TPM

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Lifelong Learning Programme

TPM

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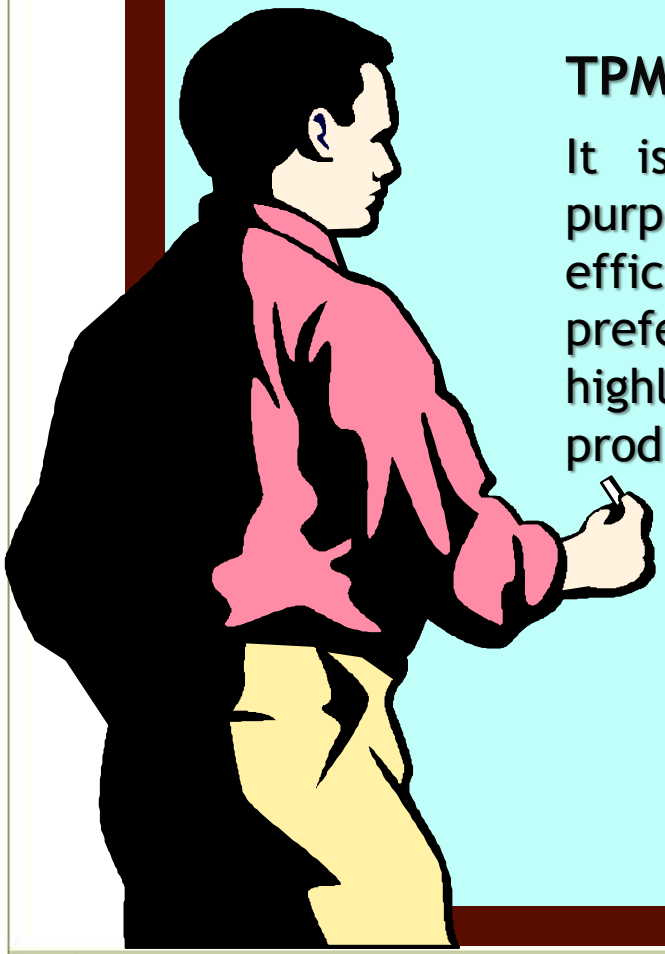
TPM - Course Content

1. What is TPM?
2. Why to use TPM?
3. How to Pursuit an Extremely Effective Production System
4. TPM Structure & Implementation
5. Focused Improvement - KAIZEN
6. Autonomous Maintenance
7. Planned Maintenance
8. Quality Maintenance
9. Office TPM
10. Safety, Health & Environment
11. Early Equipment Management
12. Education & Training
13. References

1. What is TPM?



TPM MEANS: Total Productive Maintenance

It is a comprehensive strategy that supports the purpose of equipment improvement to maximize its efficiency and product quality. Many TPM practitioners prefer to call it *Total Productive Manufacturing* to highlight the need for an equal partnership between production and maintenance.

TPM is concerned about:

- Maximization of equipment effectiveness;
- Elimination of Waste;
- Training and education.

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1. What is TPM?

Essence of TPM

- Maximize overall equipment efficiency
  -Zero Accidents, Zero Defects, Zero failures
- Preventive philosophy
  -Proactive vs. Reactive
- Participation of all management levels from senior managers to operators
  -Focused Improvement, Autonomous activities, Small Group activities
- Gemba Principle (Shop-Floor Oriented)
  -Seeking “ideal” operation, Visual management

1. What is TPM?

Essence of TPM

- TPM is not only for the maintenance departement.
- TPM is a philosophy, a way of thinking, and a culture.
- TPM is a resource management strategy for company-wide overall quality & productivity improvement.

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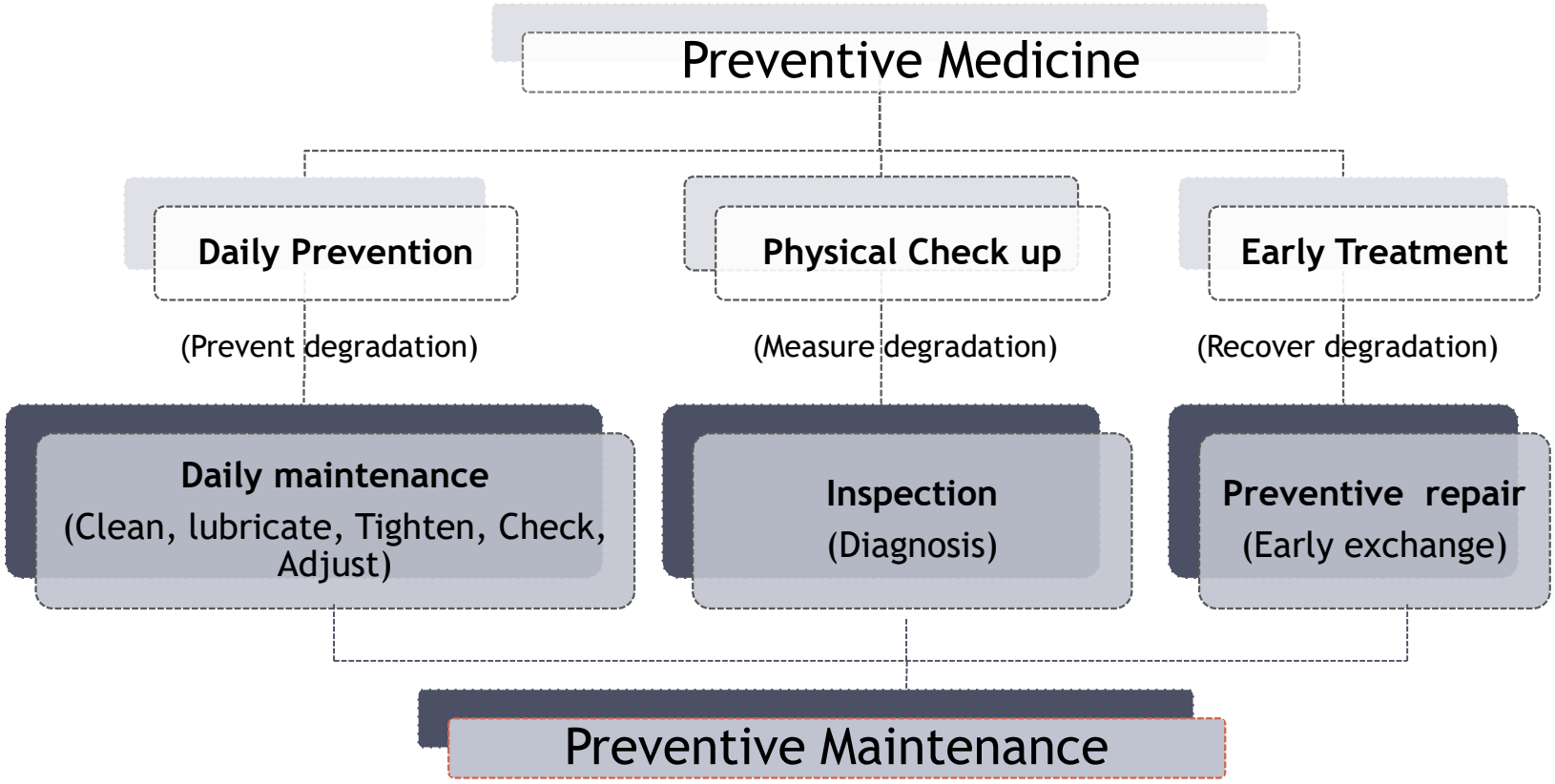
1. What is TPM?

Essence of TPM

- TPM is deeply rooted in teamwork, training, communication, ownership, and empowerment.
- TPM is not going to occur overnight.
- TPM requires the long term and full commitment and participation of the management.

1. What is TPM?

Plant Preventive Medicine = Preventive Maintenance



1. What is TPM?

- **Aims & Objectives**

The Aim of TPM

Improve the company by improving its people and its equipment

Improving the **PEOPLE**	-- Develop people with the skills required for today's highly-automated factories— 1. Operators: Do Autonomous Maintenance (Jishu-Hozen) 2. Maintenance staff: Do advanced, specialized maintenance 3. Production engineers: Plan maintenance-free equipment

➕

Improving the **EQUIPMENT**	1. Raise OEE by improving the equipment currently in use 2. Design new equipment for minimum life-cycle cost and vertical startup

⬇

Improve The Company

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1. What is TPM?

- **Aims & Objectives**

Equipment Improvement	→	Zero failures
Change the Culture	→	Zero defects
Work Environment Improvement	→	Zero accidents

2. Why to use TPM?

- As Supply Chain is becoming more synchronized, by the continuous reduction of inventories, processes are more dependent upon each other.

- Equipment available time is critical as inventory levels and production leadtimes continue to be reduced.

- Maintenance related expenses can account for over 30% of total manufacturing costs, representing a significant cost reduction opportunity.

2. Why to use TPM?

- New technology and equipment requires significant investment and therefore the related return on investment must be maximized.

- JIT requires all equipment to produce the correct product in the correct quantities when required – Reliability and Flexibility are paramount.

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2. Why to use TPM?

