Total Productive Maintenance (TPM)
WCM Supplier Academy – Speaker Introduction

Katrina Schiedemeyer – Senior Specialist
Supplier Development
Oshkosh Corporation
What is TPM?

- A **company-wide team-based effort** to build quality into equipment and to improve overall equipment effectiveness
- A method for **continuously improving** the effectiveness of manufacturing processes and equipment through the involvement of all team members in an organization
Goal of TPM

Improve performance to GPSC’s 4 Priorities

• Competitiveness
  – Reduced maintenance cost
  – Reduced inventory
  – Eliminates equipment start up losses
  – Increased bottom line savings

• Quality
  – Improved quality rates
  – Maintains quality standards
  – Expands error proofing capabilities
Eight Major Pillars of TPM

TPM Goals:
Zero Defects, Zero Breakdowns, Zero Accidents

- Autonomous Maintenance
- Planned Maintenance
- Focused Improvement
- Early Equipment Management
- Quality Maintenance
- Education & Training
- Administration TPM
- Safety & Environmental Management

5S & Visual Management
Autonomous Maintenance

TPM Goals:
Zero Defects, Zero Breakdowns,
Zero Accidents

- Autonomous Maintenance
- Planned Maintenance
- Focused Improvement
- Early Equipment Management
- Quality Maintenance
- Education & Training
- Administration TPM
- Safety & Environmental Management

5S & Visual Management
Autonomous Maintenance

• Complete initial cleaning of equipment
  • Restore equipment to ‘like new’

• Identify and eliminate sources of contamination

• Establish cleaning, inspection, and lubrication standards
  • All areas easily accessible
  • Visible inspection points

• Review 8 forms of waste (DOWNTIME)
Planned Maintenance

TPM Goals:
Zero Defects, Zero Breakdowns,
Zero Accidents

- Autonomous Maintenance
- Planned Maintenance
- Focused Improvement
- Early Equipment Management
- Quality Maintenance
- Education & Training
- Administration TPM
- Safety & Environmental Management

5S & Visual Management
Planned Maintenance

Technicians and Operators Agree on Roles and Responsibilities

- Utilize pilot team to develop equipment cleaning standards for future teams and events
- Include how to, with what, look for and where to, as well as cleaning precautions (safety issues etc.)

- Prioritize equipment
- Evaluates current maintenance and performance costs
Focused Improvement
Focused Improvement

**Equipment Performance**
- Breakdowns
- Setup and adjustment
- Idling and minor stoppages
- Speed losses
- Quality defects and rework
- Start up losses

**Operator Excellence**
- Make operators experts on their equipment
- Inspection instructions, training aids, lubrication manuals
- Employee Capabilities

**Processes**
- Maintenance systems
- Equipment reliability
- Equipment design
- Safety & environmental

**Culture**
- Employee engagement
- Process ownership
- Continuous Improvement

Plan  Do  Check  Act
Early Equipment Management

TPM Goals: Zero Defects, Zero Breakdowns, Zero Accidents

- Autonomous Maintenance
- Planned Maintenance
- Focused Improvement
- Early Equipment Management
- Quality Maintenance
- Education & Training
- Administration TPM
- Safety & Environmental Management

5S & Visual Management
Early Equipment Management

Why do capital projects fail to meet expectations?
• Project accountabilities and roles not clearly defined
• Avoidable/potential risks are identified too late in the process
• Insufficient training and support for stakeholders

Do you have the right piece of equipment for the job?
• Decisions made during design process
• Operator friendly
• OEM engagement early in planning (Spare Parts, Service Agreements, Start-up Support, Training)
Quality Maintenance

TPM Goals:
Zero Defects, Zero Breakdowns,
Zero Accidents

- Autonomous Maintenance
- Planned Maintenance
- Focused Improvement
- Early Equipment Management
- Quality Maintenance
- Education & Training
- Administration TPM
- Safety & Environmental Management

5S & Visual Management
How is preventative maintenance linked to your organization's Quality Management System?

