

TPM -Total Productive Maintenance

***TPM* Total Productive Maintenance Workshop**

For: (25/Sep/2016)

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TPM -Total Productive Maintenance

Course Overview

This is a 2 day Course which is a company wide team-based effort to build quality into equipment and to improve overall equipment effectiveness (OEE) towards Zero Breakdown.

It uses Total Quality Control and Total Employee Involvement approach, in maintaining the Equipment towards a “ready to use condition” using energy efficiently.



TPM -Total Productive Maintenance

Course Overview

This course will guide you through to assess the activities of Autonomous Maintenance (AM) on your current Equipment and to plan the execution of your Maintenance Activities using a Visual Schedule.



TPM defines your Maintenance schedule and Goals. TPM helps you plan and develop the optimal program for your facility, resulting in increased efficiencies and cost savings.

TPM -*Total Productive Maintenance*

Course Content

Day1

1. Introduction to TPM
2. Types of Maintenance
3. Overall Equipment Efficiency (OEE)
4. The Pillars of TPM (Part 1)
5. The 6 Major Equipment waste

Day2

1. Steps in Introduction of TPM
 2. The 5'S Step towards TPM
 3. Conditions Required for TPM
 4. TPM Strategy
 5. TPM Tools
 6. Set-back of TPM Implementation
- Course Evaluation, Recap and Closing

TPM -Total Productive Maintenance

Course Objective

To implement a current Lean Maintenance System,

-Total Productive Maintenance (TPM) by;

- understanding different types of Maintenance in TPM.
- synergizing Production & Maintenance Staff working together as a team to Implement TPM for Equipment.

Techniques

- - review and externalize Inspection activities to AM.
- - establishing a baseline through ‘Clean to Inspect,
- inspect to detect and Detect to Correct.’ &
- attacking the 6 Big Losses.

TPM -Total Productive Maintenance

Course Objective

Upon the completion of the workshop, participant will be :

- 1) Get their workplace in order ahead of TPM introduction
- 2) Determine the Overall Equipment Effectiveness (OEE) of their machinery
- 3) Understand how to improve the efficiency of their machinery
- 4) Predict where failures are likely to occur
- 5) Be able to design and implement a TPM program

Course Content

Day 1

- 1. Introduction to TPM**
 - *Definition of TPM,*
 - *History of TPM,*
 - *Importance and benefits of TPM,*
 - *Difference between TQM & TPM*



TPM -Total Productive Maintenance

INTRODUCTION

TPM is a company-wide team-based effort to build quality into equipment and to improve overall equipment effectiveness of Preventive & Predictive Maintenance.

It uses Total Quality Control and Total Employee Involvement approach, in maintaining the Equipment towards a “ready to use condition” using energy efficiently.



TPM -*Total Productive Maintenance*

DEFINITION

Total in TPM means '*total involvement*' from top management to shop floor personnel. TPM is not optional, everyone has to participate for it to work.

Productive- Creates cost saving and also creates cost avoidance.

(TPM) comprises Production practices in *Autonomous Maintenance (AM)* and the *Maintenance group*, both working together as a Team to maintain the smooth running of a Company's Equipment towards a *Zero Breakdown*.

TPM -Total Productive Maintenance

TPM combine Production practices in ***Autonomous Maintenance (AM)*** and the ***Maintenance practices***, both working together as a Team to maintain the smooth running of a Company's Equipment towards a ***Zero Breakdown***.



The TPM Maintenance covers;

- Autonomous Maintenance (AM)
- The 3 P'S of Maintenance Preventive (PM), Predictive Maintenance (PdM) & Plan Maintenance.

Maintenance

What does Maintenance
mean to you?

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The root word of **Maintenance** is *Maintain*, more often than not maintenance is looked at as the people that repair our equipment when it breaks.

With TPM, the focus of maintenance shifts from that of repairing, or reacting to failures to that of maintaining assets and preventing failures and quality defects in the first place.

TPM -Total Productive Maintenance

HISTORY OF TPM...

- The term “Total Productive Maintenance” was first used in the late 1960’s by Nipponese, a supplier of electrical parts to Toyota.
- In 1971, Nipponese received the Distinguished Plant Award(The PM Prize) from Japan Institute of Plant Maintenance (JIPM).
- Nipponese was the first plant to receive the award as a result of implementing TPM.
- Eventually, Seiichi Nakajima, a vice chairman of JIOPM, became known as the father of TPM, since he provided implementation support to hundreds of plants, mostly in Japan.

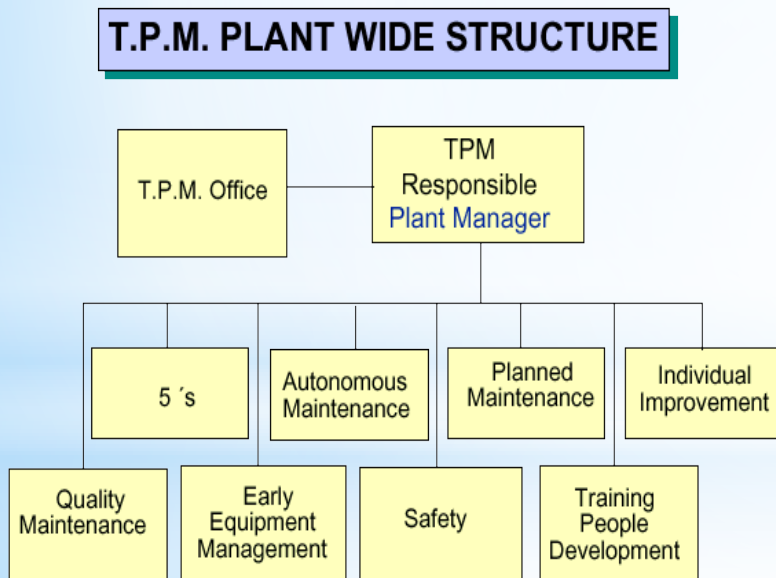
Seiichi Nakajima,
Founder of TPM



TPM -Total Productive Maintenance

HISTORY

TPM is a 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. Nippon Denso was the first company to introduce plant wide preventive maintenance in 1960.

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Origins of TPM

Dr. Deming introduced statistical analysis and used the resulting data to control quality during manufacturing (TQM) Some general concepts of TQM did not work well in the maintenance environment.



The need to go further than preventive maintenance was quickly recognized by those companies who were committed to TQM Maintenance became an integral part of TQM in the early 90's

TPM -Total Productive Maintenance

Why TPM? Its all about meeting QCDS

Reduce cost dramatically by pursuing the extreme in equipment (production) effectiveness

Cost Reduction for Survival

Strict Quality Demands

Establish conditions that will not allow defects and manage conditions that will prevent defects

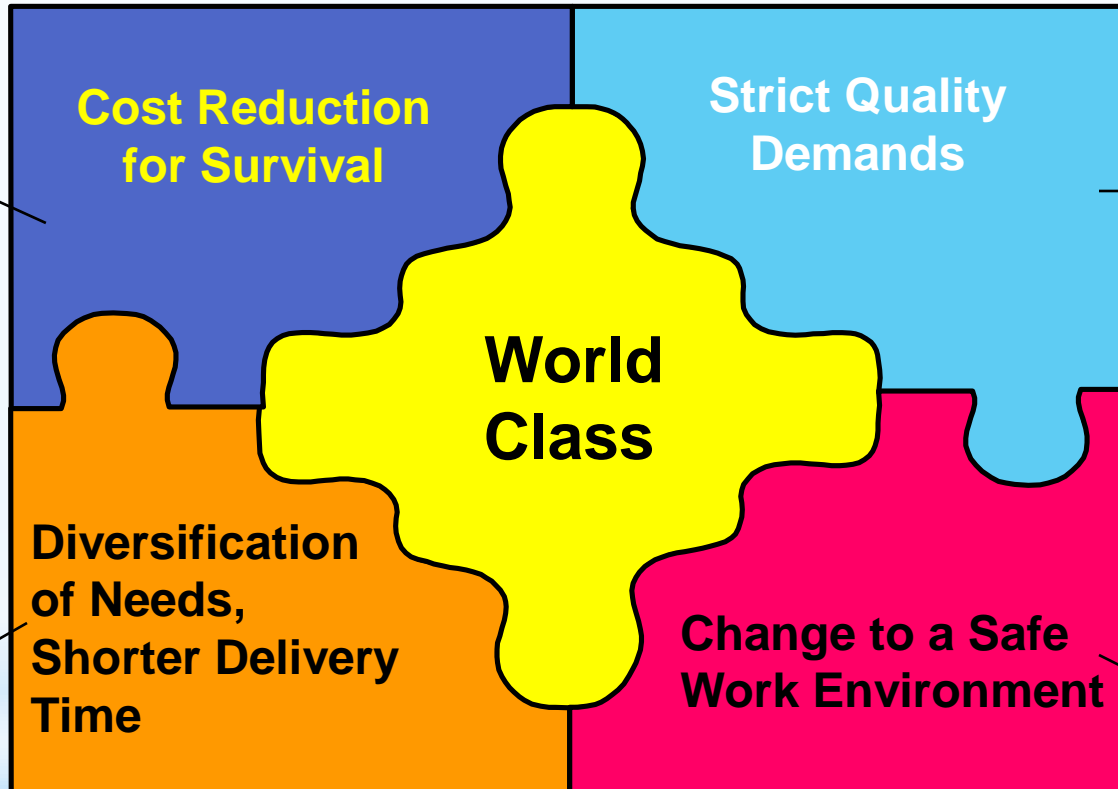
World Class

Minimize machine setup time and get the product to the customer on time

Diversification of Needs, Shorter Delivery Time

Change to a Safe Work Environment

Create unmanned operations and people friendly Safe working equipment



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Who participates in TPM?

EVERYONE!

