oiling and re-tightening), design to retain the healthy condition of equipment and prevent failure through the prevention of deterioration, periodic inspection or equipment condition diagnosis, to measure deterioration. It is further divided into periodic maintenance and predictive maintenance. Just like human life is extended by preventive medicine, the equipment service life can be prolonged by doing preventive maintenance.

#### **2a. Periodic maintenance (Time based maintenance - TBM):**

Time based maintenance consists of periodically inspecting, servicing and cleaning equipment and replacing parts to prevent sudden failure and process problems. *E.g. Replacement of coolant or oil every 15 days.*

#### **2b. Predictive maintenance:**

This is a method in which the service life of important part is predicted based on inspection or diagnosis, in order to use the parts to the limit of their service life. Compared to periodic maintenance, predictive maintenance is condition-based maintenance. It manages trend values, by measuring and analyzing data about deterioration and employs a surveillance system, designed to monitor conditions through an on-line system. *E.g. Replacement of coolant or oil, if there is a change in colour. Change in colour indicates the deteriorating condition of the oil. As this is a condition-based maintenance, the oil or coolant is replaced.*

### 3. Corrective maintenance (1957):

It improves equipment and its components so that preventive maintenance can be carried out reliably. Equipment with design weakness must be redesigned to improve reliability or improving maintainability. This happens at the equipment user level. E.g. Installing a guard, to prevent the burrs falling in the coolant tank.

### 4. Maintenance prevention (1960):

This program indicates the design of new equipment. Weakness of current machines is sufficiently studied (on site information leading to failure prevention, easier maintenance and prevents of defects, safety and ease of manufacturing). The observations and the study made are shared with the equipment manufacturer and necessary changes are made in the design of new machine.

## TPM - History:

TPM is an innovative Japanese concept. The origin of TPM can be traced back to 1951 when preventive maintenance was introduced in Japan. However the concept of preventive maintenance was taken from USA. Nippondenso was the first company to introduce plant wide preventive maintenance in 1960. Preventive maintenance is the concept wherein, operators produced goods using machines and the maintenance group was dedicated with work of maintaining those machines, however with the automation of Nippondenso, maintenance became a problem, as more maintenance personnel were required. So the management decided that the operators would carry out the routine maintenance of equipment. (This is Autonomous maintenance, one of the features of TPM). Maintenance group took up only essential maintenance works.

Thus Nippondenso, which already followed preventive maintenance, also added Autonomous maintenance done by production operators. The maintenance crew went in the equipment modification for improving reliability. The modifications were made or incorporated in new equipment. This lead to maintenance prevention. Thus *preventive maintenance* along with *Maintenance prevention* and *Maintainability Improvement* gave birth to **Productive maintenance**. The aim of productive maintenance was to maximize plant and equipment effectiveness.

By then Nippon Denso had made quality circles, involving the employees participation. Thus all employees took part in implementing Productive maintenance. Based on these developments Nippondenso was awarded the distinguished plant prize for developing and implementing TPM, by the *Japanese Institute of Plant Engineers* (JIPE). Thus Nippondenso of the Toyota group became the first company to obtain the TPM certification.

## TPM Targets:

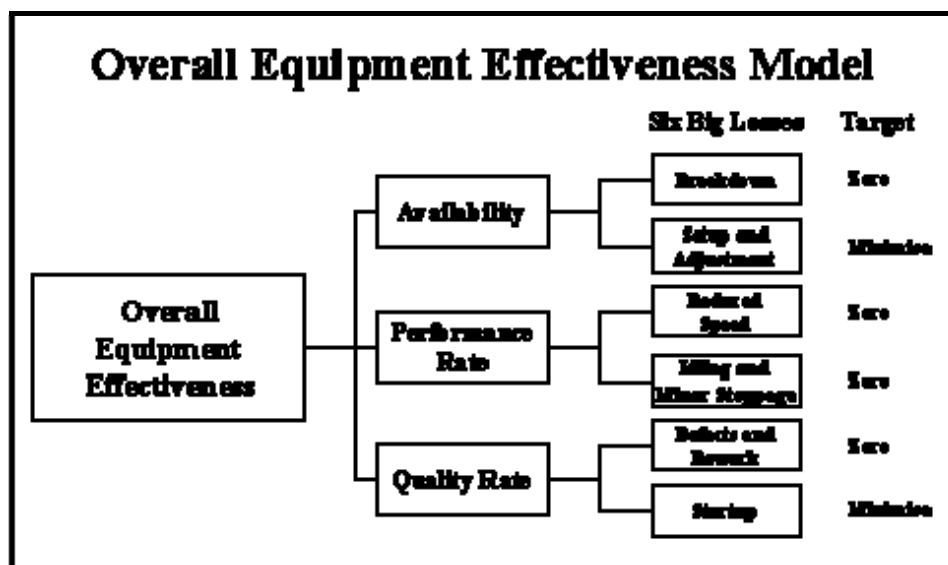
1. Obtain Minimum 90% OEE (Overall Equipment Effectiveness)
2. Run the machines even during lunch. (Lunch is for operators and not for machines!)
3. Operate in a manner, so that there are no customer complaints.
4. Reduce the manufacturing cost by 30%.
5. Achieve 100% success in delivering the goods as required by the customer.
6. Maintain an accident free environment.
7. Increase the suggestions from the workers/employees by 3 times. Develop Multi-skilled and flexible workers.

