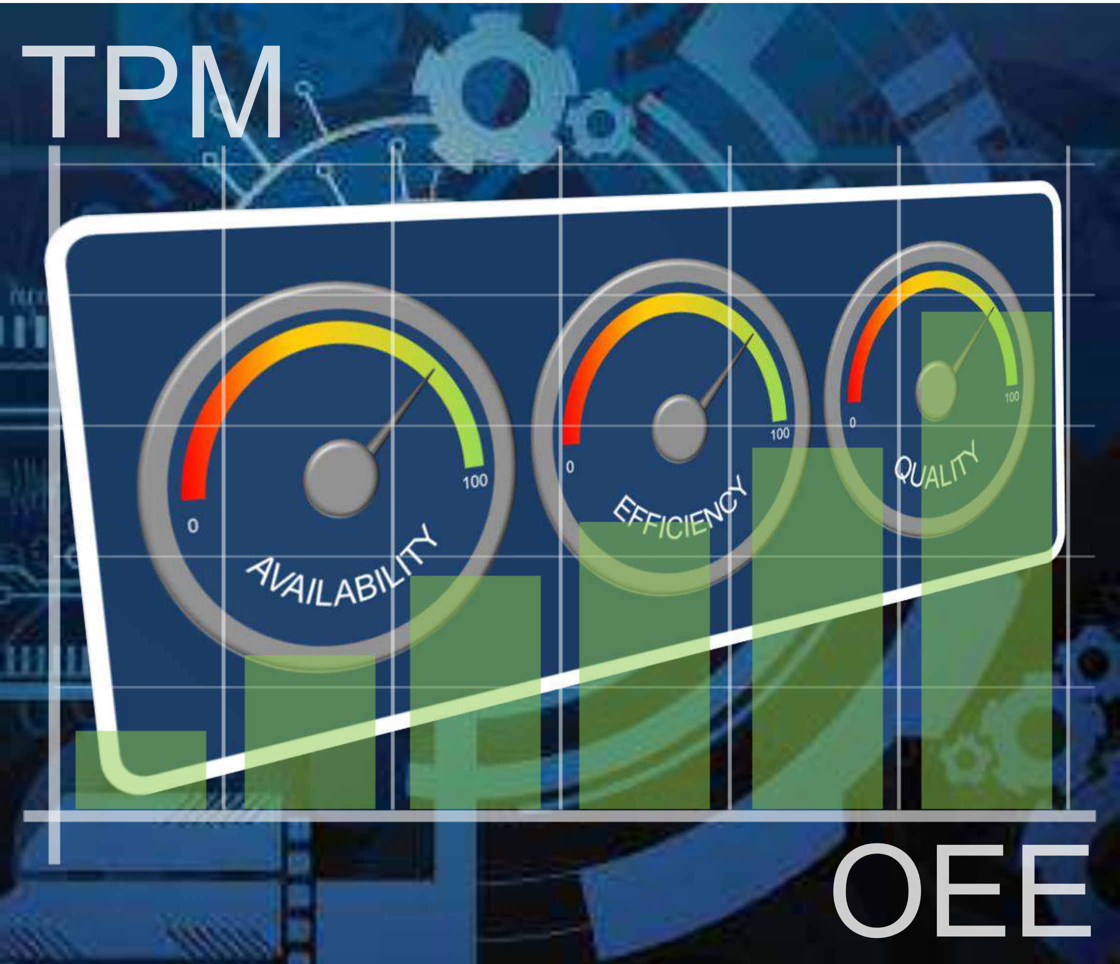
LBS Partners

TPM and OEE

Maurice O'Brien



About LBSPartners

LBSPartners was founded in Limerick in 2002 to educate and assist companies in the development of operational excellence through Lean, Lean-Sigma & 6-Sigma.

We are a hands-on business improvement consulting firm with extensive Lean and management experience. Our customer base includes SMEs, Multinationals and Public sector clients in food, engineering, life sciences, services and software.

LBS has a proven track record of delivering measurable and sustainable results to our clients through significant Lean transformations to hundreds of clients. Projects are typically delivering improvements in cost, cycle time, quality and customer service.

Published by: **LBS Partners**
Nexus Innovation Centre
Tierney Building
University of Limerick
Limerick, Ireland

Publication date: December, 2015

Printed in Ireland

Telephone: +353 (0) 61 518408

E-mail: info@lbspartners.ie

Website: http://www.lbspartners.ie

ISBN: 978-0-9570203-9-9

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Introduction

Total Productive Maintenance (TPM) is defined as a company-wide, team-based effort to build quality into equipment and to improve productivity by reducing the time lost due to breakdowns.

Overall Equipment Effectiveness (OEE) is a one of the key measures of TPM which indicates how effectively the machinery and equipment is being run.

TPM aims to increase productivity by reducing lost production time, increasing available time for production and therefore output from the process.

TPM is based on eight key strategies (also referred to as pillars) which include improved planning of maintenance activities, measurement of machine performance, continuous improvement and enhancement of safety. These pillars are listed in the overleaf and will be discussed in greater detail in a subsequent chapter.

Pillar	What it is
Autonomous maintenance	Involve the operator in daily machine maintenance
Planned maintenance	Plan maintenance activities so that production is not interrupted
Equipment and process improvement	Identification and problem solving of recurring problems
Early management of new equipment	New equipment achieves desired performance levels earlier
Quality management	Introduce improvement projects to address quality issues
TPM in the office	Address waste in administration functions
Education and training	Develop operators so that they can routinely maintain equipment
Safety and environmental management	Eliminate potential safety risks, improve the working environment

Table 1 Pillars of TPM

The goals of Total Productive Maintenance are:

- To increase productivity by eliminating or reducing breakdowns, stops and rejects
- To maximize the effective utilisation of assets (machinery and equipment)
- To reduce cycle times by eliminating stops or slow running of machines
- To extend the useful life of production equipment
- To fully support the company’s business mission to support customer demand
- To support the introduction of:
  - flow through the process
  - continuous improvement
  - standardised work
  - pull systems

6S/Workplace Organisation

Typically, a precursor to the implementation of a TPM programme is the introduction of 6S or workplace organisation.

6S describes a set of steps used to organise the workplace in the cleanest, safest and most efficient manner.