- Well maintained equipment will have higher quality performance over equipment lifecycle
- Establishes structure and accountability for maintenance resources and processes
- Documents best methodologies to meet equipment reliability requirements

Goal of Zero Defects!
Education and Training
## Education and Training

<table>
<thead>
<tr>
<th>Traditional Role</th>
<th>Traditional Responsibilities</th>
<th>TPM Role</th>
<th>TPM Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator</td>
<td>Told what to do • Ideas or opinions never asked for • Use arms and legs but not brain • Feels no connection to job, customer or company</td>
<td>Owner/Operator</td>
<td>Empowered to run their part of the business • Talks to, and visits customer • Trained to conduct daily, routine preventative maintenance tasks. Does minor repairs • Leads and contributes to problem solving.</td>
</tr>
<tr>
<td>Journeyman Maintenance</td>
<td>Fix equipment as it breaks down, never given time to do it right. • Is physically and emotionally separated from company, production, and customers</td>
<td>Maintenance Technician</td>
<td>Trains all operators in daily, routine preventative maintenance tasks. • Thinks preventative maintenance. • Conducts scheduled downtime preventative maintenance inspections and tasks • Helps to develop and implement predictive maintenance strategies.</td>
</tr>
<tr>
<td>Industrial/Manufacturing Engineer</td>
<td>Responsible for equipment design and supplier selection • Works through floor supervisors when equipment problems exist</td>
<td>Industrial/Manufacturing Engineer</td>
<td>Educates equipment suppliers on requirements for documentation and maintainability • Works on the floor with owner-operators and supervisors to solve problems. • Trains technicians.</td>
</tr>
<tr>
<td>Management</td>
<td>Limited trust of employees • Not close to production process (except supervisors). • Limited communication with operators • Comfortable with breakdown maintenance.</td>
<td>Management</td>
<td>• Spends up to 20% of their time on the floor as a TPM cheerleader and roadblock buster Encourages planned shutdowns for improvements • Open, rapid communication via daily walk-thrus • Requires people training and development.</td>
</tr>
</tbody>
</table>

Key transition characteristics for success

Supply Chain Academy
Administration TPM

TPM Goals:
Zero Defects, Zero Breakdowns,
Zero Accidents

- Autonomous Maintenance
- Planned Maintenance
- Focused Improvement
- Early Equipment Management
- Quality Maintenance
- Education & Training
- Administration TPM
- Safety & Environmental Management

5S & Visual Management
Administration TPM

- Department goals are aligned with the organization's vision and mission.
- Documented process to support TPM alignment
- Truly takes engagement and alignment from all levels to be successful!!
Safety & Environmental Management
Safety Management

- A strategic approach to ensuring a safe working environment
- TPM helps define processes, engage team members, and reduce risk
- Reactively eliminate root cause of past incidents
- Proactively reduce future risk of safety incidents
Environmental and Sustainability Management

• Intentional commitment to environment & sustainability efforts
  • Reducing energy consumption
  • Reducing waste to landfill
  • Fluid recycling

• Sustainability also includes:
  • Health & Wellness
  • Giving back to the community
  • Creating a safe, engaging, and FUN work environment

* See Oshkosh Sustainability Report for more details
# Where Do I Start?