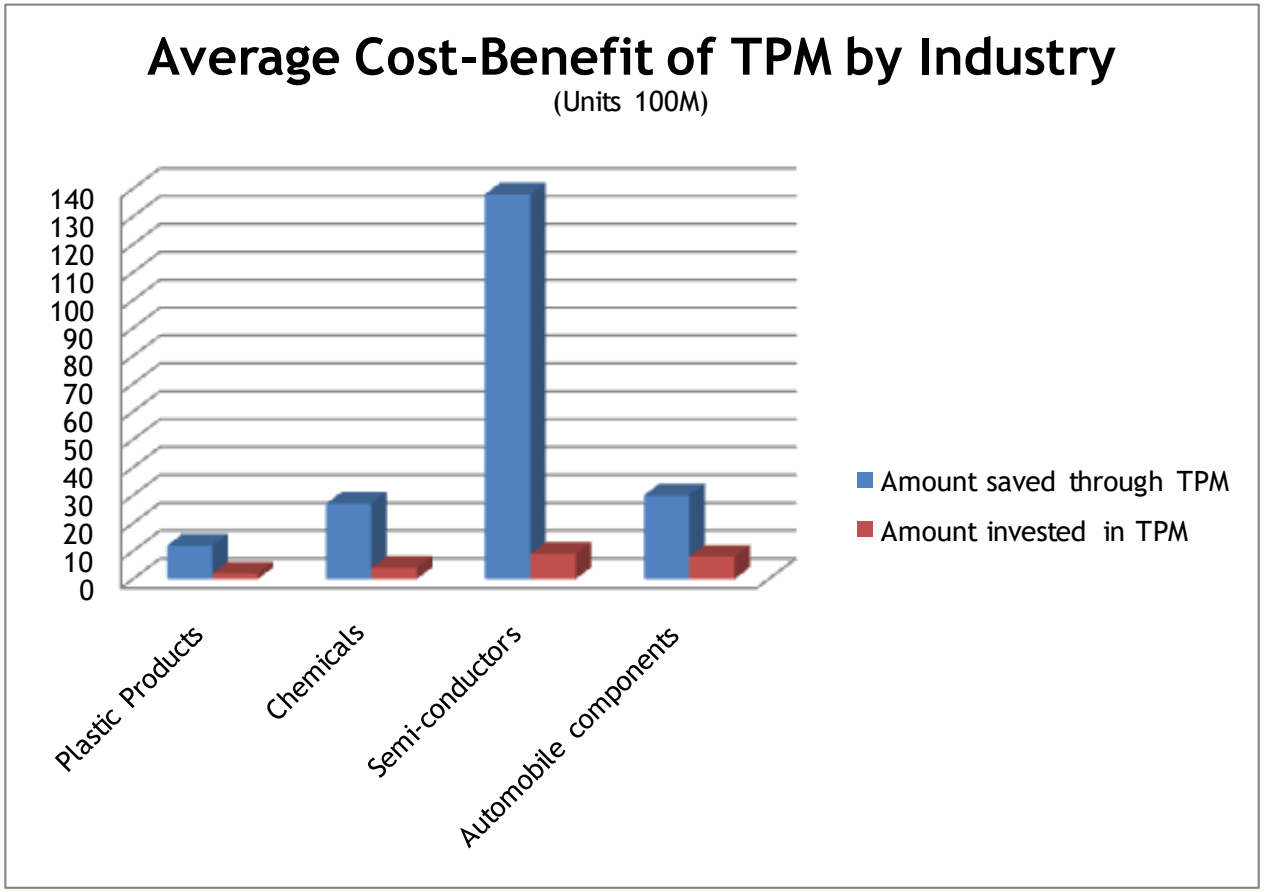
Measure	Impact of TPM	Impact of Lean Thinking
Productivity	Reduce need for intervention Reduce breakdowns	Reduce non-value-adding activities, increase added value per labour hour
Quality	Potential to reduce tolerance Control of technology Reduce start-up loss	Highlight quality defects early
Cost	Reduce material and spare parts	Lower inventories
Delivery	Zero breakdowns Predictability	Shorter lead times, faster conversion processes
Safety	Less unplanned events Less intervention Controlled wear	Less movement, less clutter Abnormal conditions become visible easily

2. Why to use TPM?

Measure	Impact of TPM	Impact of Lean Thinking
Morale	Better understanding of technology More time to manage	Less clutter Closer to the customer Higher appreciation of what constitutes customer value
Environment	Closer control of equipment Less unplanned events/human error	No ‘over-production’ Systems geared to needs not theoretical batching rules

2. Why to use TPM?

- **Cost – Benefit of TPM by Industry**



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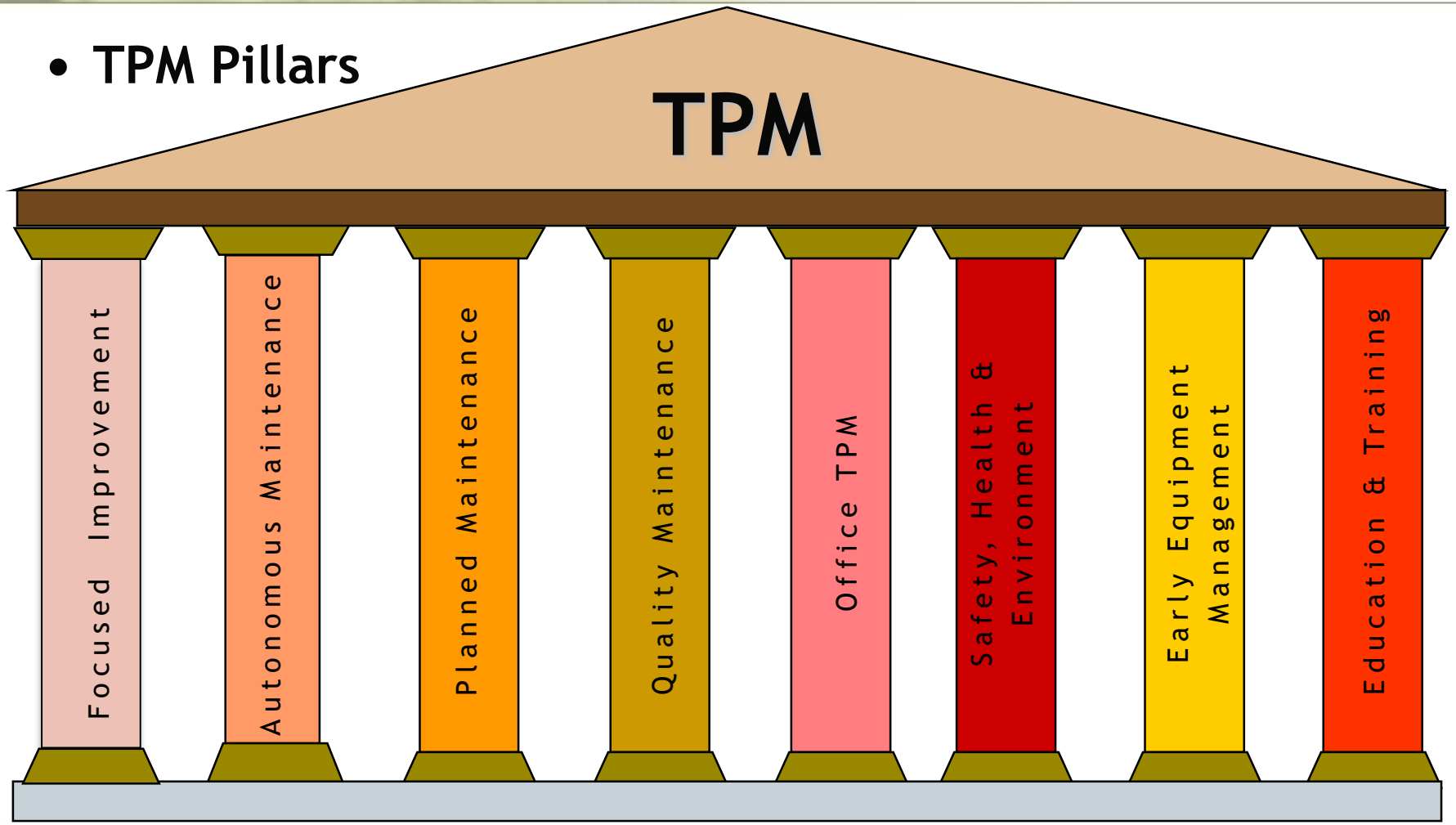
3. TPM Structure & Implementation

- **TPM Pillars**



3. TPM Structure & Implementation

Pre –TPM conditions Checklist

(Check those which exist at your company)

- ❑ Equipment availability is less than 95 %.
- ❑ Machines breakdown suddenly without warning.
- ❑ Machines do not operate at design parameters.
- ❑ Changeover and set-up of equipment requires more than 10 minutes.
- ❑ First Run Capability is less than 99%.
- ❑ New equipment is high-tech.
- ❑ Newly-installed equipment must be “de-bugged”.
- ❑ Customer’s products require higher quality performance.
- ❑ Plants are “dirty, dark, and stinky”.
- ❑ Most associates in the company are indifferent to the production facilities and equipment.
- ❑ Areas of responsibility are not clearly defined.
  - ❑ Equipment and process design
  - ❑ Equipment sourcing
  - ❑ Equipment acceptance
  - ❑ Equipment maintenance
  - ❑ Roll of the Operator (s)
  - ❑ Roll of Maintenance Personnel

3. TPM Structure & Implementation

- **Stages in TPM implementation**
  - Stage A - PREPARATORY STAGE:

    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 send to suppliers and customers.

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3. TPM Structure & Implementation

- **Stages in TPM implementation**
  - Stage A - PREPARATORY STAGE:

    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.

    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.

3. TPM Structure & Implementation

- **Stages in TPM implementation**
  - Stage A - PREPARATORY STAGE:

    4 - Establishing the TPM working system and target:

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

    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.

3. TPM Structure & Implementation

- **Stages in TPM implementation**
  - Stage 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 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.

3. TPM Structure & Implementation

- **Stages in TPM implementation**
  - 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 one for control of safety, sanitation as working environment.

3. TPM Structure & Implementation

- **Stages in TPM implementation**
  - Stage D - INSTITUTIONALISING STAGE:

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

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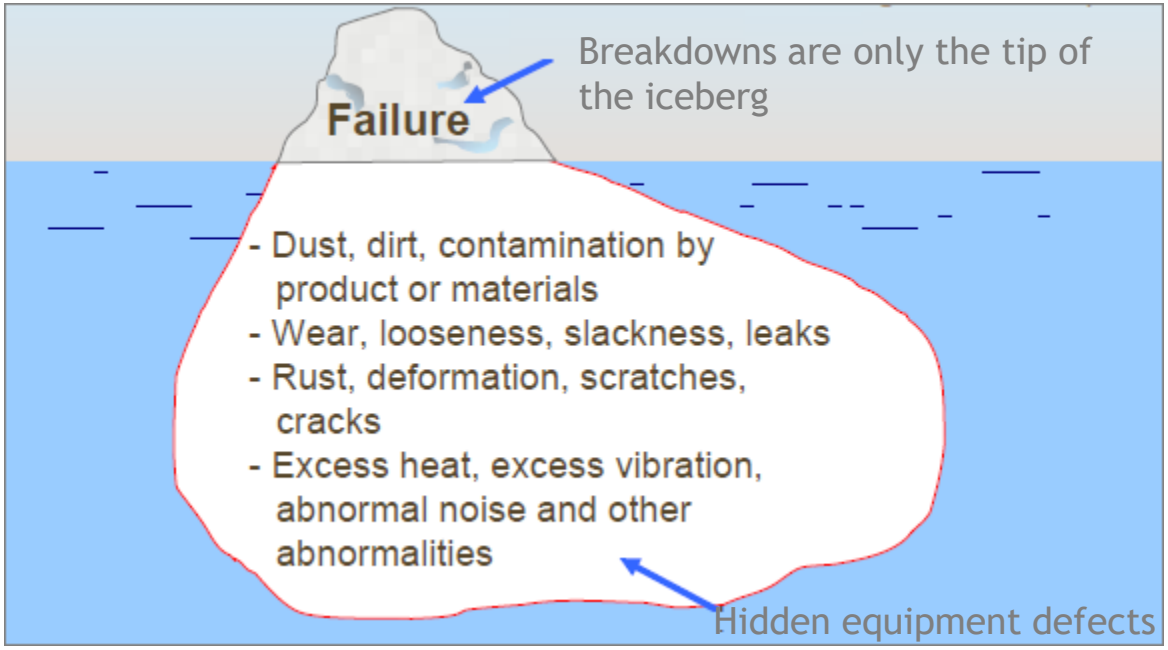
4. How to Pursuit an Extremely Effective Production System



