Total Productive Maintenance

Breakaway Lean™ Training

Breakaway LEAN™

OMNEX

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Omnex provides training, consulting and software solutions to the international market with offices in the USA, Canada, Mexico, China (PRC), Germany, India, the Middle East, and SE Asia. Omnex offers over 400 standard and customized training courses in business, quality, environmental, food safety, laboratory and health & safety management systems worldwide.

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Web: www.omnex.com

Course Objectives

- Understand Total Productive Maintenance and its importance to your company

- Give you tools, a guideline and method of implementing this practice in your company

Agenda

Day 1

- Chapter 1: A Look at History
- Chapter 2: TPM Philosophy
- Chapter 3: TPM Phases

Day 2

- Chapter 4: TPM and ISO/TS 16949 Integration
- Chapter 5: TPM Implementation – Moving Forward
- Chapter 6: TPM Case Studies

A BRIEF INTRODUCTION TO OMNEX

Omnex Introduction

- International consulting, training and software development organization founded in 1985.
- Specialties:
  - Integrated management system solutions.
  - Elevating the performance of client organizations.
  - Consulting and training services in:
    - Quality Management Systems, e.g., ISO 9001, ISO/TS 16949, AS9100, QOS
    - Environmental Management Systems, e.g., ISO 14001
    - Health and Safety Management Systems, e.g., OHSAS 18001
- Leader in Lean, Six Sigma and other breakthrough systems and performance enhancement.
  - Provider of Lean Six Sigma services to Automotive Industry via AIAG alliance.

About Omnex

- Headquartered in Ann Arbor, Michigan with offices in major global markets.
- In 1995-97 provided global roll out supplier training and development for Ford Motor Company.
- Trained more than 100,000 individuals in over 30 countries.
- Workforce of over 400 professionals, speaking over a dozen languages.
- Former Delegation Leader of the International Automotive Task Force (IATF) responsible for ISO/TS16949.
- Served on committees that wrote QOS, ISO 9001:2000, QS-9000 and its Semiconductor Supplement, and ISO IWA 1 (ISO 9000 for healthcare).
- Member of AIAG manual writing committees for FMEA, SPC, MSA, Sub-tier Supplier Development, Error Proofing, and Effective Problem Solving (EPS).

Omnex Worldwide Offices

Omnex is headquartered and operates from the United States through offices in Michigan.

The company maintains international operations in many countries to provide comprehensive services to clients throughout Western Europe, Latin America and the Pacific Rim.

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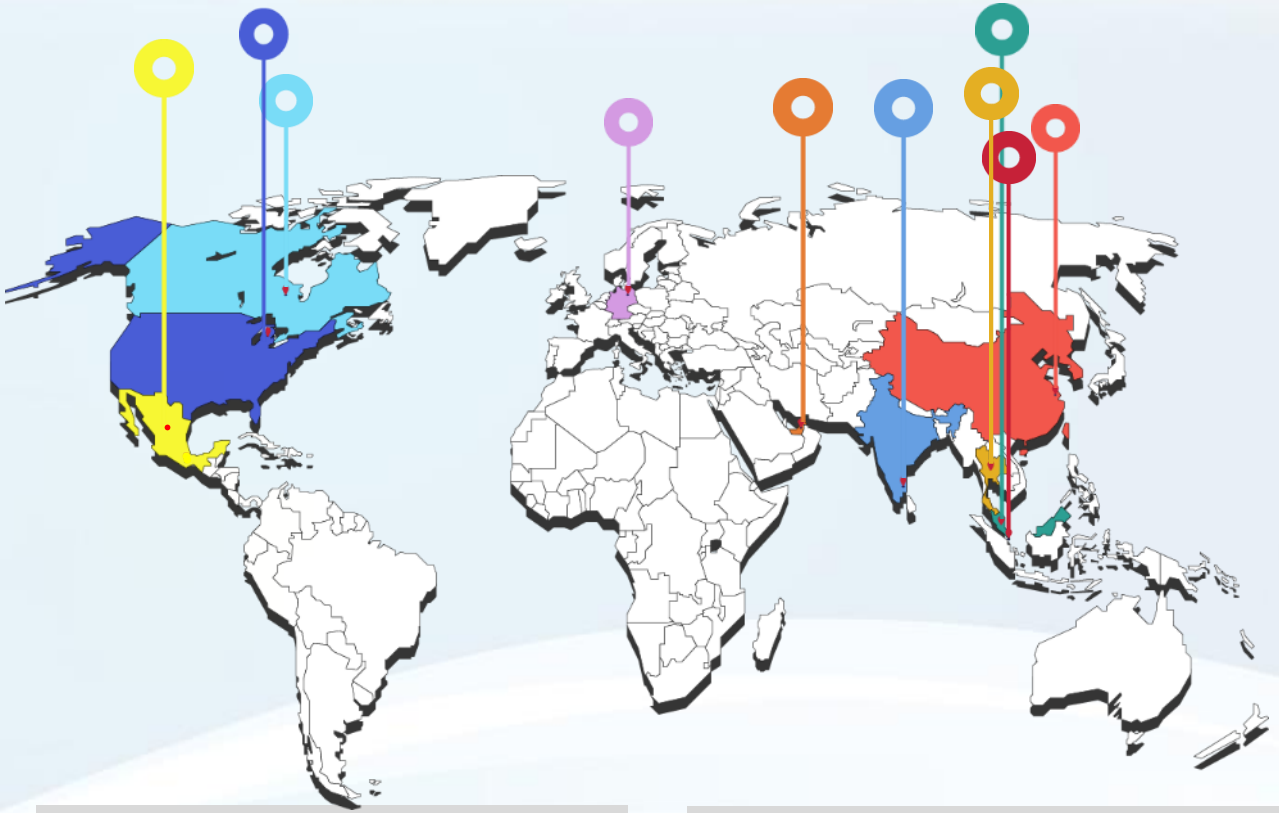

- Omnex Global Head Quarters (Michigan, USA)
  West Coast Operations (San Jose, CA)
- Asia Pacific HQ (Chennai, Pune, Delhi, Bangalore)
- China (Shanghai, Guangzhou, Wuhan, Chengdu)
- Canada (Mississauga)
- Europe (Berlin, Germany)
- Middle East (Dubai, Saudi Arabia, Bahrain)
- Thailand (Bangkok)
- Mexico (Monterrey)
- Singapore
- Malaysia (Kuala Lumpur)

Rules of the Classroom

- ✓ Start and end on time
- ✓ Return from breaks and lunch on time
- ✓ All questions welcome
- ✓ Your input is valuable and is encouraged
- ✓ Don’t interrupt others
- ✓ One meeting at a time
- ✓ Listen – and respect others’ ideas
- ✓ No “buts” – keep an open mind
- ✓ Cell phones & pagers off or silent mode
- ✓ No e-mails, texting or tweeting during class
- ✓ If you must take a phone call or answer a text please leave the room for as short a period as possible

Icebreaker

- Instructor Information:
  - Name
  - Background
- Student Introductions:
  - Name
  - Position / Responsibilities
  - What is your involvement in the Total Productive Maintenance?
  - Please share something unique and/or interesting about yourself.

Chapter 1

A Look at History

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Seiichi Nakajima

- **1950:** Began studying American preventive maintenance
- **'60s:** Visited American and European manufacturers to learn more about PM
- **'70s:** Disclosed concept of TPM in Japan
- **Early '80s:** Only 51 Japanese factories qualified for his PM prize
- **1987:** Nakajima and his study team presented results to International Maintenance Conference in Cincinnati

Why Companies Need TPM

- Improves efficiency of the entire organization and eliminates the seven major losses
  - Quality Defects in Process
  - Tooling Losses
  - Equipment Breakdowns
  - Set Up and Adjustments
  - Idling and Minor Stoppages
  - Reduced Speed
  - Start Up Losses

Automation's Influences

- Automation continues to grow, equipment can function with:
  - Speeds
  - Pressures
  - Temperatures
  - Precision
  - Safety

...not possible for humans

- Automated processes not only require fewer people, they are easier to control
- Automation is the basis for process control through reduction in variation

TPM is Not...

- Fire fighting
- Unnecessary overhead
- Short-term fix
- “Just maintenance”
- Quickly implemented buzz word of the month

TPM is...

- Innovative approach that:
  - Optimizes Equipment Effectiveness
  - Eliminates breakdowns
  - Promotes autonomous operator maintenance through day-to-day activities involving the entire workforce

TPM is essential for achieving Six Sigma quality and Lean efficiencies

And TPM is...

- Strategy that uses:
  - Profitable philosophy and practice
  - American Preventive Maintenance, total quality, employee involvement, cross-functional group activities and cooperation to get the job done

What TPM Can Do

- Achieve goals of:
  - Zero accidents
  - Zero quality defects
  - Zero productivity losses
  - 100% equipment up time
  - 100% on-time delivery
- Keep equipment Life Cycle Cost at a minimum and Overall Equipment Effectiveness at a maximum

TPM Can...