The 6S steps are:

- **SORT**
- **SET-IN-ORDER**
- **SHINE**
- **STANDARDISE**
- **SUSTAIN**
- **SAFETY**

6S Steps	Activity
SORT	• Remove all unnecessary items from the workplace • Identify all tools and equipment needed to perform the work
SET-IN-ORDER	• Organise all required tools and equipment in the most efficient manner
SHINE	• Clean the workplace thoroughly • Ensure everything is in perfect working order
STANDARDISE	• Create a consistent way to perform tasks and procedures • Achieved through continual application of the **SORT, SET-IN-ORDER** and **SHINE** steps
SUSTAIN	• Make a habit of properly maintaining correct procedures
SAFETY	• Safety first when determining where items are to be located

Table 2 6S Steps

Pillars of TPM

Total Productive Maintenance (TPM) is based on the approaches illustrated below, which are focused on proactive and preventive methods for improving equipment effectiveness:

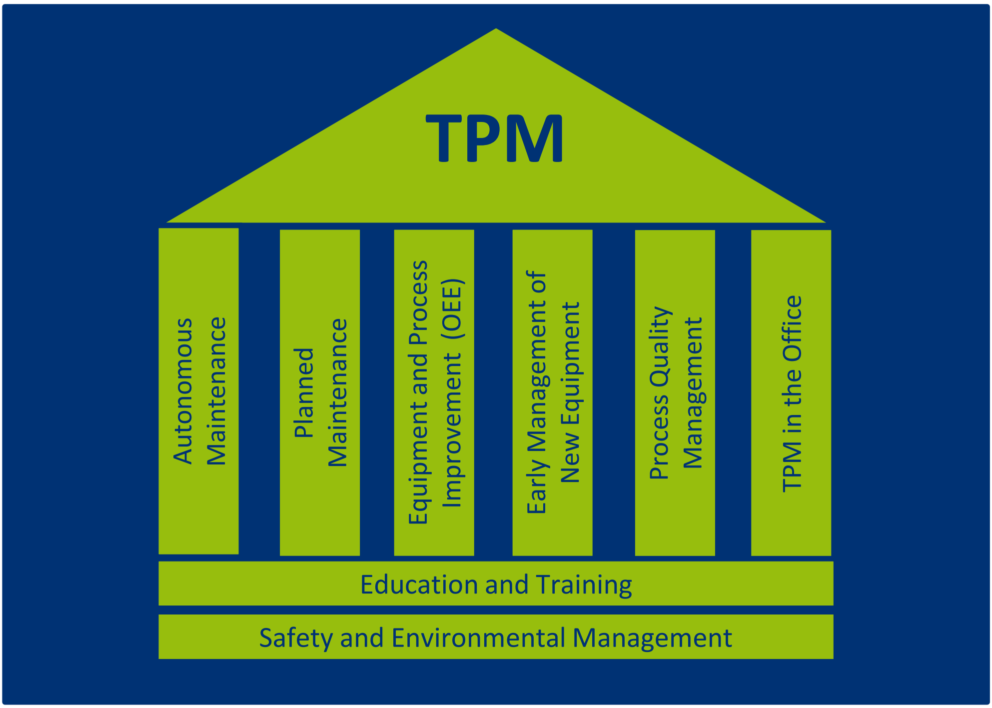


Figure 1 Pillars of TPM

1. Autonomous Maintenance

Autonomous maintenance involves training production operators to take on basic maintenance tasks, freeing maintenance staff to concentrate on more critical maintenance activities.

It encourages the operators to take and active role in maintaining their own equipment, for example the daily inspection, cleaning and lubrication of the machine.

Pillar	What it is and what it does
Autonomous Maintenance	Trains operators in the effective care and operation of their machines • Increases operator ownership for maintenance • Improves daily maintenance of equipment • Frequent cleaning of equipment leads to earlier detection of problems • Frees designated maintenance personnel for higher level maintenance tasks

Table 3 Autonomous Maintenance

2. Planned Maintenance

Planned maintenance schedules maintenance to reduce loss of available production time.

Scheduling of maintenance activities is based on predicted failure rates derived from analysis of past breakdowns and resulting downtime.

The objective is to set up preventive and predictive maintenance systems for equipment and tooling.

Pillar	What it is and what it does
Planned Maintenance	Scheduling of maintenance activities to reduce their impact on running production • Reduces interruptions to production due to breakdowns/downtime, improving machine efficiency • Schedules maintenance during periods when production is not running • Drives the implementation of a suitable spares programme, based on analysis of previous breakdowns • Contributes to improved safety and quality performance

Table 4 Planned Maintenance

3. Equipment and Process Improvement

The objective of equipment and process improvement is the reduction and elimination of waste and manufacturing losses.

Manufacturing losses are defined under three headings:

- Equipment losses
- Manpower losses
- Material losses

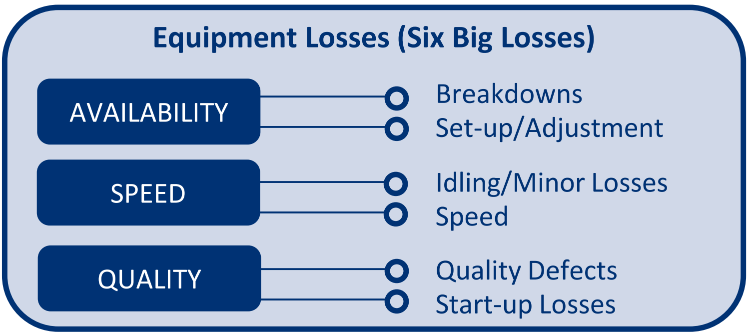


Figure 2 Equipment Losses

Equipment Loss	Description
Breakdowns	• General breakdowns • Tooling failures • Equipment failures • Unplanned maintenance
Set-up/ Adjustments	• Changeover • Shortages • Complex adjustments • Warm-up time
Idling/Minor losses	• Jams/misfeeds • Minor adjustments
Speed	• Incorrect settings • Wear • Operator inefficiency
Quality defects	• Scrap during production runs • Rework during production runs
Start-up losses	• Defects produced during the start-up process (scrap or rework)

Table 5 The Six Big Losses

These losses are typically addressed through the implementation of an Overall Equipment Efficiency (OEE) programme. OEE will be discussed in more detail in a later chapter.

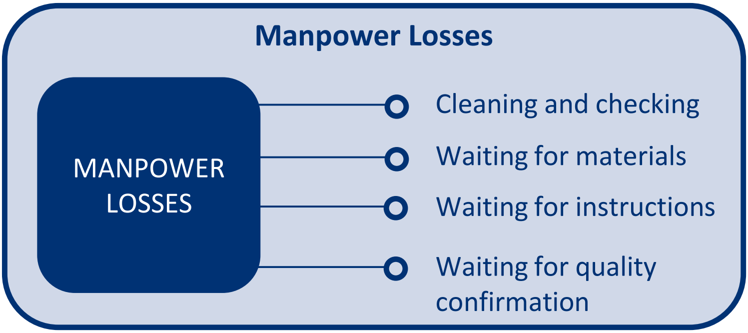


Figure 3 Manpower Losses

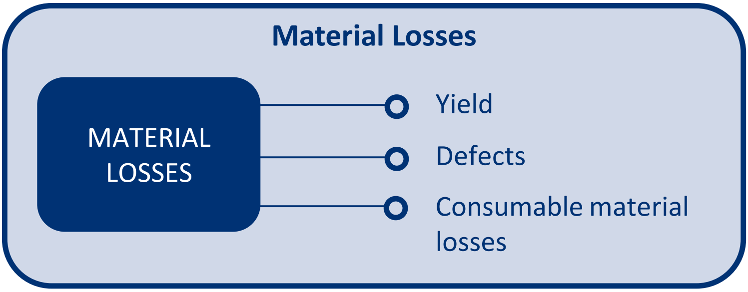


Figure 4 Material Losses

A structured programme of problem solving and process improvement is used to identify recurring issues.