FROM TOP MANAGEMENT

TO

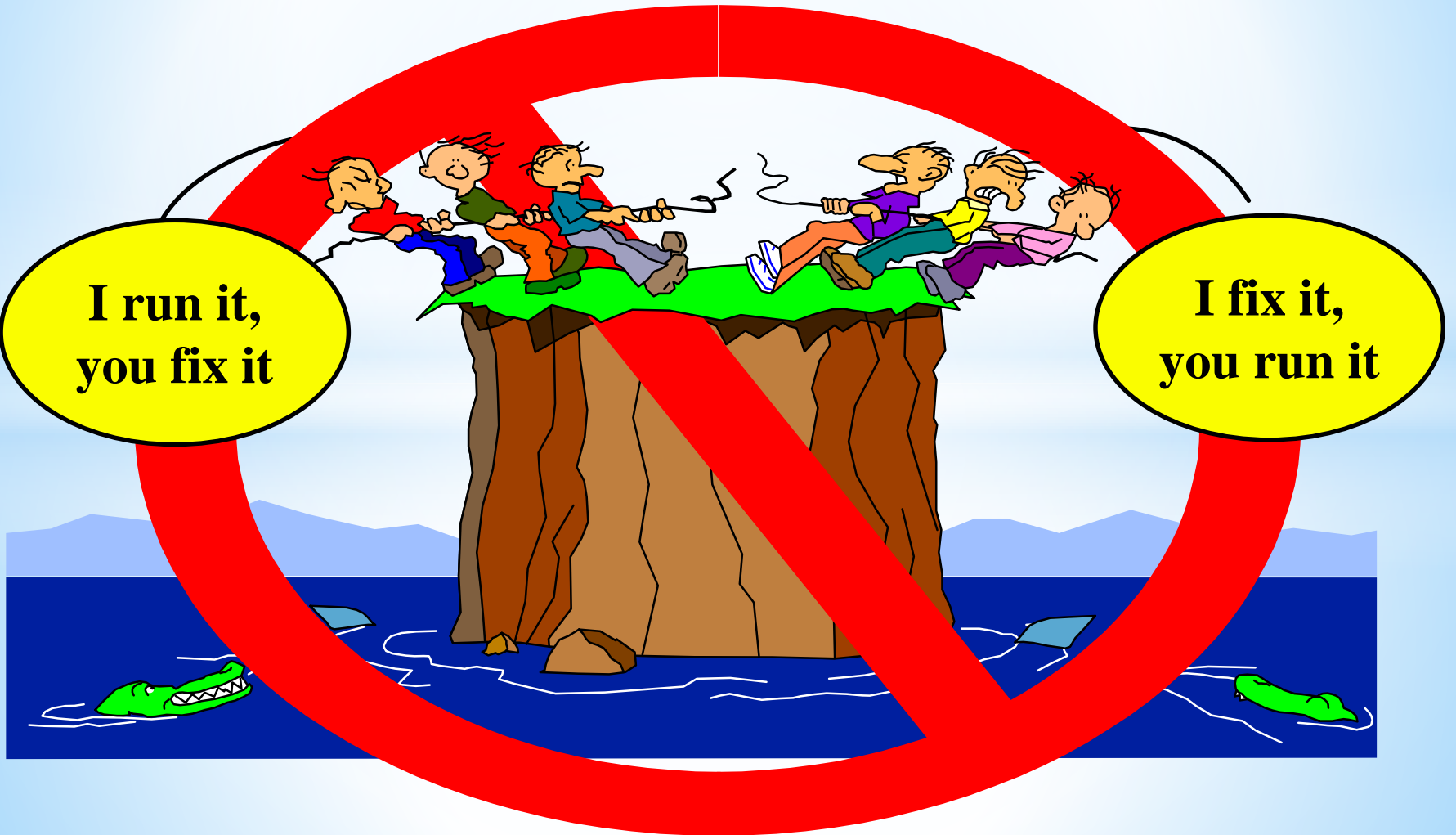
SHOP FLOOR PERSONNEL

TPM -Total Productive Maintenance

TPM is **Not**,

**I run it,
you fix it**

**I fix it,
you run it**



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Importance and benefits of TPM

The implementation of a TPM program, Autonomous Maintenance (AM) creates a shared responsibility for equipment that encourages greater involvement by plant floor workers.



In the right environment this can be very effective in improving productivity (increasing up time, reducing cycle times, and eliminating defects).

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Importance and benefits of TPM

TPM emphasizes proactive and preventative maintenance to maximize the operational efficiency (OEE) of equipment.

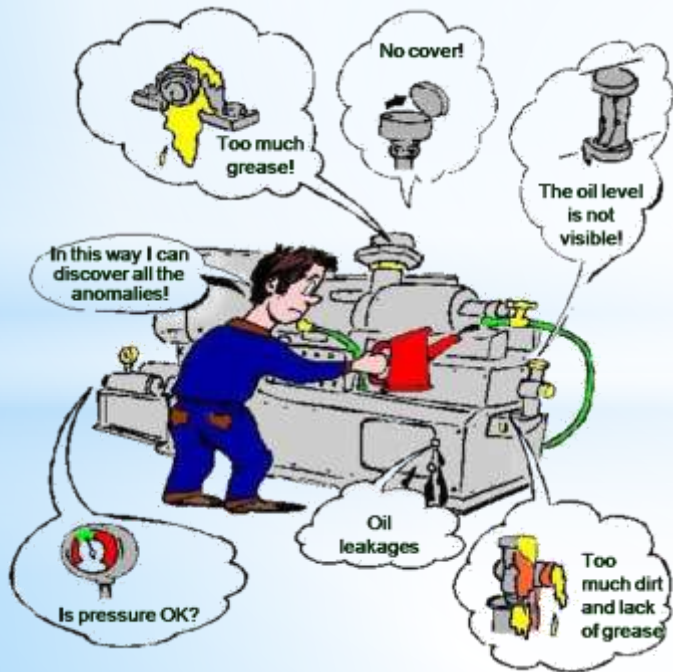


It combines the roles of production and maintenance by placing a strong emphasis on empowering operators to help maintain their equipment.

➤ **TPM** - *Total Productive Maintenance*

Importance and benefits of TPM

The benefits of getting operators involved in maintaining their own equipment, increases Overall Equipment Effectiveness on Equipment with fewer breakdowns, stops, and defects.



TPM strives to achieve:

- No Breakdowns
- No Small Stops or Slow Running
- No Defects

In addition it values a safe working environment:

- No Accidents

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Difference between TQM & TPM

TQM is a Quality Management approach that emphasizes Continuous improvement, a philosophy of "*doing it right the first time*" and striving for zero defects and elimination of all waste.



TQM philosophies emphasize quality, teamwork, and process improvement.

TPM -*Total Productive Maintenance*

Difference between TQM & TPM

TPM combines Production and Maintenance, empowering operators to maintain the equipment towards a “ready to use condition” using Total Employee Involvement approach.



The focus of maintenance shifts from that of repairing, or reacting to failures to that of maintaining assets and preventing failures and quality defects in the first place.

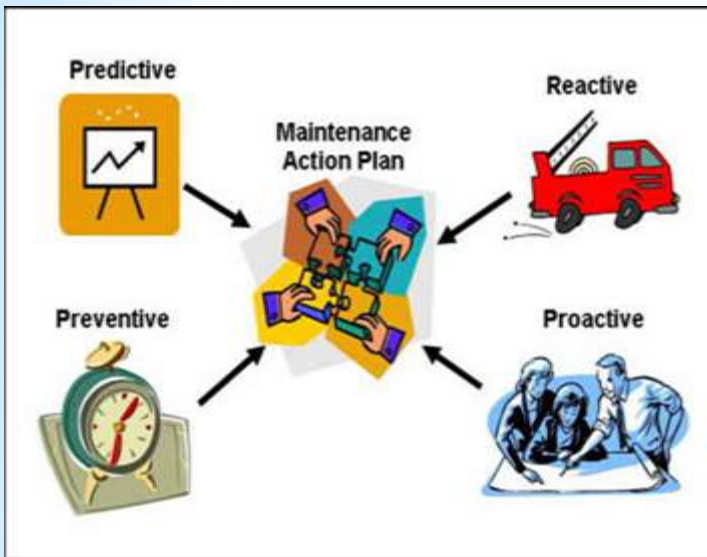
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Difference between TQM & TPM

Category	TQM	TPM
<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.

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2. Types of Maintenance



- *Breakdown Maintenance*
- *Autonomous Maintenance*
- *Preventive Maintenance*
- *Corrective Maintenance*
- *Predictive Maintenance*
- *Plan Maintenance*

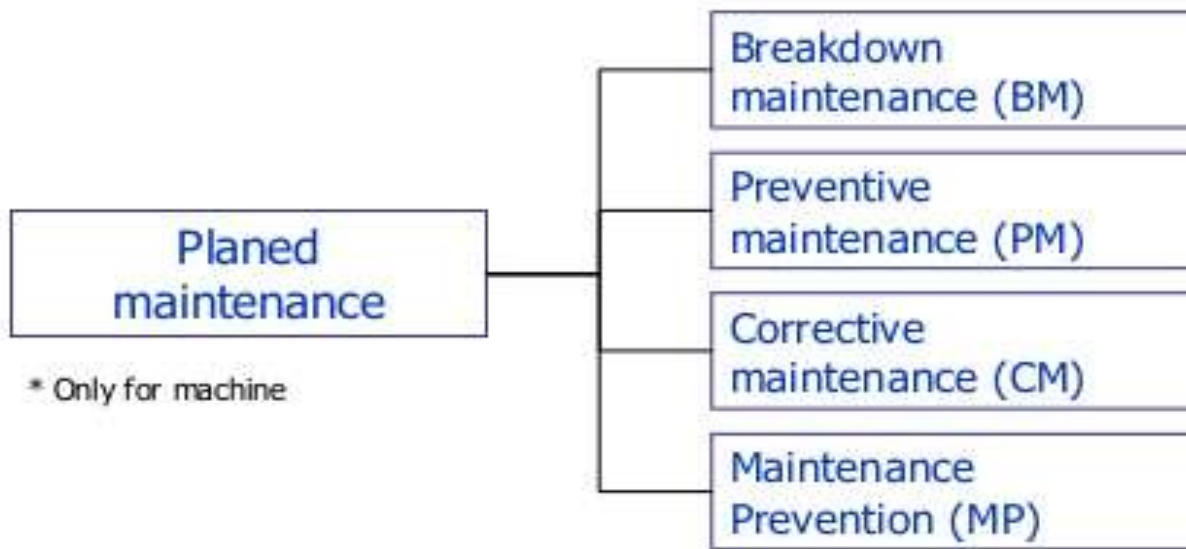
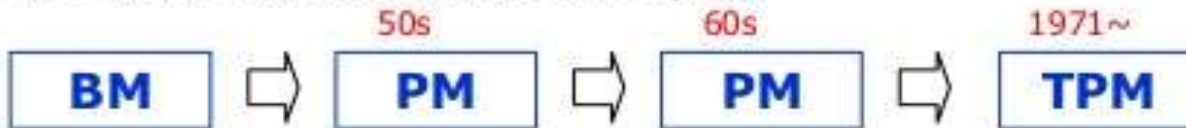


TPM - Total Productive Maintenance

2. Types of Maintenance

History of TPM

Productive maintenance in Japan



* Only for machine

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Types of Maintenance in TPM

Breakdown Maintenance (reactive):

Performed on equipment on equipment that has broken down and is unusable. It may be either planned or it can be unplanned.



Reactive Maintenance - Maintenance done in response to an equipment breakdown, also called fire fighting.

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Types of Maintenance in TPM

Autonomous Maintenance:

Machine Maintenance made by their operators who are deemed to have unique knowledge about the machines. It is a principal component TPM.



:process by which equipment operators accept and share responsibility (with Maintenance) for the performance and health of their equipment

Types of Maintenance in TPM

Preventive Maintenance:

routine maintenance to maintain the basic equipment conditions, replace deteriorating parts, and maintain equipment in on-spec condition.

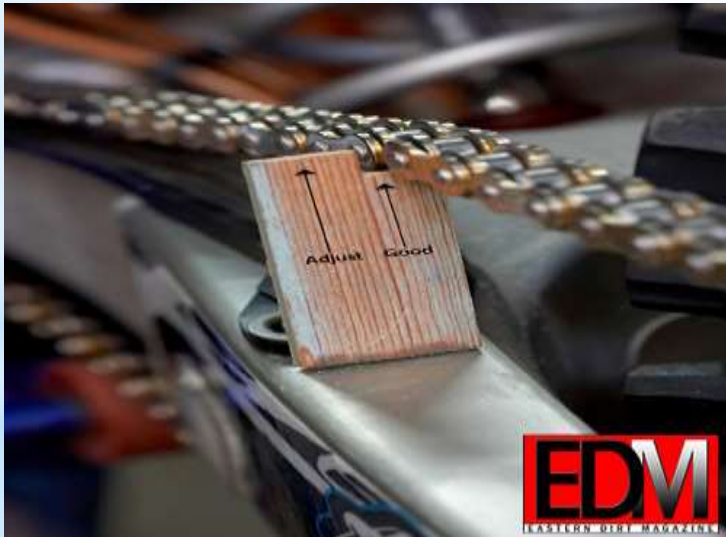


It is carried out at predetermined periods, to ensure equipment reliability

Types of Maintenance in TPM

Corrective Maintenance :

task performed to identify, isolate, and rectify a fault so that the failed equipment, machine, or system;



can be restored to an operational condition within the tolerances or limits established for in-service operations.