- Bring together people from all departments concerned about maintenance
- Requires support and cooperation of everyone from top management on down

How TPM Works

- When breakdowns and defects go down:
  - Equipment capacity and labor productivity go up
  - Inventory and quality costs go down
- Rising profits offset:
  - Initial restoration, capacities and capabilities costs
  - Workforce training costs

Essential to continuous improvement, total quality and process control

Best-in-Class Approach

- Best-in-Class companies integrate TPM into world-class operating and quality systems
- Do not isolate TPM as a separate function... core of continuous improvement, reaching company goals and customer satisfaction

Describing TPM Phases

1. Management Planning and Commitment
2. Management Plan Roll-out to Organization
3. Work Instructions Define New Roles and Standard Practices
4. Change Company Culture via Training
5. Autonomous Maintenance Program
6. Planned Preventive Maintenance System

More TPM Phases

7. Improve Overall Equipment Effectiveness (OEE) and Conduct Problem Solving

8. Collect/use Data for Predictive Maintenance System

9. Continue Training to Improve Existing Equipment and Prepare for New

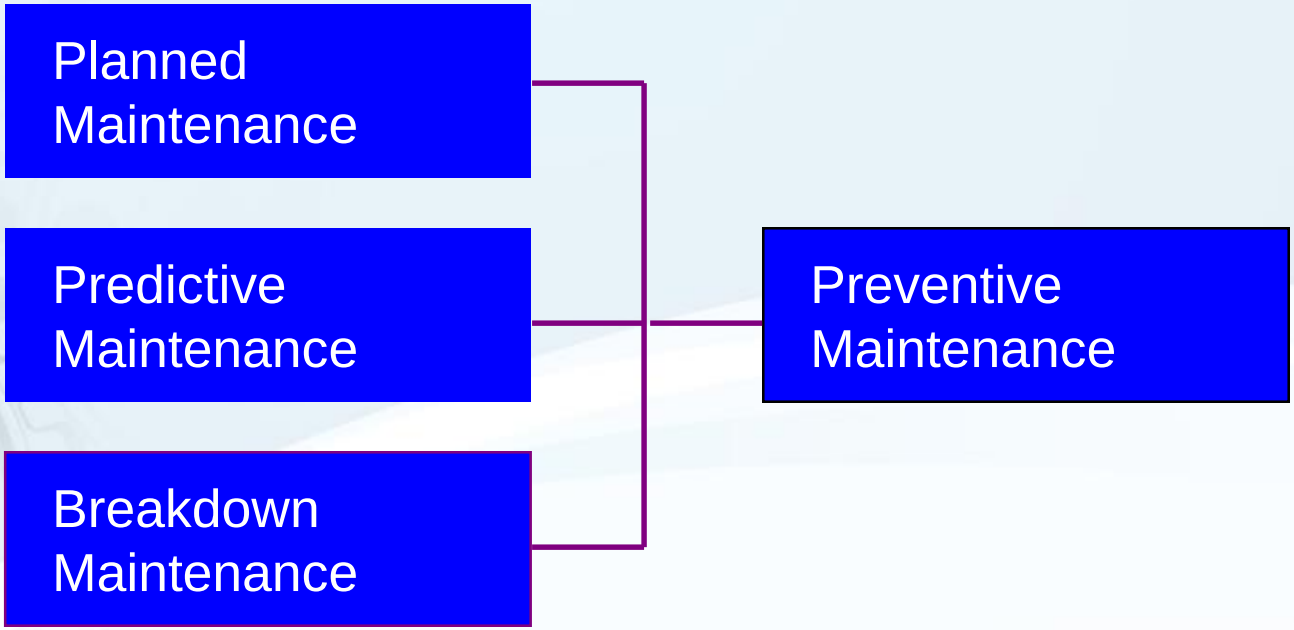
10. Include Maintenance Prevention During Equipment Design – consider: reliability, ease-of-care and user friendliness

Preventive Maintenance

Keeping equipment in good working condition; avoid failures and non conformances

1. Daily maintenance (cleaning, checking, lubricating and tightening) to prevent deterioration
2. Periodic inspections or equipment diagnosis to measure deterioration
3. Restoration to recover from deterioration

Preventive Maintenance



Planned Maintenance

- Scheduled by time elements [daily, monthly, annually]
- Most effective based on:
  - History
  - Records
  - Data
  - Trends
  - Analysis

Predictive Maintenance

- Periodic measurement and analysis, watching for potential problem conditions with the aim of forecasting potential problems using tools such as:
  - Vibration analysis
  - Thermography
  - Eddy current testing
  - Oil/fluid analysis
  - Liquid penetrant testing
  - Acoustic emission testing
  - Radiographic testing
- Analyze data over time (look for trends or unusual patterns in the data) to detect abnormal equipment conditions

Breakdown Maintenance

- On-demand, after-the-fact [broke maintenance... reactive and uncontrolled]

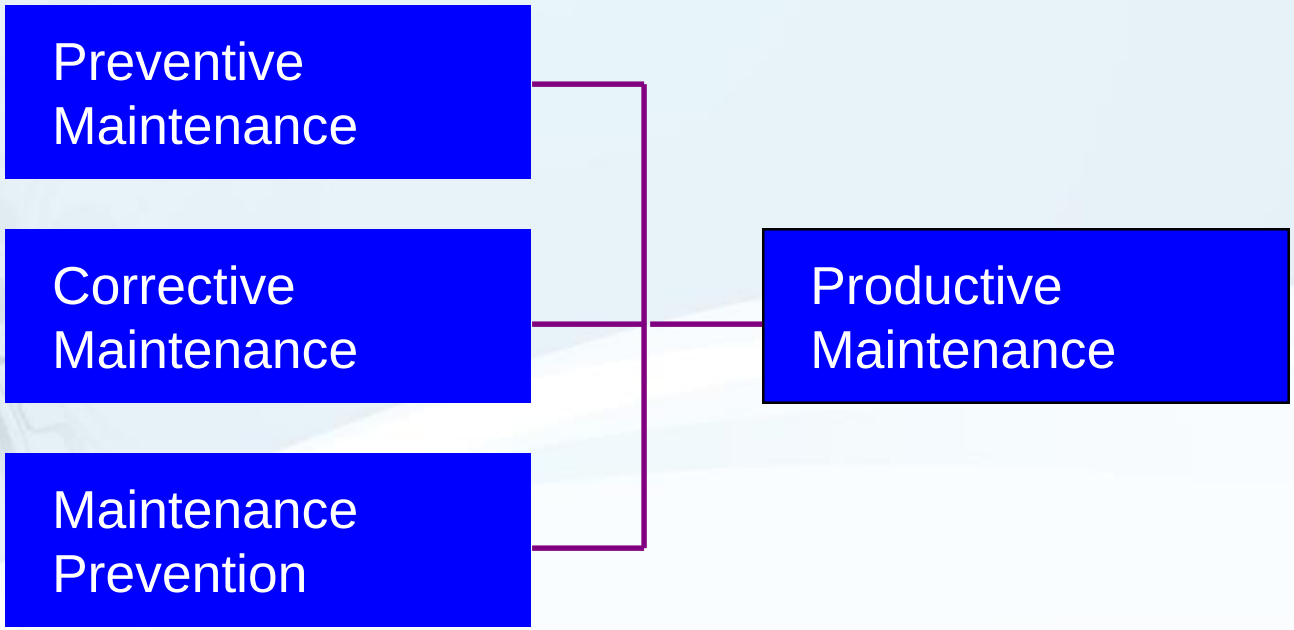
Maintenance Practice Comparison

- Any maintenance program could include any or all of these categories
- Maintenance strategy varies by industry, business culture and management philosophy

Maintenance Practice Comparison

	Reactive	Planned	Predictive
Definition	Fix it when it breaks	Check the "oil" frequently	Monitor equipment continuously
Philosophy	Always will be some unforeseen problems	Monitor equipment periodically to catch some problems before they become large ones	Preventive maintenance is good, but not thorough enough
Scheduling	Maintenance scheduled when the machine or process ceases to function properly	Maintenance personnel take vibration readings on a routine schedule, following a predefined route through a facility	Maintenance is scheduled when an alarm threshold is exceeded, but before a major breakdown occurs
Effects on Production	Disruptive – affects upstream and downstream operations	Minimal – maintenance can be scheduled for off-production times	Same as Preventive
Effective When	Opportunity costs of downtime are low	Organization has the discipline to follow preventive maintenance routine	Costs of downtime are high
Minimize Downtime By	Maintaining large crews of maintenance personnel and spare parts	"Checking the oil" frequently	Installing permanent sensors and monitoring equipment

Productive Maintenance



Corrective Maintenance

- Machine improvements by:
  - Data collection
  - Problem solving to improve or modify machines

Maintenance Prevention

- Machine improvements by:
  - Data collection
  - Develop “maintenance-free” design

Productive Maintenance

- Proactive, combines practices and lessons learned
- Small groups performing problem solving and continuous improvement activities
- Long-term commitment with structure and formality supported by documentation and data

Chapter 2

TPM Philosophy by Seiichi Nakajima

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Why You Are Here

- Your company and department needs to make changes
- Management sent you
- Need new:
  - Understanding to change to TPM system
  - Skills to effect change
- Compare your company status to TPM system

How to Make It Happen

Everyone must:

Get involved

Be trained

Participate

What Needs to Change

The organization must change its philosophy

- from: forever fighting fires
- to: planning, prioritizing, preventing and predicting
- how: by preparing, proceeding positively and pursuing persistently

That means changing

- from: if it ain't broke, don't fix it
- to: making it better than new and always ready to meet the demands of mass production and continuous service