Permanent fixes are then put in place through the implementation of improvement projects to reduce or eliminate manpower and material losses.

Generally, these projects are achieved by setting up cross-functional teams with specific targets for improvement with associated target dates.

Pillar	What it is and what it does
Equipment and Process Improvement	Improves the operating efficiency of processes and machines/equipment • Installs permanent fixes for recurring issues • Encourages teamwork through the establishment of cross-functional project teams • Introduces problem solving techniques and enhances employee skills

Table 6 Equipment and Process Improvement

4. Early Management of New Equipment

Early Management of New Equipment means using the knowledge and experience gained from TPM programmes to improve the design of new equipment.

The objective is to make the equipment:

- Easy to operate
- Easy to clean
- Easy to maintain
- More reliable
- Reduce set-up times
- Operate at the lowest life cycle cost

Pillar	What it is and what it does
Early Management of New Equipment	Reduces the time required to get the piece of equipment running at stated level of performance • Reduces the number of start-up issues leading to a decrease in the time taken to reach desired performance • Reduces start-up, commissioning and stabilisation time for improved quality and efficiency

Table 7 Early Management of New Equipment

5. Process Quality Management

Process Quality Management is defined as a process for controlling the condition of equipment components that affect variability in product quality.

This includes elements such as error proofing, introducing systems to prevent mistakes from happening in the first place and root cause analysis to find the true cause, to fix it permanently.

These initiatives are used to reduce the cost of quality by continually improving the systems to catch defects as early in the process as possible or to prevent them from happening at all.

Pillar	What it is and what it does
Process Quality Management	Introduces improvement projects to address recurring quality issues • Identifies and resolves quality issues to decrease the cost of quality • Introduces Lean initiatives such as error proofing and root cause analysis to reduce the occurrence of defects, improving quality levels

Table 8 Process Quality Management

6. TPM in the Office

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 and reduce redundant operations.

Often problems experienced by production often originate earlier in the process, for example in how the order was taken, entered into the system or planned through production.

TPM in the office uses TPM and other Lean methodologies to streamline support operations, improving flow through all processes.

Pillar	What it is and what it does
TPM in the Office	Addresses waste in administration and support functions • Applies TPM techniques to support activities to reduce waste and streamline processes • Improves efficiency of the production by reducing the issues generated in the administrative tasks such as raw material procurement, order entry and release of orders to production

Table 9 TPM in the Office

7. Education and Training

Equip all employees with the skills required to perform basic machine maintenance.

This process of empowering operators means maintenance personnel can be released to get involved in analysis and root cause of downtime issues, so they can be more proactive in setting up systems to reduce future occurrences.

Pillar	What it is and what it does
Education and Training	Develop operators so they can routinely maintain production equipment • Upskills operators to clean and maintain their equipment daily • Frees-up maintenance personnel to concentrate proactively on improvement activities such as preventive maintenance • Trains managers to mentor and coach employees on TPM techniques

Table 10 Education and Training

8. Safety and Environmental Management

Aims to improve the workplace, reducing safety risks and maintaining a safe and healthy environment.

The implementation of a 6S programme is the first step to improving safety by eliminating defective machinery, equipment and safety hazards.

Pillar	What it is and what it does
Safety and Environmental Management	Eliminate potential safety risks, improve the working environment • Identifies potential risks and puts countermeasures in place to eliminate or al least mitigate the risk • Ensures all guards and PPE are in place to reduce the likelihood of injury to operators

Table 11 Safety and Environmental Management

OEE

Overall Equipment Effectiveness (OEE) was already defined as one of the key measures of TPM which indicates how effectively the machinery and equipment is being run.

It combines measures of machine Availability, Performance and Quality.

- **AVAILABILITY** is the time the machine is actually running, obtained by subtracting machine downtime from the planned operating time.
- **PERFORMANCE** compares the speed at which the machine actually runs to the manufacturer's rating under ideal conditions i.e. the actual cycle time vs. the ideal cycle time.
- **QUALITY** is defined as the quantity of good parts produced i.e. total output – defects. This includes the defects produced on start-up and those produced when the machine is in stable production.

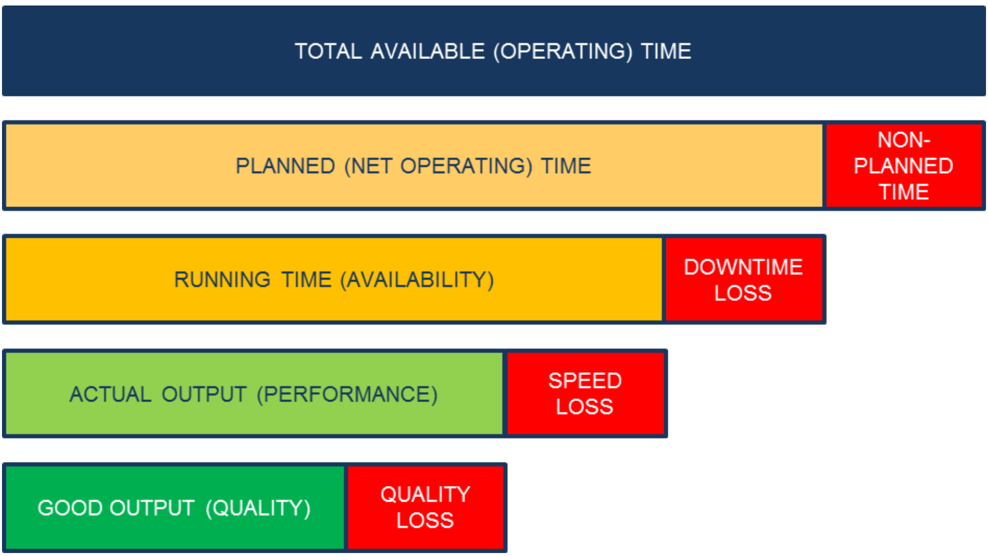


Figure 5 OEE Components/Losses

$$\text{AVAILABILITY} = \frac{\text{Time available for production} - \text{Downtime}}{\text{Time available for production}}$$

$$\text{PERFORMANCE} = \frac{\text{Ideal cycle time} \times \text{No. of parts produced}}{\text{Operating time}}$$

$$\text{QUALITY} = \frac{\text{Total number of parts produced} - \text{No. of defects produced}}{\text{Total number of parts produced}}$$

Figure 6 OEE Measures

OVERALL EQUIPMENT EFFECTIVENESS is calculated using this formula:

OEE = AVAILABILITY x PERFORMANCE x QUALITY

It is important to consider that even if each of these OEE factors is quite high, for example 85% or 0.85, the final product for OEE will work out as 0.61 (i.e. 0.85 x 0.85 x 0.85).

