Module: TPM

Element: Effective Maintenance
Training pack
Aims and Objectives

Target Audience:

Engineering, Maintenance, Facilities, Procurement, Operations.

Purpose of Module:

To understand & implement the techniques of effective maintenance to minimise Life Cycle Cost.

Aims & Objectives:

• Relate to TPM/OEE/Autonomous Maintenance
• Planned Maintenance
• Preventative Maintenance
• Predictive Maintenance
• Design of effective maintenance strategy
• Understand how to work with historical analysis
Contents

• Introduction

• Effective Maintenance Overview

• Planned Maintenance

• Preventative Maintenance

• Predictive Maintenance

• Breakdown Maintenance

• Effective Equipment Design
Effective Maintenance

- Planned Maintenance
- Preventative Maintenance
- Predictive Maintenance
- Effective Equipment Design
- Breakdown Maintenance

INFORMATION

TRAINING

AUTONOMOUS MAINTENANCE
Effective Maintenance

Is not :-

“ Repairing equipment as quickly and efficiently as possible when it breakdowns“

Is :-

“ Zero Breakdowns”
Effective Maintenance

- Introducing an Effective Maintenance system is not a “quick fix”.
- Effective Maintenance should involve all areas of the organisation.
- Information is key.

- **Operator and Maintainer training**
  - Up-skill Maintenance to be trainers and equipment improvers
  - Up-skill Operators to be equipment maintainers
Autonomous Maintenance

- Definition:

“The partnership of Production and Maintenance departments to accomplish a common goal, stabilising equipment conditions and halting further deterioration”
Autonomous Maintenance

• Operator skills development programme.
• Allow problems to be identified and solved quickly.
• Stop accelerated deterioration of plant and equipment.
• An approach to stop deterioration related failures.
• Stabilise equipment conditions (standards).
• Develop training materials on how to run, operate & maintain equipment.
Planned Maintenance

• Definition:-

“The scheduling of maintenance activities on a time based or usage basis regardless of the current performance levels of the equipment”
Planned Maintenance

- Planned Maintenance as part of an Effective Maintenance system takes time and to be effective has to be “a way of life”.

- Planned Maintenance can make or break the relationship between production and maintenance functions.

- Partnership is the key.

- The schedule and time required should be both sympathetic to production needs and be effective.

- Key elements should be Lubrication Control and Spare Parts Management.
Planned Maintenance

- Autonomous Maintenance
- Planned Checking & Replacement
- Factory Wide PM System
- Predictive Maintenance
- Zero Breakdown
Planned Maintenance

STEPS TO INTRODUCTION

• Evaluation of equipment and knowledge of existing conditions.

• Restore equipment condition and improve weaknesses.

• Creating an information management system.

• Creating and maintaining a Planned Maintenance system.
Planned Maintenance

EVALUATION OF EQUIPMENT & KNOWLEDGE OF EXISTING CONDITIONS

- Identify critical machines - Bottlenecks.
- Existing machine maintenance records?
- Combine with Autonomous Maintenance activities.

- Criticality Assessment.
- Initial equipment survey.
- Existing Overall Equipment Effectiveness (OEE) data.
# Planned Maintenance

## CRITICALITY ASSESSMENT

<table>
<thead>
<tr>
<th>No</th>
<th>Type: Machine: Date:</th>
<th>Equipment Description</th>
<th>Availability</th>
<th>Performance</th>
<th>Quality</th>
<th>Reliability</th>
<th>Maintainability</th>
<th>Safety</th>
<th>Environment</th>
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Planned Maintenance

CRITICALITY ASSESSMENT

• AVAILABILITY
  – If this failed what would be the impact on running, set-up or adjustment.

• PERFORMANCE
  – Impact on the cycle time or processing capacity.

• QUALITY
  – Impact on start up or process.

• RELIABILITY
  – Impact of this components failure rate.

• MAINTAINABILITY
  – Ease of maintenance.