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Types of Maintenance in TPM

Predictive Maintenance (condition-based): corrects equipment deterioration by condition monitoring to predict when **maintenance** should be performed.



This approach promises cost savings over routine or time-based **preventive maintenance**, because tasks are performed only when warranted.

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Types of Maintenance in TPM

Planned Preventive Maintenance (PPM); commonly referred to as simply **planned maintenance (PM)** or **scheduled maintenance**, is any variety of **scheduled maintenance** to an object or item of equipment.



Planned Preventative maintenance is performed while the equipment is still working, so that it does not break down unexpectedly.

3. Overall Equipment Efficiency (OEE)

- *Measuring your OEE,*
- *MTBF and MTTR,*
- *Calculating Performance Efficiency,*
- *Quality Yield*

$$\begin{aligned} \text{OEE} = & \\ & \text{Availability} \\ & \times \\ & \text{Performance} \\ & \times \\ & \text{Quality Yield} \end{aligned}$$



3. Overall Equipment Efficiency (OEE)

OEE measures the efficiency of the machine during its planned loading time.

$$\begin{array}{c} \text{OEE} = \\ \text{Availability} \\ \times \\ \text{Performance} \\ \times \\ \text{Quality Yield} \end{array}$$

OEE figures are determined by combining the availability and performance of your equipment with the quality of parts made.

Planned downtime does not effect the OEE figure.

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OEE is an internationally accepted measure of equipment effectiveness during planned production.

$$\text{OEE} = \text{Availability} \times \text{Performance} \times \text{Quality Yield}$$

Availability

Downtime loss

Performance

Speed loss

Quality Yield

Quality loss

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MTBF and MTTR

Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR) are two very important indicators when it comes to **availability** of an application.



Despite its importance in the performance of the processes, most managers do not make full use of these key performance indicators (KPIs) in their control activities.

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MTBF : Mean Time Between Failures

-is the average time elapsed between a failure and the next time it occurs. These lapses of time can be calculated by using a formula.

MTTR: Mean Time To Repair

-is the time it takes to run a repair after the occurrence of the failure. That is, it is the time spent during the intervention in a given process.

4. The Pillars of TPM (Part 1)

Pillar 1 : 5'S as the foundation for TPM

Pillar 2 :Autonomous Maintenance,

Pillar 3 : Kaizen (Focused Improvement),

Pillar 4 : Planned Maintenance,

Pillar 5 : Quality Maintenance,

Pillar 6 : Training & Education,

Pillar 7 : Office (Administration) TPM,

Pillar 8 : Safety/ Health and Environment



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PILLARS OF TPM

AUTONOMOUS MAINTENANCE
JISHU HOZEN

KOBE TSU KAIZEN

PLANNED MAINTENANCE

QUALITY MAINTENANCE

TRAINING

OFFICE TPM

SAFETY, HEALTH AND
ENVIRONMENT

5S

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Characteristics of World Class requirements **Customer-Value Focused**



$$\text{Cost} + \text{Profit} = \text{Price}$$

$$\text{Price} - \text{Profit} = \text{Target Cost}$$

World class companies adopts 'Lean' System to vigorously eliminate **Wastes**, focusing on **adding Value** to Customer .

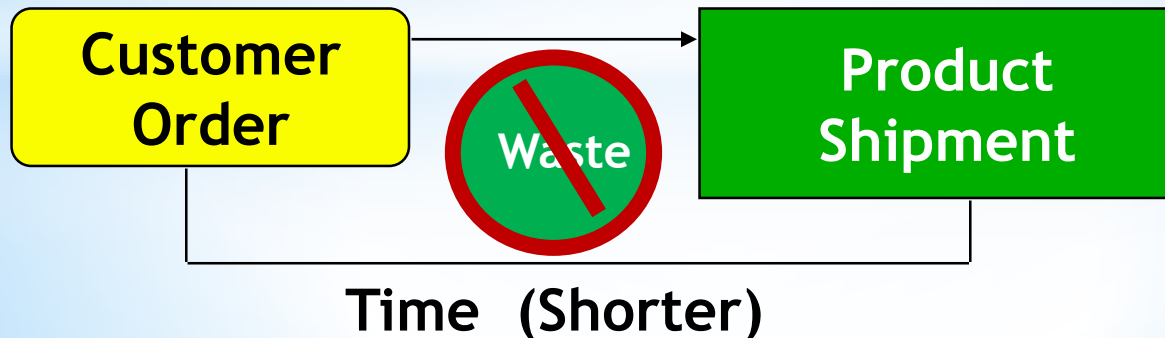
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Lean System is the super-efficient production system pioneered by Toyota which shortens the time line between the customer order and the product shipment by eliminating **Waste**.

Business as Usual



Lean Manufacturing



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Pillar 1. 5S as the foundation for TPM

TPM starts with 5S. 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.

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5S Definition

5'S represents **5 Japanese Disciplines** for maintaining a **Visual** workplace.

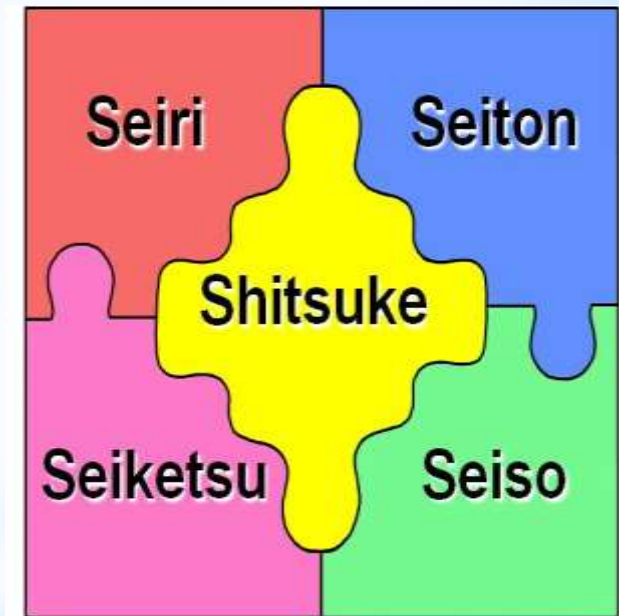
Seiri - Sort (Organize)

Seiton - Simplify
(Visibility)

Seiso - Sweep
(Cleanliness)

Seiketsu - Standardize
(Adherence)

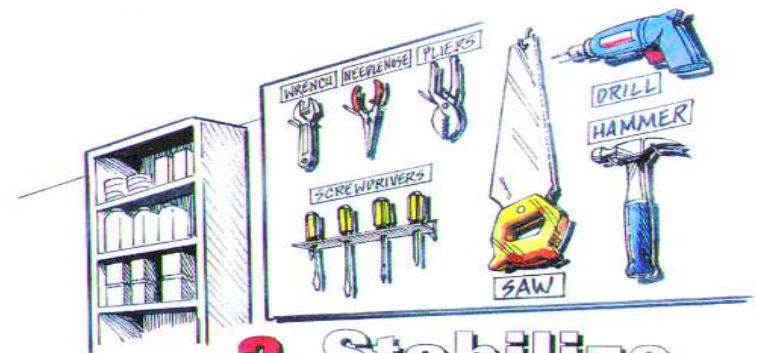
Shitsuke - Self-discipline
(Sustain)



Pillar 1. 5S as the foundation for Lean System



1. Sort



2. Stabilize

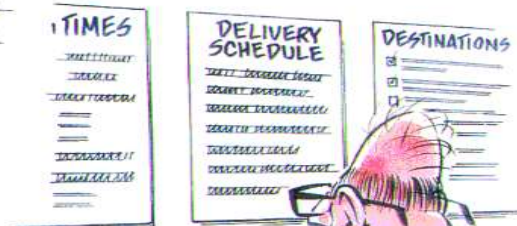
5 S's



5. Sustain



3. Shine



4. Standardize

* **TPM** - *Total Productive Maintenance*

5S is a philosophy and a way of organizing and managing the workplace towards an organized, clean, high-performance environment.



Its primarily intention is to *improve* efficiency by eliminating *Waste*.

Benefits of a 5's Environment

The goal of 5S is to create a work environment that is clean and well-organized practicing all the **FIVE** elements of 5'S.



“It gives Ability to understand the status of a area in **5 minutes** or less by simple observation without use of computers or speaking to anyone”

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It should be reasonably intuitive how 5S creates a foundation for well-running equipment.



For example, in a clean and well-organized work environment, tools and parts are much easier to find, and it is much easier to spot emerging issues such as fluid leaks, material spills, metal shavings from unexpected wear, hairline cracks in mechanisms, etc.

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Where are we today?

*Lets take
a quick
perk*



3rd Class Workplace ...



Necessary & Unnecessary items are mixed together in the same workplace

2nd Class Workplace ...



Necessary & Unnecessary items had been seperated within identified work area (including inventory)

1st Class Workplace ...

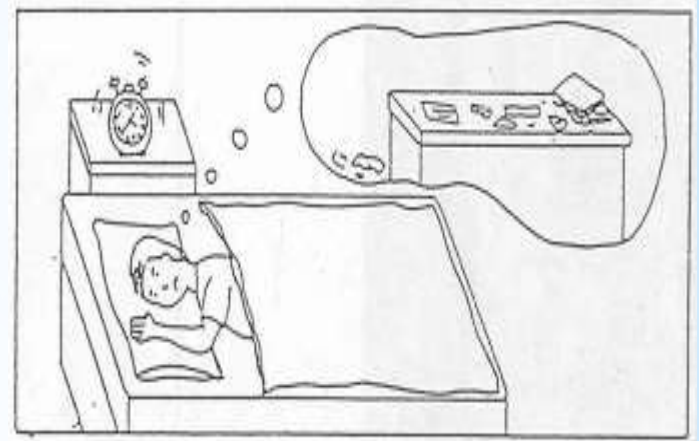
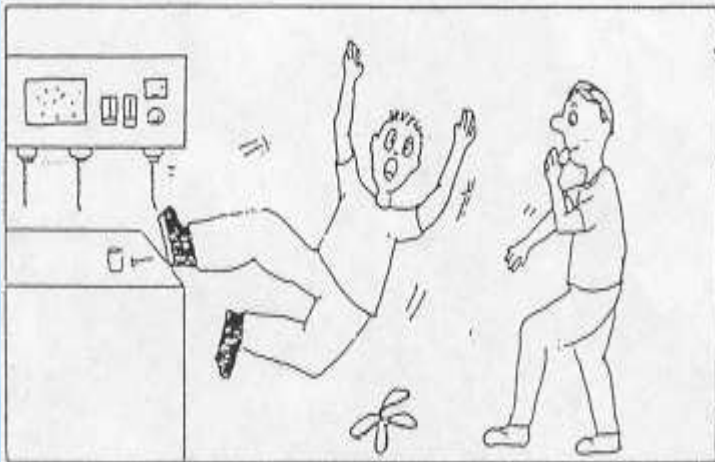


Only **Necessary** supplies, tools and items are stored in the **Work Environment**.