OEE Factor	World Class Figure
Availability	90% = 0.9
Performance	95% = 0.95
Quality	99.9% = 0.99
OEE	85% = 0.85

Table 12 World Class OEE

Example

- A factory runs a single shift of 8 hours. There are three breaks, one of 30 minutes and two other breaks of 10 minutes each.
- During the shift in question, downtime of 50 minutes is recorded.
- The machine being studied has a stated production rate of 1 part every 20 seconds (3 per minute). In this particular shift 957 parts are produced.
- The number of defects produced during this shift is measured as 97 parts which must be scrapped.

AVAILABILITY	
Hours in shift	8
Minutes in shift	480
Breaks (minutes)	50
Planned Operating Time (minutes)	430
Downtime (minutes)	50
AVAILABILITY (=430 – 50/430)	**0.88**
PERFROMANCE	
Target output (3 parts/min x 430 mins)	1290
Actual output	957
PERFROAMNCE (=957/1290)	**0.74**
QUALITY	
Total number of parts produced	957
Number of good parts produced	860
QUALITY (=860/957)	**0.89**

OEE = 0.88 x 0.74 x 0.89 = 0.58

Improving OEE

OEE is impacted by three categories of losses:

- Downtime Losses
- Speed Losses
- Quality Losses

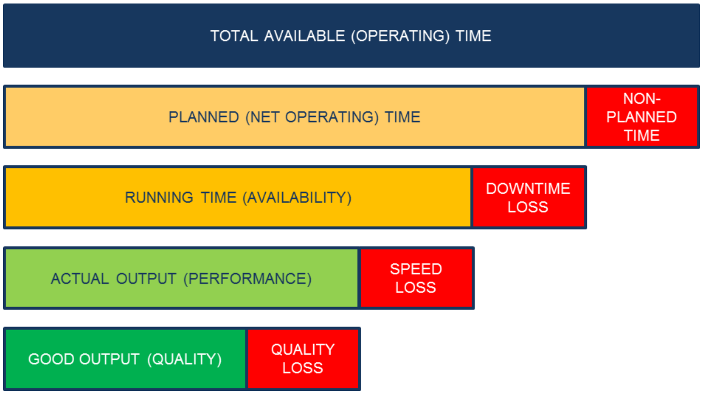


Figure 7 OEE Components/Losses

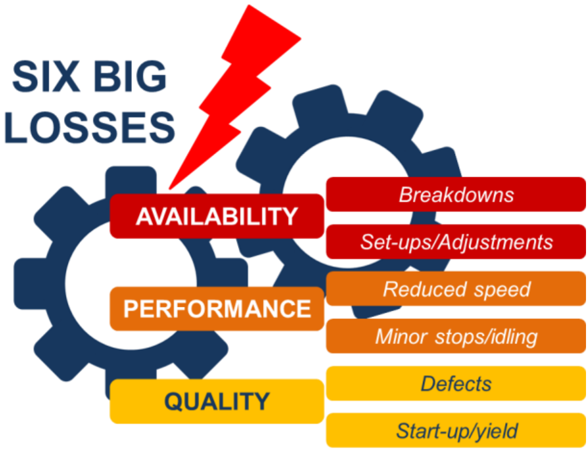


Figure 8 The Six Big Losses

The three categories of loss are further divided into what is referred to as the Six Big Losses, illustrated in figure 8.

One of the main aims of any TPM/OEE programme is to focus on the elimination of these Six Big Losses.

Table 13 gives a brief description of each of these losses.

OEE Factor	OEE Loss	Description
AVAILABILITY (Downtime Losses)	Breakdowns	Random machine failures causing stoppages of more than 10 minutes
	Set-ups/ adjustments	Time lost when changing from one product to another
PERFORMANCE (Speed Losses)	Reduced speed	Not running at ideal cycle time caused by wear or poor maintenance
	Minor stops/idling	Stoppages of less than 10 minutes caused by jams/misfeeds/blocked or dirty sensors
QUALITY (Defect Losses)	Defects	Process rejects requiring rework or scrap
	Start-ups/ yield	Time taken for a machine to reach stable process after a changeover or on starting the machine i.e. warm-up time

Table 13 Description of the Six Big Losses

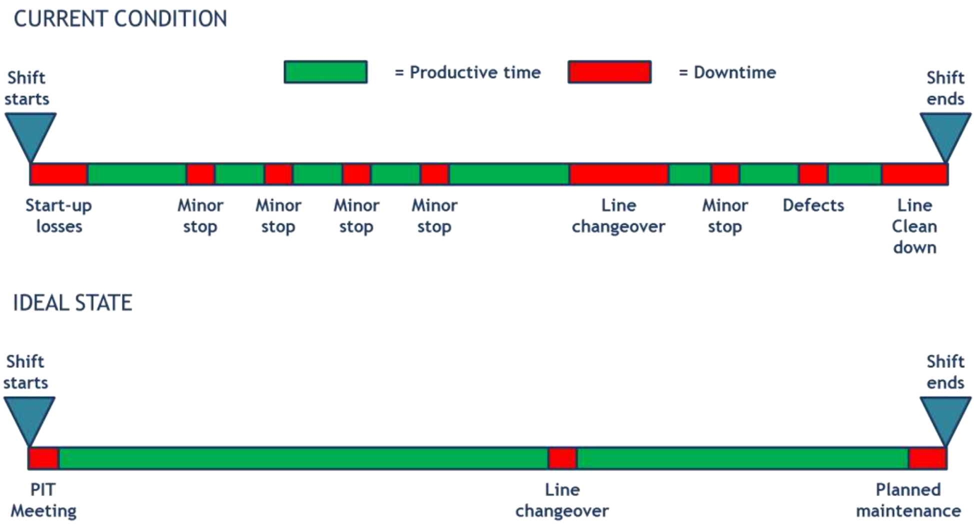


Figure 9 Production Shift Timelines

The timeline in Figure 9 represents a typical production shift. The total productive time is reduced by start-up losses, small component jams (short stops) and long changeover times.

The aim of the implementation of a TPM/OEE programme is the elimination of these wastes of time, re-organising the shift to have a production focused meeting and planned maintenance as the only interruptions.

There will also be lost time due to changeovers. However, the aim should be to reduce the time taken to clean down a line and set it up to produce the next item/part.

Refer to page 21 for more on reducing changeover times.

Eliminating The Six Big Losses

AVAILABILITY LOSSES

Typically, tackling the Six Big Losses begins by concentrating on ***DOWNTIME***, because if the machine or process is not running then none of the losses can be addressed.

- The first step is to collect information on the amount of downtime experienced by the process to understand the extent of the problem.
- The next step is to understand the reasons for the downtime, best practice involves assigning reason codes under which the downtime can be recorded.
- This is done by working with the people closest to the process, brainstorming possible causes why the machine or process is stopped. Different processes will need their own set of reason codes, particular to that process.
- It can be useful, when running the brainstorming exercise to think of causes in terms of machine/mechanical, process or people to prompt ideas.
- Once data has been collected on the downtime and reasons for it, this is used to rank causes in the order they should be tackled. Then root cause analysis can be performed to introduce permanent fixes for the causes of the downtime.