<b><i>Motives of TPM</i></b>	<ol style="list-style-type: none"> <li>1. Adoption of life cycle approach for improving the overall performance of production equipment.</li> <li>2. Improving productivity by highly motivated workers, which is achieved by job enlargement.</li> <li>3. The use of voluntary small group activities for identifying the cause of failure, possible plant and equipment modifications.</li> </ol>
<b><i>Uniqueness of TPM</i></b>	The major difference between TPM and other concepts is that the operators are also made to involve in the maintenance process. The concept of " <i>I (Production operators) Operate, You (Maintenance department) fix</i> " is not followed.
<b><i>TPM Objectives</i></b>	<ol style="list-style-type: none"> <li>1. Achieve Zero Defects, Zero Breakdown and Zero accidents in all functional areas of the organization.</li> <li>2. Involve people in all levels of organization.</li> <li>3. Form different teams to reduce defects and self-Maintenance.</li> </ol>
<b><i>Direct benefits of TPM</i></b>	<ol style="list-style-type: none"> <li>1. Increase in productivity and OEE (Overall Equipment Efficiency)</li> <li>2. Reduction in customer complaints.</li> <li>3. Reduction in the manufacturing cost by 30%.</li> <li>4. Satisfying the customers needs by 100 % (Delivering the right quantity at the right time, in the required quality.)</li> <li>5. Reduced accidents.</li> </ol>
<b><i>Indirect benefits of TPM</i></b>	<ol style="list-style-type: none"> <li>1. Higher confidence level among the employees.</li> <li>2. A clean, neat and attractive work place.</li> <li>3. Favourable change in the attitude of the operators.</li> <li>4. Achieve goals by working as team.</li> <li>5. Horizontal deployment of a new concept in all areas of the organization.</li> <li>6. Sharing knowledge and experience.</li> <li>7. The workers get a feeling of owning the machine.</li> </ol>

## **OEE (Overall Equipment Efficiency):**

The basic measure associated with Total Productive Maintenance (TPM) is the OEE. This OEE highlights the actual "Hidden capacity" in an organization. OEE is *not* an exclusive measure of how well the maintenance department works. The design and installation of equipment as well as how it is operated and maintained affect the OEE. It measures both efficiency (doing things right) and effectiveness (doing the right things) with the equipment. It incorporates three basic indicators of equipment performance and reliability. Thus OEE is a function of the three factors mentioned below.

1. Availability or uptime (downtime: planned and unplanned, tool change, tool service, job change etc.)
2. Performance efficiency (actual vs. design capacity)
3. Rate of quality output (Defects and rework)



$$\text{Thus } OEE = A \times PE \times Q$$

**A - Availability of the machine.** Availability is proportion of time machine is actually available out of time it should be available.

$$\text{Availability} = \frac{\text{Planned production time} - \text{unscheduled downtime}}{\text{Planned production time}}$$

$$\text{Production time} = \text{Planned production time} - \text{Downtime}$$

Gross available hours for production include 365 days per year, 24 hours per day, 7 days per week. However this is an ideal condition. Planned downtime includes vacation, holidays, and not enough loads. Availability losses include equipment failures and changeovers indicating situations when the line is not running although it is expected to run.

**PE - Performance Efficiency.** The second category of OEE is performance. The formula can be expressed in this way:

$$\text{Performance (Speed)} = \frac{(\text{Cycle time} \times \text{Number of products processed})}{\text{Production time}}$$

Net production time is the time during which the products are actually produced. Speed losses, small stops, idling, and empty positions in the line indicate that the line is running, but it is not providing the quantity it should.

*Q* - Refers to quality rate. Which is percentage of good parts out of total produced. Sometimes called "yield". Quality losses refer to the situation when the line is producing, but there are quality losses due to in-progress production and warm up rejects. We can express a formula for quality like this:

$$\text{Quality (Yield)} = \frac{(\text{Number of products processed} - \text{Number of products rejected})}{(\text{Number of products processed})}$$

A simple example on how OEE is calculated is shown below.

- Running 70 percent of the time (in a 24-hour day)
- Operating at 72 percent of design capacity (flow, cycles, units per hour)
- Producing quality output 99 percent of the time

When the three factors are considered together (70% availability x 72% efficiency x 99% quality), the result is an overall equipment effectiveness rating of 49.9 percent.

## **Stages in TPM implementation:**

### **Step A - PREPARATORY STAGE:**

#### **STEP 1 - Announcement by Management to all about TPM introduction in the organization:**

Proper understanding, commitment and active involvement of the top management is needed for this step. Senior management should have awareness programmes, after which announcement is made. Decision to implement TPM is published in the in house magazine, displayed on the notice boards and a letter informing the same is sent to suppliers and customers.

#### **STEP 2 - Initial education and propaganda for TPM:**

Training is to be done based on the need. Some need intensive training and some just awareness training based on the knowledge of employees in maintenance.

#### **STEP 3 - Setting up TPM and departmental committees:**

TPM includes improvement, autonomous maintenance, quality maintenance etc., as part of it. When committees are set up it should take care of all those needs.

#### **STEP 4 - Establishing the TPM working system and target:**

Each area/work station is benchmarked and target is fixed up for achievement.

STEP 5 - A master plan for institutionalizing:

Next step is implementation leading to institutionalizing wherein TPM becomes an organizational culture. Achieving PM award is the proof of reaching a satisfactory level.