Chapter 3

TPM Phases 1o 4

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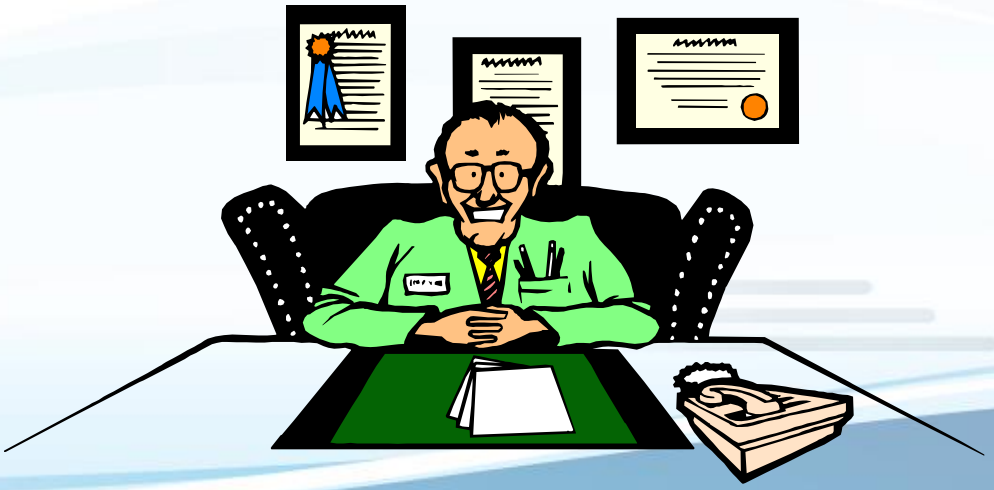
TPM Phases 1 to 4

1. Management Planning and Commitment
2. Management Plan Roll-out to Organization
3. Work Instructions Define New Roles and Standard Practices
4. Change Company Culture via Training

Management's Role and Responsibility

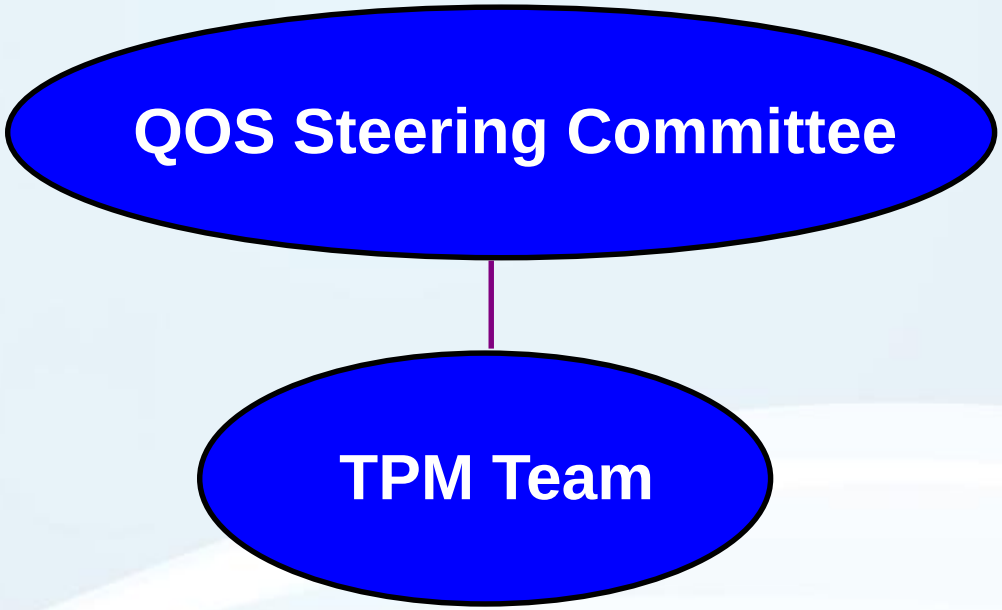
- Understanding, then commitment
- Establish goals – choose
- Appropriate resources and finances – both people and time



TPM Plan

- What they will do?
- Who will do it?
- Identify time lines

TPM Organizational Structure



Omnex View

The TPM implementation works as any new QOS improvement project

Management Action Plan

- Appoint a champion and implementation team
- Formulate a TPM plan
- Establish basic TPM policies
- Define support and reporting structure for TPM, publish organizational chart
- Identify skills, responsibilities, job duties and training needs for all who affect TPM process
- Supply hardware/software to list, track, schedule and report

More Action Plan Items

- Formalize controlled documents for the TPM process:
  - Policies, procedures and work instructions
  - Lists: approved suppliers, process and support equipment, test and measurement equipment [with calibration schedules], replacement parts and MRO inventory
- Review progress, problems and overall results...encourage positive trends while acting on negative indicators
- Provide maintenance audit system
- Develop supplier partnerships
- **Stay involved!**

Who Should be Trained?

- Senior Management
- TPM Team
- Operators
- Maintenance
- Supervisors

Training will be dictated by TPM strategy

Training – Changing Company Culture

- What is TPM?
- How it will benefit them
- New work roles and skills
- Company TPM plan/deadlines

On-Going Training

- Skill improvement
- Problem-solving
- Team work/activities
- Use of data
- Equipment design enhancement

Production's Role

Training for supervisors, group leaders and all associates about...

- Company plan for improvement
- Each associate's involvement in the big picture
- Record keeping, data collection and reporting
- Job-specific and equipment-specific topics necessary for Man-Machine partnership
- Functioning as teams for problem solving, Kaizen and continuous improvement
- Standards for compliance, ISO 9001, ISO 14001, Tooling & Equipment, Reliability & Maintainability

Example Directive

PRESIDENT
EXECUTIVE VICE PRESIDENTS
VICE PRESIDENTS
DIVISION GENERAL MANAGERS
GENERAL MANAGERS AND MANAGING DIRECTORS, OVERSEAS MANUFACTURING AND ASSEMBLY AFFILIATES
PRESONS DESIGNATED BY THE ABOVE

Directive: PHYSICAL ASSET PRESERVATION
Date: APRIL 1, 2005

The purpose of this directive is to set forth the Company's position on the preservation of physical assets.

It is a primary objective of the Company to maintain its physical assets. Deterioration in the condition of facilities and tools reduces production capability, increases operating costs, and adversely affects product quality. To insure continued preservation of the Company's physical assets, it is imperative that:

- Every operating facility develop and sustain a cost-effective preventive maintenance program.

  The program should provide for a formal plan that establishes appropriate intervals for routine maintenance and for diagnostic inspections, documents problems, initiates remedial action plans, and provides for verification of the effectiveness of the repairs. Complete maintenance documentation shall be established as the basis for analysis of equipment failure data and for determining further rehabilitation or modification actions.
- Skilled trade requirements be projected; appropriate levels of apprentice and journeyman training should be established and maintained to meet future needs.
- Financial systems control maintenance costs without inhibiting needed repair or replacements. Appropriate budgeting provisions should be made for apprenticeship training programs and for continuing training of journeymen.

Manufacturing and Finance Staffs are responsible for interpretation and administration of this Directive in their respective areas.

It is recommended that all Company subsidiaries and affiliates adopt a similar Directive.

J.M. Rusher T.P. Oberman

Example Procedure

Manufacturing Procedure	Subject:	Number: 101 Date: March 1997
	Physical Asset Preservation - Preventive Maintenance and Maintenance Training	**Applicable to:**
		[ ] Manufacturing Engineering
		[X] Plant Engineering
		[ ] Quality Control
		[X] Operating Management
[ ] New [X] Revised		Effective: **Immediately**

I. Purpose

This practice addresses the development and implementation of a comprehensive preventive maintenance program which supports the Company's philosophy of continuous improvement in quality and productivity. The concepts contained in this procedure are necessary to ensure effective maintenance of the Company's facilities as set forth in Directive D-98 entitle "Physical Asset Preservation." This procedure identifies (1) the essential elements of a preventive maintenance program and (2) training requirements for upgrading maintenance skill levels and developing new skills. The procedure also establishes the need for acquiring and retaining qualified analytical, engineering and supervisory personnel for the maintenance organization.

II. Application

This procedure is directed primarily to Company manufacturing and assembly operations. The operating principles presented here will also apply to other Company operations where appropriate. It is recommended that all Company subsidiaries and affiliates adopt controls which accomplish the intent of this procedure.

III. Definitions

Preventive Maintenance (PM) is a comprehensive management methodology by which the entire maintenance effort is organized and administered in order to maximize efficiency in the use of Company assets - human, physical and financial. Its objectives include optimizing productivity, product quality and the useful life of physical assets. Under PM, scientific and engineering techniques in training, design, planning, scheduling, inspections, corrections, and redesign are applied wherever possible to improve facility and tooling performance. The ideal is to prevent minor defects from resulting in major repairs or production interruption.

Example Procedure – pg. 2

Manufacturing Procedure	Subject: Physical Asset Preservation - Preventive Maintenance and Maintenance Training	Number: 101 Date: March 1997 Page 2 of 3

IV. Operating Principles

Preventive Maintenance

Formal preventive maintenance is the most appropriate method for accomplishing effective maintenance. For optimum preservation of physical assets, programs should be implemented which contain the following basic elements: Planning and Scheduling; Inspections; Corrective Actions; Data Collection and Analysis; Measurement of Results.

Planning and Scheduling

Of primary importance is the development of a plan for accomplishing preventive maintenance. This involves determining the equipment or process components which require inspection, monitoring or scheduled maintenance and developing a timetable for implementation. The plan should recognize the factors of equipment complexity, age, severity of environment, degree of utilization, susceptibility to failure and availability of access. Supplier recommendations for maintenance on new equipment should be carefully considered and incorporated as appropriate. Equipment surveys and analysis of historical records can reveal the needs of existing equipment.

Inspections

Inspections are conducted for the purpose of detecting unfavorable conditions, which if not corrected, could lead to breakdowns, accelerated deterioration and premature replacement. During inspections the need for adjustments, component repair or replacement can be determined and corrective actions can be taken immediately or scheduled for followup repairs.

Corrective Actions

Problems which have been identified through direct observation of equipment, or through the analysis of equipment repair or downtime records, should be pursued until they are eliminated or reduced to an acceptable level.