Figure 10
Sample Reason Codes

Number	Reason code
01	Machine down/fault
02	Maintenance
03	Set-up/changeover
04	Waiting on material
05	Waiting on quality check
06	Meetings
07	Breaks

Figure 11
Sample Data Collection Sheet

Process/Machine Bridgeport milling machine **Week No.** 22

Date	Down time Starts	Down time Finishes	Total minutes	Reason code	Comment
27-May	11:47	12:23	36	01	Machine stopped – tool broken
29-May	09:13	09:36	23	03	Changed to different product

Once the data has been collected over an acceptable period of time, the results can be plotted (as a bar chart for example) to understand the most significant cause.

The purpose of completing this exercise is to prioritise where the effort should be put to obtain the best return. Each cause can then be tackled in turn and a permanent fix put in place for each.

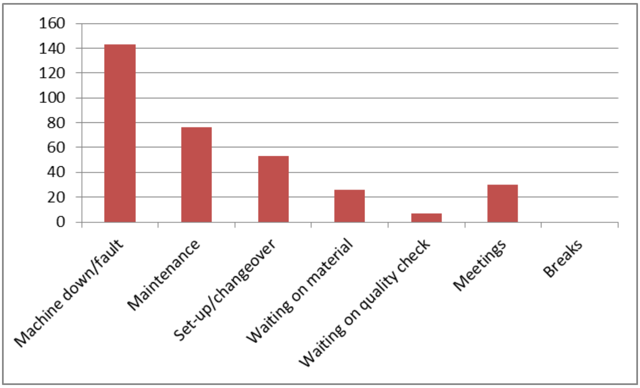


Figure 12 Bar Chart of Reasons for Downtime

NOTE: *a separate guide to Problem Solving is available from LBS Partners*

QUICK CHANGEOVER

In production environments, lines manufacture numerous different products and it is rare that all the products can be made using the same physical tools and fixtures.

When changing from the manufacture of one product to another, the previous configuration will generally change and a different set of dies, tools and fixtures will be put in place.

SET-UP/CHANGEOVER TIME is defined as the time between the last good unit produced before changing from the previous product run, to the first good unit of the new product produced after the changeover.

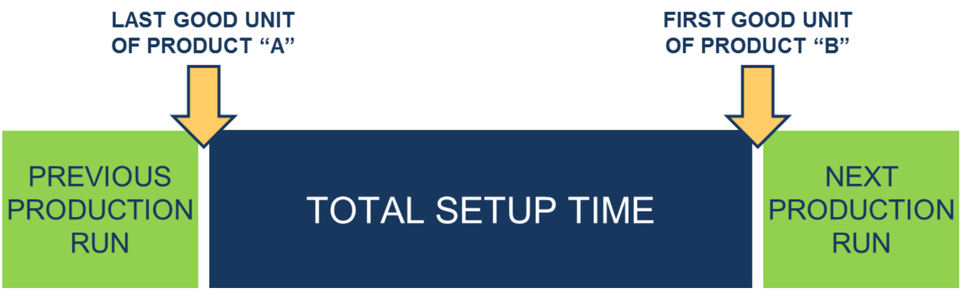


Figure 13 Set-up changeover time

Examples of changeovers/set-ups include:

- Switching out the mould on an injection moulding machine and running the new mould
- Cleaning down the dough mixing equipment in a bakery, before starting a new product
- Changing from the production of one product to another on a pet food production line

In the course of an OEE programme, initiatives such as SMED (Single Minute Exchange of Dies) typically will be employed to reduce the time lost due to changeovers, set-ups and adjustments.

SMED is a tool which is used to reduce the amount of time spent getting ready to perform a new job, or changeover time.

As with downtime, data on set-ups must be collected and analysed to standardise the changeover, and make the operation as efficient as possible.

Ways of approaching the reduction of set-up time include ensuring that all tools or equipment required to complete the changeover are close to hand.

This can be achieved by the implementation of 6S in the area. An example of how this can be achieved is to install a mobile cart/trolley which holds all tools & supplies needed and can be easily moved to where it is required.

Figure 14 Sample Changeover Trolley

Similarly, a shadow board mounted on the machine itself which holds all the tools required for the changeover for that machine will reduce the time spent searching for tools and equipment.

A considerable amount of time expended in the changeover can be down to making small adjustments. Using set-up gauges, set stops or marked settings can reduce the amount of adjustment required.

Another way of reducing the set-up time may be to arrange with an operator to come in a half hour early in the morning to switch on the machine so that the rest of the production staff don't have to wait for it to warm up.

One of the most important considerations in managing and improving changeovers is simply better planning of the changeover.

For example, ensure all relevant personnel are aware that a changeover is planned. Make sure that if approval by quality inspectors is required to proceed with production, they're available when they're needed to eliminate waiting.

A simple white board giving the detail of when the change is due and what it is planned to change to can be a useful aid. The example below shows mould changes but this could equally refer to any product change.

PLANNED CHANGEOVERS

Line No. ______ Week no. ______ M/C No. ______

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Date							
MOULD CHANGE 1							
From							
To							
MOULD CHANGE 2							
From							
To							
MOULD CHANGE 3							
From							
To							
MOULD CHANGE 4							
From							
To							
MOULD CHANGE 5							
From							
To							

Figure 15 Sample Changeover White Board

So far, the first two of the Six Big Losses have been discussed:

- Breakdowns/Downtime
- Set-up/Adjustments

These are the losses related to the ***AVAILABILITY*** OEE factor and are summarised below with some suggested approaches to resolving them.

OEE Factor	OEE Loss	Description	Potential Approach
AVAILABILITY (Downtime Losses)	Breakdowns	Random machine failures causing stoppages of more than 10 minutes	• Autonomous Maintenance • Planned Maintenance (asset care) • Kaizen Blitz
	Set-ups/ Adjustments	Time lost when changing from one product to another	• Set-up reduction (SMED) programmes

Table 14 Availability Losses

PERFORMANCE LOSSES

Performance related stops are defined as "r**educed speed**" and "**minor stops**".

OEE Factor	OEE Loss	Description
PERFORMANCE (Speed Losses)	Reduced Speed	Not running at ideal cycle time caused by wear or poor maintenance
	Minor stops/Idling	Stoppages of less than 10 minutes caused by jams/misfeeds/blocked or dirty sensors

Table 15 Performance Losses

Typical factors which influence the speed at which the machine runs include wear, machine age, lack of maintenance and poor operator training, basically anything which prevents the machine running at its theoretical maximum (designed) speed.

OEE Loss	Potential Causes
Reduced Speed	• Incorrect settings • Equipment wear • Timing problems • Operator inefficiency • Variation in process parameters

Table 16 Some Causes for Reduced Speed Losses

If the theoretical running speed is not available from the manufacturer then a standard will need to be established, i.e. the maximum speed at which the machine can be run safely.

A dividing line needs to be set between a standard cycle and one which is considered to be running slow. This is different from a minor stop.

A minor stop is an interruption to production which is too short to be considered downtime.