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4. How to Pursuit an Extremely Effective Production System

In order to achieve high production efficiency, TPM is aiming at eliminating the “16 major losses” :

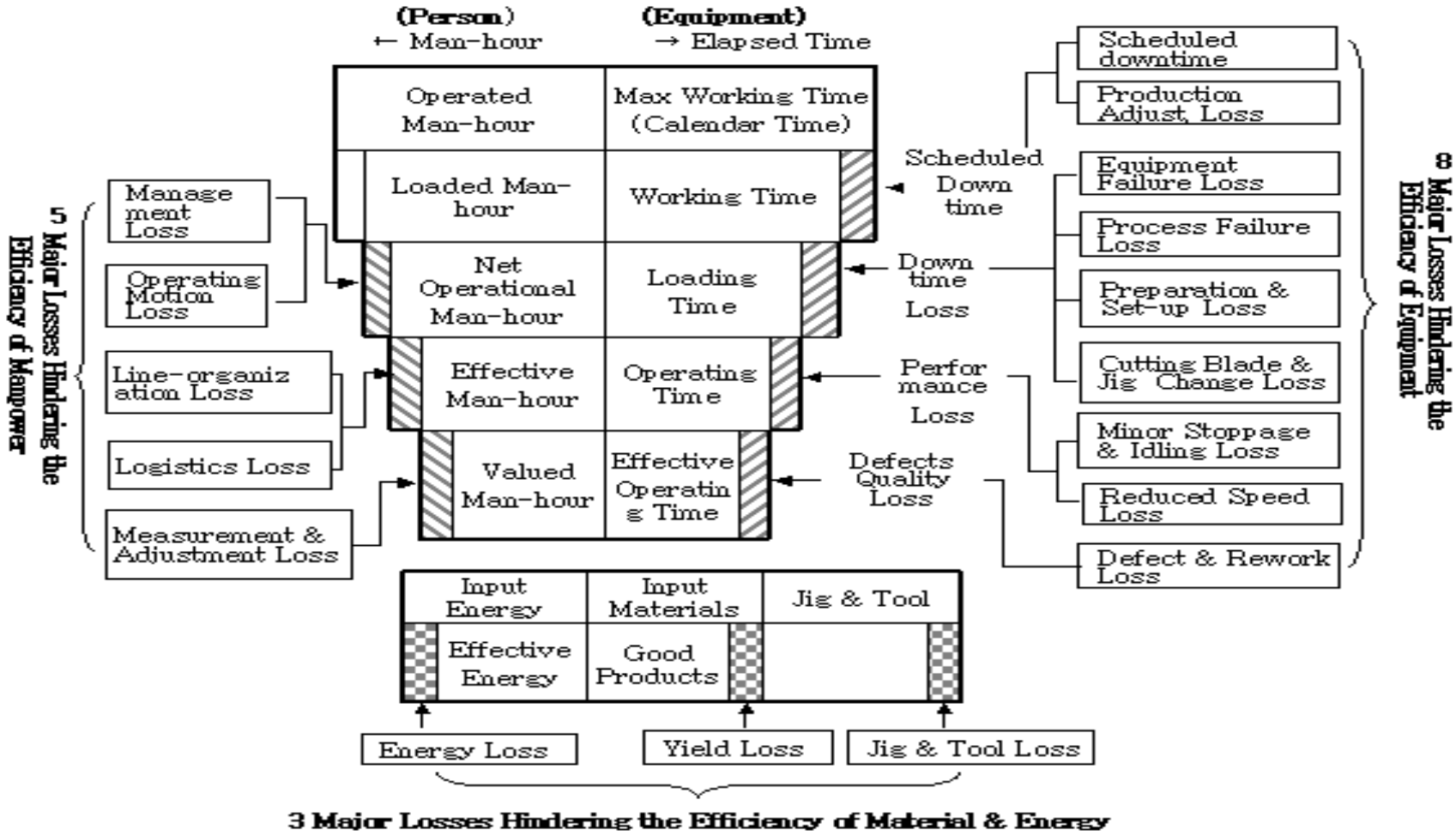
Loss	Category
1. Failure losses-Breakdown loss 2. Setup/adjustment loss 3. Cutting blade and jig change loss 4. Minor stoppage and idling loss 5. Speed loss 6. Start up loss 7. Defect/rework loss 8. Scheduled down time loss	Losses that impede equipment efficiency

4. How to Pursuit an Extremely Effective Production System

In order to achieve high production efficiency, TPM is aiming at eliminating the “16 major losses” :

Loss	Category
1. Management loss 2. Operating motion loss 3. Line organization loss 4. Logistics loss 5. Measurement loss	Losses that impede human work efficiency
1. Energy loss 2. Die, jig and tool breakage loss 3. Yield loss	Losses that impede effective use of production resources

4. How to Pursuit an Extremely Effective Production System



4. How to Pursuit an Extremely Effective Production System

- **Five Principles in TPM Deployment**

① Establish the system to achieve production efficiency.

1. Individual improvement
2. Autonomous maintenance
3. Planned maintenance
4. Education and training to raise the skill levels for operation and Maintenance

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

4. How to Pursuit an Extremely Effective Production System

- **Five Principles in TPM Deployment**

③ Establish the quality maintenance system.

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

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

5. PILLAR 1 – Focused Improvement - KAIZEN

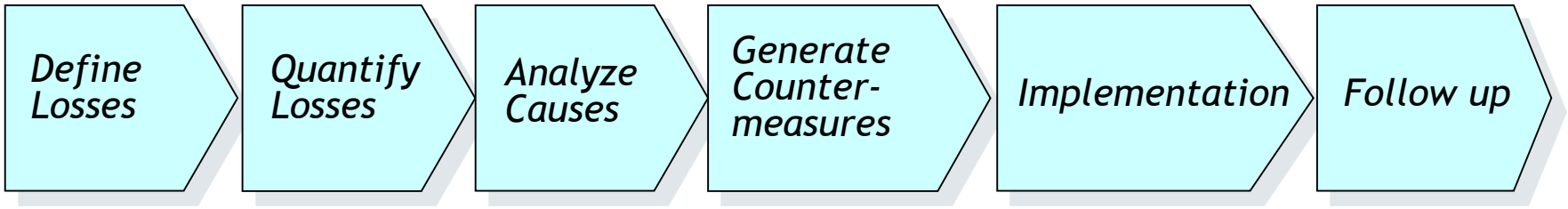
Objectives

Maximizing the performance of equipment by minimizing equipment losses → *Problem Solving by Teamwork*

Compare the ACTUAL operating time versus the OPTIMUM operating time

Highlight the causes of Productivity losses : Availability, Performance and Quality losses

Improvement Steps



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5. PILLAR 1 – Focused Improvement - KAIZEN

- **Overall Equipment Efficiency (OEE)**
  - The basic measure associated with Total Productive Maintenance
  - 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.

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- **Overall Equipment Efficiency (OEE)**

  It incorporates three basic indicators of equipment performance and reliability:

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

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

5. PILLAR 1 – Focused Improvement - KAIZEN

- **OEE calculation**

<u>The availability of the equipment</u>

This is the ratio of the amount of time that the tool is capable of running quality product to the total time it could be running.

$$\text{Availability (\%)} = \frac{(\text{total time available - downtime})}{\text{total time available}} \times 100$$

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- **OEE calculation**

<u>The performance of the equipment</u>

Is defined as the ratio of the amount of product made to the amount of product that could have been made. For a given production uptime,

$$\text{Performance}\,(\%) = \frac{\text{number of units manufactured}}{\text{possible number of units}} \times 100$$

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- **OEE calculation**

<u>The quality of the product</u>

Is defined as the ratio of the amount of *acceptable product made to the total amount of product made (including* any unacceptable product).

$$\text{Quality}(\%) = \frac{(\text{number of units produced} - \text{number of defects})}{\text{number of units produced}} \times 100$$

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- **OEE calculation**

  OEE = availability × performance × quality

Availability		Performance	Quality	OEE
100% (1)		100% (1)	100% (1)	100%
50% (0,5)		100% (1)	100% (1)	50%
50% (0,5)		50% (0,5)	100% (1)	25%
50% (0,5)		50% (0,5)	50% (0,5)	12,5%
100% (1)		75% (0,75)	75% (0,75)	56%
90%(0,9)		95%(0,95)	99%(0,99)	85%

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- **OEE calculation**

  OEE = availability × performance × quality

Availability		Performance	Quality	OEE
Before TPM	-	-	-	*40 to 60 %*
After TPM	*90%(0,9)*	*95%(0,95)*	*99%(0,99)*	*85%*