## What Does It Take to Improve a Capability?

<table>
<thead>
<tr>
<th>Domains of a Capability</th>
<th>Culture</th>
<th>Practice</th>
<th>Process</th>
<th>Metrics</th>
<th>Tools</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>↓ Maturity Levels</strong></td>
<td>Values, Beliefs, Expectations</td>
<td>Knowledge, Skills, Abilities</td>
<td>Policy, Procedure</td>
<td>Measurements, Quality Control</td>
<td>Information Tools, Physical Tools, Mixed Tools</td>
<td>Data, Analytics</td>
</tr>
<tr>
<td><strong>Level 5: Quantitatively Optimizing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prescriptive, Reflective</td>
<td>• Contributions to enterprise capability initiatives are rewarded</td>
<td>• The performance, requirements and improvement efforts for functional skills are quantitatively aligned</td>
<td>• Scientific method, PDCA, and Six Sigma employed for review of experiment results by remote peers</td>
<td>• Defects prevented</td>
<td>• The performance, requirements and improvement efforts for a tool are quantitatively aligned</td>
<td>• Data unified across sources</td>
</tr>
<tr>
<td></td>
<td>• Pride is taken in the collaborative achievement of an improvement, not in ownership of the new or old.</td>
<td>• Simulations used for analysis of current and future state processes</td>
<td>• Candidate metrics hypothesized and experimented using new or legacy data</td>
<td>• Performance metrics aligned across the organization and to strategic goals</td>
<td>• Performance, requirements and improvement efforts for a tool are quantitatively aligned</td>
<td>• Designs of information are assessed for availability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Prescriptive analytics bring influence - &quot;How can we make it happen?&quot;</td>
<td>• Prescriptive analytics bring influence - &quot;How can we make it happen?&quot;</td>
</tr>
<tr>
<td><strong>Level 4: Quantitatively Managed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Predictive, Controlled</td>
<td>• The degree of capability is assessed quantitatively and objectively. No other voices are offered nor heard.</td>
<td>• Training programs integrated with skills needs, assessments and availability</td>
<td>• Policies &amp; procedures are audited</td>
<td>• Defects consistently disclosed and well understood.</td>
<td>• Ability of a tool to meet the users' needs is tracked</td>
<td>• Metadata and analytics insights visually portrayed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Skills are assessed quantitatively and inventoried as an organizational asset</td>
<td>• Processes aligned to and measured for customer value</td>
<td>• Metrics measured for indication of real-world trends</td>
<td>• The performance and requirements for a tool are monitored before and after commissioning</td>
<td>• Data unified &quot;as if one database&quot;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Processes are mapped to capabilities</td>
<td>• Statistical techniques used to predict &amp; minimize defects</td>
<td>• Interfaces and indications are visual</td>
<td>• Predictive analytics bring foresight - &quot;What will happen?&quot;</td>
</tr>
<tr>
<td><strong>Level 3: Defined</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Descriptive, Standardized</td>
<td>• Forums for learning and sharing are structured and harmonized</td>
<td>• Skills understood by role, shared and propagated across enterprise</td>
<td>• Responsibilities understood by role, across enterprise</td>
<td>• Enterprise framework of metrics</td>
<td>• Portfolios of tools and projects managed for the enterprise</td>
<td>• Datestets described</td>
</tr>
<tr>
<td></td>
<td>• Enterprise experts, process, systems, data, and measures are trusted as fullest depiction of the capability.</td>
<td>• Widely available team member development services</td>
<td>• Team members know how to influence policy and process</td>
<td>• The metrics of a capability roll-up and drill down.</td>
<td>• Application architecture is upheld and updated</td>
<td>• Stewards of data sets recognized</td>
</tr>
<tr>
<td></td>
<td>• Training programs developed and documented.</td>
<td>• Training programs developed and documented.</td>
<td>• Company-wide process architecture defined and linked to organization.</td>
<td>• Metrics reported beyond project management and governance</td>
<td>• Modelling and simulation tools reduce risks and perform what-if studies</td>
<td>• Analytics standardized &amp; shared</td>
</tr>
<tr>
<td><strong>Level 2: Managed</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactive, Reported</td>
<td>• Use of required persons, process, tools, data and measures is rewarded</td>
<td>• Skills needed for established and ad hoc roles are understood</td>
<td>• Locally established processes</td>
<td>• The performance, requirements and improvement efforts for a tool are quantitatively aligned</td>
<td>• Inaccurate data reclassified</td>
<td>• Descriptive and diagnostic analytics bring hindsight and insight - &quot;What happened and why?&quot;</td>
</tr>
<tr>
<td></td>
<td>• Skills needed for established and ad hoc roles are understood</td>
<td>• Training is reactive to needs of the project</td>
<td>• Work as a team per assigned roles</td>
<td>• Metrics of a capability roll-up and drill down</td>
<td>• Owners of data sets recognized</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Training is reactive to needs of the project</td>
<td>• Work products and compliance to process are managed</td>
<td>• Work products and compliance to process are managed</td>
<td>• Metrics are measured, planned and tracked in response to a project or a risk</td>
<td>• Metadata understood &amp; used by few</td>
<td></td>
</tr>
<tr>
<td><strong>Level 1: Ad Hoc</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unpredictable</td>
<td>• Achievement is rewarded</td>
<td>• Competent individuals</td>
<td>• Locally established processes</td>
<td>• Toolsset improvement is reactive to the needs of the project</td>
<td>• Effective tools are available</td>
<td>• Redundant data in different repositories and formats</td>
</tr>
<tr>
<td></td>
<td>• Reliance on individual herculean efforts</td>
<td>• Training is on-the-job</td>
<td>• Work as a team per assigned roles</td>
<td>• Information workflows used effectively per project</td>
<td></td>
<td>• Metadata understood &amp; used by few</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Undocumented, undeveloped, outdated, and/or inconsistent.</td>
<td>• Work products and compliance to process are managed</td>
<td>• Information workflows used effectively per project</td>
<td></td>
<td>• Data migrations unversioned and performed manually.</td>
</tr>
</tbody>
</table>
# Measuring a Capability