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Benefits of 5'S

- 5S makes one's workplace more pleasant
- 5S helps in work efficiency
- 5S and safety go hand-in-hand



- 5S leads to better quality products and higher productivity

1st S' Seiri (Sort)

To take out unnecessary items either sort, **red tag** or throw them away



Necessary:

Used for daily work

Used periodically

I am the source

Unnecessary:

Unsafe

Defective

Obsolete or outdated

Unused

Extra or duplicate

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5' S Red Tag

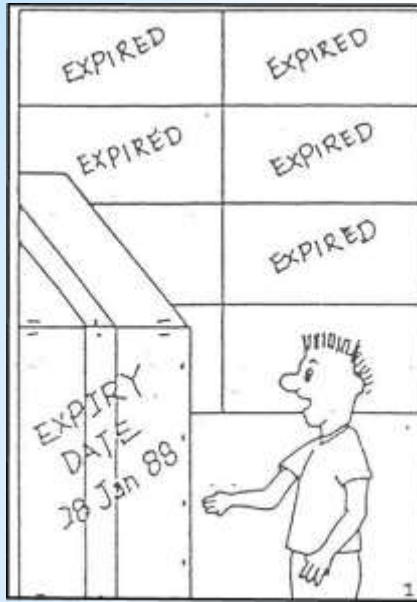
5S **Red Tags** are used to keep the process of change going throughout the 5S program while remaining organized in the process. These 5S Red Tags are used for visual management of a workspace, clearly marking items that need to be moved creating workplace organization.

Red Tag Sample

The image shows two identical red 5S Red Tag forms. Each form has a white circular hole at the top center for a string. The forms are divided into several sections:

- RED TAG** (Header)
- General Information**
 - Date: _____ Tagged By: _____
 - Item Name: _____
 - Location: _____
- Category**
 - Equipment Raw Materials
 - Tools & Jigs Work in Progress
 - Finished Goods Inventory
 - Waste Misc.
 - Consumable Materials Other
 - Material Parts
 - Other: _____
- Reason for Red Tag**
 - Not Required Excess Inventory
 - Defect Obsolete
 - Broken
 - Other: _____
- Action to Take**
 - Return to: _____
 - Location: _____
 - Move to Red Tag Storage Area
 - Move to Storage Site: _____
 - Date: _____
- Additional Comments**
 - _____
 - _____
 - _____
 - _____
- 5S/TPM** (Footer)
 - Log No.

1st S' Seiri (Sort)

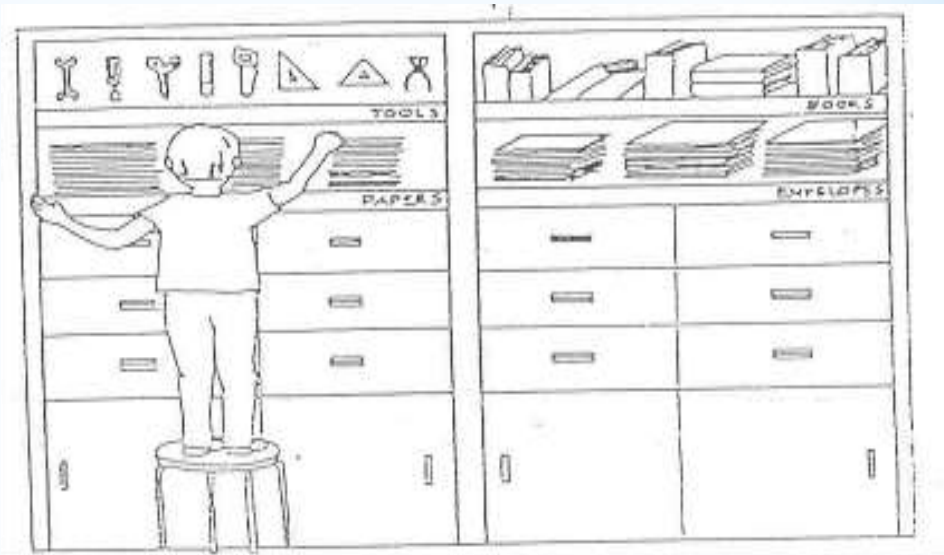
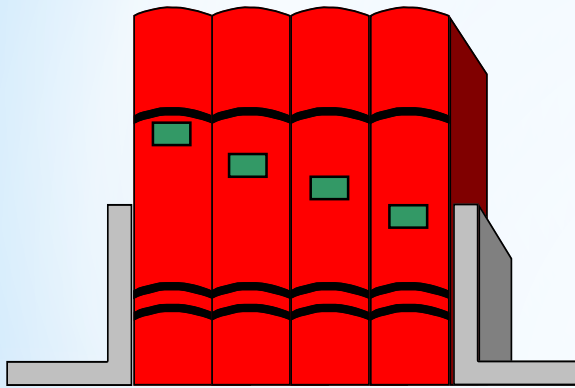


Critical items for use should be kept nearby. Items that are not be used should be Red Tagged.

Items sorted should be decided based on utility and not cost to reduce the Search time.

2nd S' Seiton (Simplify)

To arrange necessary items in a proper order so that they can be easily picked up for use

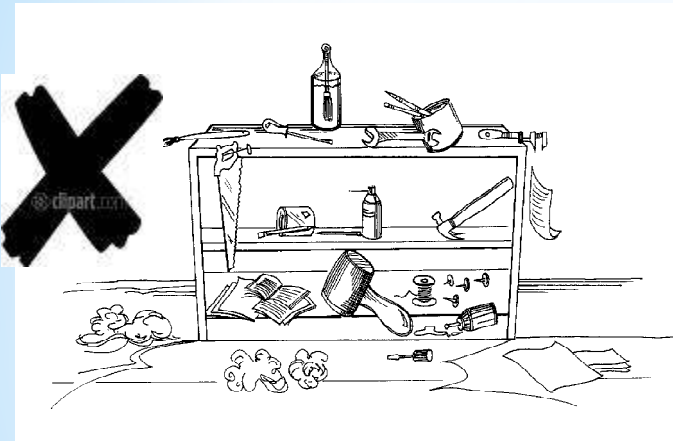


Consider:

- *Visual aids are encouraged in for fast retrieval and minimize complexity.*
- *Labeling locations where necessary items are kept but not in use, especially moveable items.*
- *Labeling drawers and notebooks to identify their contents.*

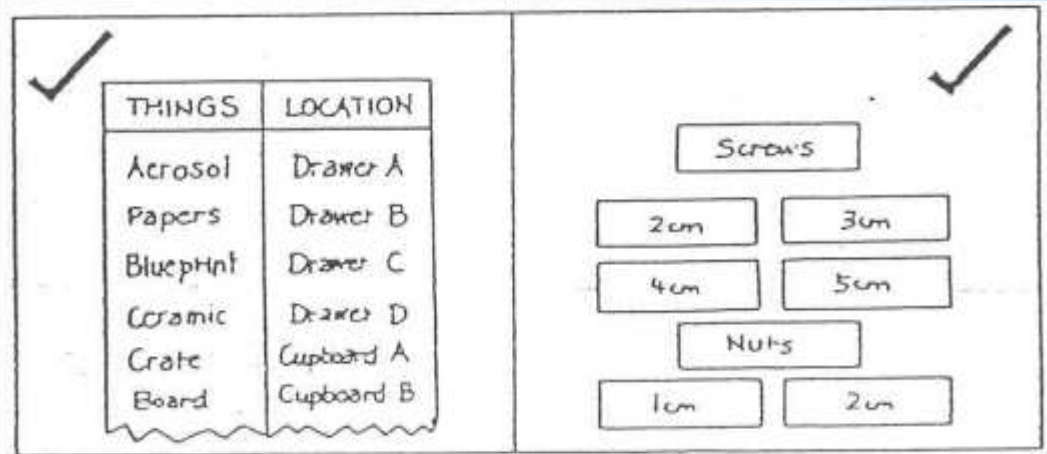
2nd S' Seiton (Simplify)

Label & shadow board



5S Map to decide location

"Anyone should be able to easily understand proper arrangement and abnormalities."

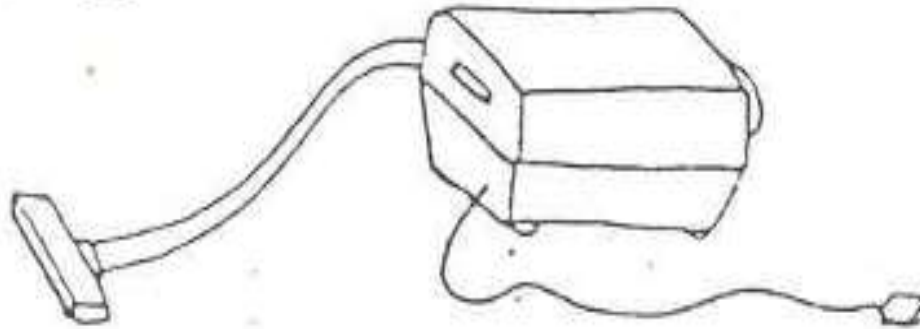
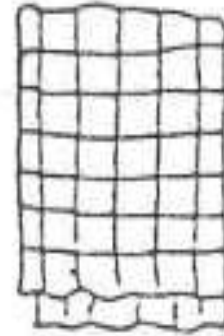
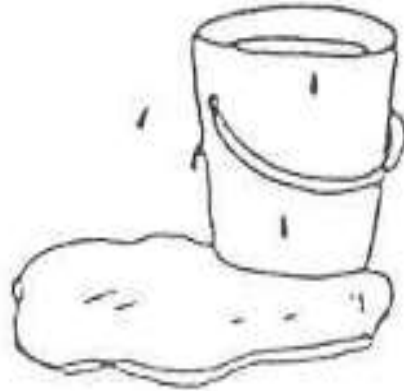


3rd S' Seiso (Sweep)

To clean your workplace completely so that there is no dust anywhere



Tools for Seiso (Sweep)