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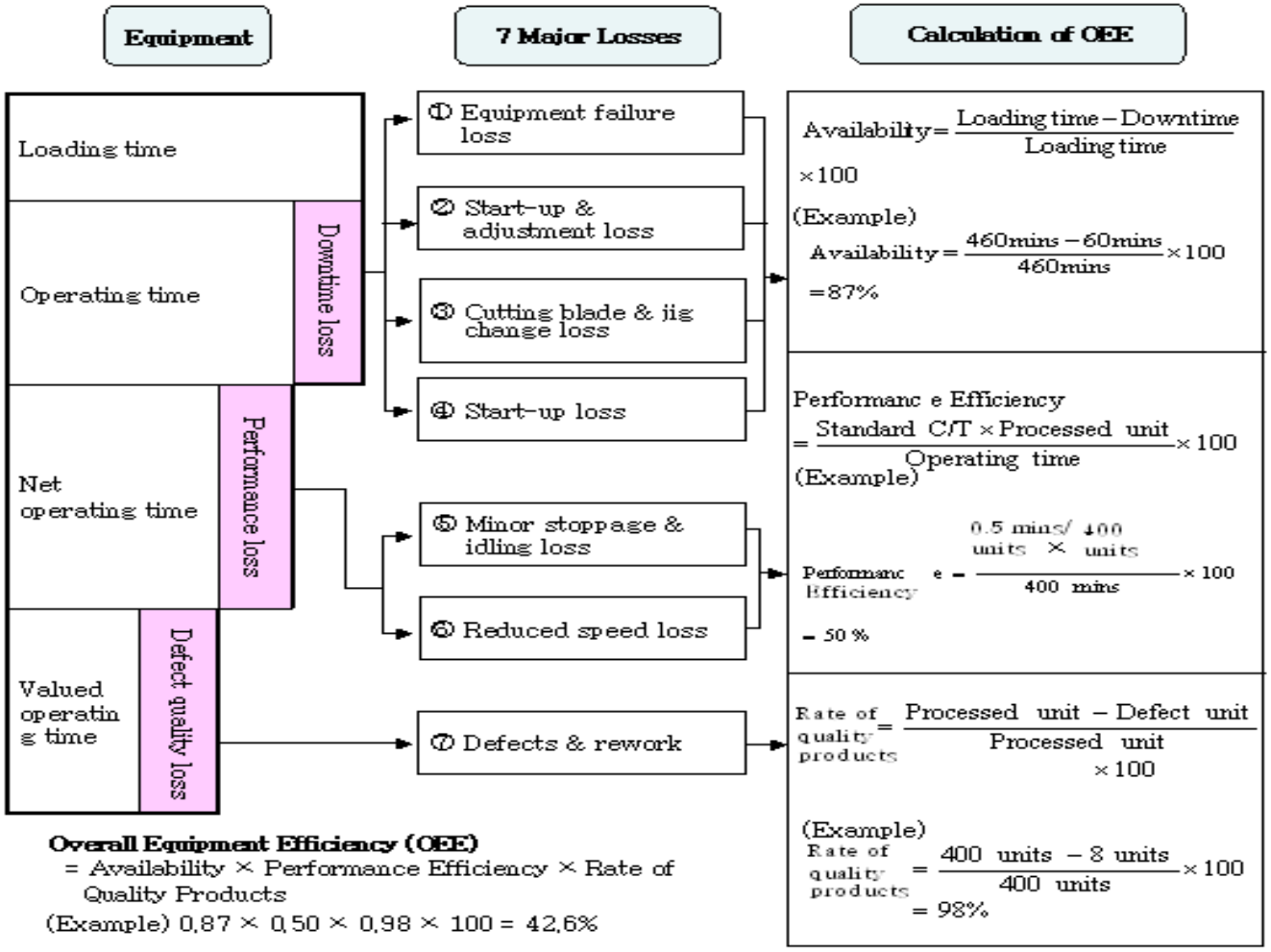
5. PILLAR 1 – Focused Improvement - KAIZEN

Relationship between 7 Major Losses on Equipment and Overall Equipment Efficiency



5. PILLAR 1 – Focused Improvement - KAIZEN

- **Example**

  Identifying losses

Day	Machine name	Losses	Time (min)
1	Single needle	Idling & Minor stoppage (Needle break & Bobbin case)	3+3 = 6
	Single needle	Reduced speed	4
	Overlock	Idling & Minor stoppage (False stitch)	8
	Overlock	Set up & adjustment	20
2	Overlock	Idling & Minor stoppage (False stitch)	10
	Single needle	Idling & Minor stoppage (Needle break & Bobbin case)	3+7+4 +4 = 18
	Single needle	Reduced yield	5
	Two needle	Breakdown	30
3	Overlock	Set up & adjustment	20
	Single needle	Idling & Minor stoppage (Needle break, Bobbin case & others)	13+4+3 = 20
4	Single needle	Idling & Minor stoppage (Needle break & Bobbin case)	6+4 = 10
	Two needle	Set up & adjustment	30
	Overlock	Reduced speed	4
	Single needle	Defects in process	10

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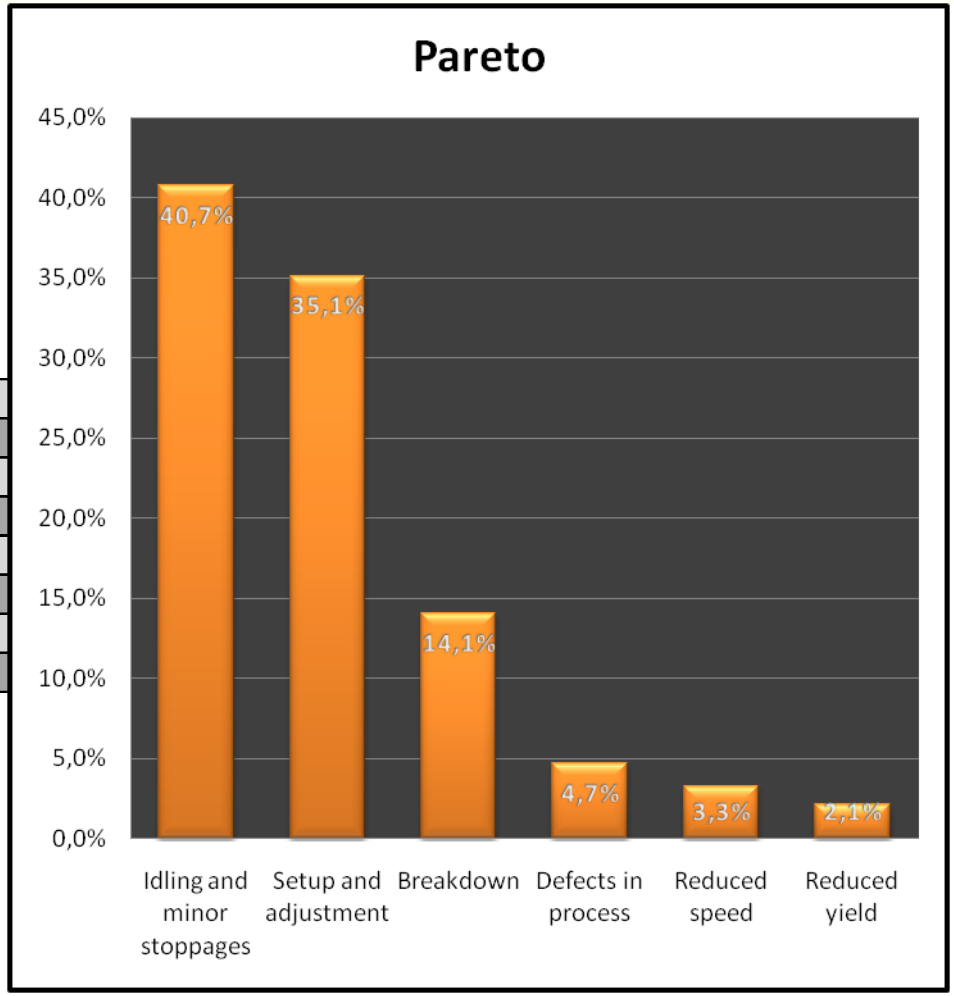
- **Example**

  Identifying significant losses

Major Losses	Time (min)	%	Cum %
Idling and minor stoppages	174	40,7%	40,7%
Setup and adjustment	150	35,1%	75,9%
Breakdown	60	14,1%	89,9%
Defects in process	20	4,7%	94,6%
Reduced speed	14	3,3%	97,9%
Reduced yield	9	2,1%	100,0%
Total	427	100,0%	



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- **Example**

  Impact on OEE

A	Running time per day (60 min x 8hrs)	480	min
B	Down time per day	20	min
C	Loading time per day (A-B)	460	min
D	Stoppage losses per day (174 min/10 days)	17,4	min
E	Operating time per day (C-D)	442,6	min
F	Output per day (70 un/hr x 8 hrs)	560	un
G	Rate of quality products (Processed amount – Defect amount)/Processed amount x 100	97,3%	
H	Ideal cycle time	0,5	min
I	Actual cycle time	0,58	min
J	Actual processing time (I x F)	324,8	min
K	Operating speed rate (H/I x 100)	86,2%	
L	Net operating rate (J/E x 100)	73,4%	
M	Availability (E/C x 100)	96,2%	
N	Performance efficiency (K x L x 100)	63,3%	
	Overall Equipment Efficiency (M x N x G) x 100	59,2%	

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Why does equipment suffer from failures and how do these failures change from minor issues to major problems?

Failures have a range of causes:

- Natural deterioration;
- Forced deterioration;
- Deterioration due to use conditions;
- Design flaws (poor mechanisms, unsuitable materials, inadequate support systems);
- Lack of skill;
- Poor or no procedures;
- Procedures that are not followed.

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5. PILLAR 1 – Focused Improvement - KAIZEN

Some are due to real unpredictable, “sporadic,” equipment failures…
…but we will also discover that a very large number of failures, if not most of them, are due to what TPM rightly calls “deterioration from the ***basic condition***.”

The Basic Condition
This is the starting point: the zero line of the rule. Any variation is measured from here, so it has to be accurate.

The simplest description of the basic condition is the condition the equipment would be expected to be in when it was first manufactured and operating to its original specification.

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The Use Condition

conditions in which the equipments are *used can be a root cause of machine failures. Fixing* the improper use will stop not only the fails, but also any consequential failures caused by the original fail.

The Ideal Condition

This is the way the equipment *should have been designed! After we have used* the equipment for a while, its limitations begin to show up. It should have had faster throughput, used more accurate components, been easier to maintain, produced products with less variation in output parameters,…

The ideal condition is the state that can be reached by redesign after the basic condition has been achieved and maintained.

5. PILLAR 1 – Focused Improvement - KAIZEN

- ***Sporadic Failures*** - These are not normally predictable unless there is a flaw in a new part, the design, or the way the failure is repaired.

- ***Chronic Failures*** - happen regularly or we choose to live with. These faults are present all the time and would prevent the fails from ever reaching zero.

  Proper fault analysis will identify and eliminate chronic fails. They are targeted by TPM as an area for positive action.