## Capability Scorecard

<table>
<thead>
<tr>
<th>Capability</th>
<th>Culture</th>
<th>Practice</th>
<th>Process</th>
<th>Metrics</th>
<th>Tools</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Equipment Management</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Capability Scorecard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured Capability: Maintenance</td>
</tr>
<tr>
<td>Scored By: Josh Oliver</td>
</tr>
<tr>
<td>Date:</td>
</tr>
<tr>
<td>Assessment Attempt: 1st 2nd 3rd 4th 5th</td>
</tr>
<tr>
<td>Reason for Assessment: Tied to any business initiatives? What is the desired outcome of the capability?</td>
</tr>
</tbody>
</table>

## Assessment Notes

**Culture**: Based on the complexity of equipment, enterprise experts are largely the trusted source of information and planning.

**Practice**: Skills to manage the development of equipment are understood by individual roles. Previous experience or outside training on equipment to provide insight.

**Process**: Part of the design review process involves a tooling/fixtureing review. This covers most the major items, however not all fixtures/tooling is determined in the design process.

**Metrics**: Progress is tracked by project manager in Work Breakdown Structure and rolled up into a program status. The complexity of the equipment determines the need for individual equipment measures.

**Tools**: Standard project management tools utilized at an enterprise level. Tools are monitored for effectiveness and performance.

**Information**: Data is mostly standardized, assessed, and shared locally. Data stewards established locally.
TPM Implementation Prerequisites

Leadership must:
• Understand TPM implementation takes time
• Provide support during changes
• Be passionate about wanting improvement
• Empower the workforce to support the change

Organizational Infrastructure
• A dedicated TPM facilitator
• Flexible, cross-trainable maintenance personnel
• Flexible, cross-trainable operators
Implementation

5S / TPM Relationship

Standard Work
Policies and Procedures

5S
Sort
Set in order

TPM
Roles and Responsibilities
Problem Solving

Checklists
Shine
Standardize
Sustain
TPM Operator Checklist

Daily Operator PM

- 1. Check coolant level through clear Plexiglas
- 2. Check heat exchanger fans (strings should be moving)
- 3. Check servo drive fans (string should be moving)
- 4. Check heat exchanger air filter (change when dark)
- 5. Check servo drive air filter (change when dark)
- 6. Check lube reservoir (add when low)
- 7. Check main motor air filter (change when dark)
- 8. Check main motor cooling fan (string should move)
- 9. Check mist collector motor and air filter (change when dark)
- 10. Check bar feeder hydraulic motor air filter
- 11. Check bar feeder hydraulic oil level (add when low)
# TPM Audit

## TOTAL PRODUCTIVE MAINTENANCE AUDIT

<table>
<thead>
<tr>
<th>Audit No.</th>
<th>Audit Date</th>
<th>Department</th>
<th>Scope of Audit</th>
<th>Auditor(s)</th>
<th>Lead By:</th>
<th>Team:</th>
<th>Method of Audit</th>
<th>Reference Standards</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Type of Audit</th>
<th>Audit Start - Date / Time</th>
<th>Audit End - Date / Time</th>
<th>Schedule Ref. Document</th>
<th>Other Ref. Documents</th>
</tr>
</thead>
</table>

### Audit Checklist

<table>
<thead>
<tr>
<th>A. TPM - Objectives</th>
<th># Checklist Points</th>
<th>Observation</th>
<th>Status</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>B. TPM - Organization / Operation</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>C. TPM - Training</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>D. TPM - Machinery / Equipment / Devices - Maintenance &amp; Production Costing</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>E. TPM - Safety and Assessment</th>
</tr>
</thead>
</table>

### Audit Conclusion: | Auditor(s) - Sign. | Auditor(s) - Sign. |
|---------------------|---------------------|---------------------|
TPM Improvement Measurements