• SAFETY
  – Impact if this failed or was in poor condition.

• ENVIRONMENT
  – Impact on the environment.

• COST
  – Impact if failed / cost to the business.
## Planned Maintenance

### INITIAL EQUIPMENT SURVEY

<table>
<thead>
<tr>
<th>AREA</th>
<th>CHECK FOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Main body of equipment</td>
<td>Damage, dirt, dust, excess oil, splatter and foreign matter.</td>
</tr>
<tr>
<td></td>
<td>Unnecessary objects on machine.</td>
</tr>
<tr>
<td></td>
<td>Broken parts, loose or missing nuts, bolts etc.</td>
</tr>
<tr>
<td></td>
<td>Wear and play of machine.</td>
</tr>
<tr>
<td>2. Ancillary Equipment</td>
<td>Damage, dirt, dust, excess oil, splatter and foreign matter.</td>
</tr>
<tr>
<td></td>
<td>Broken parts, loose or missing nuts, bolts etc.</td>
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<td>Leaks of oil, air, gas, steam.</td>
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<td></td>
<td>Indicator lamps not working.</td>
</tr>
<tr>
<td>3. Lubrication</td>
<td>Dirt, dust, sludge.</td>
</tr>
<tr>
<td></td>
<td>Proper lubrication levels.</td>
</tr>
<tr>
<td></td>
<td>Lubricating devices capped?</td>
</tr>
<tr>
<td></td>
<td>All lubrication pipes clean with no leaks.</td>
</tr>
<tr>
<td></td>
<td>Are lubrication levels clearly visible?</td>
</tr>
<tr>
<td>4. Housekeeping around machine</td>
<td>Name plates and labels are clean and visible.</td>
</tr>
<tr>
<td></td>
<td>Safety shields are free from dirt, dust &amp; fog.</td>
</tr>
<tr>
<td></td>
<td>Are pipe routings organised around machine?</td>
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<td>Check floor condition for rubbish &amp; parts.</td>
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<tr>
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<td>Are good parts, rejects, scrap material clearly segregated.</td>
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<td>5. Safety</td>
<td>Check safety devices for damage, malfunctioning or missing parts.</td>
</tr>
<tr>
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<td>Are there any obvious safety hazards or violations.</td>
</tr>
</tbody>
</table>
Planned Maintenance

INITIAL EQUIPMENT SURVEY

CLEAN, CHECK & TAG

- Operator involvement with maintenance.
- Operators to “Tag” all elements of the equipment that they believe require improvement.
- Description of fault and effect on each tag (can be used in conjunction with a machine map).
- Maintenance to list and answer all tags, i.e. counter-measure and time-scales or reasons for not undertaking.
Planned Maintenance

INITIAL EQUIPMENT SURVEY

MACHINE MAPPING

• Group exercise.

• Lead by an experienced engineer/maintainer.

• Use in conjunction with
# Planned Maintenance

## INITIAL EQUIPMENT SURVEY

### Clean, Check & Tag Issues Register

<table>
<thead>
<tr>
<th>Check / Tag No.</th>
<th>Location</th>
<th>Code Class</th>
<th>Cause</th>
<th>Customer Protection</th>
<th>Countermeasure</th>
<th>Owner</th>
<th>Status</th>
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**Code**
- **W** WATER
- **P** PNEUMATIC
- **M** MECHANICAL
- **L** LUBRICATION
- **H** HYDRAULIC
- **E** ELECTRICAL

**Class**
- **1** BROKEN
- **2** MISSING
- **3** DIRTY
- **4** WORN
- **5** LEAKING
- **6** POOR DESIGN
- **7** DIFFICULT TO CLEAN

**Last Updated:**

- ![Countermeasure Proposed](Image)
- ![Countermeasure Agreed](Image)
- ![Problem Solved](Image)
- ![Reoccurrence Prevented](Image)
Planned Maintenance