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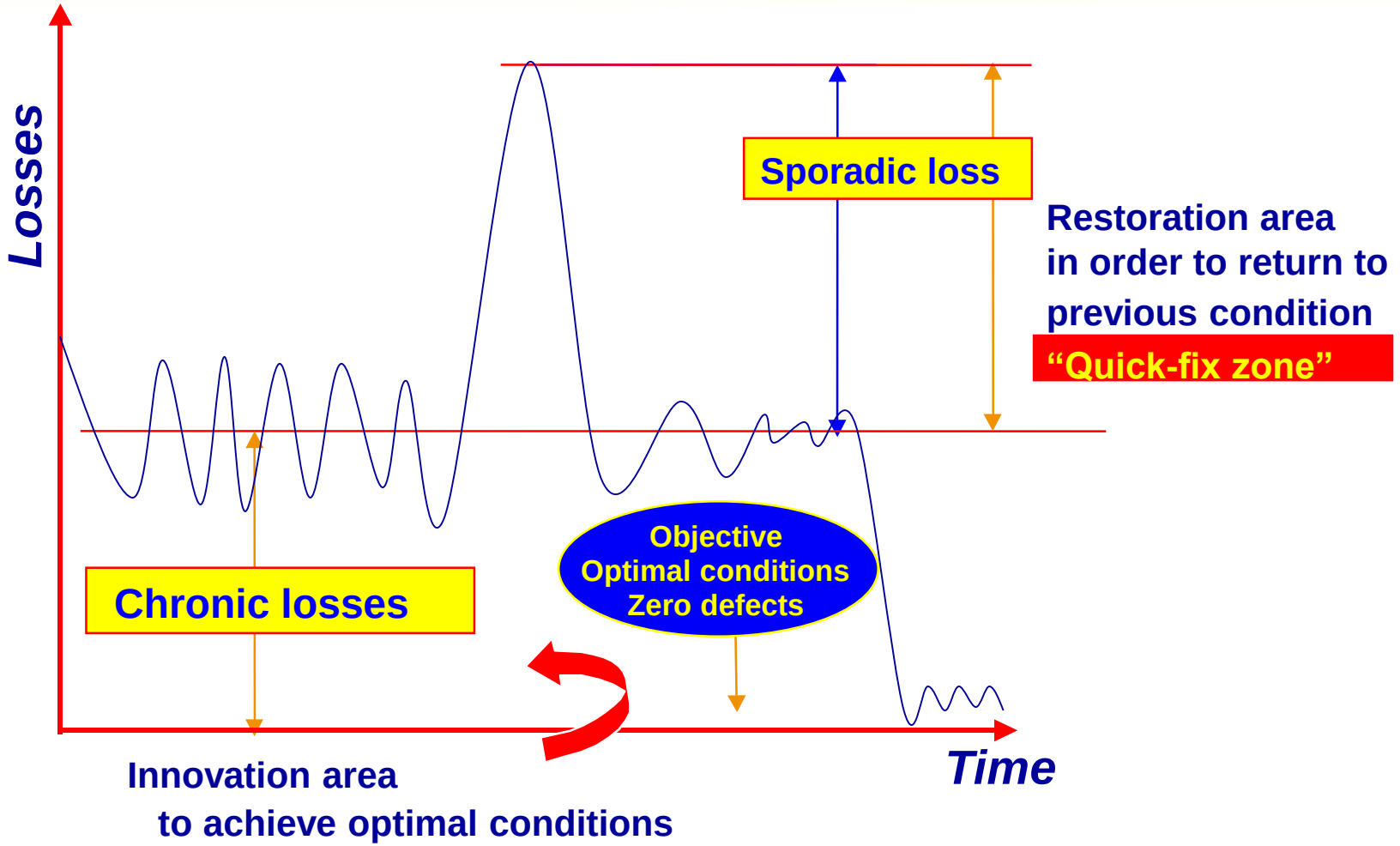

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5. PILLAR 1 – Focused Improvement - KAIZEN

- **The Basic Approach to Zero Failure**

ESTABLISH THE BASIC CONDITION

KEEP OPERATING CONDITION
(the Use Condition)

MAINTENANCE DEPARTMENT (Planned Maintenance)

PREVENT THE DEGRADATION
(Restore)

PRODUCTION DEPARTMENT (Autonomous Maintenance)

IMPROVE WEAK POINTS IN DESIGN
(the Ideal Condition)

IMPROVE THE SKILL LEVEL OF OPERATORS AND TECHNICIANS
(Training)

5. PILLAR 1 – Focused Improvement - KAIZEN

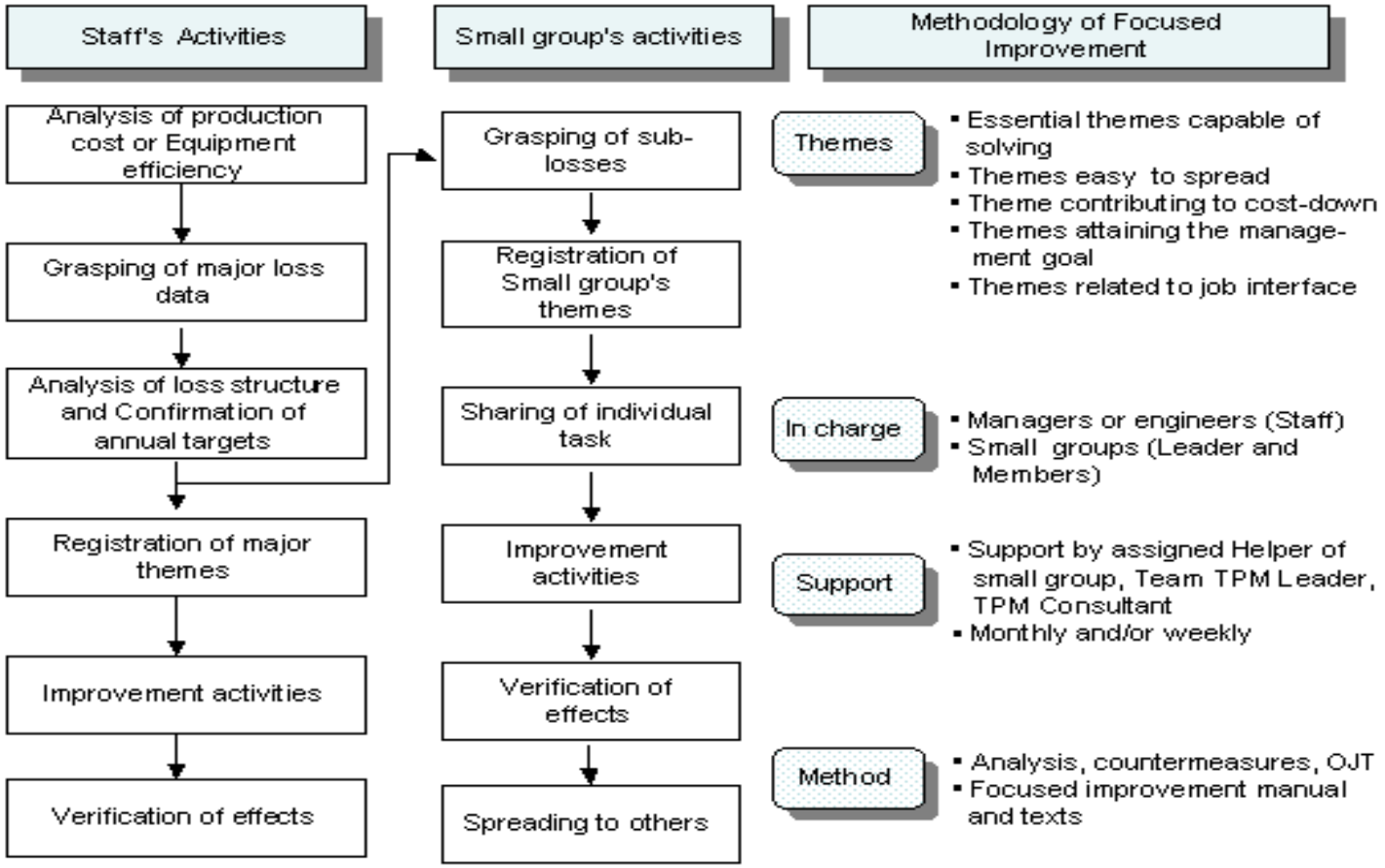
- **Kaizen Target**

  Achieve and sustain zero losses with respect to:

  - Minor stops
  - Measurement and adjustments
  - Defects
  - Unavoidable downtimes

5. PILLAR 1 – Focused Improvement - KAIZEN

- **Progressing Methodology of Focused Improvement**



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5. PILLAR 1 – Focused Improvement - KAIZEN

- **Practice for Focused Improvement**

Theme Step	Activity Contents	Recommended Tools
Background analysis of theme	* Recognition of losses and analysis of problem. (Equipment overall efficiency, Failure intensity rate, Failure frequency rate, Failure times, Etc.) * Analysis of reliability and maintainability (MTBF, MTTR, Etc.).	* Pareto analysis * Graph analysis

5. PILLAR 1 – Focused Improvement - KAIZEN

- **Practice for Focused Improvement**

Theme Step	Activity Contents	Recommended Tools
Determination of theme	* Selection of improvement theme : Poor efficiency and equipment and/or process capable of applying to others easily. * Criteria on selecting the process or equipment to be improved: - Process with low efficiency. - Process capable of applying to others easily. - Bottleneck process, process with big losses. - Theme corresponding to Model Equipment helped by Team leader. - Process corresponding to Team leader's policy or annual targets.	* Matrix diagram * Brainstorming

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- **Practice for Focused Improvement**

Theme Step	Activity Contents	Recommended Tools
Set-up of step plan	* Organize the improvement team and share the small group's duties. * Set-up the detailed implementing plan of improvement theme	•Graphs
Collecting data	* Survey the parts to cause the problems. - Capability analysis and confirmation of bottleneck process. * Extraction of malfunctions and list-up of them. * Grasp the fundamental conditions and eight big losses.	* QC 7 tools •IE Tools •OEE

5. PILLAR 1 – Focused Improvement - KAIZEN

- **Practice for Focused Improvement**

Theme Step	Activity Contents	Recommended Tools
Cause analysis	* Cause analysis of malfunction or problem. - Use of PM analysis and 5-Why analysis tools. * Utilization of inherent manufacturing technology.	* PM analysis * FMEA / FTA * 5 Why analysis
Set-up of target	* Set-up of improvement targets - Grasp the level which shall be attained. - Set the target to challenge the “Zero” level * Set-up the attainable target reasonably.	* Bar Graph
Set-up of countermeasures	* Set-up the countermeasures for improving the problem or malfunctions.	* PM analysis * FMEA * 5 Why analysis

5. PILLAR 1 – Focused Improvement - KAIZEN

- **Practice for Focused Improvement**

Theme Step	Activity Contents	Recommended Tools
Implementation of countermeasures	* Implement the improvement plan after determining the Implementing priority.	* PDCA cycle
Grasping effects	* Analyze the gap, that is, the difference between target and result.	* QC 7 Tools
Standardization & on-going control	* Standardize the improved results into the related business standards.	* Control chart * Graphs
Reflection & next plan	* Reflect the step-by-step process of theme and review the application to others.	