• A way to monitor and improve the efficiency of your manufacturing process by quantifying how well a manufacturing unit performs relative to its designed capacity, during periods when it is scheduled to run

• OEE = Availability % x Performance % x Quality %

\[ \text{A} \times \text{P} \times \text{Q} = \text{OEE} \]
Components of OEE

Equipment **Availability (EA)**

- The portion of the OEE Metric represents the percentage of scheduled time that the operation is available to operate. Often referred to as uptime
  - EA = Run Time/ Planned Production Time
  - EA = 90%

### Example:

**Planned Production Time:**
- Shift Length - Breaks
  - 480 min - 60 min = 420 min

**Run Time:**
- Planned Production Time - Stop Time
  - 420 min - 47 min = 373 min

**Equipment Availability**
- Run Time / Planned Production Time
  - 373 minutes / 420 minutes = 0.8881 (88.81%)
Components of OEE

Equipment Efficiency **Performance** (EEP):

- Performance = the percentage of total parts produced to the designed production rate of the operation
- EEP = (Ideal Cycle Time x Total count) / Run Time
- EEP = 95%

Example:

<table>
<thead>
<tr>
<th>Item</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift Length</td>
<td>8 hours (480 minutes)</td>
</tr>
<tr>
<td>Breaks</td>
<td>(2) 15 minute and (1) 30 minute</td>
</tr>
<tr>
<td>Down Time</td>
<td>47 minutes</td>
</tr>
<tr>
<td>Ideal Cycle Time</td>
<td>1.0 seconds</td>
</tr>
<tr>
<td>Total Count</td>
<td>19,271 widgets</td>
</tr>
<tr>
<td>Reject Count</td>
<td>423 widgets</td>
</tr>
</tbody>
</table>

Example: **Performance**

\[
\text{Performance} = \frac{(\text{Ideal Cycle time} \times \text{Total Count})}{\text{Run Time}}
\]

\[
\begin{align*}
\text{Example: Performance} & = \frac{(1.0 \text{ seconds} \times 19271 \text{ widgets})}{(373 \text{ min} \times 60 \text{ sec})} \\
& = .8611 \times 100 \% \\
& = 86.11\%
\end{align*}
\]
Components of OEE

Equipment **Quality** Performance (EQP)

- Portion of good units produced as a percentage of the total units started
- EQP = # of Good Pieces / total # produced
- EQP = 99%

<table>
<thead>
<tr>
<th>Item</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift Length</td>
<td>8 hours (480 minutes)</td>
</tr>
<tr>
<td>Breaks</td>
<td>(2) 15 minute and (1) 30 minute</td>
</tr>
<tr>
<td>Down Time</td>
<td>47 minutes</td>
</tr>
<tr>
<td>Ideal Cycle Time</td>
<td>1.0 seconds</td>
</tr>
<tr>
<td>Total Count</td>
<td>19,271 widgets</td>
</tr>
<tr>
<td>Reject Count</td>
<td>423 widgets</td>
</tr>
</tbody>
</table>

Example: Quality

Good Count / Total Count
18,848 widgets / 19,271 widgets = .9780 (97.80%)
TPM Improvement Measurements

- **Overall Equipment Effectiveness (OEE) is the product of these measurements:**
  - Equipment Availability (EA)
  - Equipment Efficiency Performance (EEP)
  - Equipment Quality Performance (EQP)
  - \( \text{OEE} = 85\% \)
  - \( \text{OEE} = (\text{EA}) \times (\text{EEP}) \times (\text{EQP}) \)

- **Example:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shift Length</td>
<td>8 hours (480 minutes)</td>
</tr>
<tr>
<td>Breaks</td>
<td>(2) 15 minute and (1) 30 minute</td>
</tr>
<tr>
<td>Down Time</td>
<td>47 minutes</td>
</tr>
<tr>
<td>Ideal Cycle Time</td>
<td>1.0 seconds</td>
</tr>
<tr>
<td>Total Count</td>
<td>19,271 widgets</td>
</tr>
<tr>
<td>Reject Count</td>
<td>423 widgets</td>
</tr>
</tbody>
</table>

\[ \text{OEE} = 0.8881 \times 0.8611 \times 0.9780 = 0.7479 (74.79\%) \]