Data Collection and Analysis

Accurate historical records of significant maintenance actions on all critical operations should be accumulated through a data collection system with sufficient detail for analysis. Maintenance staffs should be organized and responsibilities assigned to assure that data analysis will use statistical concepts and methods to identify improvement opportunities and prevent problems.

Measurement of Results

The effectiveness of preventive maintenance programs should be monitored on a regular basis. Although PM sometimes yields short-term benefits, it is basically a long-term activity intended to provide continuous improvement of such things as machine uptime, maintenance, material usage, product quality and process yield. Evaluation should measure appropriate factors over a sufficient period of time.

Training

Training is a key element in determining the effectiveness with which preventive maintenance can be accomplished. Formal training programs should be established and administered by persons qualified in the technical aspects of Plant Engineering and in the administration of personnel training.

Key factors in a successful preventive maintenance program include the quality and level of training. Changing technology, manufacturing practices and government regulations have greatly increased manufacturing complexity. Greater technical competence as well as improved decision making skills are required. Periodic updating of knowledge is necessary to cope with these rapidly changing requirements.

Example Procedure – pg. 3

Manufacturing Procedure	Subject: Physical Asset Preservation - Preventive Maintenance and Maintenance Training	Number: 101 Date: March 1997 Page 3 of 3

V. Responsibilities

Manufacturing Staff
Manufacturing staff has the responsibility to provide technical assistance to the Division on preventive maintenance and training programs.
Operations
Operating Divisions have the responsibility to implement the Physical Asset Preservation Directive and this procedure.

VI. Reference

Corporate Directive No. D-101, Physical Asset Preservation (see attachment A)
Plant Engineering Procedure II d 8, Uniform Maintenance Operations

M.J. McElmeel

M.J. McElmeel

TPM Phase 5

Autonomous Maintenance Program

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Start Autonomous Maintenance with Cleaning

- As operators learn to clean their machine, they learn more about it
- Surrounding area always included in cleanliness and orderliness methods
- Become a "*parlor factory*"
- Environmental responsibility met by:
  - Cleanliness
  - Disposal of waste
  - Pure air and water

Management Support

- To provide for many issues, often tied to the type of processes, for:
  - Compliance to government, health, safety and environmental regulations
  - Everyone's participation in their area and at their machine
  - Housekeeping philosophy structure using a well-known program such as the 5Ss

5Ss

Seiri – sort & organize

Seiton – set in order

Seiso – shine & clean

Seiketsu – standardize

Shitsuke – sustain & support

Working Together…

6th S **Shikkari** – satisfaction & excitement

Achieving the 6th S is possible is you try hard, show initiative and make a special effort

Autonomous Maintenance

- Eliminate sources of contamination and inaccessible areas
- Check oiling and tightening [**moving toward autonomous maintenance**]
- Train operators to distinguish normal from abnormal equipment conditions
- Perform daily inspections

Operator's Role

- Expect operators to:
  - Tighten loose bolts
  - Lubricate dry parts
  - Examine friction surfaces and switches
  - Be watchful for:
    - Signs of wear
    - Non-normal sights, sounds and smells

Operators Need To…

- Use measuring instruments designed and integrated into the system for precision equipment set up
- Combine standardized cleaning procedures with inspection activities [**also documented and standardized**]
- Know when to quickly respond to minor abnormalities, notify managers, or stop a process and shut down equipment, if necessary
- Share the observations and record-keeping duties

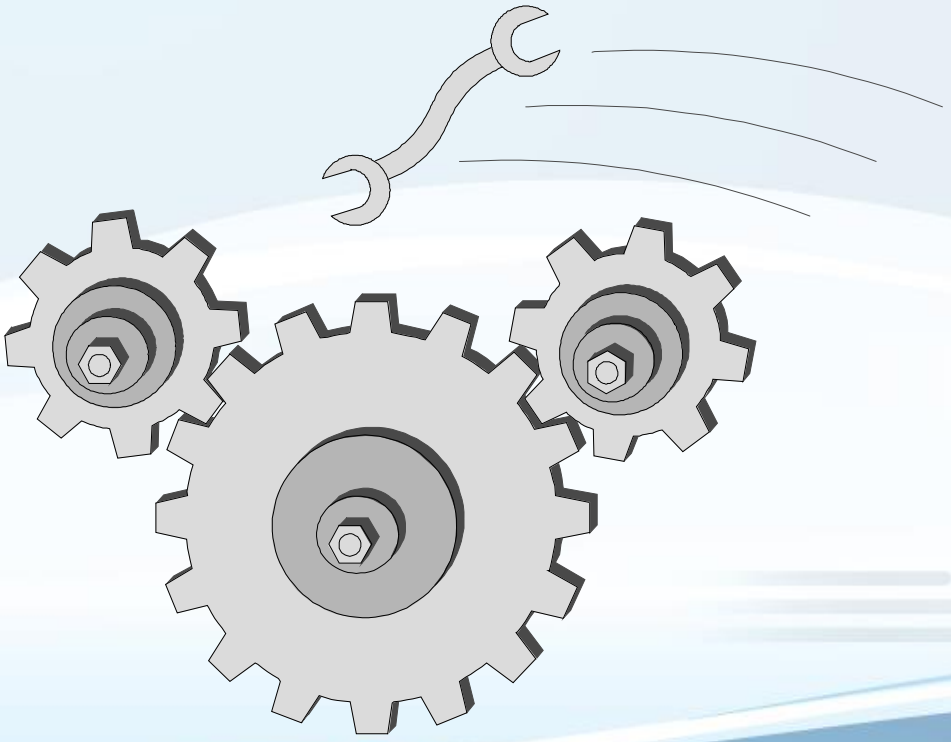
What is Autonomous Maintenance?

- Activities designed to involve operators in maintaining their own equipment, independent of the maintenance department

- Activities include:
  - Daily inspections
  - Lubrication
  - Parts replacement
  - Simple repairs
  - Abnormality detection
  - Precision checks

Step 1: Clean & Inspect

- Eliminate all dirt and grime on the machine, lubricate and tighten bolts, find and correct problems



Step 2: Get Rid of the Grime

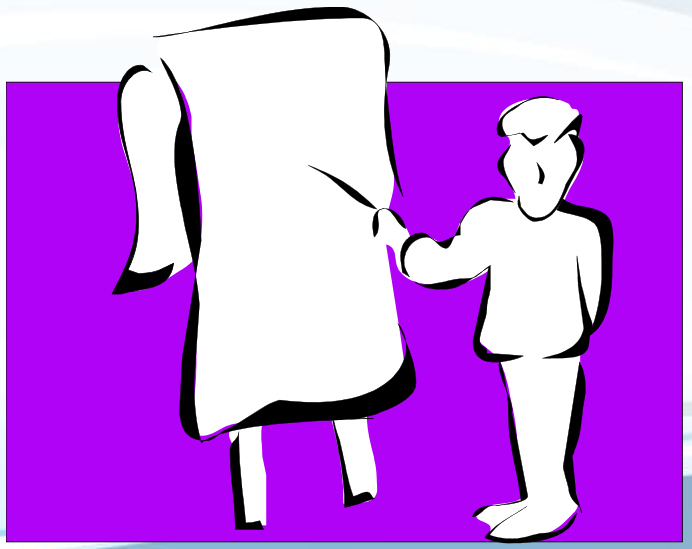
- Correct sources of dirt and grime; prevent spattering and improve accessibility for cleaning and lubrication
- Shorten the time it takes to clean and lubricate

Step 3: Develop Standards

- Write standards that will ensure that cleaning, lubricating and tightening can be done efficiently
- Make a schedule for periodic tasks

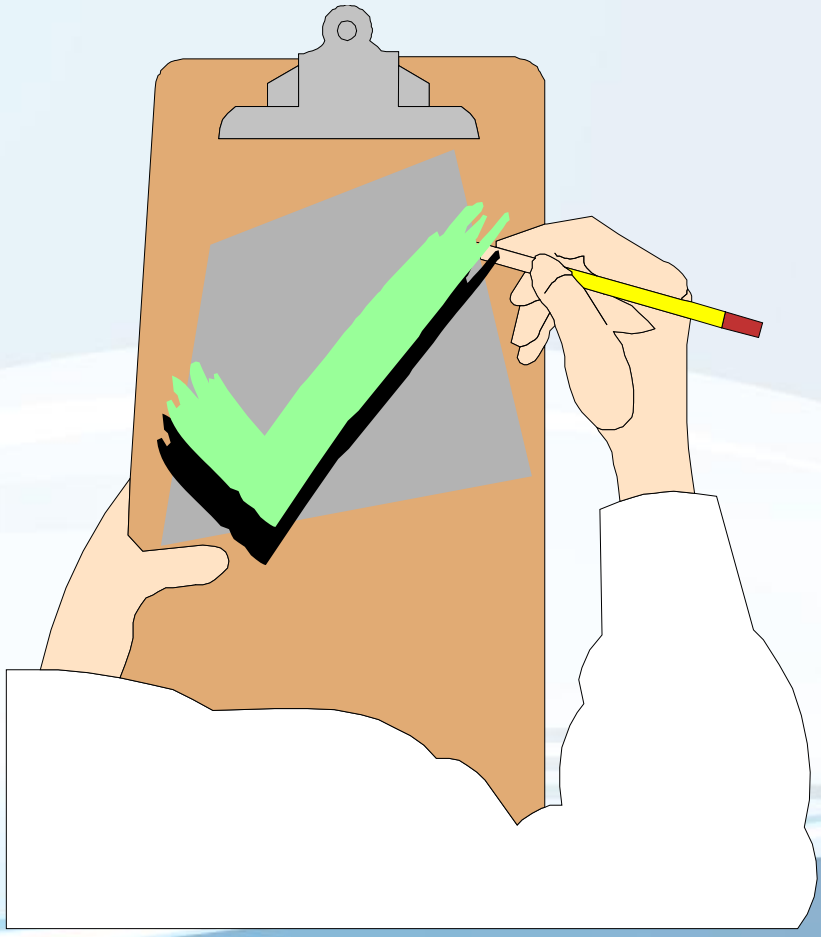
Step 4: Conduct General Inspections

- Conduct skills training with inspection manuals
- Use general instructions to find and correct slight abnormalities in the equipment