**STEP B - INTRODUCTION STAGE**

A small get-together, which includes our suppliers and customer's participation, is conducted. Suppliers as they should know that we want quality supply from them. People from related companies and affiliated companies who can be our customers, sisters concerns etc. are also invited. Some may learn from us and some can help us and customers will get the message from us that we care for quality output, cost and keeping to delivery schedules.

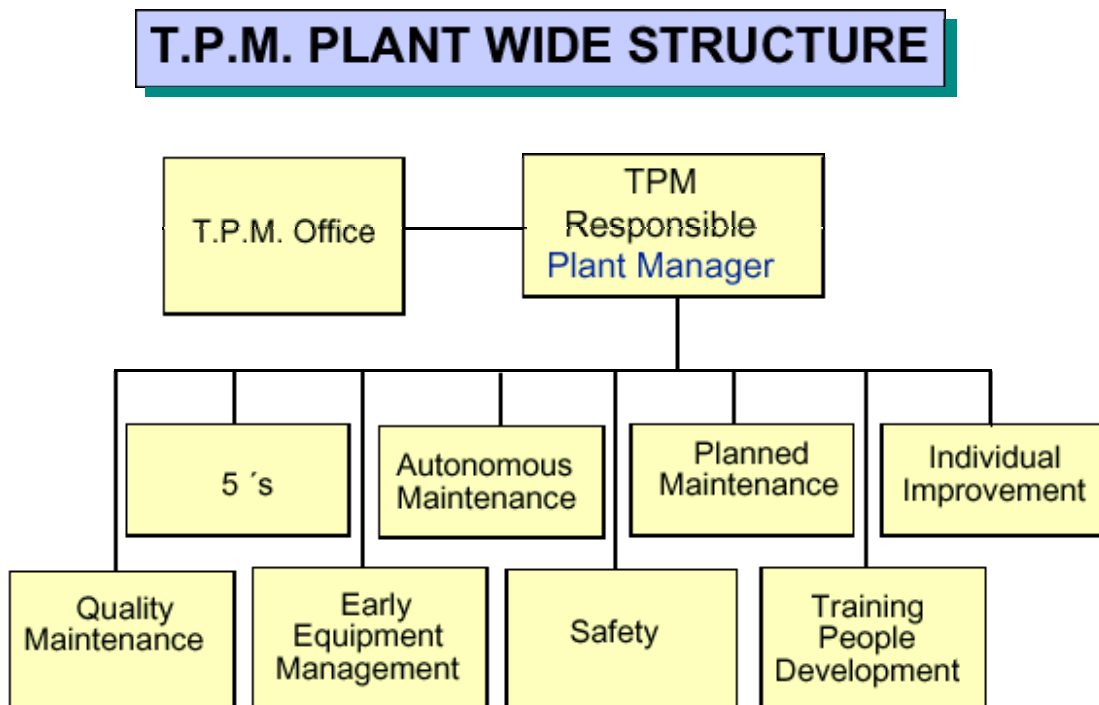
**STAGE C - IMPLEMENTATION**

In this stage eight activities are carried which are called eight pillars in the development of TPM activity. Of these four activities are for establishing the system for production efficiency, one for initial control system of new products and equipment, one for improving the efficiency of administration and are for control of safety, sanitation as working environment.