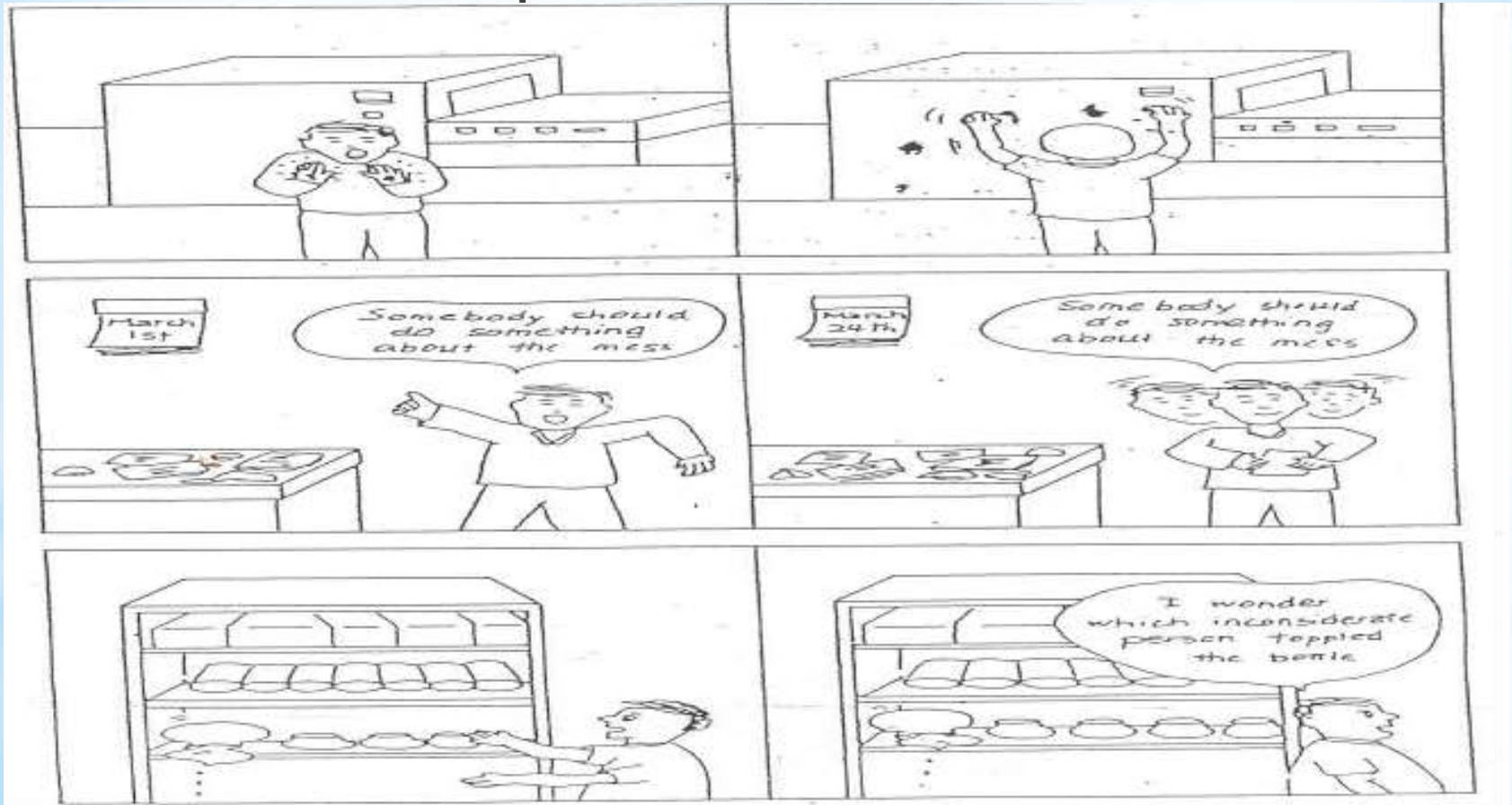


5S' Assignment Map

5S' schedule

4th S' Seiketsu (Standardize)

To maintain a high standard of housekeeping and workplace organization at all times. Visual checks to maintain the process.



5th S' Shitsuke (Self Discipline)

To train people to follow good housekeeping discipline independently



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Why 5 S' is so necessary and practiced in a World Class Facility?



- Standards so management can evaluate performance,
- Necessary to enforce discipline,

- Standards for diagnosis, self-evaluation, a necessity to enforce discipline 'Buy in'
- With buy-in, "discipline" isn't necessary

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The 8 Pillars of TPM (Part 1)

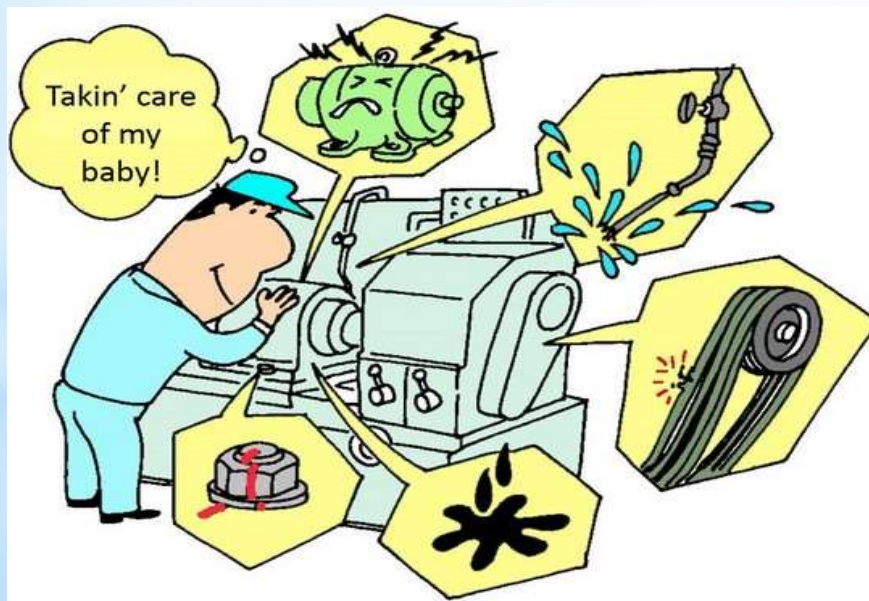
The traditional TPM model consists of a **5S**' as the *foundation* and eight supporting Pillars of activities towards World Class results.



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Pillar 2. Autonomous Maintenance (AM)

Operator assumes ownership for the efficiency of their equipment by involvement in early problem detection, through routine cleaning, lubrication and equipment inspection.

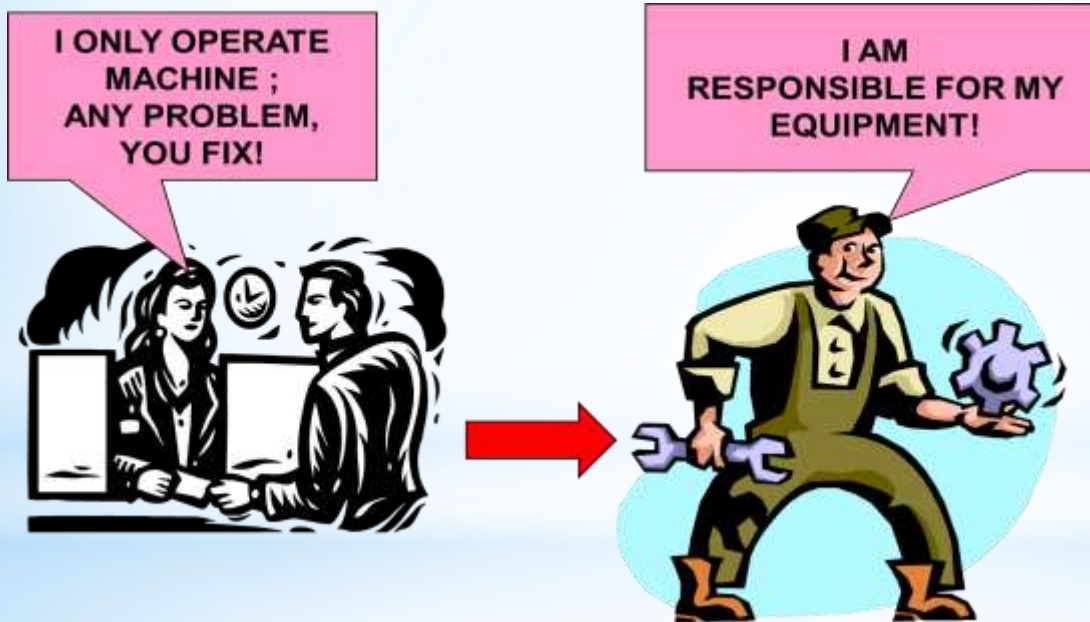


This also includes being a member of a Small Group Activity improvement team formed after completion of a workshop.

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Autonomous Maintenance (AM)

Train the operators to close the gap between them and the maintenance staff;

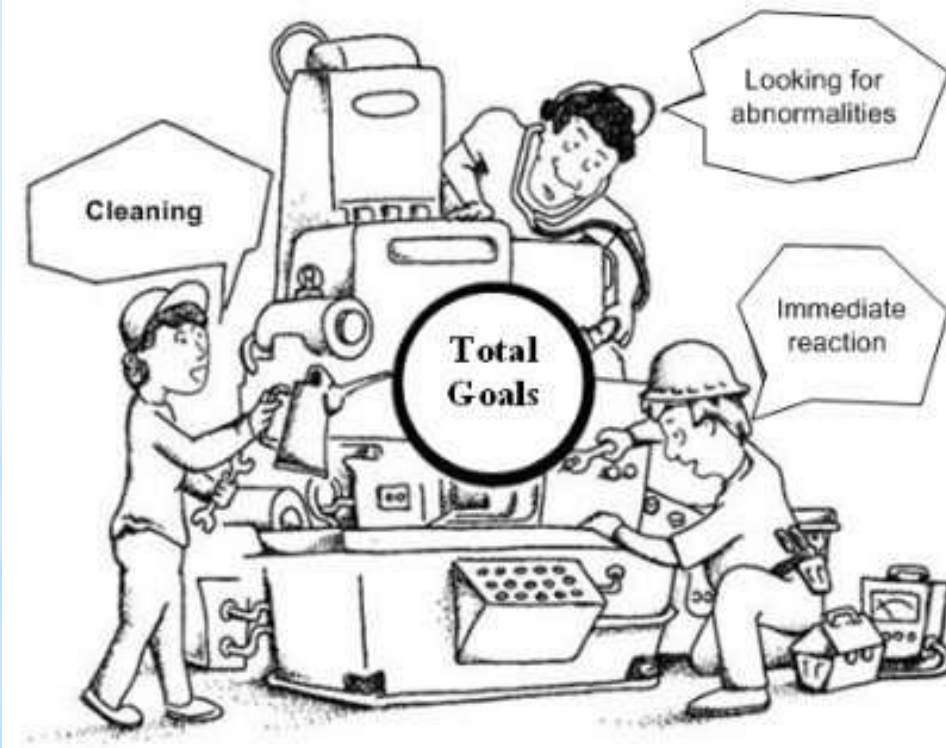


making it easier for both to work as one team.

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Autonomous Maintenance (AM);

change the equipment so the operator can identify any abnormal conditions and;



measure
deterioration
before it affects
the process or
leads to a failure

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7 Steps Autonomous Maintenance (AM):

are implemented to progressively increase operators knowledge, participation and responsibility for their equipment.



1. Perform initial cleaning and inspection
2. Countermeasures to address causes and effects of dirt and dust
3. Establish cleaning and lubrication standards
4. Conduct general inspection training
5. Carry out equipment inspection checks
6. Workplace management and control
7. Continuous improvement

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Pillar 3. Kaizen (Focus improvement)

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 little or no investment. The principle behind is that "a very large number of small improvements are more effective in an organizational environment than no improvements.

Pillar 3. Kaizen (Focus improvement)

Kaizen is aimed at reducing losses in the workplace that affect our efficiencies

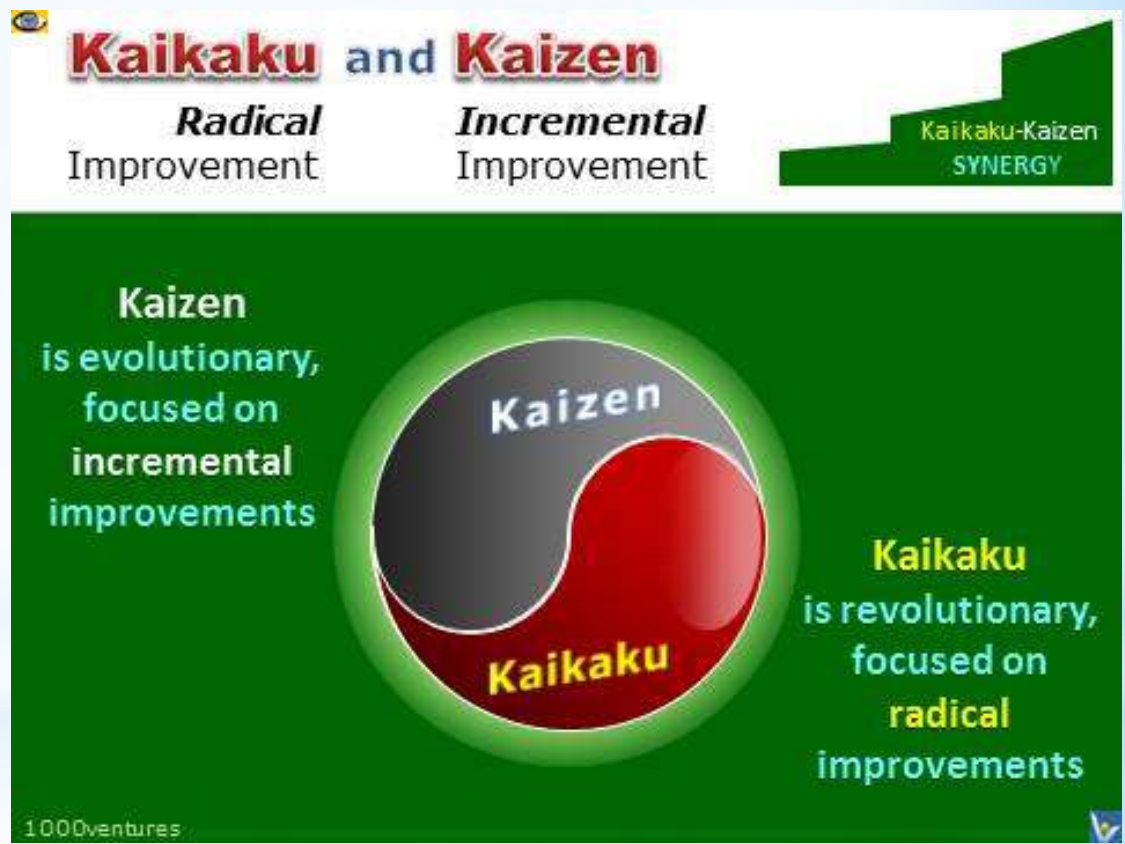
By using a detailed and thorough procedure we eliminate losses in a systematic method using various Kaizen tools. These activities are not limited to production areas and can be implemented in administrative areas as well.