Step 5: Conduct Autonomous Inspections

- Prepare standard check sheets for autonomous inspections
- Carry out the inspections



Step 6: Carry Out Visual Maintenance Management

- Standardize and visually manage all shop floor maintenance routines
- Build a comprehensive system of maintenance management

Step 7: Carry Out Consistent Autonomous Management

- Develop company policies and objectives
- Make improvement activities part of everyday practice
- Keep reliable MTBF data, analyze it and use it to improve equipment

Cleaning Work Instructions

- Cleanliness is not optional – **world-class facilities are showcases**

- Develop machine cleaning, inspection, tightening and lubrication procedures / standards
  - Developed jointly by operators, maintenance and supervision

Work Instruction Guidelines

- Use:
  - Common words in short sentences [7th grade reading level]
  - Illustrations whenever possible, especially for critical measurements
- Refer to routine tasks by name only; save detailed explanations for less frequent tasks
- Protect daily/weekly checklists with transparent covers and keep on the equipment
- Issue specific work orders for tasks scheduled once per month or less
- Require employee signature on completed tasks
- Record time along with completed tasks
- Management follow-up inspection on large job sample to assure quality

TPM Phase 6

Planned Preventive Maintenance System

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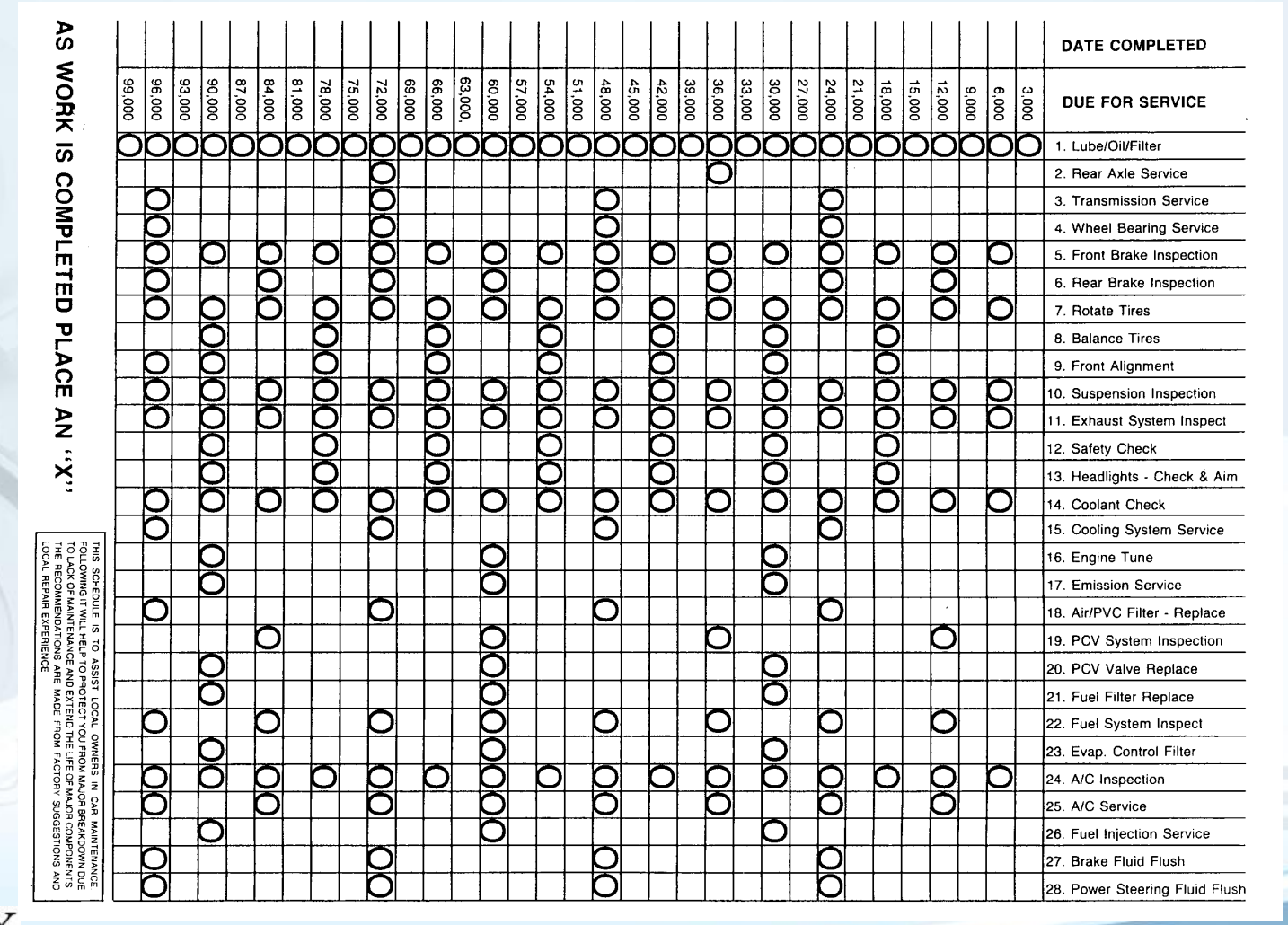
Maintenance's Role

- Identify departmental training needs:
  - Specialized trade skills, new maintenance policy, practices and procedures, Team Problem Solving, Statistical Process Control
- Identify key processes with production – thereby determining key equipment
- Write and use work instructions for planned and breakdown equipment maintenance

Example Check Sheet



Example Checklist

TRUCK 3500 MILE OIL CHANGE

Purpose: List cautions and steps required for changing oil
References: Driver's manual for vehicle
Cautions: *Assure vehicle is blocked securely before going under it!*
Hot oil from a recently operating motor can burn!
Assure adequate ventilation when running gas or diesel engine:

Procedures:

	Get replacement oil from stockroom
	Get tools: catch basin, oil spout, wrench, wipe
	Run motor at least 3 minutes to warm oil and mix contaminant particles
	Position vehicle on grease rack, lift or oil change station
	Assure lift lock, blocks and all safety devices are in safe position
	Position catch basin under oil drain
	Remove drain plug with wrench and drain oil into catch basin
	When oil slows to a trickle, replace drain plug
	If engine has a second sump, drain it the same way
	Open hood, remove oil fill cap and fill engine with fresh oil
	Run engine 1 minute to circulate oil - check underneath for any leaks
	Check dip stick to assure oil level indicates in full area
	Clean any spilled oil
	Close hood and clean off any oil or finger prints
	Fill out oil change sticker with mileage and stick inside driver's door hinge column - remove any old stickers
	Drive vehicle toparking area - be alert for indication of other problems
	Sign and date this checklist; write in mileage

Completed by: _____ Date:_____
Vehicle ID#: _____ License: _____ Odometer miles: _____
Further work required:

Planning Questions

- What are bottleneck and/or unique pieces of equipment?
- If this equipment...
  - "*goes down*" will we miss shipment requirements?
  - is not kept "*up to par*" will it affect the quality of the product?
- Is this equipment responsible for special, significant, safety or other features that are critical to the fit and function of the product?

Rating Key Process & Support Equipment

- **Absolutely Critical**
  - Very expensive downtime; system function disruption; missed shipments likely
- **Important**
  - There is an alternative that can buy time [hours, days or weeks]
- **Low Productive Value**
  - Direct ties to production
- **Low Productive Value**
  - No direct ties to production

Why Rate Equipment?

- So people can identify:
  - Replacement parts and equipment needed
  - What parts come with the equipment
  - What parts are unique and can only be obtained from the manufacturer or a specialty supplier
  - Parts under warranty
  - Special tools needed to make a repair

Creating Equipment Histories

- Use information provided by the manufacturer
- Specifications, parts lists, warranties
- Expected machine life cycle
- Depreciation status of each machine
- Set up according to manufacturer's recommendations/requirement?
- Machine capacity – running at the correct settings?
- Machine capability

Scheduled Equipment History

- Machine:
  - Name
  - Number
  - Location
- Date acquired
- Scheduled maintenance & inspection frequency
- Instructions:
  - Inspection
  - Preventive maintenance
  - Refurbishment
- Dates of maintenance work
- Repair/refurbishment costs

Determining PM Intervals/Frequencies

- Evaluate key equipment first, then all equipment
- Use manufacturer's recommendations and your own internal information and experience
- Is warranty dependent on prescribed types and intervals of maintenance?