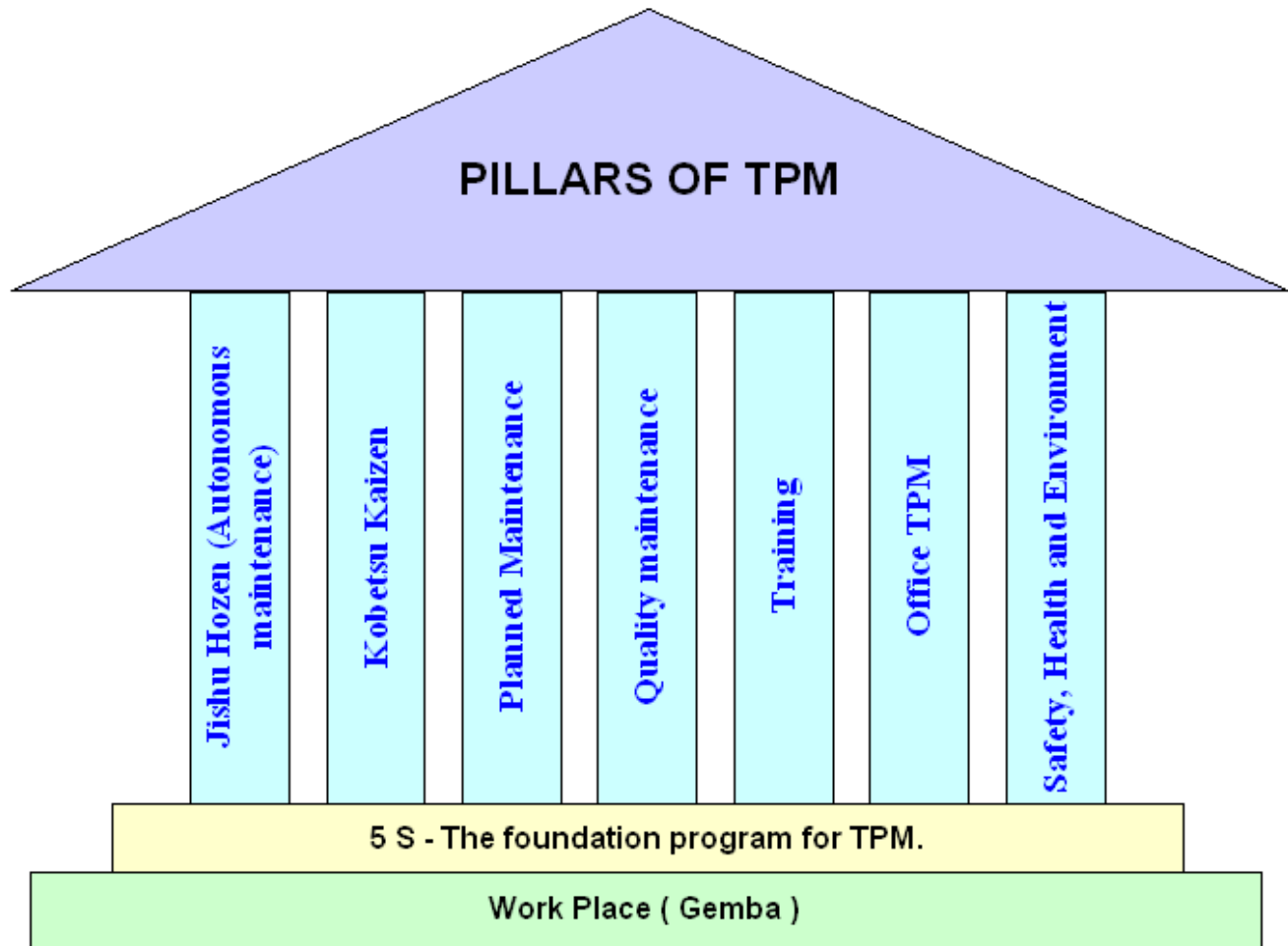
**STAGE D - INSTITUTIONALISING STAGE**

By now the TPM implementation activities would have reached maturity stage. Now is the time to apply for PM award.

**TPM Organization Structure:**



## Pillars of TPM:

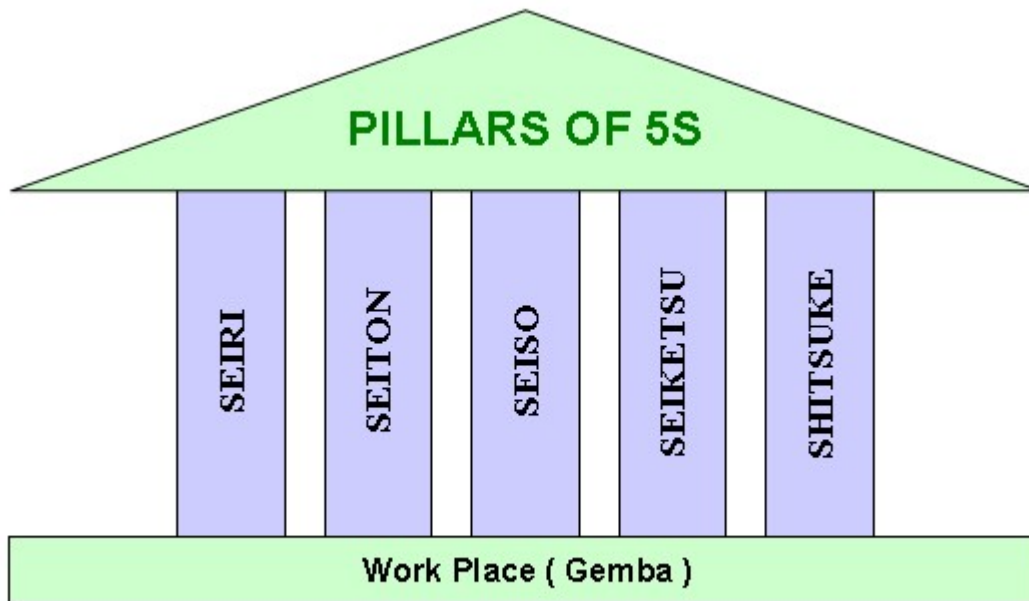


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### PILLAR 1 - 5S:

TPM starts with 5S. It is a systematic process of housekeeping to achieve a serene environment in the work place involving the employees with a commitment to sincerely implement and practice house keeping. Problems cannot be clearly seen when the work place is unorganized. Cleaning and organizing the workplace helps the team to uncover problems. Making problems visible is the first step of improvement. 5s is a foundation program before the implementation of TPM, hence in the above figure, 5s has been positioned in the base. **If this 5S is not taken up seriously, then it leads to 5D. They are Delays, Defects, Dissatisfied customers, declining profits and Demoralized employees.** Following are the pillars of 5S.





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Japanese Term	English Translation	Equivalent term	'S'
<i>Seiri</i>	Organisation	Sort	
<i>Seiton</i>	Tidiness	Systematise	
<i>Seiso</i>	Cleaning	Sweep	
<i>Seiketsu</i>	Standardisation	Standardise	
<i>Shitsuke</i>	Discipline	Self - Discipline	

**SEIRI - Sort out:**

This means sorting and organizing the items as critical, important, frequently used items, useless, or items that are not need as of now. Unwanted items can be salvaged. Critical items should be kept for use nearby and items that are not be used in near future, should be stored in some place. *For this step, the worth of the item should be decided based on utility and not cost.* As a result of this step, the search time is reduced.