5. PILLAR 1 – Focused Improvement - KAIZEN

- **Tools used in Kaizen**
  - PDCA / 7 QC Tools (Identify, prioritize and analyze failures)
  - Why - Why analysis (Identify root causes of failures)
  - FTA - Fault tree analysis (Identify causes of failures and their logic connections)
  - PM analysis (Reduce all chronic losses to zero)
  - FMEA - Failure Mode Effect analysis (Identify and evaluate potential weaknesses) – insert hiperlink to FMEA course
  - SMED – Single Minute Exchange Die (reduce setup and adjustment losses) insert hiperlink to SMED course
  - 5 S´s - insert hiperlink to 5S course

5. PILLAR 1 – Focused Improvement - KAIZEN

- **Tools used in Kaizen - PDCA**

Step	Content	Explanation
PLAN	**Assortment of problems and planning of improvement actions**	• Description of the problem, gathering of information, analysis of the actual state • Formulation of objectives • Assessment of actions to solve, improve or optimize
DO	**Realization of concrete actions to solve the problem**	• Performing actions subject to the time- and resource-plan • Documentation of actions
CHECK	**Validation of results and controlling of aims**	• Description and controlling of results • Adaption in case of aberration • Comparison of results with objectives
ACT	**Improvement of actions, of the situation, etc.**	• Standardization of successful approaches • Starting follow-up actions • Reflecting of processes • Standardization of successful results

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5. PILLAR 1 – Focused Improvement - KAIZEN

- **Tools used in Kaizen - Why - Why analysis ("5 Why's.")**

1. ***Why has the computer failed?***
Answer: The fuse has blown in the chassis.

2. ***Why has the fuse blown?***
Answer: The hard drive is overheating and taking too much current.

3. ***Why is the hard drive overheating?***
Answer: It is generating a lot of heat.

4. ***Why is it generating a lot of heat?***
Answer: It is a high-speed drive and generates more heat.

5. ***Why is it not being cooled?***
Answer: The fan is not cooling it.

…

5. PILLAR 1 – Focused Improvement - KAIZEN

- **Tools used in Kaizen - Why - Why analysis ("5 Why's.")**

Tool ID:				
Date:			Team:	
Problem Description:				
Step	**Why?**	**Answer**	**Comment**	**Final Action**
1				
2				
3				
4				
5				

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5. PILLAR 1 – Focused Improvement - KAIZEN

- **Tools used in Kaizen - PM analysis**

Physical Phenomenon and the ***M***echanism Analysis provides the common man on the shop floor the ability to exactly identify the real causes behind each of such minor stops and quality defect each time.

5. PILLAR 1 – Focused Improvement - KAIZEN

- **Tools used in Kaizen - PM analysis**

PM Analysis is a refined variation of cause-and-effect analysis that considers all causal factors instead of trying to decide which are the most important.

PM analysis steps:

1. Physically analyse chronic problems such as defects and failures according to the machine´s operating principles.

2. Define the essencial or constituent conditions underlying the abnormal phenomena. Pick every case which might contribute to the symptom if the conditions are met.

5. PILLAR 1 – Focused Improvement - KAIZEN

- **Tools used in Kaizen - PM analysis**

3. Identify all factors that logically contribute to the phenomena in terms of the 4Ms:

    - Equipment mechanisms;
    - Materials;
    - Methods used and
    - Man (people actions)

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5. PILLAR 1 – Focused Improvement - KAIZEN

- **Tools used in Kaizen - PM analysis**

For each failure we identify, we must complete a Failure Analysis Sheet. This is used to document the failure cause(s) in engineering terms and record the solution. It includes estimated repair costs. By documenting the failure it can be revisited at any time and the decisions can be challenged, improved, or approved.

5. PILLAR 1 – Focused Improvement - KAIZEN

Failure & PM Analysis Sheet							
Equip. ID:			Equip. Functional Area:				
Describe the fault Symptoms. How should the module work? Use engineering terms and units			Module:				
			Fail Number(s):				
Reason for failure. How do you intend to fix the problem permanently.							
Repair Start Date:			Failure Date:				
Start Time:			Fail Time:				
Estimated Cost of Repair:							
Labour-hours/Equip.:			Repair End Date:				
Parts/Equip.:			Repair End Time:				
Total Cost/Equip.:			Total Cost for All Equip.s:				
Number of Equip.s:			Is Repair Viable?:				

6. PILLAR 2 – Autonomous Maintenance

6. PILLAR 2 – Autonomous Maintenance

- The TPM Paradigm Shift

	Traditional	**TPM**	
Operator	I operate, you fix	I operate and I care of my equipment	**We are <u>ALL</u> responsible for <u>OUR</u> Equipment**
Technician	I fix the equipment when it fails	I prevent the equipment failures	
Engineer	I design equipments to produce	I design equipments with high process capability and reliability	

6. PILLAR 2 – Autonomous Maintenance

- **Policy**
  - Uninterrupted operation of equipments.
  - Flexible operators to operate and maintain other equipments.
  - Eliminating the defects at source through active employee participation.
  - Stepwise implementation of AM activities.

6. PILLAR 2 – Autonomous Maintenance

- **Steps:**
  1. Preparation of employees
  2. Initial cleanup of machines
  3. Take counter measures
  4. Fix tentative AM standards
  5. General inspection
  6. Autonomous inspection
  7. Standardization
  8. Autonomous management

6. PILLAR 2 – Autonomous Maintenance

1. Preparation of employees – Training on:

✓TPM and its advantages

✓ AM advantages and its Steps

✓Safety

- List prediction items such as injuries and accidents before initial clean-up (electric shock, remaining air pressure, dust in eyes, moving parts, skin irritation by detergents,…) and provide training on countermeasures on unsafe condition

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6. PILLAR 2 – Autonomous Maintenance

1. Preparation of employees – Training on:

✓Understanding Equipment

- Sketch equipment structure
- Know machine function
- Conditions in which defects, failures and minor stoppages occur

✓Needed Skills

- Cleaning – method to clean dirtiness skillfully
- Method to find defects
- Lubricating – purpose, type, method, quantity and period
- Retightening – purpose, correct fastening method, tools and their use

6. PILLAR 2 – Autonomous Maintenance

2. Initial cleanup of machines

- ✓ Arrange all items needed for cleaning
- ✓ On the arranged date, employees should clean the equipment completely with the help of maintenance department.
- ✓ Dust, stains, oils and grease has to be removed.

6. PILLAR 2 – Autonomous Maintenance

2. Initial cleanup of machines

- Following are the things that has to be taken care while cleaning:
  - Oil leakage
  - Loose wires
  - Unfastened nits and bolts
  - Worn out parts

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6. PILLAR 2 – Autonomous Maintenance

2. Initial cleanup of machines

- After clean up problems are categorized and suitably tagged:
  - White tags is place where problems can be solved by operators
  - Pink tag is placed where the aid of maintenance department is needed.
- Contents of tag is transferred to a register.
- Make note of area which were inaccessible.
- Finally close the open parts of the machine
- and run the machine.

6. PILLAR 2 – Autonomous Maintenance

3. Counter Measures

- Inaccessible regions had to be reached easily
- To prevent work out of machine parts necessary action must be taken
- Machine parts should be modified to prevent accumulation of dirt and dust

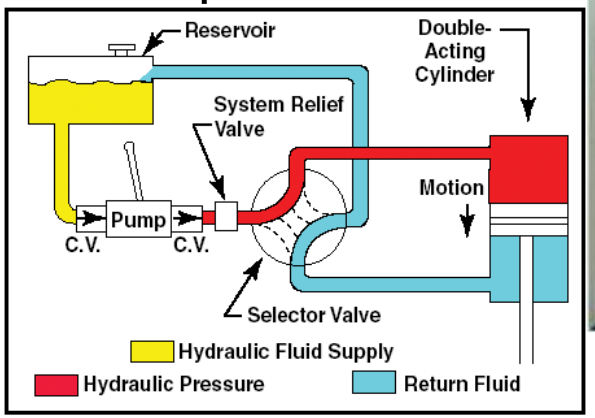
4. Tentative Standard

- AM 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

6. PILLAR 2 – Autonomous Maintenance

5. General Inspection

- The employees are trained in disciplines like:
  - Pneumatics
  - Electrical
  - Hydraulics
  - Lubricant and coolan
  - Drives, bolts and nuts
  - Safety



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6. PILLAR 2 – Autonomous Maintenance

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
- Inspection that is made in preventive maintenance is included in AM
- The frequency of cleanup and inspection is reduced based on experience

6. PILLAR 2 – Autonomous Maintenance

7. Standardization

- 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

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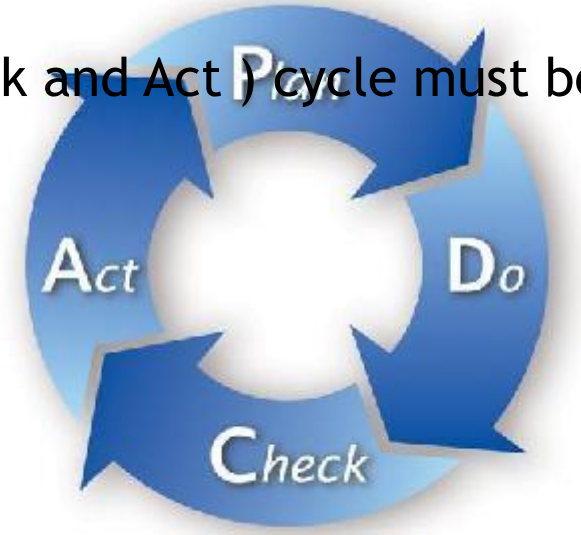
6. PILLAR 2 – Autonomous Maintenance

8. Autonomous Management

- Autonomous team working
- OEE and OPE and other TPM targets must be achieved by continuous improve through Kaizen
- PDCA (Plan, Do, Check and Act) cycle must be implemented for Kaizen



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6. PILLAR 2 – Autonomous Maintenance

8. Autonomous Maintenance Exercise

- Think about what could be Autonomous Maintenance activities for your computer to keep it in good shape

- Create an Autonomous Maintenance plan for your computer

7. PILLAR 3 – Planned Maintenance

Objectives:

Increase Equipment Reliability and Production Up-Time

Minimize the maintenance cost by:

1. *Reducing breakdowns*
2. *Development of efficient maintenance methods*

To clarify *which parts and locations* of *which equipment* should receive *what type of maintenance* and to implement it in a *planned manner.*

7. PILLAR 3 – Planned Maintenance

- The development of Planned Maintenance is based on 4 phases:

  Phase 1: Reduce the distribution of failure interval (MTBF)

  Phase 2: Extend equipment life time

  Phase 3: Restore deterioration periodically

  Phase 4: Failure prediction

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7. PILLAR 3 – Planned Maintenance

Phase 1: Reduce the distribution of failure interval (MTBF)

- Repair deteriorating machines;
- Align the performance of all machines belonging to the same technology and process;
- Scattering between failures for each equipment.

$$MTBF = \frac{\text{OPERATING TIME}}{\text{NUMBER OF FAILURES DURING THAT TIME}}$$

MEAN TIME BETWEEN FAILURE

Example: Suppose 10 devices are tested for 500 hours. During the test 2 failures occur. The estimate of the MTBF is: MTBF= 10*500/2 = 2,500 hours / failure.