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“Lean Management“ to vigorously eliminate **Wastes** adopts **Kaizen Methodology**



- Radical Change
- **Kaikaku**
- Kaizen Workshop
- **Continuous improvement**
- Daily Improvements
- **Standard Work**



TPM -*Total Productive Maintenance*

TPM is a long-term strategic initiative, rather than a short term tactical fix.

TPM is Not



Everyone must understand why we are doing TPM and must be fully supported from Top to Bottom.

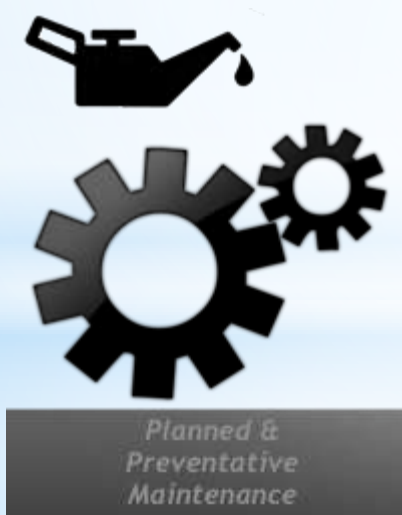
Cannot be done only if time permits.

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Pillar 4. Planned Maintenance (PM)

Planned Maintenance

Moving from reactive to proactive maintenance using Planned and Condition Based Maintenance (CBM).



Focus is now emphasized on reliability of our assets using technology in executing Maintenance.

Where are we today?

Reactive



Is most of your time spent fire fighting?

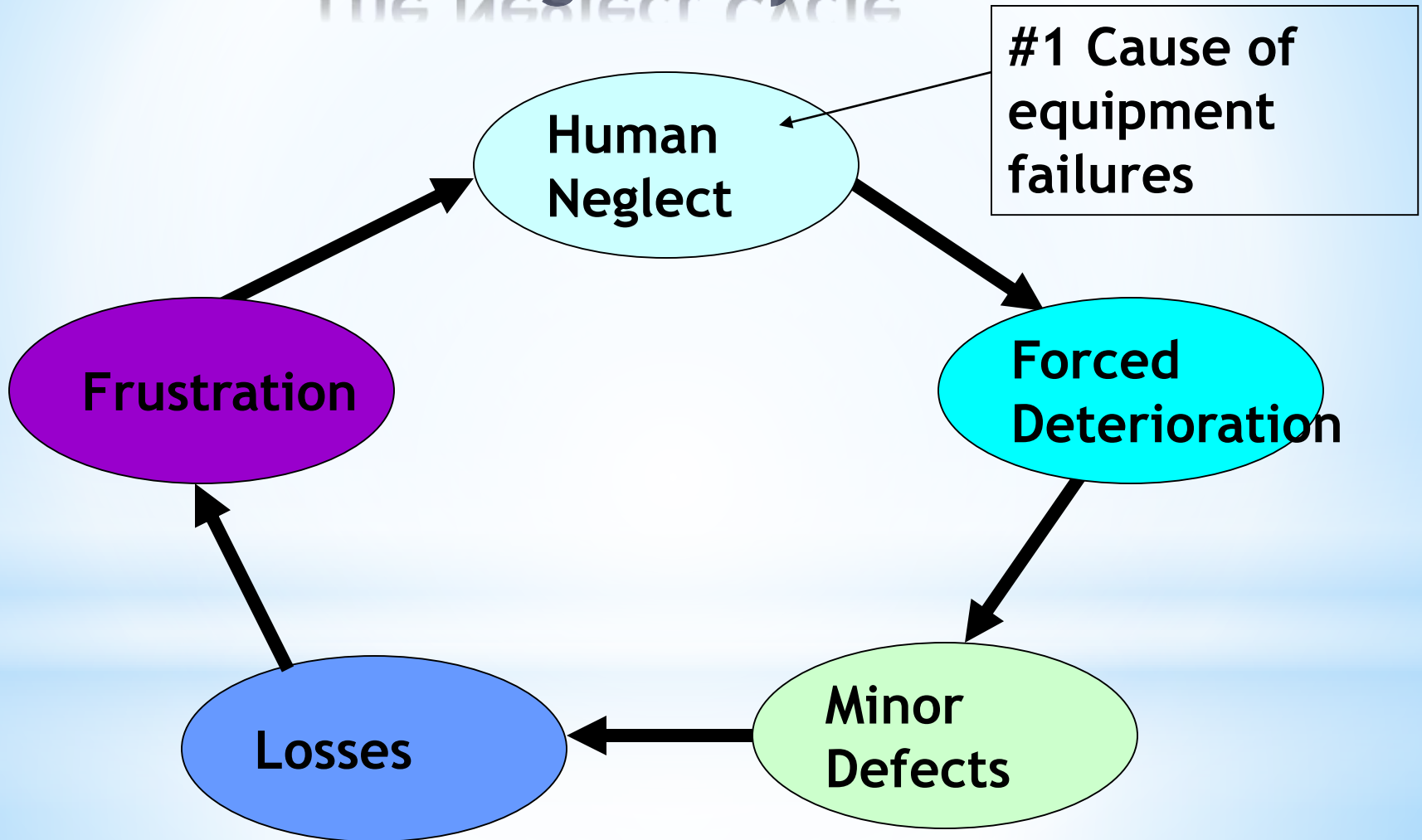
Are equipment failures and quality issues a problem?

Is very little time spent on preventing the failures and quality defects from occurring?

Do you have institutionalized rework in your facilities?

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The Neglect Cycle



Where do we want to be?

Proactive

TPM teaches to plan ahead by preventing equipment failures and quality defects before they occur.



TPM -Total Productive Maintenance

Pillar 5. Quality Maintenance

Quality Maintenance

Achieving and sustaining quality by proactively maintaining equipment condition for zero breakdowns;



and improving processes to accomplish zero defects on Products delivered to customers.

TPM -Total Productive Maintenance

Pillar 5. Quality Maintenance

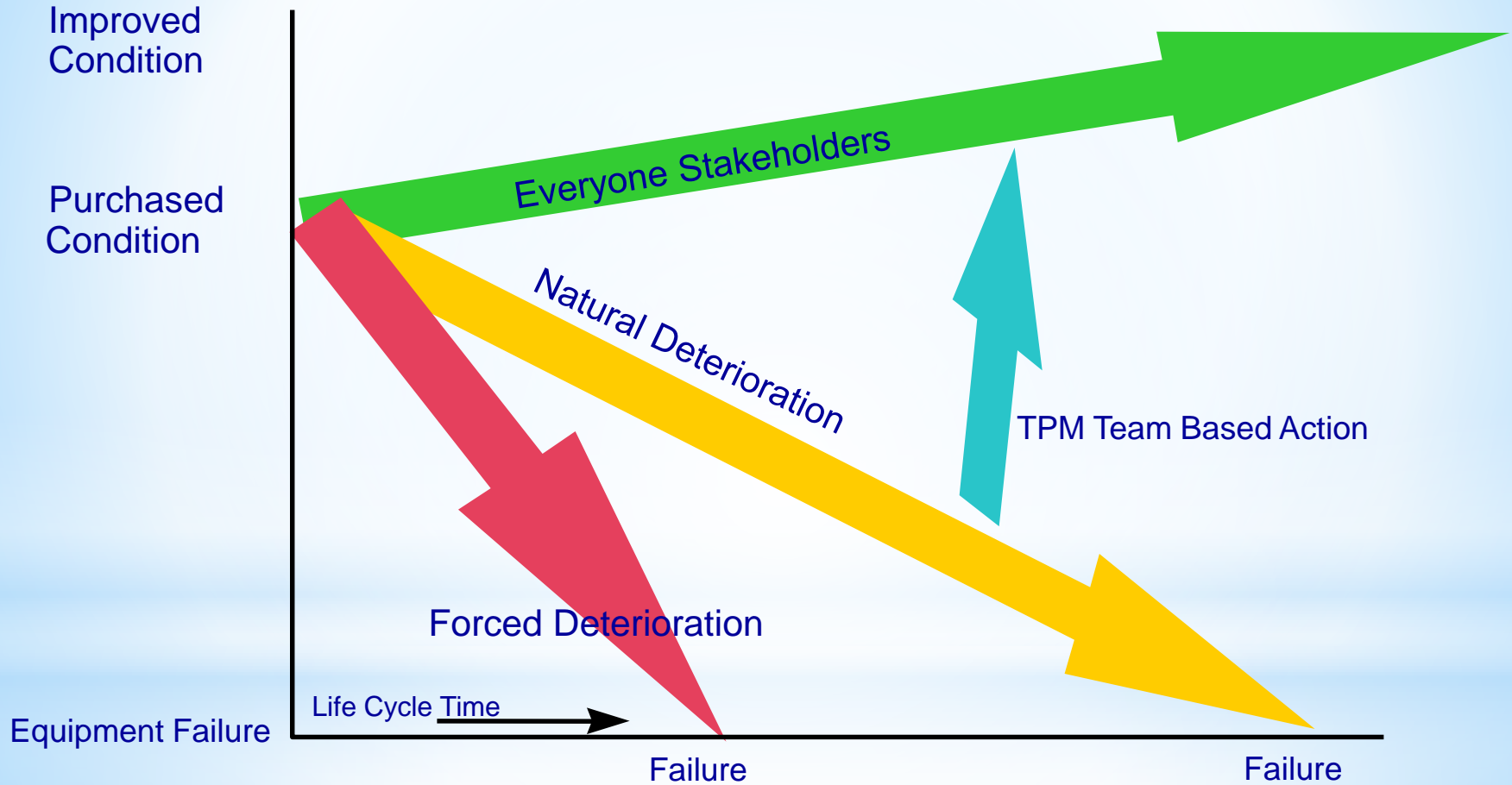
Definition: a process for controlling the condition of equipment components that affect variability in product quality

Objective: to set and maintain conditions to accomplish zero defects



Quality rate has a direct correlation with
material conditions
equipment precision
production methods
process parameters

Improved Asset Condition



TPM -Total Productive Maintenance

The Goal for Quality maintenance is **ZERO!**

ZERO

- * Accidents
- * Equipment Failures
- * Quality Defects
- * Adjustments
- * Minor Stoppages
- * Speed Losses
- * Customer Complaints
- * Pollution



TPM -*Total Productive Maintenance*

Pillar 6. Training and Education

Training and Education Is the foundation for the other elements. Operators, maintenance and stakeholders receive the correct training for improving operator and maintenance skill levels.