Priority	Frequency of Use	How to use
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<i>Low</i>	Less than once per year, Once per year<	Throw away, Store away from the workplace
<i>Average</i>	At least 2/6 months, Once per month, Once per week	Store together but offline
<i>High</i>	Once Per Day	Locate at the workplace

**SEITON - Organise:**

The concept here is that *"Each items has a place, and only one place"*. The items should be placed back after usage at the same place. To identify items easily, name plates and coloured tags has to be used. Vertical racks can be used for this purpose, and heavy items occupy the bottom position in the racks.

**SEISO - Shine the workplace:**

This involves cleaning the work place free of burrs, grease, oil, waste, scrap etc. No loosely hanging wires or oil leakage from machines.

**SEIKETSU - Standardization:**

Employees has to discuss together and decide on standards for keeping the work place / Machines / pathways neat and clean. This standards are implemented for whole organization and are tested / Inspected randomly.

**SHITSUKE - Self discipline:**

Considering 5S as a way of life and bring about self-discipline among the employees of the organization. This includes wearing badges, following work procedures, punctuality, dedication to the organization etc.

This 5S implementation has to be carried out in phased manner. First the current situation of the workplace has to be studied by conducting a 5S audit. This audit uses check sheets to evaluate the current situation. This check sheet consists of various parameters to be rated say on a 5-point basis for each 'S'. The ratings give the current situation. The each of the above-mentioned 5S is implemented and audit is conducted at regular intervals to monitor the progress and evaluate the success of implementation. After the completion of implementation of 5S random audits could be conducted using these check sheets to ensure that it is observed in true spirits by every one in the work place. A sample check sheet is shown below. The check sheet shown below takes a general industry into consideration. It may vary from even from one plant to another, and more exhaustive. The points shown below could be used as rough guidelines.

<b>1-S</b>	<b>SEIRI (Sorting out)</b>	<b>Score on 5 point basis</b>
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	<p>Floor area of the hangar is free of unwanted items.</p> <p>Tops and inside of all the cupboards, shelves, tables, drawers are free of unwanted items.</p> <p>Rules for disposal and detecting non moving stocks are adhered to</p> <ul style="list-style-type: none"> <li>• Red labelling done.</li> <li>• Disposal standards maintained</li> <li>• Regular clearing of all storage areas</li> <li>• Regular removal of garbage and waste bins</li> </ul> <p>Items are stored according to frequency of use.</p> <p>Notice boards are free of old notices.</p>	
<b>2-S</b>	<b>SEITON (Set in order)</b>	
	<p>All gangways are specified and clearly marked and machines have identification labels.</p> <p>All equipments / tools / files / cupboards etc are arranged. Cup boards have index list pasted in the door.</p> <p>Parking areas are specified and marked for vehicles, pallets, trolleys, garbage bins etc.</p> <p>Colour coding is effectively used for easy identification wherever necessary.</p>	
<b>3-S</b>	<b>SEISO (Shine)</b>	
	<p>All equipments, tools, accessories, furniture are maintained at high level of cleanliness, maintenance schedules are displayed and followed.</p> <p>Floors walls windows are maintained at high level of cleanliness.</p> <p>There no oil spillage or dust in the work area.</p> <p>There is general appearance of cleanliness all around.</p>	
<b>4-S</b>	<b>SEIKETSU (Standardization)</b>	
	<p>All aisles / gangways have a standard size and colour. All labels and notices are standardized.</p> <p>Standards procedures related to are followed.</p> <p>Periodic disposal of waste organized.</p> <p>Fire extinguisher type, validation, position in order. First aid kit fully equipped.</p> <p>Standard visual management viz., warning signs, labelling for correct identification, colour coding checklists etc are followed and maintained</p>	

5-S	SHITSUKE (Self-discipline)	
	Uniforms / overcoats / shoes worn by all.  Machines, lights and fans switched off whenever not necessary  ISO / company norms are displayed and followed.  Punctuality, adherence to safety rules and usage of gloves and goggles.	

**PILLAR 2 - JISHU HOZEN (Autonomous maintenance):**

This pillar is geared towards developing operators to be able to take care of small maintenance tasks, thus freeing up the skilled maintenance people to spend time on more value added activity and technical repairs. The operators are responsible for upkeep of their equipment to prevent it from deteriorating. By use of this pillar, the aim is to maintain the machine in new condition. The activities involved are very simple nature. This includes cleaning, lubricating, visual inspection, tightening of loosened bolts etc.

**Policy:**

1. Uninterrupted operation of equipments.
2. Flexible operators to operate and maintain other equipments.
3. Eliminating the defects at source through active employee participation.

**Steps in JISHU HOZEN:**

1. Preparation of employees.
2. Initial cleanup of machines.
3. Take counter measures
4. Fix tentative JH standards
5. General inspection
6. Autonomous inspection
7. Standardization and

Each of the above-mentioned steps is discussed in detail below.

1. Train the Employees:  
 Educate the employees about TPM, Its advantages, JH advantages and Steps in JH. Educate the employees about the equipment they use, the frequency of oiling, day-to-day maintenance activities required and the abnormalities that could occur in the machine and way to find out the abnormalities.
2. Initial cleanup of machines:
  - o Arrange all items needed for cleaning.
  - o On the arranged date, employees clean the equipment with the help of maintenance department.
  - o Dust, stains, oils and grease has to be removed.