Typically a minor stop is less than five minutes and results from parts jamming or misfeeding, cleaning or checking sensors, generally anything which obstructs product flow.

OEE Loss	Potential causes
Minor stops/idling	• Obstructed flow • Jams • Misfeeds • Blocked sensors • Cleaning • Checking • Quality problems • Technical failures

Table 17 Some Causes for Minor Stops

The ***PERFORMANCE*** losses are summarised below with some suggested approaches to resolving them.

OEE Factor	OEE Loss	Description	Potential approach
PERFORMANCE (Speed Losses)	Reduced speed	Not running at ideal cycle time caused by wear or poor maintenance	• Standard machine set-up • Standard process parameter set-up • Operator training • Planned maintenance
	Minor stops/ idling	Stoppages of less than 10 minutes caused by jams/misfeeds/ blocked or dirty sensors	• Autonomous maintenance • Process (continuous) improvement

Table 18 Performance/Speed Losses and how they may be Addressed

QUALITY LOSSES

Quality losses are categorised as “**Start-up losses**” and “**Defects**”.

OEE Factor	OEE Loss	Description
QUALITY (Defect Losses)	Start-up loss	Rejects during “early” production i.e. warm-up, start-up
	Defects	Process rejects requiring rework or scrap

Table 19 Quality Losses

Start-up losses occur when a new production run is started, for example waiting for a machine to warm-up, or making minor adjustments to get the machine running to specification.

OEE Loss	Potential causes
Start-up loss	• Waiting for machine to warm-up • Incorrect settings • Minor adjustments

Table 20 Some Causes for Start-up Losses

Defects are the poor quality products generated during steady-state production which must be reworked or scrapped.

OEE Loss	Potential causes
Defects	• Incorrect settings • Poor training • Damaged product • Process variation

Table 21 Some Causes for Losses due to Defects

The losses related to the ***QUALITY*** OEE factor are summarised below with some suggested approaches to resolving them.

OEE Factor	OEE Loss	Description	Potential approach
QUALITY (Defect Losses)	Start-up loss	Rejects during "early" production i.e. warm-up, start-up	• Planned maintenance • Standard operating procedures/ checksheets • Optimised processes
	Defects	Process rejects requiring rework or scrap	• Continuous improvement • Six Sigma • Error-proofing

Table 22 Some Causes for Losses due to Quality

Implementing TPM

There are four basic phases in the implementation of a TPM/OEE programme:

- Preparation
- Pilot programme
- Plant-wide programme
- Stabilisation

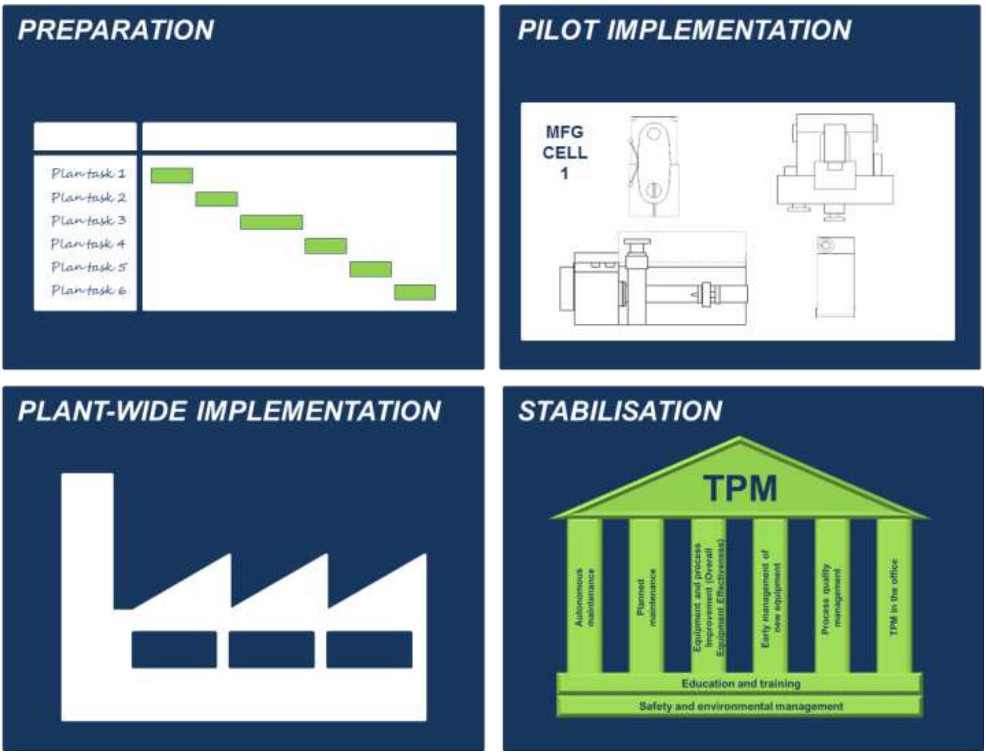


Figure 16 Phases in the Implementation of a TPM/OEE Programme

1. Preparation

The goal of the Preparation phase is to establish a plan to achieve sustainable improvement from the implementation of TPM and OEE.

Firstly, the rationale for the introduction of TPM should be communicated to all employees whether they will be directly involved in TPM or not e.g. office staff.

At this stage it's important that all employees understand the importance of TPM and how its introduction will benefit them.

Figure 17 Phases in the Preparation Phase

The chance of success for the overall implementation will be greatly increased by adopting an inclusive approach, engaging employees from the start.

Tell everyone what is happening, demonstrate why it important that it is done and provide basic training for everyone.

In areas where TPM and OEE are to be deployed directly, there will be a requirement for more in-depth training, but everyone should have at least a basic understanding of what the organisation is trying to achieve.

It will fall to Senior Management to provide active leadership during the implementation of the TPM/OEE programme.

Figure 18 Roles of Senior Management

They will have responsibility for:

- Setting the goals for the TPM programme, setting out what the expectations will be
- The formulation of the overall implementation plan
- Establishment of teams
- Acting as the steering committee for the programme, driving achievement of the programme goals - programme governance
- On an ongoing basis, displaying an interest in making it happen
- Monitoring the OEE Key Performance Indicator (KPI)
- Approving the choice for the pilot area

Typical outcomes from the Preparation Phase are:

- A plan for the implementation of the TPM project
- Implementation team appointed
- Strategy/goals communicated to all employees
- A pilot area agreed – and training completed in this area

2. Pilot Implementation

The purpose of the pilot project is to demonstrate in practice the benefits which TPM and OEE bring to the organisation.

The choice of the area in which the pilot is to be completed is critical to the success of the overall programme.

OEE Factor	Description	Potential approach
Easy to Achieve?	Ease of completion	*Possibly low payback*
	Allows for limited experience in implementing TPM	*May not gain a full experience of TPM Process*
Bottleneck?	High, rapid payback	*Risk of downtime on critical equipment during implementation*
	Increased Productivity	
Difficult to achieve? (causes most problems)	Good example of what can be achieved through TPM	Risk of not achieving the improvement target
	Will probably be well supported by operations	

Table 23 Selection of the pilot area

It will be useful to set up a display board in the pilot area to communicate the status on the project to other employees.