INITIAL EQUIPMENT SURVEY

**CONCERN / FAULT ANALYSIS**

<table>
<thead>
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<th>H</th>
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<th>P</th>
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**CODE CLASS**

- **E** = ELECTRICAL
- **M** = MECHANICAL
- **L** = LUBRICATION
- **H** = HYDRAULIC
- **W** = WATER
- **P** = PNEUMATIC

- **1** = BROKEN
- **2** = MISSING
- **3** = DIRTY
- **4** = WORN
- **5** = LEAKING
- **6** = POOR DESIGN
- **7** = DIFFICULT TO CLEAN
Planned Maintenance

OEE AND THE 6 BIG LOSSES

Equipment

- Available time
- Available operating time
- Actual operating time
- Effective operating time

Six Big Losses

1. Breakdowns
2. Setup / adjustment
3. Idling / minor stoppages
4. Speed
5. Defects in process and rework
6. Start up losses
Planned Maintenance

RESTORE EQUIPMENT CONDITION AND IMPROVE WEAKNESSES

• Through the evaluation of the equipment, initial survey and tagging exercise, return equipment to an improved standard.

• Define the standard and maintain it.

• Without undertaking initial improvement planned, preventative and autonomous maintenance activities will be less effective.
  – Changes to machine conditions will not be clear
  – Operators time will be wasted
  – Planned Maintenance will take longer
Planned Maintenance

RESTORE EQUIPMENT CONDITION AND IMPROVE WEAKNESSES

- Set and maintain standards

Now you can see any problems easily!
Look at my shiny machine
Planned Maintenance

CREATING AN INFORMATION MANAGEMENT SYSTEM

• Without information an effective maintenance system cannot function.

• Data is gathered to measure and improve performance.

• OEE is the key performance indicator for Effective Maintenance.

• Information should be gathered from :-
  – OEE data collection (Operators)
  – Autonomous Maintenance activities (Operators)
  – Planned Maintenance Activities (Maintenance)
  – Predictive Maintenance (Maintenance)
  – Preventative Maintenance (Maintenance)
  – Breakdowns (Maintenance)
Planned Maintenance

CREATING AND MAINTAINING A PERIODIC MAINTENANCE SYSTEM

CREATING (Plan/Do)

• Planned Maintenance should be mostly inspection - identify parts for immediate or future replacement, etc.

• Ensure timings for tasks to the schedule are realistic (buying off with production).

• Single Point Lessons (SPL) and training to support them.

• Ensure the schedule is visible to both Production and Maintenance.
# Planned Maintenance Activities

<table>
<thead>
<tr>
<th>No.</th>
<th>Period</th>
<th>Activity</th>
<th>Setting</th>
<th>SPL</th>
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<tbody>
<tr>
<td>1</td>
<td>3 mth</td>
<td>Hydraulic Pressure</td>
<td>8-10 PSI</td>
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<td>2</td>
<td>6 mth</td>
<td>Replace - Work head Drive Belt</td>
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Planned Maintenance

CREATING AND MAINTAINING A PERIODIC MAINTENANCE SYSTEM

MAINTAINING (Check/Act)

- Check breakdown frequency between Planned Maintenance and adjust schedule and/or content accordingly.

- Check the results of Planned Maintenance and if items are continuously OK or always need replacing, adjust frequency.

- Always look to reduce time for a Planned Maintenance activity, identify items that can be checked in-process.

- Check information gained from OEE data collection.
Planned Maintenance

INTRODUCING

Choose Model M/C in each Area

- Time Between Failures
- Breakdowns
- Process Capability
- Restore / Improve Weaknesses
- Frequency
- Data Collection
- Predictive
- Assign Duties
- Yield
- Capacities
- Downtime
- Data Collection
- Lubrication Schedule
- Corrective

Gather Accurate Data

Develop Full PM

Spare Parts

Monitor & Display Results

Continue To Check and Act

Implement on Model M/c

Horizontal Development
Planned Maintenance

LUBRICATION CONTROL

• A frequently overlooked element which is a contributing factor in 70% of all hydraulic system failures.