7. PILLAR 3 – Planned Maintenance

- **Improvement of Equipment MTBF**
  - Corrective Maintenance
  - Preventive Maintenance
  - Maintenance Prevention
  - Reliability Centered Maintenance
  - Breakdown Maintenance
  - Support for Autonomous Maintenance

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7. PILLAR 3 – Planned Maintenance

- **Improvement of Equipment MTBF**

  - Corrective Maintenance

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.

  - Preventive Maintenance

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. Just like human life is extended by preventive medicine, the equipment service life can be prolonged by doing preventive maintenance. It is further divided into ***periodic maintenance*** and ***predictive maintenance***.

7. PILLAR 3 – Planned Maintenance

- **Improvement of Equipment MTBF**

  - 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.

  - 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.

7. PILLAR 3 – Planned Maintenance

- **Improvement of Equipment MTBF**

  - Maintenance Prevention

It indicates the design of a new equipment. Weakness of current machines are sufficiently studied (on site information leading to failure prevention, easier maintenance and prevents of defects, safety and ease of manufacturing) and are incorporated before commissioning a new equipment.

  - Reliability-Centered Maintenance (RCM)

Prioritizing maintenance efforts based on equipment's importance to operations, its downtime cost in revenue and customer loss, its impact on safety, and its cost of repair. Depends on the same measurements used in predictive maintenance, but saves additional maintenance resources by spending less effort on less important machinery.

7. PILLAR 3 – Planned Maintenance

- **Improvement of Equipment MTBF**

  - Breakdown Maintenance

It means that people waits until equipment fails and repair it. Used when the equipment failure does not significantly affect the operation or production or generate any significant loss other than repair cost.

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7. PILLAR 3 – Planned Maintenance

Phase 2: Extend equipment life time

- Find weak machine design points

Phase 3: Restore deterioration periodically

- Improve Maintainability;
- Reduce MTTR

$$MTTR = \frac{\text{MEAN TIME TO REPAIR}}{\text{TOTAL CORRECTIVE MAINTENANCE TIME}}{\text{TOTAL NUMBER OF CORRECTIVE MAINTENANCE ACTIONS}}$$

7. PILLAR 3 – Planned Maintenance

- **Improvement of Equipment MTTR**
  - Specialized maintenance skills
  - Equipment repair skills
  - Inspection and measurement skills
  - Equipment diagnostic skills
  - Develop new maintenance technologies

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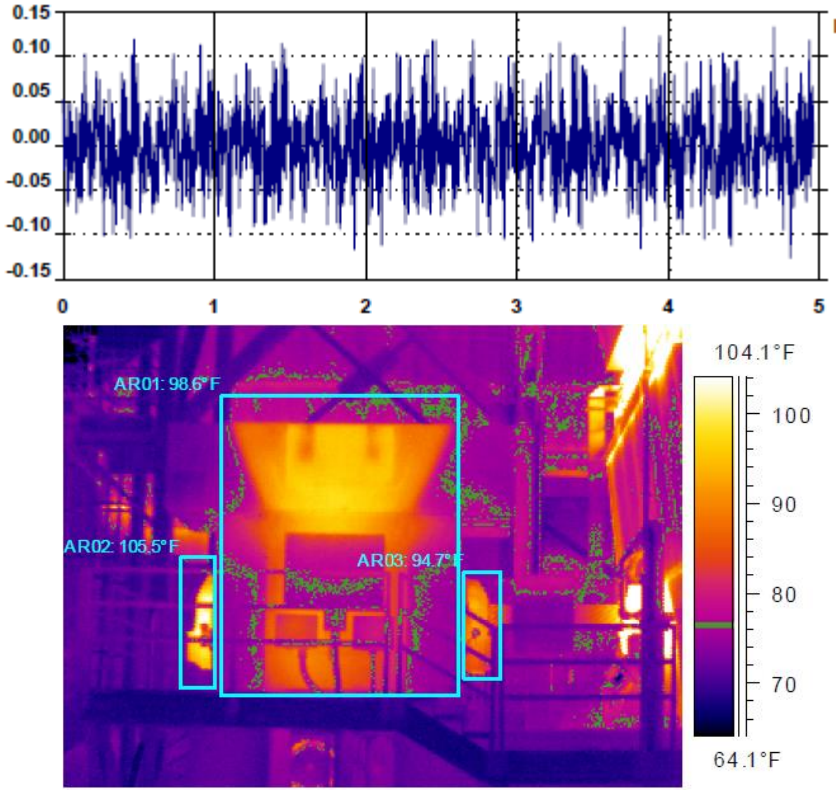
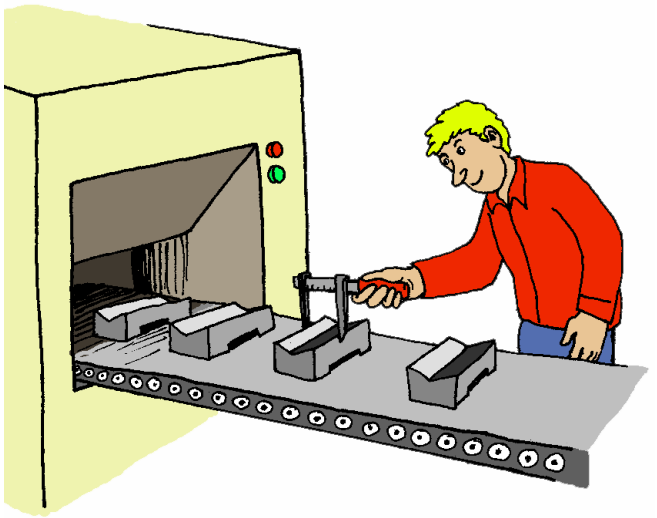
7. PILLAR 3 – Planned Maintenance

Phase 4: Failure prediction - Prediction of failure by equipment diagnosis:

- Vibration analysis
- Ultrasound
- Oil analysis
- Wear-particle analysis
- Thermography



7. PILLAR 4 – Quality Maintenance



Result Oriented Approach
"after it has happened"

Cause Oriented Approach
"before it happens"

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7. PILLAR 4 – 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

MAINTAINING PERFECT EQUIPMENT TO MAINTAIN PERFECT QUALITY OF PRODUCTS

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7. PILLAR 4 – Quality Maintenance

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

7. PILLAR 4 – Quality Maintenance

- The development of Quality Maintenance is based on 5 Steps:

Step 1: Establish conditions for “zero defects”

Step 2: Prevent the occurrence of quality defects by maintaining the conditions within certain standards

Step 3: Inspect and monitor such conditions in time series

Step 4: Predicting the possibility of quality defect occurrence by reviewing changes in measured values

*Step 5:*Take countermeasures in advance

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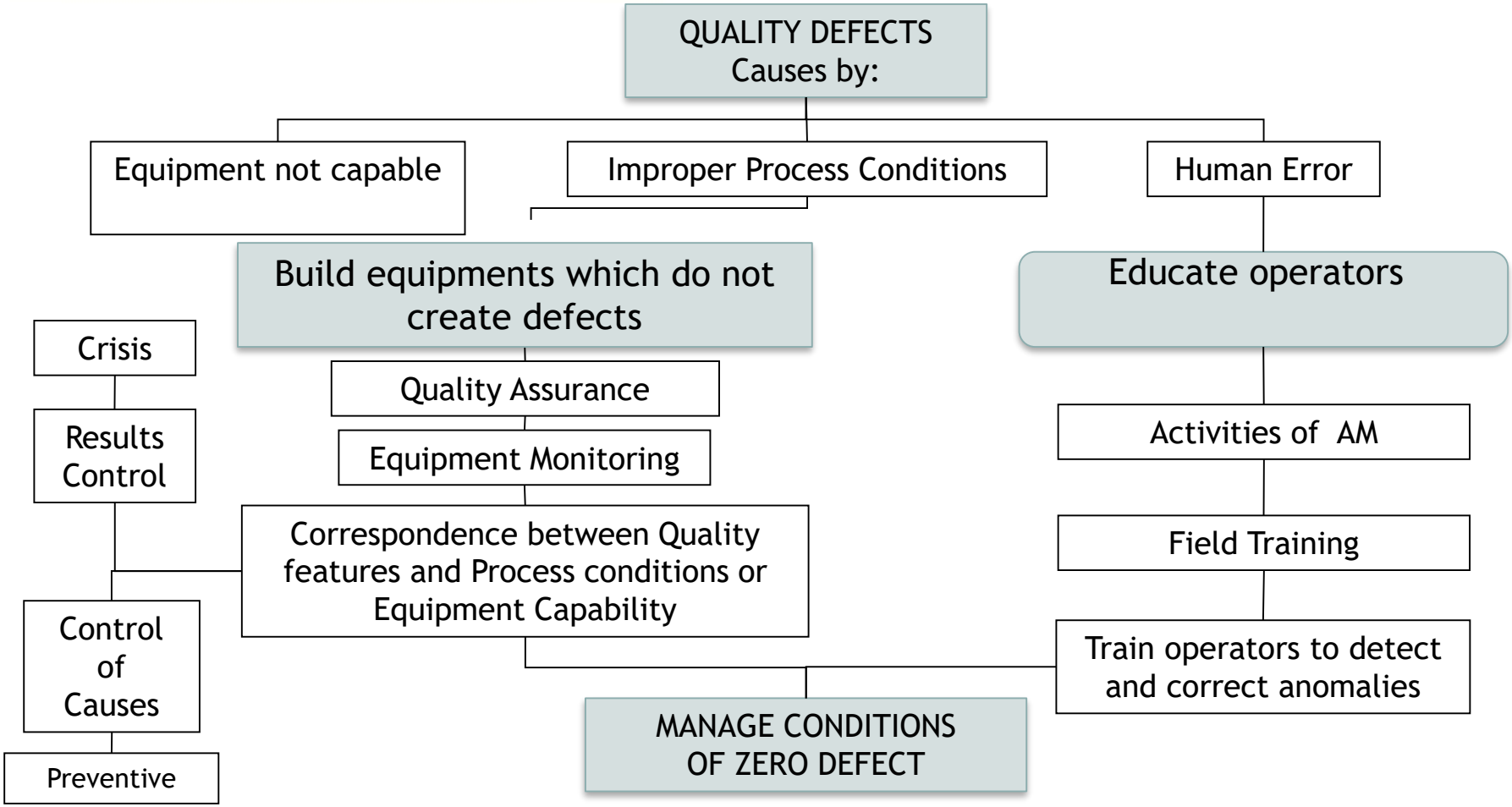
7. PILLAR 4 – Quality Maintenance



7. PILLAR 4 – Quality Maintenance

- **Quality Maintenance 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.