This board could typically contain the following items as they become available:

- Project name
- Reason for undertaking the project
- Team names
- “Before” photos
- Graphs/charts displaying performance
- “After” photos
- 6S/Maintenance checklists

In selecting the area for the pilot implementation, it is important to bear in mind that a substantial win early in the project can significantly help in securing support for the overall project.

The pilot project should commence by restoring everything in pilot area to perfect working order. Two tools will help the team to achieve this and keep everything in working order:

A. 6S/Workplace Organisation

It was stated earlier (page 5) that typically a pre-cursor to TPM implementation is the introduction of 6S in the area.

The basic steps involved here are:

- Take “Before” photos as a reference which will be used to demonstrate progress as the project progresses
- SAFETY – Identify all potential safety risks, put in place countermeasures to eliminate these risks
- SORT – remove all clutter and un-used items
- SORT – List exactly what is needed in the area in terms of tools/equipment/furniture
- SET-IN-ORDER – Layout what was listed in the SORT step in the most efficient way
- SHINE – Clean the area thoroughly, ensure all equipment is in perfect working order, replace any broken tools and equipment.
- STANDARDISE – Set the standard, document it in a photograph which is posted in the area. Create a checklist for the area defining cleaning requirements.
- SUSTAIN – Introduce an basic audit process to ensure the 6S standard is maintained and that people don’t slip back in old habits.

The 6S project in the pilot area could involve completing mini-improvement projects concentrating on an aspect of the area, for example:

- bench layout
- area layout
- shadow boards for tools
- cleaning a machine to restore it to “as new - factory” condition

The use of “before” and “after” photos of the pilot area is a very effective method of demonstrating progress.

B. Autonomous Maintenance

Get the operator involved in basic maintenance tasks, such a simple daily cleaning and lubrication of the machine, thereby reducing the number of calls to the maintenance department, allowing them to concentrate on more serious issues.

Steps involved here include:

- Completion of a review of safety in the area – for example, ensure all required guarding is in place
- Identification of simple checks or inspections which can be carried out by the operator on a daily basis
- Completion of any basic training with the operators in machine maintenance where necessary
- Identification and marking of as many settings or adjustments as possible to simplify changeovers for the operator
- Completion of a checklist to which the operator can refer
- Establishment a schedule for the completion of basic audits of the required maintenance activities

At this point the everything in the area should be in good working order.

The next step is to start to measure OEE in the pilot area.

C. Set a Baseline for OEE

If you don't measure something, it's hard to understand it and if you don't understand it, it's hard to improve it.

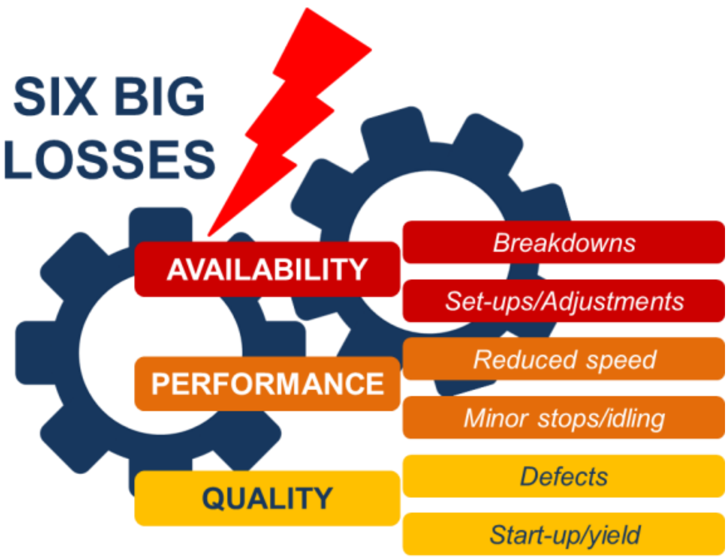
The improvement process begins by understanding the current situation. This is achieved by collecting data and measuring present performance.

Then, using a structured problem solving process and identifying the underlying issues , actions are put in place to put permanent fixes in place to ensure these issues don't recur.

In this case, the process is kicked-off by starting to record downtime in the pilot area, as this is generally the source of the most losses.

By talking to the operators and benefitting from their experience, it should be possible to establish a set of basic reason codes to which the downtime is attributed.

The reason codes should be related to the major losses.



Examples are given in the table below.

OEE Loss	Sample reason code
Breakdown	01 – Machine failure 02 – Unplanned maintenance
Set-up/Adjustments	03 - Changeover
Reduced speed	04 – Incorrect settings
Minor stops	05 – Waiting for material 06 – Waiting on quality control 07 – Meetings/breaks
Defects	08 – Quality issues
Start-up/Yield	09 – Machine warming up
Unallocated	10 – Other (include details)

Table 24 Sample Reason Codes

To facilitate a manual data collection process, a simple data collection sheet can be designed. The operator records the data under the agreed headings. There should also be an “unallocated” heading to capture downtime due to unforeseen reasons.

Date		Shift			
Product		Process		Equipment	
Downtime (minutes)	Description of Issue			Action taken	

Figure 19 Downtime Collection Sheet

Data on downtime should be collected for at least two weeks, to give a representative picture of the downtime encountered, identifying the recurring issues.

D. Tackle the Major Losses

Identify the source of the most significant losses of productive machine run time.

The use of a cross-functional team with the most relevant machine/process knowledge and experience is recommended.

Using a structured problem solving process* start to identify the likely causes of the problem.

- Identify the root cause for the issues which cause most downtime
- Identify potential actions to counteract and permanently eliminate these causes
- Plan to implement potential fixes (without adversely impacting production)
- Verify the results i.e. that the issue has been fixed and measurable improvement achieved
- Ensure the gains are maintained by regularly reviewing performance

A separate guide to structured Problem Solving is available from LBS Partners

Typical outcomes from the Pilot Phase are:

- Successful implementation of an improvement project
- Measurable, sustainable results
- Updated project summary board
- Commitment from management to proceed with plant-wide implementation of TPM/OEE

3. Plant-Wide Roll-Out

Roll-out of TPM plant-wide, involves similar steps to the pilot process, expanding the project in a controlled fashion across the remaining areas in the organisation.

Each area will have its own project board where other employees can view the progress of the implementation in that area.

In the process of this roll-out, learnings from each individual improvement project should be employed to help embed the TPM pillars in the organisation.

In particular, development in certain areas will support this embedding of the TPM pillars across the organisation.