• Should include activities across all disciplines.

• Minimising cost through rationalisation.

• Lubrication beyond scope of operators (as part of Autonomous Maintenance), i.e. expensive hydraulic oil.

• Does it need replacing? Analyse the condition, what does it tell you about the m/c? What is in it?

• Consider filters. Frequency of change? Level of filtration?
Planned Maintenance

LUBRICATION CONTROL - Example

4 POINTS FOR LUBRICATION CHECKS

Change Oil after 2.0 point degradation......

Check quantity of Oil
Do not mix oils

Check quality of Oil
Avoid contamination
Planned Maintenance

LUBRICATION CONTROL

BENEFITS

• Reduced friction > reduced wear > extends equipment life.

• Reduces accidents.

• Maintains accuracy.

• Maintains optimum process conditions.

• Reduces waste.
Planned Maintenance

SPARE PARTS MANAGEMENT

• Balance stock costs v disruption v achievable delivery.

• Consumable (wear parts) and Non-consumable.

• Modular Parts - easy to replace elements.

• Clearly identified condition of spares, i.e. anything taken off machines should be tagged (visual - red / amber / green)

Scrap - Strip for spares, etc.  Repair Required  Ready to fit
Preventative Maintenance

- Planned Maintenance
- Effective Equipment Design
- Breakdown Maintenance
- Predictive Maintenance

INFORMATION

TRAINING

AUTONOMOUS MAINTENANCE
Preventative Maintenance

• Definition:-

“A systematic approach to eliminate catastrophic failure/breakdowns through regular care and attention, early diagnosis and rectification”
Preventative Maintenance

ANALOGY

Preventative Medicine

Daily Health Care  Regular Check Ups  Early Treatment

Daily Maintenance (Clean/Lubricate)  Inspection Diagnosis  Preventive Repairs

Preventative Maintenance
Preventative Maintenance

- Establish where abnormalities will occur without disassembling the equipment.

- Permits quality checks of repairs already made to overhauled equipment.

- Permit estimation of repair periods.

- Reduce maintenance costs by eliminating periodic overhauls.

- Prevent Accelerated Deterioration.

- Maintain Operating Conditions.
Preventative Maintenance

PREVENT ACCELERATED DETERIORATION

- Deterioration accelerated by neglect.
- Interface with Autonomous Maintenance.
- Daily / weekly check lists.
- Single Point Lessons (SPL).
# Preventative Maintenance

**Preventative Maintenance Check Sheet.**

<table>
<thead>
<tr>
<th>Date:</th>
<th>Machine:</th>
<th>Activity:</th>
<th>Freq.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process:</td>
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</tbody>
</table>

Check no. 1
Preventative Maintenance

MAINTAIN OPERATING CONDITIONS

• Equipment “straining” to operate beyond its normal range because correct conditions not maintained.

• Ensure out of specification conditions are clearly visual or audible, i.e. red zones, level markers, buzzers, etc.
Predictive Maintenance

Information

- Planned Maintenance
- Preventative Maintenance
- Predictive Maintenance
- Effective Equipment Design
- Breakdown Maintenance

Training

Autonomous Maintenance
Predictive Maintenance

• Definition:-

“A systematic approach utilising history and equipment condition monitoring to predict and prevent catastrophic failure/breakdowns”
Predictive Maintenance

- Sophisticated.
- Requires Planned and Preventative Maintenance systems in place.
- Identify point at which critical part fails.
- Common method is simply time or frequency based, i.e. no. of rev’s, no. of hours in service, etc.
- More sophisticated methods are condition based, i.e. temp. of oil, condition of oil, speed of operation.
- Links with Autonomous Maintenance, i.e. basic predictions based on visual and audible indications.
Predictive Maintenance

WHY?