- When cleaning oil leakage, loose wires, unfastened nuts and bolts and worn out parts must be taken care.
  - After clean up, problems are categorized and suitably tagged. White tags are placed where operators can solve problems. Pink tag is placed where the aid of maintenance department is needed.
  - Contents of tag are transferred to a register.
  - Make note of area, which were inaccessible.
  - Open parts of the machine are closed, and the machine is run.
3. Counter Measures:
- Inaccessible regions had to be reached easily. E.g. If there are many screws to open a flywheel door, hinge door can be used. Instead of opening a door for inspecting the machine, acrylic sheets can be used.
  - To prevent work out of machine parts necessary action must be taken.
  - Machine parts should be modified to prevent accumulation of dirt and dust.
4. Tentative Standard:
- JH schedule has to be made and followed strictly.
  - Schedule should be made regarding cleaning, inspection and lubrication and it also should include details like when, what and how.
5. General Inspection:
- The employees are trained in disciplines like Pneumatics, electrical, hydraulics, lubricant and coolant, drives, bolts, nuts and Safety.
  - This is necessary to improve the technical skills of employees and to use inspection manuals correctly.
  - After acquiring this new knowledge the employees should share this with others.
  - By acquiring this new technical knowledge, the operators are now well aware of machine parts.
6. Autonomous Inspection:
- New methods of cleaning and lubricating are used.
  - Each employee prepares his own autonomous chart / schedule in consultation with supervisor.
  - Parts, which have never given any problem, or part, which don't need any inspection, are removed from list permanently based on experience.
  - Including good quality machine parts. This avoids defects due to poor JH.
  - Inspection that is made in preventive maintenance is included in JH.
  - The frequency of cleanup and inspection is reduced based on experience.
7. Standardization:
- Upto the previous step only the machinery / equipment was the concentration. However in this step the surroundings of machinery are organized. Necessary items should be organized, such that there is no searching and searching time is reduced.
  - Work environment is modified such that there is no difficulty in getting any item.
  - Everybody should follow the work instructions strictly.
  - Necessary spares for equipments is planned and procured.

### **PILLAR 3 - KAIZEN:**

"Kai" means change, and "Zen" means good (for the better). Basically kaizen is for small improvements, but carried out on a continual basis and involve all people in the organization. Kaizen is opposite to big spectacular innovations. Kaizen requires no or little investment. The principle behind is that "a very large number of small improvements are more effective in an organizational environment than a few improvements of large value. This pillar is aimed at reducing losses in the workplace that affect our efficiencies. By using a detailed and thorough procedure we eliminate losses in a systematic method using various Kaizen tools. These activities are not limited to production areas and can be implemented in administrative areas as well.

**Kaizen Policy:**

1. Practice concepts of zero losses in every sphere of activity.
2. Relentless pursuit to achieve cost reduction targets in all resources
3. Relentless pursuit to improve over all plant equipment effectiveness.
4. Extensive use of PM analysis as a tool for eliminating losses.
5. Focus of easy handling of operators.

**Kaizen Target:**

Achieve and sustain zero losses with respect to minor stops, measurement and adjustments, defects and unavoidable downtimes. It also aims to achieve 30% manufacturing cost reduction.

**Tools used in Kaizen:**

1. Why - Why analysis.
2. Poka yoke. (Poka-Yoke is Japanese term, which in English means 'Mistake Proofing' or 'error prevention').
3. Summary of losses.
4. Kaizen register.
5. Kaizen summary sheet.

The objective of TPM is maximization of equipment effectiveness. TPM aims at maximization of machine utilization and not merely machine availability maximization. As one of the pillars of TPM activities, Kaizen pursues efficient equipment, operator and material and energy utilization that is extremes of productivity and aims at achieving substantial effects.

Classification of losses:

<b>Aspect</b>	<b>Sporadic Loss</b>	<b>Chronic Loss</b>
Causation	Causes for this failure can be easily traced. Cause-effect relationship is simple to trace.	This loss cannot be easily identified and solved. Even if various counter measures are applied

Remedy	Easy to establish a remedial measure	This is caused by hidden defects in machine, equipment and methods.
Impact / Loss	A single loss can be costly	A single cause is rare - a combination of causes trends to be a rule
Frequency of occurrence	The frequency of occurrence is low and occasional.	The frequency of loss is more.
Type of analysis required	Why-Why analysis. Here the question 'Why' is queried against the problem for five times, within which the solution is reached	Intricate and complex method required. This includes cause and effect analysis and correlation analysis.
Corrective action	Usually the line personnel in the production can attend to this problem.	Specialists in process engineering, quality assurance and maintenance people are required.

Six losses in the work place:

The objective of TPM is maximization of equipment effectiveness. TPM aims at maximization of machine utilization and not merely machine availability maximization. As one of the pillars of TPM activities, Kaizen pursues efficient equipment, operator and material and energy utilization that is extremes of productivity and aims at achieving substantial effects. Kaizen activities try to thoroughly eliminate losses. Six major losses that were identified. Details of which is given below.