Maintenance Scheduler/Planner

- Identify and train (or hire):
  - As a full-time job for most medium and all large production facilities [200+ pieces equipment]
  - To issue work orders to maintenance personnel and **coordinate scheduling with production**
  - To keep records of all these activities, maintain equipment histories and report information to management for review and action
  - To order, maintain, issue and track inventory

Example Planning Checklist

Planning Checklist		
Job Scope		
	☐	Is the work description clear?
	☐	Does the Work Order have proper approval?
	☐	Is the Work Order completely filled out?
	☐	Has the work been requested before?
	☐	Has the work been done before?
Job Location		
	☐	Where is the machine or job located?
	☐	Any special rigging, handling or equipment required?
	☐	Has anyone visited the job site for verification?
Priority		
	☐	Does this job interrupt planning of other work, either maintenance or production?
	☐	Any special parts, materials and/or tools needed?
	☐	Does this job need to be expedited?
Requirements		
	☐	Tools, equipment or other MRO items required?
	☐	Any safety considerations or procedures that need to be followed?
	☐	Who is qualified to do this job?
Methods		
	☐	Has this job been broken into elements?
	☐	Has a good sequence been developed?
	☐	Have all the materials and equipment been staged in the work area?
	☐	Has the amount of time and proper number of personnel been determined?
Materials		
	☐	Are all needed materials and equipment on hand and available?
	☐	Are prints, drawings, sketches or equipment manuals needed and available?
Communication		
	☐	With the originator?
	☐	With the scheduler?
	☐	With each craft?
	☐	With production?
	☐	With all affected personnel
	☐	Will equipment and machine be available when scheduled?

Work Order System

- Assign a person to issue, maintain and record work orders that allow for performing tasks on time
  - **Schedule:**
    reactive, corrective, preventive, predictive, productive, planned and improvement maintenance
  - **Record:**
    all scheduled and unscheduled activities & equipment histories – essential to TPM

Work Orders

- A work order system is a communications system by which work is requested, classified, planned, scheduled, controlled and analyzed
- A typical large firm example:
  - **maintenance work order:** for planned, scheduled work
  - **work request:** for unscheduled repairs
  - **verbal orders:** for emergency repairs
  - **standing work order:** for routine, repetitive work
  - **engineering work order:** for non-maintenance work

Organizing Inventory

- Store goods in a central crib or in locations where most often used
- Label all goods and corresponding storage locations
- Determine min-max requirements for all key replacement parts
- Commonize as many items as possible, such as motors, pumps, lights, electrical and plumbing
- Commonize equipment wherever feasible

TPM Phase 7

Improve OEE and Conduct Problem Solving

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Engineering's Role

- Plan for new products, processes, equipment, tools and facilities
- Determine activities and timelines for managing the project
- Identify possible new equipment and tools—buy or build?
- Determine need for total design or modifications to existing
- Lead the program team, making sure there is input from production, maintenance and operators

Additional Engineering Activities

- Develop Process Flows, PFMEAs, and Work Instructions with teams
- Research existing evidence to see where mistake-proofing and **preventing maintenance** can be built into new processes
- Lead in-house process improvement activities with cross-functional teams including operators and maintenance workers
- Collect and analyze data

Reliability FMEA

- Reliability FMEAs can be used as effective tools in the TPM effort
- Operation failure modes relate to the 6 losses:
  - Equipment failure
  - Setup and adjustment
  - Idling and minor stoppages
  - Reduced speed
  - Process defects
  - Reduce yield (start-up to stable production)

Reliability FMEA

- Team creates lists for each failure mode:
  - Effect of failure to department, plant or customer
  - Cause of failure
  - Current controls to manage loss
- Develop consensus on rating scales, if using:
  - Severity
  - Occurrence
  - Detection
- Develop rating scale for the Reliability FMEA

Engineering Problem Solving Help

- Assist in selection of appropriate measureables for:
  - Number of equipment failures each day or week
  - Equipment downtime due to failures
  - Planned vs unplanned maintenance activities
  - Completed work orders vs overdue, missed, outstanding
  - Process and product characteristics that quantify process capabilities
  - Equipment capacity vs actual output

Measuring Equipment Effectiveness

- TPM is not limited to breakdowns affecting availability... it raises total equipment effectiveness by improving:
  - Availability
  - Performance
  - Quality [rate of quality products]

Equipment Effectiveness Goal...

- 85% or more
  Calculated by:

availability x performance rate x quality rate

• breakdown • setup adjustment • other	• idling & minor stoppage loss • reduced speed loss	• scrap rework defects loss • start-up loss

Using Data for Improvement

Analyze breakdown maintenance data to identify problems to improve availability

- Study:
  - Actual cycle time against cycle time at purchase
  - Quality data to identify problems to improve quality
- Conduct:
  - Problem solving (8D) with cross-functional team to identify root cause
  - Corrective action
  - System corrective action (i.e., change machine design)

Computers

- Highly recommended... easily justified once you list needs
- Linking a maintenance computer into the intranet of your company is:
  - A visible signal that TPM is a pillar of the company
  - Maintenance participation in planning, start up and ongoing health of equipment and processes is a contributor to the bottom line

System Approach

- Most companies of 100+ people have computers controlling:
  - Processes
  - Support services, such as accounting
- Technology supporting maintenance doesn't seem to be a priority
- If accounting, quality, engineering, scheduling, production and human resources need a computer... why not maintenance that services ***all*** of them?

Why Maintenance Software?

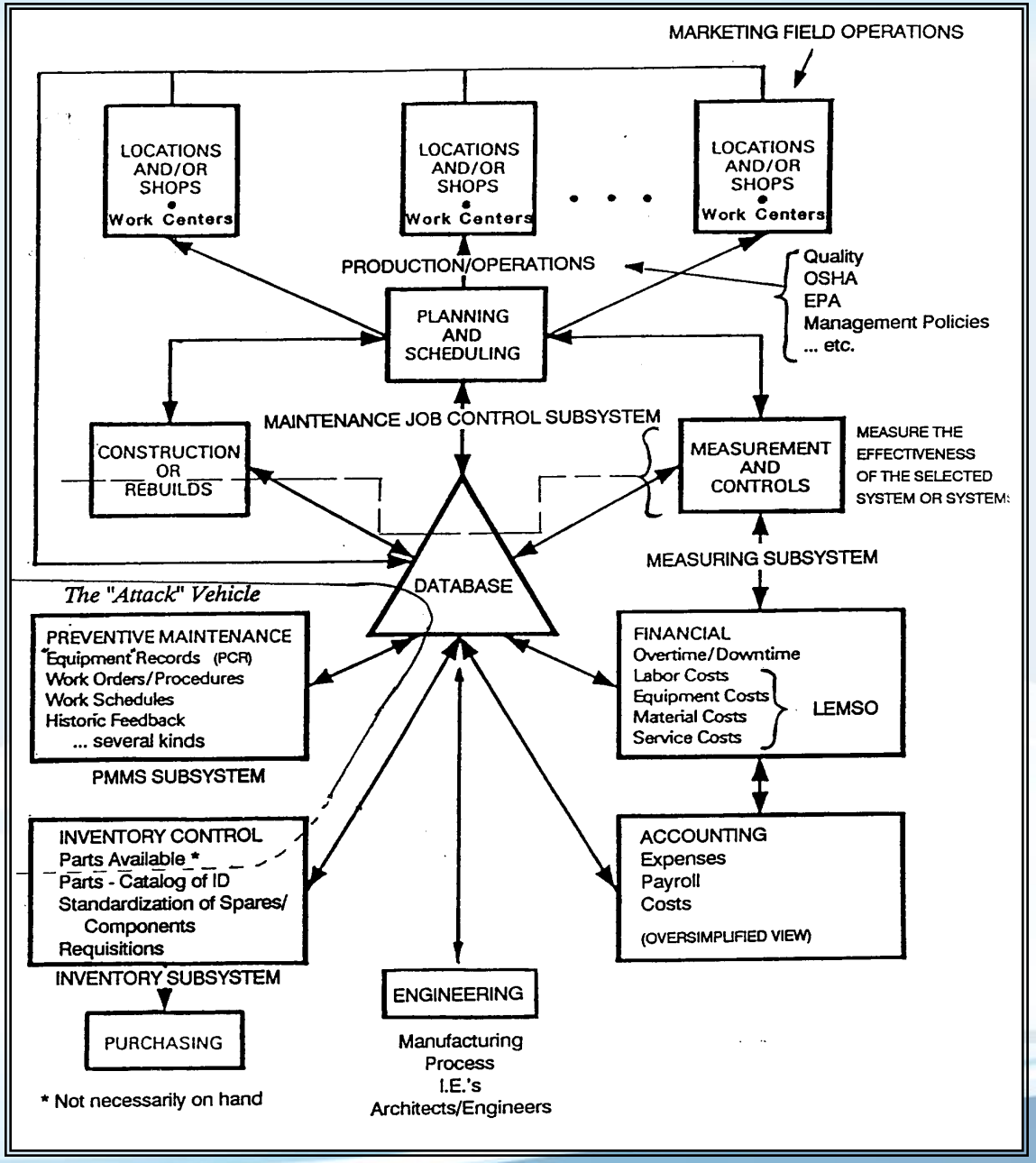
- Maintain equipment history files
- Process work orders, record and track completion
- Schedule all types of maintenance
- Provide data in numerical and graphic form
- Provide “snapshots” of maintenance information
- Be interactive with MRO inventory, work order and equipment files
- Track parts and supplies through identification, ordering, receiving, storing and use
- Link with other systems in the company
- Possible bar coding capability

Maintenance Software

- Hardware issues need to be resolved in keeping with overall operating system

- Some software packages:
  - Maintenance Pro
  - Maximo
  - Penguin
  - COMMS [**Computerized Maintenance Management System**]
  - Datastream

MMIS



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TPM Phase 8

Predictive Maintenance

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Using Real Tools

We usually don't have a hard time getting maintenance personnel interested in this part of the process.

Indeed, an entire day could be spent on this aspect for each different process and the many types of equipment.