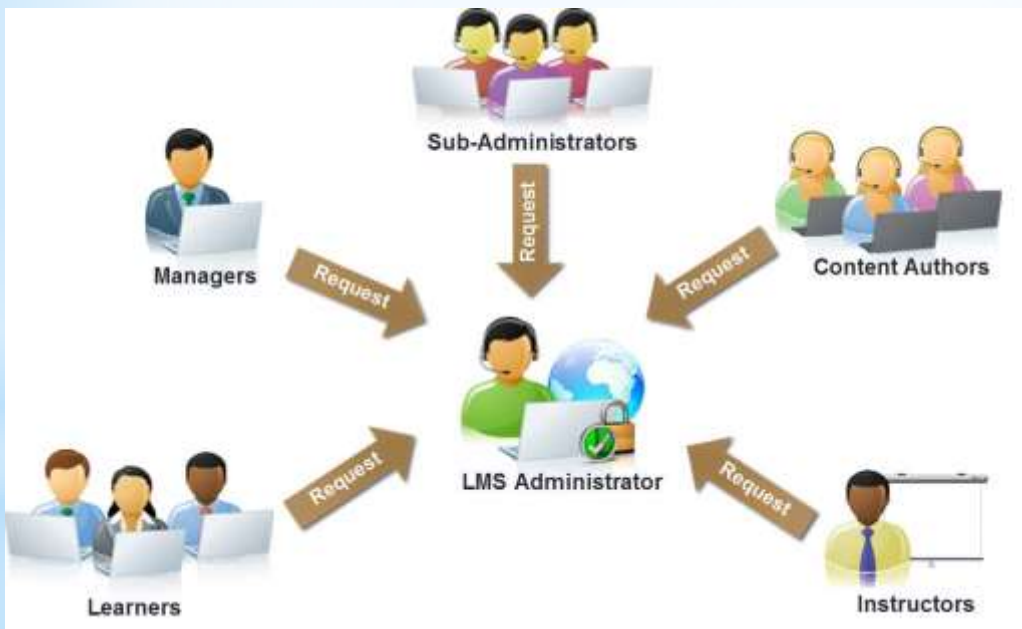


Also by making material available for self development fosters equipment competent employees through TPM.

TPM -Total Productive Maintenance

Pillar 7. Office TPM

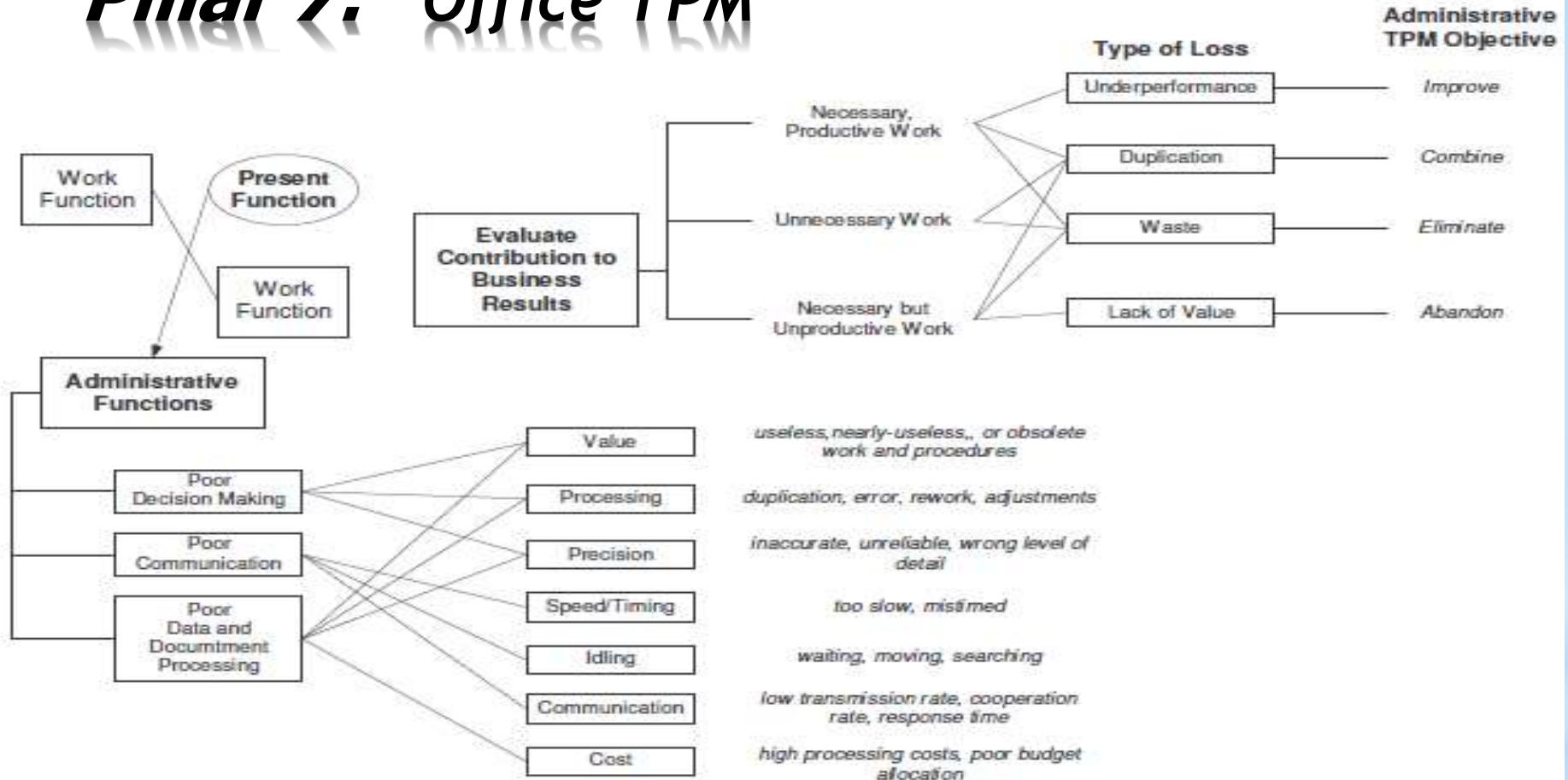
Administrative and support departments can be seen as process plants whose principal tasks are to collect, process, and distribute information



Process analysis should be applied to streamline information flow

TPM - Total Productive Maintenance

Pillar 7. Office TPM



Administrative TPM Effectiveness Losses

TPM -*Total Productive Maintenance*

Pillar 8. Safety Health and Environment

Safety Health and Environment

Is the roof on the TPM house and is paramount in all we do.



This coupled with a clean and healthful workplace makes for excellent working and living conditions in our community.

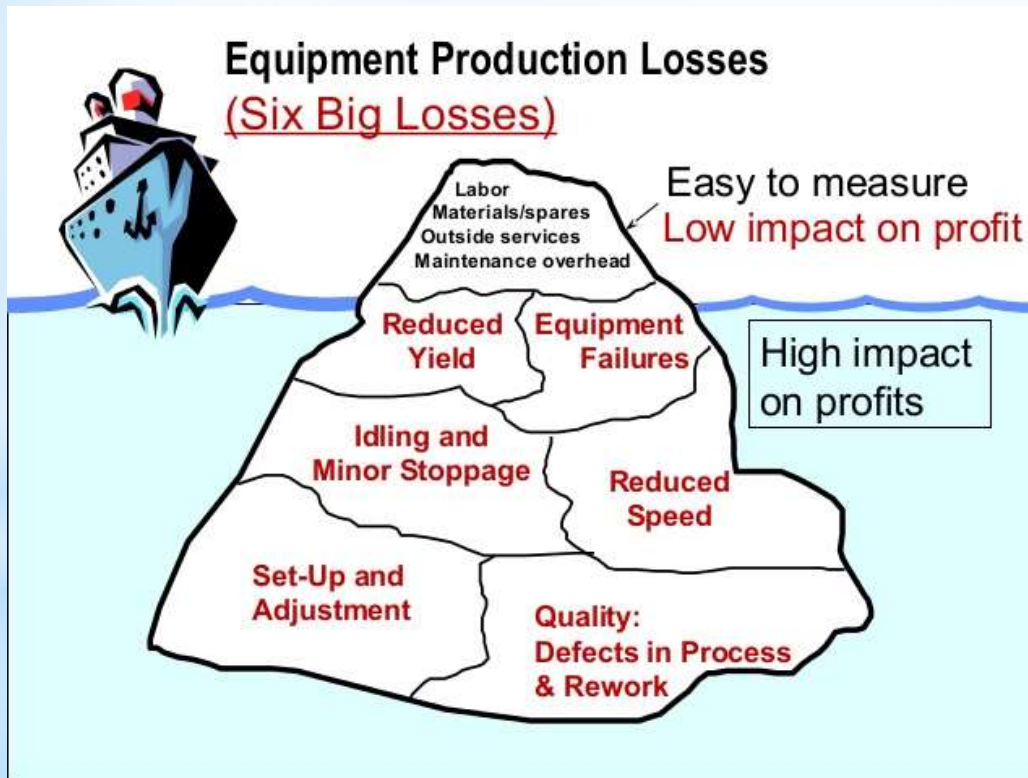
Assuring safety and preventing adverse environmental impacts are important priorities in any TPM effort

TPM -Total Productive Maintenance

5. The 6 Major Equipment Wastes (Losses)

Type of Equipment Waste (loses)

How TPM could be used to eliminate this 6 losses



ITS

TPM - Total Productive Maintenance

Equipment Production Waste (Losses)

(Six Big Losses)



Easy to measure
Low impact on profit

High
impact
on profits

Labor
Materials/spares
Outside services
Maintenance overhead

Reduced
Yield

Equipment
Failures

Idling and
Minor Stoppage

Reduced
Speed

Set-Up and
Adjustment

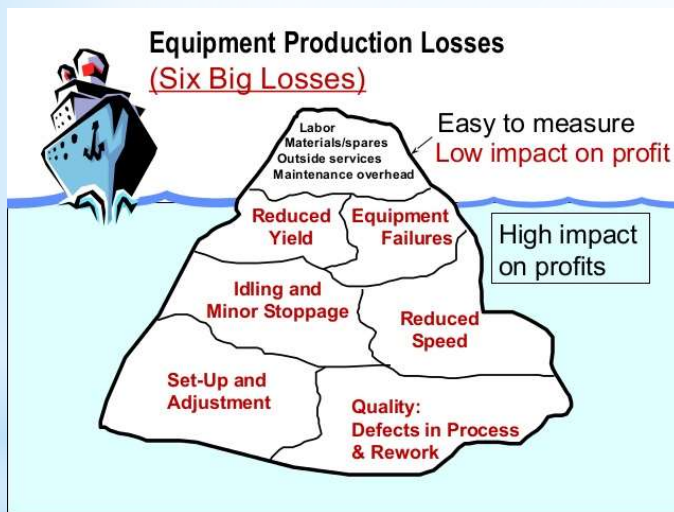
Quality:
Defects in Process
& Rework

TPM -Total Productive Maintenance

Equipment Production Losses at your Facilities

QUESTION

- What are the examples of each of these losses?
- Which loss is usually the biggest?