1. *Equipment failure* causes production downtime. Equipment failure requires maintenance assistance and can be prevented with the use of appropriate preventive maintenance actions, developed and applied operating procedures, and design changes. Most importantly, equipment failure requires an improvement effort that should be the result of a successful partnership between production and maintenance. Predictive maintenance techniques such as vibration, oil, and thermo graphic analysis can be used to anticipate equipment failure. If the failure occurs, it is important to use Root Cause Failure Analysis (RCFA) techniques to identify the root cause of the problem and effective and applicable solutions that will eliminate or mitigate the failure occurrence and impact.
2. *Set-up and adjustments*: this refers to loss of productive time between product types, and includes the warm-up after the actual changeover. Changeover time should be included in this loss opportunity and it should not be part of the planned downtime.
3. *Small stops* are typically less than 5-10 minutes and they are typically minor adjustments or simple tasks such as cleaning. They should not be caused by logistics.

4. *Speed losses* are caused when the equipment runs slower than its optimal or designed maximum speed. Examples include machine wear, substandard materials, operator inefficiency, equipment design not appropriate to the application, etc.
5. *Losses during production* include all losses caused by less-than-acceptable quality after the warm-up period.
6. *Losses during warm-up* include all losses caused by less-than-acceptable quality during the warm-up period.

*However with the passage of time, more losses were added to the above list. Each organization has its own classification of losses. Given below is one such elaborate classification listing 16 types of losses.*

<b>Loss</b>	<b>Category</b>
1. Failure losses - Breakdown loss 2. Setup / adjustment losses 3. Cutting blade loss 4. Start up loss 5. Minor stoppage / Idling loss. 6. Speed loss - operating at low speeds. 7. Defect / rework loss 8. Scheduled downtime loss	Losses that impede equipment efficiency
9. Management loss 10. Operating motion loss 11. Line organization loss 12. Logistic loss 13. Measurement and adjustment loss	Losses that impede human work efficiency
14. Energy loss 15. Die, jig and tool breakage loss 16. Yield loss.	Losses that impede effective use of production resources.

#### **PILLAR 4 - PLANNED MAINTENANCE:**



It is aimed to have trouble free machines and equipments producing defect free products for total customer satisfaction. This breaks maintenance down into four "families" or groups, which was defined earlier.

1. Preventive Maintenance
2. Breakdown Maintenance
3. Corrective Maintenance
4. Maintenance Prevention

With Planned Maintenance we evolve our efforts from a reactive to a proactive method and use trained maintenance staff to help train the operators to better maintain their equipment.

**Policy:**

1. Achieve and sustain availability of machines
2. Optimum maintenance cost.
3. Reduces spares inventory.
4. Improve reliability and maintainability of machines.

**Target:**

1. Zero equipment failure and break down.
2. Improve reliability and maintainability by 50 %
3. Reduce maintenance cost by 20 %
4. Ensure availability of spares all the time.

**Six steps in Planned maintenance:**

1. Equipment evaluation and recoding present status.
2. Restore deterioration and improve weakness.
3. Building up information management system.
4. Prepare time based information system, select equipment, parts and members and map out plan.
5. Prepare predictive maintenance system by introducing equipment diagnostic techniques and
6. Evaluation of planned maintenance.

**PILLAR 5 - QUALITY MAINTENANCE:**

It is aimed towards customer delight through highest quality through defect free manufacturing. Focus is on eliminating non-conformances in a systematic manner, much like Focused Improvement. We gain understanding of what parts of the equipment affect product quality and begin to eliminate current quality concerns, and then move to potential quality concerns. Transition is from reactive to proactive (Quality Control to Quality Assurance).

QM activities is to set equipment conditions that preclude quality defects, based on the basic concept of maintaining perfect equipment to maintain perfect quality of products. The condition is checked and measure in time series to very that measure values are within standard values to prevent defects. The transition of measured values is watched to predict possibilities of defects occurring and to take counter measures before hand.

**Policy:**

1. Defect free conditions and control of equipments.
2. QM activities to support quality assurance.
3. Focus of prevention of defects at source.
4. Focus on poka-yoke. (Fool proof system)
5. In-line detection and segregation of defects.
6. Effective implementation of operator quality assurance.

**Target :**

1. Achieve and sustain customer complaints at zero
2. Reduce in-process defects by 50 %
3. Reduce cost of quality by 50 %.

**Data requirements:**

Quality defects are classified as customer end defects and in house defects. For customer-end data, we have to get data on

1. Customer end line rejection
2. Field complaints.

In-house, data include data related to products and data related to process

**Data related to product:**

1. Product wise defects
2. Severity of the defect and its contribution - major/minor
3. Location of the defect with reference to the layout
4. Magnitude and frequency of its occurrence at each stage of measurement
5. Occurrence trend in beginning and the end of each production/process/changes. (Like pattern change, ladle/furnace lining etc.)
6. Occurrence trend with respect to restoration of breakdown/modifications/periodical replacement of quality components.

**Data related to processes:**

1. The operating condition for individual sub-process related to men, method, material and machine.
2. The standard settings/conditions of the sub-process
3. The actual record of the settings/conditions during the defect occurrence.

**PILLAR 6 - TRAINING:**

It is aimed to have multi-skilled revitalized employees whose morale is high and who has eager to come to work and perform all required functions effectively and independently. Education is given to operators to upgrade their skill. It is not sufficient know only "Know-How" by they should also learn "Know-why". By experience they gain, "Know-How" to overcome a problem what to be done. This they do

without knowing the root cause of the problem and why they are doing so. Hence it becomes necessary to train them on knowing "Know-why". The employees should be trained to achieve the four phases of skill. The goal is to create a factory full of experts. The different phase of skills is

- Phase 1: Do not know.
- Phase 2: Know the theory but cannot do.
- Phase 3: Can do but cannot teach
- Phase 4: Can do and also teach.