Equipment Inspection

- When inspecting equipment as part of predictive maintenance, record actual readings and verify they are within specification limits
- File check sheet with equipment history file or transcribe to database
- Monitor and/or chart actual readings where merited to determine patterns or trends that signal need for corrective action

Nondestructive Inspection

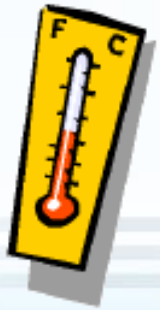
- Always the *Preferred Choice*... (you don't have to take it apart or put it back together again!)
- Does not harm equipment **and** is safe for the technician

Predictive Maintenance Team

- Train all users and maintenance technicians in most basic NDT and common sense use of sight, sound, smell and feeling
- Those most familiar with the equipment... use it and care for it most frequently – important first alert and response team

Performing Predictive Maintenance

- **Temperatures:** thermometer, thermister, crayons, stickers, paint, infrared, thermopile or heat flow meter
- **Vibration / Wear:** accelerometer, stethoscope, stroboscope, ultrasound or laser alignment



Performing Predictive Maintenance

- **Material Defects (cracks, holes, etc.):** magnetics, penetrating dyes, eddy currents, radiographs, ultrasonics, Rockwell hardness tests, sonic resonance, Corona listener or fiber optics bore scopes

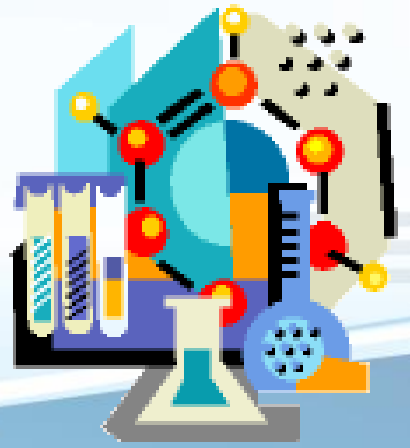
- **Erosion, Corrosion, Deposits and Rust:** ultrasonics, radiographs, cathodic potential readings and weight

Performing Predictive Maintenance

- **Flow:** freon detector, smoke bomb, gas sensor, quick connect gage or manometer
- **Electrical:** cable fault detector, outlet checker, hipot, VOM, oscilloscope, static meter gun, frequency recorder, phase angle meter, circuit breaker tester, voltage tester, amp probe, current sensor and amp meters

Performing Predictive Maintenance

- **Tension:** V-Belt depression, backlash feeler or torque meter
- **Chemical / Physical Testing:** particle analysis, spectrographic oil analysis, tests for O2, CO2, pH readings and viscosity



Using Sensors

- Build or add to equipment and tools – sensors of every kind, size and sensitivity are available
- Lasers and ultrasonics are common and inexpensive in hand-held testers that complement and extend human senses

TPM Phase 9

Continue Training to Improve Existing Equipment and Prepare for New Equipment

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Training Disciplines

- Machine operators and maintenance personnel need training in:
  - Attitude of service to the company
  - Participation and involvement in activities of:
    - Planning and Scheduling
    - Process Control
    - Inspection
    - Data Collection
    - Record Keeping
    - Auditing
    - Problem Solving
    - Continuous Improvement
    - Cost Control
    - Management Review

Training is Essential

…in the use of testing, inspection and measuring equipment

- To properly record data and use it to analyze problems and make improvements by operators, maintenance, engineering and management as partners in this great technology

Improve Skills; On-Going Training

- Identify need for advanced maintenance training
- Begin training maintenance personnel to enhance skills
- Use qualified craftspeople to train technical skills
- Organize first-line supervisors to train machine operators in daily maintenance activities
- Teamwork and SPC training for all groups

Why Learn Problem Solving?

- Other departments have asked you to help them solve problems
- Team Problem Solving can improve your own department, solve some very difficult problems and provide essential help to other departments or units of your company

TPM Phase 10

Maintenance Prevention

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Advanced Planning

- Maintenance and engineering must participate in APQP cross-functional team

- New products or equipment require all departments to:
  - Investigate and visit manufacturers and/or other facilities running similar machines or processes
  - Share planned completion dates
  - Understand departmental responsibilities
  - Include every department at planning meetings

Advanced Planning Activities

- **Investigate and visit...**
  - Manufacturer's location prior to order and shipment of new equipment by maintenance, engineering, production and quality
- **Train with operators on...**
  - Production, maintenance, expected volumes and product quality
- **Plan for...**
  - Sealed bearings
  - One access point for all normal maintenance activities
  - Sensors, safeguards and other maintenance free attributes
  - Preventing maintenance

Subcontractor Development

- Use TE supplement
- Use APQP
- Conduct machine run-off
- Improve design with problem solving

By the Time Equipment Arrives

- Have a check list [or several] ready
- Install and run within a few hours or days, depending on project size
- Planning ensures that at start-up equipment is stable, capable, runs at the designed speed and makes 100% good parts

Example New Equipment Checklist

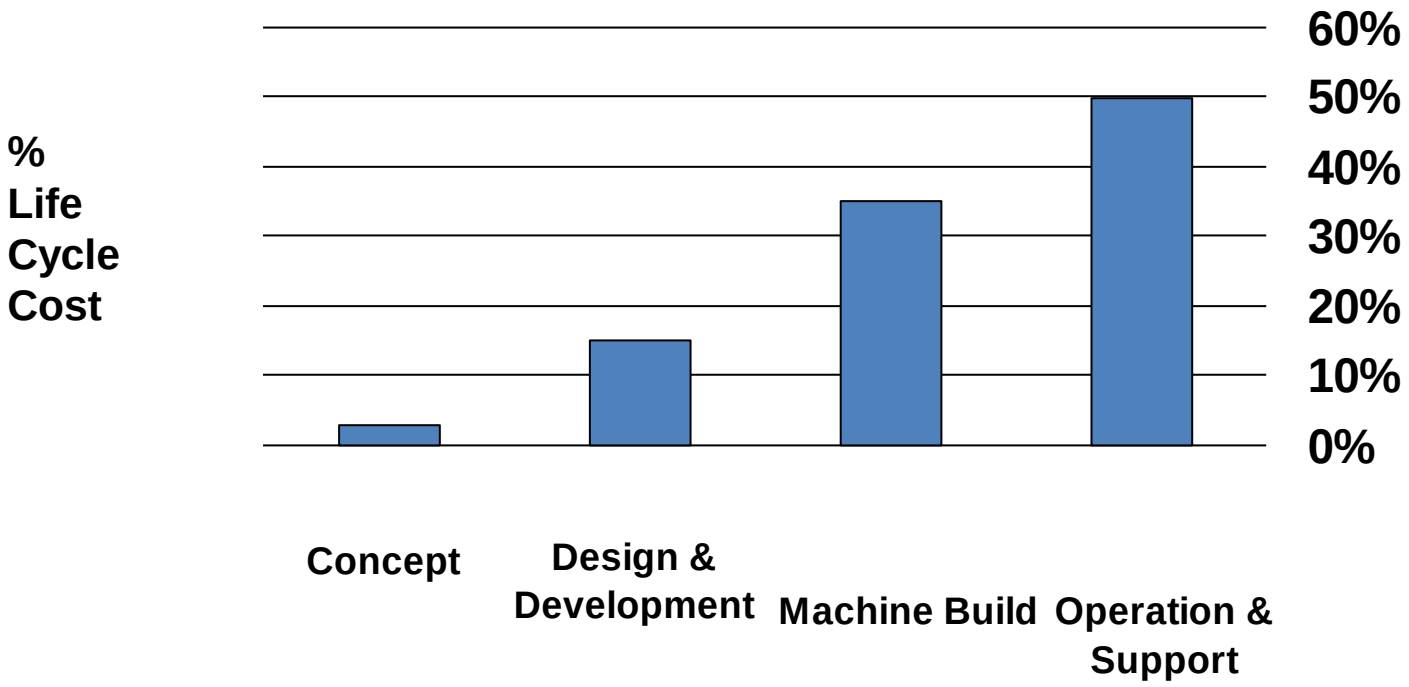
Maintenance Considerations	Yes	No	Comment
1. Standardization a. Is equipment already in use that provides the desired function? b. Is this the same as existing equipment? c. Are there equipment problems with existing equipment? d. Can we maintain this equipment with existing personnel? e. Are maintenance requirements compatible with our current procedures?			
2. Reliability and Maintainability a. Can vendor prove the equipment will operate at least to ore minimum specifications? (Detail where possible) b. Warranty of all parts and labor for 90+ days? c. Is design fault-tolerant? d. Are tests go/no go?			
3. Service Parts a. Is recommended replacement list provided? b. Is the dollar amount of spares less than 10% of the equipment cost? c. Do we already have usable parts? d. Can parts be purchased from other vendors? e. Are any especially high quality or expensive parts required?			
4. Training a. Is special technician training required? b. Will manufacturer provide training? I. at no additional cost for first year? II. at our location as required?			
5. Documentation a. All tech manuals provided? I. installation II. operation III. corrective and preventive maintenance IV. parts			
6. Special Tools and Test Equipment a. Do we already have all required tools and test equipment? b. Can at least 95% of all faults be detected by use of proposed test equipment and procedures? c. Are calibration procedures minimum and clear?			
7. Safety a. Are all UL/CSA, OSHA, EPA, and other applicable requirements met? b. Are any special precautions required? c. Can one person do all maintenance?			