(Setup is typically the biggest loss) Many TPM activities are strictly focused on setup reduction with the goal being less than 10 minutes.

Key Points:

What gets measured gets done.

Let's make what's important more measurable,
Instead of what's measurable more important!!

TPM -Total Productive Maintenance

How TPM could be used to eliminate the Six Big Losses (Waste)



- Increase Overall Equipment Effectiveness (OEE)
 - Improve existing planned maintenance systems
 - Develop Autonomous Maintenance Program
-
- Provide training to upgrade operations and maintenance skills
 - Involve everyone and utilize cross-functional teamwork

TPM -*Total Productive Maintenance*

Increase Overall Equipment Effectiveness (OEE)

WORLD CLASS OEE

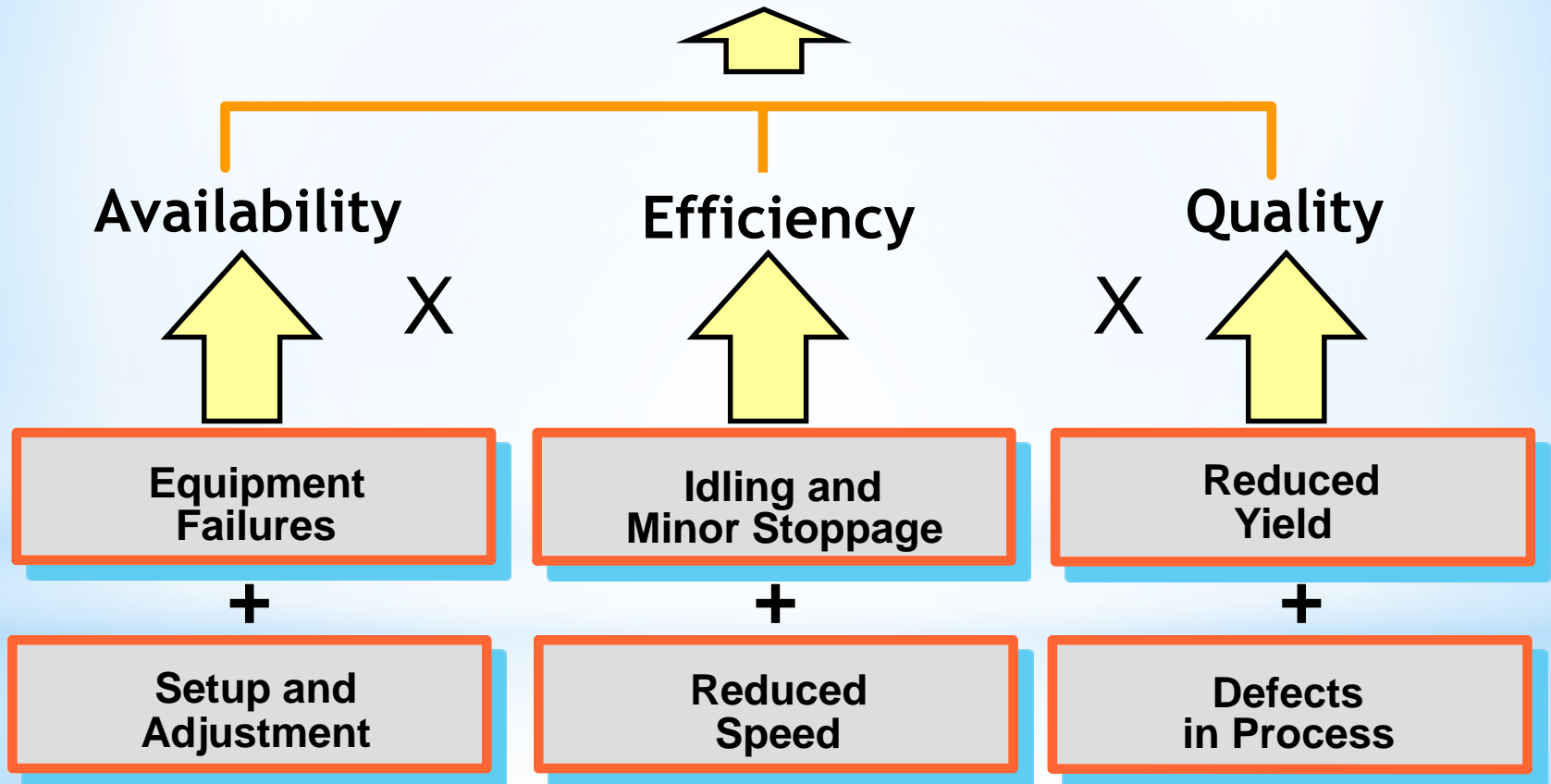
- World class OEE is a standard which is used to compare the OEE of the firm.

OEE Factor	WORLD CLASS
Availability	90%
Performance	95%
Quality	99%
Overall Equipment Effectiveness	85%

Most companies find their OEE at 40 - 50% before TPM.

TPM - Total Productive Maintenance

Measuring your OEE



TPM - *Total Productive Maintenance*

Measuring your OEE (Overall Equipment Efficiency)

Overall Equipment Effectiveness = Availability x Performance x Quality Yield

Availability = $\frac{\text{time available for production} - \text{downtime}}{\text{time available for production}}$

Availability is proportion of time machine is actually available out of time it should be available. $A = (\text{MTBF} - \text{MTTR}) / \text{MTBF}$.

Performance = $\frac{\text{ideal cycle time} \times \text{number of parts produced}}{\text{operating time}}$

Quality Yield = $\frac{\text{total number of parts produced} - \text{defect number}}{\text{total number of parts produced}}$

Q - Refers to quality rate. Which is percentage of good parts out of total produced sometimes called "yield".

TPM -*Total Productive Maintenance*

**MTBF = total time of correct operation in a period
number of failures**

For example:

a system should operate correctly for 9 hours During this period, 4 failures occurred. Adding to all failures, we have 60 minutes (1 hour). Calculating the MTBF, we would have:

$$\begin{aligned} \text{MTBF} &= \frac{(9-1)}{4} \\ &= 2 \text{ hours} \end{aligned}$$

This index reveals that a failure in the system occurs every 2 hours, leaving it unavailable and generating losses to the company. The opportunity to spot this index allows you to plan strategies to reduce this time.

TPM -*Total Productive Maintenance*

MTTR = *total hours of downtime caused by system failures*
number of failures

Using the same example, we come to the MTTR, by using the following formula:

$$\begin{aligned} \text{MTTR} &= \frac{60 \text{ min}}{4 \text{ failures}} \\ &= 15 \text{ minutes} \end{aligned}$$

Above, we have the average time of each downtime. Therefore, the company knows that every 2 hours, the system will be unavailable for 15 minutes. Being aware of our limitations is the first step to eliminate them.

TPM -*Total Productive Maintenance*

Improve existing planned maintenance systems

Establish Preventative and Predictive Maintenance systems for equipment and tooling.

Natural life cycle of individual machine elements must be achieved for:

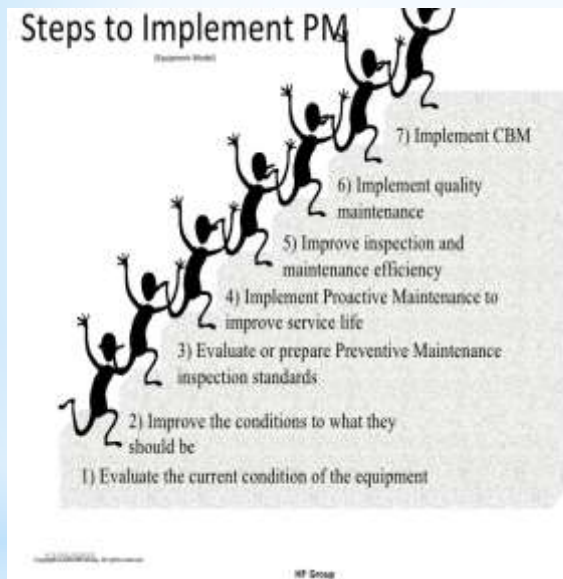


- Correct operation
- Correct set-up
- Cleaning
- Lubrication
- Retightening and repair of minor defects
- Quality spare parts

TPM -Total Productive Maintenance

Improve existing planned maintenance systems

How? Develop a planned maintenance program:



- Set up plans and schedules to carry out work on equipment before it breaks down, in order to extend the life of the equipment
- Include periodic and predictive maintenance

➤ Include management of spare parts and tools

Improve existing planned maintenance systems Reliability Maintenance

Meantime to Failure

(Goal - Maximise)

- Machine Breakdown
- Tool Breakdown
- Part Failure

Meantime to Repair

(Goal - Minimise)

- Diagnose problem
- Correct problem
- Set up Machine to make good parts
- Spare parts control

Analyse

(Statistical Tools)

- Reliability Measures
- Problem Solving Tools
- Vibration Analysis Tools

TPM -*Total Productive Maintenance*

Develop an Autonomous Maintenance Program

A handing-over of maintenance tasks from specialized maintenance personnel to production operators.
Promote the seven steps of AM Workshop.

Tasks to hand over:

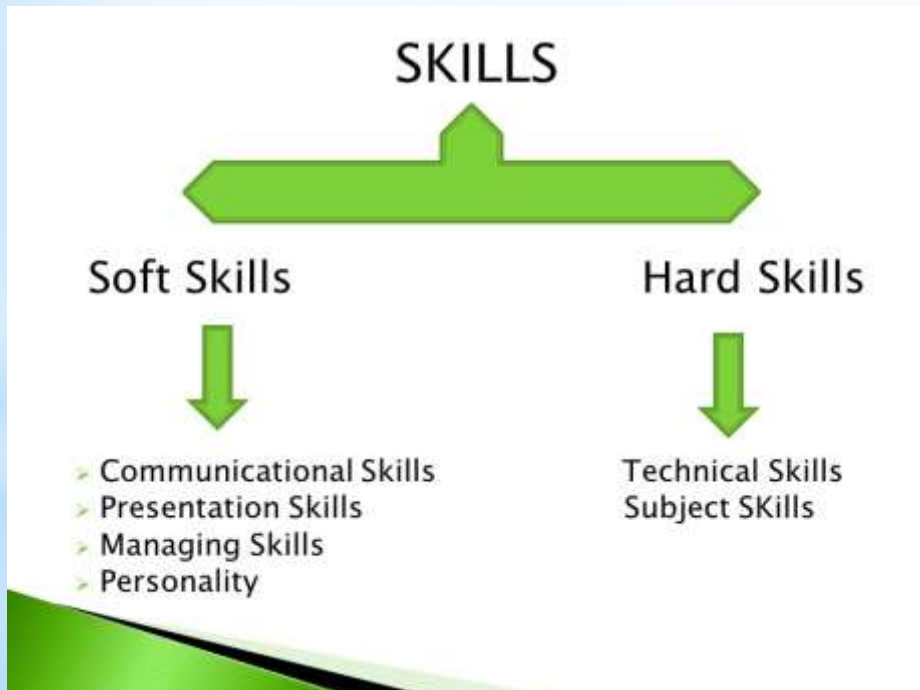
- cleaning
- lubricating
- inspecting
- set-up and adjustment



TPM -Total Productive Maintenance

Provide training to upgrade operations and maintenance skills

Train leaders together. Have leaders share information with group members



➤ **soft skills** training: how to work as teams, diversity training and communication skills

➤ **technical** training: upgrading problem-solving and equipment-related skills

TPM -*Total Productive Maintenance*

Involve everyone and utilize cross-functional teamwork

Increasing motivation: changing peoples attitudes

- Increasing competency and peoples skills
- Improving the work environment, so that it supports the establishment of a program for implementing TPM





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