**Policy:**

1. Focus on improvement of knowledge, skills and techniques.
2. Creating a training environment for self-learning based on felt needs.
3. Training curriculum / tools /assessment etc conducive to employee revitalization
4. Training to remove employee fatigue and make, work enjoyable.

**Target:**

1. Achieve and sustain downtime due to want men at zero on critical machines.
2. Achieve and sustain zero losses due to lack of knowledge / skills / techniques
3. Aim for 100 % participation in suggestion scheme.

**Steps in Educating and training activities:**

1. Setting policies and priorities and checking present status of education and training.
2. Establish of training system for operation and maintenance skill up gradation.
3. Training the employees for upgrading the operation and maintenance skills.
4. Preparation of training calendar.
5. Kick-off of the system for training.
6. Evaluation of activities and study of future approach.

**PILLAR 7 - OFFICE TPM:**

Office TPM should be started after activating four other pillars of TPM (JH, Kaizen, QM, PM). Office TPM must be followed to improve productivity, efficiency in the administrative functions and identify and eliminate losses. This includes analyzing processes and procedures towards increased office automation. Office TPM addresses twelve major losses. They are

1. Processing loss
2. Cost loss including in areas such as procurement, accounts, marketing, sales leading to high inventories
3. Communication loss
4. Idle loss
5. Set-up loss
6. Accuracy loss
7. Office equipment breakdown

8. Communication channel breakdown, telephone and fax lines
9. Time spent on retrieval of information
10. Non availability of correct on line stock status
11. Customer complaints due to logistics
12. Expenses on emergency dispatches/purchases.

### **How to start office TPM?**

A senior person from one of the support functions e.g. Head of Finance, MIS, Purchase etc should be heading the sub-committee. Members representing all support functions and people from Production & Quality should be included in sub committee. TPM co-ordinate plans and guides the sub committee.

1. Providing awareness about office TPM to all support departments
2. Helping them to identify P, Q, C, D, S, M in each function in relation to plant performance
3. Identify the scope for improvement in each function
4. Collect relevant data
5. Help them to solve problems in their circles
6. Make up an activity board where progress is monitored on both sides - results and actions along with Kaizens.
7. Fan out to cover all employees and circles in all functions.

### **Kaizen topics for Office TPM:**

- Inventory reduction
- Lead time reduction of critical processes
- Motion & space losses
- Retrieval time reduction.
- Equalizing the work load
- Improving the office efficiency by eliminating the time loss on retrieval of information, by achieving zero breakdown of office equipment like telephone and fax lines.

### **Office TPM and its Benefits:**

1. Involvement of all people in support functions for focusing on better plant performance
2. Better utilized work area
3. Reduce repetitive work
4. Reduced administrative costs
5. Reduced inventory carrying cost
6. Reduction in number of files
7. Productivity of people in support functions
8. Reduction in breakdown of office equipment
9. Reduction of customer complaints due to logistics
10. Reduction in expenses due to emergency dispatches/purchases
11. Reduced manpower
12. Clean and pleasant work environment.

### **Extension of office TPM to suppliers and distributors:**

This is essential, but only after we have done as much as possible internally. With suppliers it will lead to on-time delivery, improved 'in-coming' quality and cost reduction. With distributors it will lead to accurate demand generation, improved secondary distribution and reduction in damages during storage and handling. In any case we will have to teach them based on our experience and practice and highlight gaps in the system, which affect both sides. In case of some of the larger companies, they have started to support clusters of suppliers.

## **PILLAR 8 - SAFETY, HEALTH AND ENVIRONMENT:**

### **Target:**

1. Zero accident,
2. Zero health damage
3. Zero fires.

In this area focus is on to create a safe workplace and a surrounding area that is not damaged by our process or procedures. This pillar will play an active role in each of the other pillars on a regular basis.

A committee is constituted for this pillar, which comprises representative of officers as well as workers. Senior vice President (Technical), heads the committee. Utmost importance to Safety is given in the plant. Manager (Safety) is looking after functions related to safety. To create awareness among employees various competitions like safety slogans, Quiz, Drama, Posters, etc. related to safety can be organized at regular intervals.

### **Difficulties faced in TPM implementation:**

One of the difficulties in implementing TPM as a methodology is that it takes a considerable number of years. The time taken depends on the size of the organization. There is no quick way for implementing TPM. This is contradictory to the traditional management improvement strategies. Following are the other difficulties faced in TPM implementation.

- Typically people show strong resistance to change.
- Many people treat it just another “Program of the month ” without paying any focus and also doubt about the effectiveness.
- Not sufficient resources (people, money, time, etc.) and assistance provided
- Insufficient understanding of the methodology and philosophy by middle management
- TPM is not a “quick fix ” approach, it involve cultural change to the ways we do things
- Departmental barrier existing within Business Unit
- Many people considered TPM activities as additional work/threat.

## **Conclusion:**

Today, with competition in industry at an all time high, TPM may be the only thing that stands between success and total failure for some companies. It has been proven to be a program that works. It can be adapted to work not only in industrial plants, but also in construction, building maintenance, transportation, and in a variety of other situations. Employees must be educated and convinced that TPM is not just another "*Program of the month*" and that management is totally committed to the program and the extended time frame necessary for full implementation. If everyone involved in a TPM program does his or her part, an unusually high rate of return compared to resources invested may be expected.

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