Start In-House Records

- Manufacturer communication and partnership provides feedback on intended Reliability & Maintainability and Life Cycle Cost to improve current machines help design future equipment
- Track Reliability & Maintainability factors (or probabilities as they are known)
- Generate equipment Life Cycle Cost

New Equipment Records

- Communication and partnership with manufacturer generates data for LCC



Tracking R&M

Reliability

- Probability that machinery/equipment performs continuously, without failure, for specified time interval when operating under stated conditions
- Less failure of machinery
- Less downtime and loss of production

Maintainability

- Characteristic of design, installation and operation
- Expressed as probability that machine can be retained in, or restored to, specified operable condition within specified time interval

T&E and R&M

- Two new documents that describe the impact of tooling and equipment on:
  - Process Control
  - Productivity
  - Quality
  - Profitability
  - Customer Satisfaction

T&E R&M Publications

- ***Reliability and Maintainability Guideline for Manufacturing Machinery Equipment***
  - 1993 by SAE & NCMS

- ***Tooling and Equipment Supplement to QS-9000***
  - 1996 by AIAG

Measuring R&M

Reliability

- Mean Time Between Failure (MTBF) or Mean Cycles Between Failure (MCBF) for repairable equipment
- Mean Time To Failure (MTTF) or Mean Cycles To Failure (MCTF) for non-repairable equipment

Maintainability

- Mean Time To Repair or Mean Time To Replace (MTTR)

Maintenance/Supplier Partnerships

Equipment, Parts, MRO and Sublet Services Suppliers' Requirements

- Approved list of suppliers
- Time between order and delivery for critical replacement parts
- Partnership agreement for equipment, MRO and sublet services [**recommended**]
- Delivery and quality ratings [**good idea for long term suppliers**]
- Price

Learn New Technology

- With a productive maintenance system, you have time to:
  - Attend tool shows
  - Learn new technologies to help your company improve
  - Help other departments solve their problems
  - Audit your facility and sister plants or others in your area

Continual Improvement

- Problem solving and continuous improvement within a system is **not a singular activity** – you need a team
- With the complexity of business today, there is great benefit to working as a team
- When you are starting out on the quest for Total Productive Maintenance, you will have a lot more problem solving than improvement opportunities

Traditional Process Measures

These maintenance items are identified as "most important to the customer"

- Unscheduled maintenance downtime
- Machine setup & changeover time
- Excessive cycle time
- Scrap, rework and repair
- Wasted floor space
- Excessive variation
- First run capability
- Overall Equipment Effectiveness
- Problem solving
- Benchmarking
- Ergonomics
- Mistake proofing

Linkage with Other Processes

- Facilities, equipment, process planning and effectiveness
- Capabilities identified using APQP and cross-functional teams, including Maintenance to control processes and operations for:
  - Work Plans
  - Automation
  - Ergonomics
  - Line Balances
  - Inventory Control

Linkage with Tools

- Prior to equipment purchase, uses mistake proofing tools of:
  - FMEAs
  - Capability studies
  - Historical equipment data such as:
    - MTBF – Mean Time Between Failures
    - MCBF – Mean Cycles Between Failures
    - MCTR – Mean Cycles To Repair
    - MTTR – Mean Time To Repair

Chapter 5

TPM Implementation – Moving Forward

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Integrating Tools is the Key

- You can use the disciplines and tools we've discussed to improve those functions also
- There are other topics we only touched on that are intimately linked to the services and responsibilities of the overall concept of maintenance:
  - ISO 9001
  - ISO/TS 16949
  - ISO 14001
  - Tooling & Equipment
  - Reliability & Maintainability
  - Problem Solving
  - Advance Product Quality Planning (APQP)

Omnex Training

- We offer training to understand and implement all of these standards available at your own facility
- These disciplines are all vital to successful change within each department and within any company

Changing the Course

- Maintenance has been a reactive, necessary evil over the past 50 years
- Maintenance leaders must have support for continuous maintenance improvements
- Maintenance leaders must develop valid economic justifications

Maintenance Comes of Age

Using your new tools and knowledge, you have the strength to be the glue that holds the manufacturing community together

It Takes Time

- Benefits come only **after the 1st year** of at least a *three year* improvement program

- By the 3rd year, the ability to interpret data gathered, make good projections and return on investment is a standardized process involving maintenance, management, purchasing and finance

Best-in-Class Approach

- Do a gap analysis of where you are and where you want to be in order to get a jump start on the project
- Identify bottlenecks – calculate costs associated with equipment and process failures
- Use resources such as books and training tapes on specific topics related to these issues
- Benchmark your system against sister plants or other factories

Example Award from Ford

PREVENTIVE MAINTENANCE EXCELLENCE AWARDS

In 1988, Mr. W. E. Scollard, Vice President for Manufacturing Operations, North American Automotive Operations suggested the creation of a Preventive Maintenance Excellence Award Program. The purpose of the Award Program was to - "provide recognition of exemplary efforts in the field of Preventive Maintenance and to positively promote the cultural changes necessary to fully incorporate the benefits of Preventive Maintenance in our manufacturing and assembly activities."

The objective of the program has been to move from a competitive award system to one of achievement, similar to the Q-1 award program. Candidates for the Award were selected on how well they perform against 15 elements of a complete program. The elements chosen by the NAAO "blue ribbon committee" of judges were as follows:

1. Dedicated PM system.
2. Strong management commitment with supporting structure.
3. System of inspections engineered by a broad-based group of experts.
4. High priority PM schedules for safety related items such as cranes, hoists, trolleys.
5. Formal, well-documented feedback from required inspections.
6. Formal lubrication program with measuring disciplines for effectiveness.
7. Leak tag program for hydraulic oil, compressed air and steam.
8. Instructional training for PM personnel.
9. Comprehensive and historical maintenance data collection.
10. Work sampling plant to assure the inspections occur.
11. Corrective engineering to remedy repetitive problems.
12. Predictive Maintenance program that includes vibration analysis, infrared thermography and oil analysis.
13. Establish objectives for continuous improvement.
14. Measurement of results - quality, productivity, etc.
15. Appropriate reporting processes.

To date, 29 plants have been approved for the PM Excellence Award. A list of 29 plants is included in the handout Preventive Maintenance Excellence Award, Preventive Maintenance Excellence Award II.

Effective February 1, 1991, the role of PM Excellence Award sponsor was passed to Mr. H. A. Nickol, upon Mr. Scollard's retirement from the Company.

Special Appendix
Ford Specific Exhibit
February 12, 1991

World-Class Goals

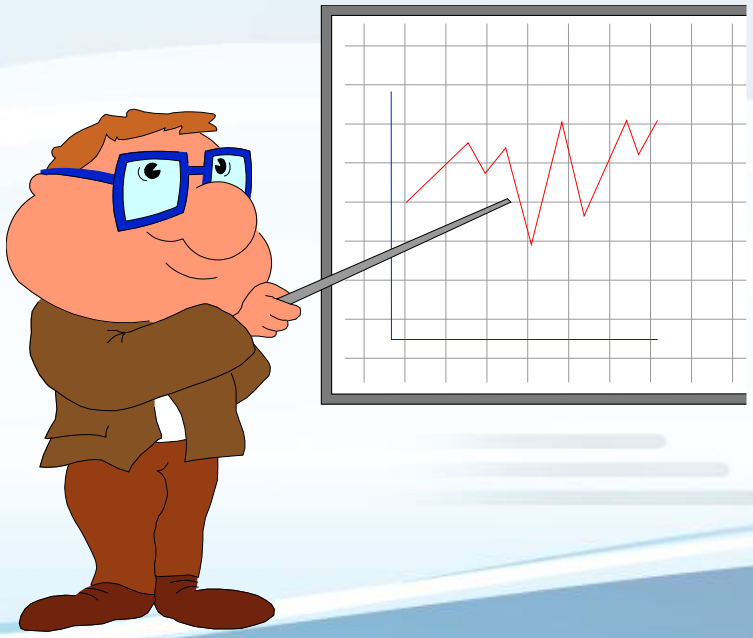
- Overall Equipment Effectiveness at least 85%
  - equipment effectiveness equals:
    % up time x % cycle time x % yield
  - you need:
    - up time > 90%
    - cycle time > 95%
    - yield > 99%

Your Goals

- Calculate your Overall Equipment Effectiveness
- Compare your data with world-class data

Get Management Commitment

- Calculate your plant OEE
- Correlate it to dollars ($)
- Present findings to management



Connecting OEE to Company Success

- Current plant sales: $100 million
- Current plant OEE: 50%
- Possible sales at 85% OEE =
  $100 million / 50 x 85 = $170 million
- Profit margin on incremental sales = 25%
- Increase in profits =
  (170 - 100) x 25 =
  $17.5 million

Set Your Organizational Structure

Establish Process Milestones

- Where are you now?
  - CMMS
  - Preventive maintenance
  - Data collection
- Establish baseline measureables:
  - Result measure – OEE
  - Process measures
- Conduct training for management and the union
- Set TPM strategy – complete year 1 to 3 goals (see TPM phases)
- Complete detailed implementation plan
- Launch TPM using your QOS
- Get an outside TPM audit each year to gage success

Reviewing TPM Phases

1. Management Planning and Commitment
2. Management Plan Roll-out to Organization
3. Work Instructions Define New Roles and Standard Practices
4. Change Company Culture via Training
5. Autonomous Maintenance Program
6. Planned Preventive Maintenance System

More TPM Phases

7. Improve Overall Equipment Effectiveness (OEE) and Conduct Problem Solving

8. Collect/use Data for Predictive Maintenance System

9. Continue Training to Improve Existing Equipment and Prepare for New

10. Include Maintenance Prevention During Equipment Design – consider: reliability, ease-of-care and user friendliness

TPM Improvement Activities

1. Improve Individual Equipment Effectiveness
2. Autonomous Maintenance
3. Plan for Maintenance Department
4. Increase Operator and Maintenance Technician Skill Levels
5. Participate in Planning for New Equipment Design

Overall Summary

- TPM goes beyond preventive maintenance
- TPM involves improvement activities
- TPM gets to the root of quality, productivity and efficiency

Thank You!

Questions?

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