7. PILLAR 4 – Quality Maintenance

- **Quality Maintenance Data requirements:**

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.

7. PILLAR 4 – Quality Maintenance

- **Quality Maintenance Data requirements:**

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.

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8. PILLAR 5 – Office TPM

- Definition: a methodology to improve productivity, efficiency in the administrative functions and identify and eliminate losses. This includes analyzing processes and procedures towards increased office automation.

- **Objectives:**
  - Minimize losses
  - Improve quality of work
  - Clear work allocation

8. PILLAR 5 – Office TPM

- **Office TPM addresses twelve major losses:**

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

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8. PILLAR 5 – Office TPM

- **Office TPM addresses twelve major losses:**

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.

8. PILLAR 5 – Office TPM

- **P Q C D S M in Office TPM**

P - Production output lost due to want of material, Manpower productivity, Production output lost due to want of tools.

Q - Mistakes in preparation of cheques, bills, invoices, payroll, Customer returns/warranty attributable to BOPs, Rejection/rework in BOP's/job work, Office area rework.

C - Buying cost/unit produced, Cost of logistics - inbound/outbound, Cost of carrying inventory, Cost of communication, Demurrage costs.

D - Logistics losses (Delay in loading/unloading)

Delay in delivery due to any of the support functions Delay in payments to suppliers Delay in information

S - Safety in material handling/stores/logistics, Safety of soft and hard data.

M - Number of kaizens in office areas.

8. PILLAR 5 – Office TPM

- **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.

8. PILLAR 5 – Office TPM

- **How to start office TPM?**

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

8. PILLAR 5 – Office TPM

- **How to start office TPM?**

TPM co-ordinate plans and guides the sub committee:

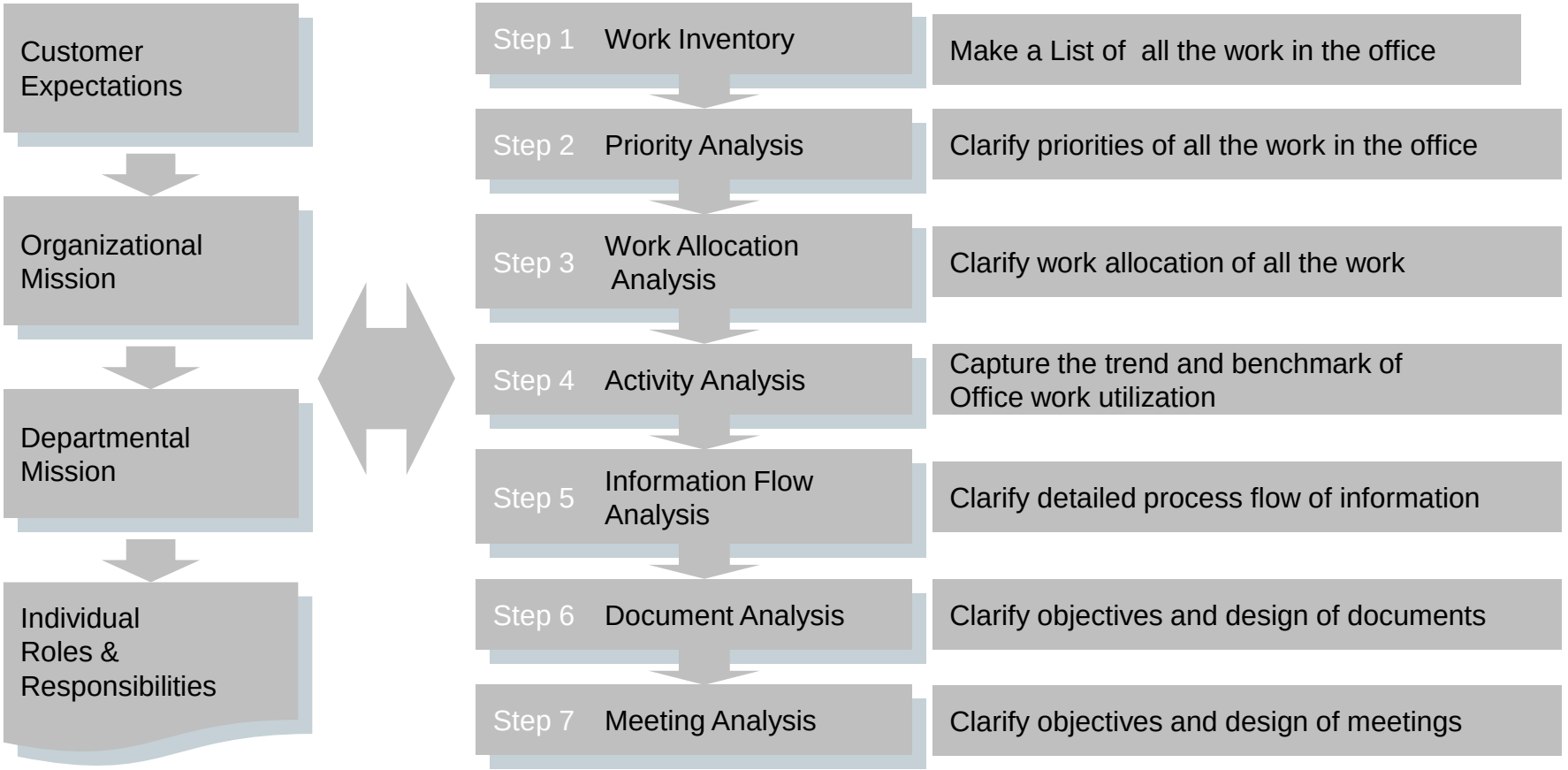
5. Help them to solve problems in their circles
6. Make up an activity board where progress is monitored on both sides - results and actions along with Kaizens.
7. Fan out to cover all employees and circles in all functions.

8. PILLAR 5 – Office TPM

- **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.

8. PILLAR 5 – Office TPM

- **Office TPM steps:**



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8. PILLAR 5 – Office TPM

- **Work Inventory (example):**

Job Title: Name:

Work Activity				Frequency				Quantity			Cycle time			Document Forms Being Used	Remarks
Category		Sub-Element		Daily	Weekly	Monthly	Yearly	Maximum	Minimum	Average	Maximum	Minimum	Average		
No		No		(Check one)				(Times/How many)			(Minutes)				
1	Monthly Inventory	1	Plan and assign inventory			X								>Inventory Assignment	
		2	Physical Inventory			X		1	2	1			2hrs	>Inventory Sheet	
		3	Inventory Data Entry and Verification			X							5hrs	>Inventroy Sheet	
		4	Report Generation			X								>Resins >Finished Inventory >Inprocess Inventory	
2	Data Entry of Job Card	1	Daily Data Entry	X						15			2hrs	>Job Card (Molding) >Job Card (Finishing)	
3	QS/ISO	1	Maintain and update documents for QS 9000			X									
		2	Maintain and update documents for ISO14001			X									
		3	Create Weekly QS Report		X					3			12	>Molding Summary	
		4	Perfom Internal Audits												
		5	Preparing for external Audits											>Finishing Summary	
4	Office TPM	1	5S	X									1hrs		
		2													
5	Programming Support	1	Programming for Access												
		2													
6	Meetings	1	Production Meeting	X						15			5hrs		
		2	Staff Meeting		X					15			1hr		
		3	Muda-tori meeting			X									
		4	QS/ISO Meetings												

8. PILLAR 5 – Office TPM

- **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

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8. PILLAR 5 – Office TPM

- **Office TPM and its Benefits:**

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.

8. PILLAR 5 – Office TPM

- **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

9. PILLAR 6 – Safety, Health & Environment

- Aims: assuring safety and preventing adverse environmental impacts
- Objectives:
  - Zero Accidents
  - Zero Injuries
  - Zero Pollution
  - Zero Waste

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9. PILLAR 6 – Safety, Health & Environment

- **Establishes policies and leadership in:**
  - Safety
  - Higiene and Environmental control
- **Scientifically analyses plant accidents**
- **Provides safety checks manuals and emergency manuals**
- **Provides safety assessments before introducing new technologies and equipment**

10. PILLAR 7 – Early Equipment Management

- **Objective: establish systems to shorten cycle time for:**
  - New product or equipment development
  - System adds
  - Start-up and commissioning time (to reach stable, full speed production at start-up)
- **New equipment and system adds needs to be:**
  - Easy to operate
  - Easy to clean
  - Easy to maintain and reliable
  - Have quick set-up times
  - Operate at the lowest life cycle cost

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11. PILLAR 8 – Education & Training

- **Objectives:**
  - Enhance employees' ability and skill in TPM methods
  - Provide necessary TPM methodology at the right time
  - Provide challenge targets for individuals by clarifying the hierarchy of skills

11.PILLAR 8 – Education & Training

- **Policy:**

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

The employees should be trained to achieve the four phases of skill. The goal is to create a factory full of experts. The different phases of skills are:

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.

11.PILLAR 8 – Education & Training

- Education & Training implementation steps:

Step 1: Skills/Techniques Inventory and Hierarchy

  - Create a list of Operational and Maintenance Skills and Techniques

Step 2: Design Training System

  - Including follow-up system such as OJT (on the job training)
  - Documentation of Individual Skill Levels

Step 3: Set Individual Skill Challenge Target

Step 4: Training and Evaluation

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