• Predictive Maintenance should not be just a passive activity.
• Root cause problem solving - reduction or elimination.
Breakdown Maintenance

- Planned Maintenance
- Preventative Maintenance
- Predictive Maintenance
- Effective Equipment Design
- Breakdown Maintenance

INFORMATION

TRAINING

AUTONOMOUS MAINTENANCE
Breakdown Maintenance

- Definition:-

“When all else fails ensuring that equipment availability is achieved in the shortest possible time whilst eliminating root cause faults with sustainable repairs”
Breakdown Maintenance

- Take repair work beyond quick-fix measures.
- Always seek the root cause.
- Historical data.
- Single Point Lessons (SPL).
- Record repair work in sufficient detail.
- Problem solving techniques.
**Breakdown Maintenance**

**SINGLE POINT LESSON (SPL) - Example**

<table>
<thead>
<tr>
<th>LINE</th>
<th>AREA/MACHINE</th>
</tr>
</thead>
</table>

**THEME**

<table>
<thead>
<tr>
<th>PREPARED BY</th>
<th>DATE</th>
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**BASIC KNOWLEDGE** | **IMPROVEMENT CASES** | **TROUBLE CASES**

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**ONE POINT LESSON**

Gauge needs to read between red markers within green zone.

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Breakdown Maintenance

RECORD REPAIR WORK IN SUFFICIENT DETAIL

• **Lost Time (pareto, OEE)**
  – Response time, On/Off
  – Type of repair (mechanical / electrical)

• **Spares Used (spare management)**
  – Description, part numbers, reason for failure

• **Cause/Effect**
  – What the maintainer believes

• **Conditions**
  – Conditions on equipment when it failed
Breakdown Maintenance

Big problems deserve attention
Breakdown Maintenance

PROBLEM SOLVING TECHNIQUES

- 5 Why’s.
- Pareto.
- Cause & Effect.
- Brainstorming - at the machine.
- Include operators - man/machine interface is critical.
Effective Equipment Design

- Planned Maintenance
- Preventative Maintenance
- Predictive Maintenance
- Breakdown Maintenance
- Effective Equipment Design

Information

Training

Autonomous Maintenance
Effective Equipment Design

• Definition:

“A systematic approach to equipment design which maximises equipment availability, minimises life cycle costs and eliminates waste”
Effective Equipment Design

• Establish design goals for new equipment.

• Incorporate TPM improvement activities.

• Involve the customer and suppliers.

• Use information derived from OEE data collection and maintenance activities.

• Understand waste.
  – Life cycle costs
  – Concept
  – Design and development

• Focus on reliability and maintainability.
Effective Equipment Design

LIFE CYCLE COSTS

- Operational & Support - 50%
- Equipment Build - 35%
- Design & Develop - 12%
- Concept - 3%
Effective Equipment Design

CONCEPT

• Product.

• Customers and Suppliers.

• Define reliability and maintainability expectations.

• Production goals -
  – Hours of work & demand (TAKT)
  – Performance - Output - Life

• Waste elimination.

• Flexibility.

• Implementation plan.
Effective Equipment Design

DESIGN & DEVELOPMENT

• Man and machine - ergonomics, ease of access, health & safety.

• Formalise concepts.

• Incorporate standards
  – Components
  – User interfaces
  – Standard maintenance equipment
  – User/maintainer manuals

• Spares
  – Component reliability/predictability (supplier data)
  – Spares lists / stocking requirements
Effective Equipment Design

DESIGN & DEVELOPMENT

• Audit against reliability and maintainability.
  – Autonomous Maintenance.
  – Effective Maintenance.

• Failure Mode and Effects Analysis (FMEA).
Effective Maintenance

- Planned Maintenance
- Preventative Maintenance
- Predictive Maintenance
- Effective Equipment Design
- Breakdown Maintenance

INFORMATION

TRAINING

AUTONOMOUS MAINTENANCE