ACTIVITY	DESCRIPTION
Safety and environmental management	Improve the working environment by identifying potential safety risks and putting measures in place to mitigate their effect
Education and training	Develop operators so that they can routinely maintain equipment – leaving the maintenance staff to work on more serious problems, not routine maintenance activities

For example, learning from the projects completed should feed in specifically to make improvements in maintenance activities. In particular:

ACTIVITY	DESCRIPTION
Planned maintenance	Improve the planning of all maintenance activities to minimise disruption to production activities
Equipment and process improvement	Identify, root cause and resolve recurring problems permanently in a proactive manner
Early management of new equipment	Implement plans so that equipment achieves desired performance levels earlier in its life cycle based on past experience of better managing equipment

As the programme progresses, the improvement effort extends outside the boundary of the production areas, spreading out to support functions.

ACTIVITY	DESCRIPTION
TPM in the office	Identify and address waste in administration/ support processes

4. Standardisation

Once a baseline level of OEE measurement has been established in the organisation, the focus should be on the continually improving the OEE measurement and further embedding TPM pillars across the organisation.

Establishing the baseline OEE measurement should allow an improvement target to be set.

Specific improvement projects are then undertaken which focus on each of the OEE components: Availability, Performance and Quality.

These projects are established to address particular issues in a time-based, goal focused manner.

Time-based – the project has a defined duration by which the outcomes must be achieved

Goal-focused – the project is formed to achieve certain pre-defined outcomes e.g. productivity improvement of X%, reduction of downtime by Y%.

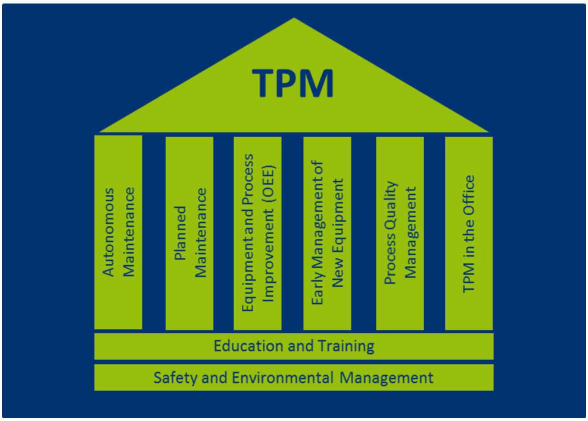
Table15 on page 40 summarises suggested approaches to improving each of the OEE components.

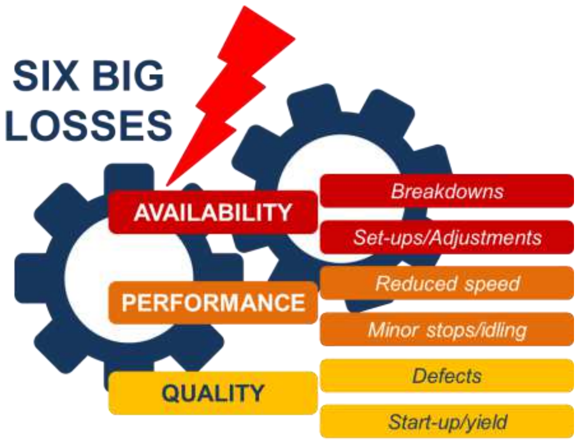
OEE Component	Improvement tools
Availability	• Analysis/reduction of downtime • 6S Workplace Organisation • Problem Solving/Root Cause Analysis • Planned maintenance • SMED – Quick Changeover • Continuous improvement projects
Performance	• Cycle time analysis/reduction • Standardised machine set-up • Problem Solving/Root Cause Analysis • Line balancing • Operator training • Continuous improvement projects
Quality	• Six Sigma • Standard Work/Standard Operating Procedures • Check sheets • Error-proofing • Continuous improvement projects

Table 25 OEE Components and Improvement Tools

SUMMARY

The key concepts associated with TPM and OEE are summarised in the following pages.





TPM & OEE

TOTAL PRODUCTIVE MAINTENANCE(TPM) is defined as a company-wide ,team-based effort to build quality into equipment and to improve productivity by reducing the time lost due to breakdowns.

Total Productive Maintenance is based on eight key strategies (also referred to as pillars).

Pillar	What it is
Autonomous maintenance	Involve the operator in daily machine maintenance
Planned maintenance	Plan maintenance activities so that production is not interrupted
Equipment and process improvement	Identification and problem solving of recurring problems
Early management of new equipment	New equipment achieves desired performance levels earlier
Quality management	Introduce improvement projects to address quality issues
TPM In the office	Address waste in administration functions
Education and training	Develop operators so that they can routinely maintain equipment
Safety and environmental management	Eliminate potential safety risks, improve the working environment

OVERALL EQUIPMENT EFFECTIVENESS (OEE) is a one of the key measures of TPM which indicates how effectively the machinery and equipment is being run.

It combines measures of machine Availability, Performance and Quality and is calculated using this formula:

OEE = AVAILABILITY x PERFORMANCE x QUALITY

AVAILABILITY is the time the machine is actually running, obtained by subtracting machine downtime from the planned operating time.

PERFORMANCE compares the speed at which the machine actually runs to the manufacturer's rating under ideal conditions i.e. the actual cycle time vs. the ideal cycle time.

QUALITY is defined as the quantity of good parts produced i.e. total output – defects. This includes the defects produced on start-up and those produced when the machine is in stable production.

World class figure for ***Overall Equipment Effectiveness (OEE)*** is typically stated as:

OEE Factor	World Class Figure
Availability	90% = 0.9
Performance	95% = 0.95
Quality	99.9% = 0.99
OEE	85% = 0.85

The SIX BIG LOSSES defined in OEE are listed as:

OEE Factor	OEE Loss	Description
AVAILABILITY (Downtime Losses)	Breakdowns	Random machine failures causing stoppages of more than 10 minutes
	Set-ups/ adjustments	Time lost when changing from one product to another
PERFORMANCE (Speed Losses)	Reduced speed	Not running at ideal cycle time caused by wear or poor maintenance
	Minor stops/idling	Stoppages of less than 10 minutes caused by jams/misfeeds/blocked or dirty sensors
QUALITY (Defect Losses)	Defects	Process rejects requiring rework or scrap
	Start-ups/ yield	Time taken for a machine to reach stable process after a changeover or on starting the machine i.e. warm-up time

Resources

Sample standard forms are presented on the succeeding pages, to assist in any OEE implementation.

These are listed as follows:

1. **OEE Downtime sheet**– to facilitate in collecting data on the extent of downtime in the area
2. **Planned changeover list** – to help in communicating the plan for changeovers

*Original templates are available from **www.lbspartners.ie***

1. OEE Downtime Sheet

Date ________ Shift ________

Product ________ Process ________ Equipment ________

Downtime (minutes)	Description of Issue	Action taken

2. Planned Changeover List

PLANNED CHANGEOVERS

Line No. ____ Week no. ____ M/C No. ____

Day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Date							
CHANGE 1							
From							
To							
CHANGE 2							
From							
To							
CHANGE 3							
From							
To							
CHANGE 4							
From							
To							
CHANGE 5							
From							
To							

LBS Partners
Nexus Innovation Centre
Tierney Building
University of Limerick
Limerick, Ireland

Tel: 061-518408
e-mail: info@lbspartners.ie
Website: www.lbspartners.ie