

WORLD-CLASS OUTSTANDING INTERNATIONAL  
PROGRAM | EXHIBITION | NETWORKING

# Maintenance Philosophy

John P. Joseph II

Rotating Equipment Systems Technical Associates, LLC



42<sup>nd</sup> Turbomachinery  
29<sup>th</sup> Pump SYMPOSIA



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# Goal

- Develop a Maintenance Program that will Assure:
  - Safety of Personnel and Equipment
  - Environmental Compliance
  - Long Term Business Profit for Share Holders

# Path

- Proper and Clear Operating Plans and Procedures
- A Supportive Maintenance Plan
- Thorough Risk Assessments and Safety Plan based on Risk Mitigation to an Acceptable Level
- Containment and Control to Meet Environmental Acceptance Levels
- Profit = Income (Revenue) – (Fixed Costs + Variable Costs + Annual Capital Expenditure)

# Terms

- $\text{Income (Revenue)} = \text{Oil or Product Sales} + \text{Gas Sales}$
- $\text{Fixed Costs} = \text{People} + \text{Parts and Storage} + \text{Platform or Facility Support} + \text{Transportation} + \text{Project Support Overhead and Personnel}$
- $\text{Variable Costs} = \text{Maintenance Activities} + \text{Maintenance Parts} + \text{Chemicals} + \text{Contract Support} + \text{Vendor Support} + \text{Project Activities}$
- $\text{Annual Capital Costs} = \text{Yearly Capital Improvement or Expansion Program Costs}$

# Incentives and Drivers for a Proper Maintenance Philosophy

- Every decision is an economic decision.
- What is the cost to mitigate risk versus paying for a safety or environmental event?
- What is the value of an incremental barrel per day of oil produced or product sold?
- What is the value of an incremental 1KSF per day of gas produced?
- What is the investment needed to achieve the incremental benefit?

# Presentation Methodology

- Description of the types of maintenance
- Concerns, impact, and consequences of each type of maintenance related to the events
- Methods of tracking and analyzing events
- Modification of conditions, processes, or equipment to positively impact attainment and maximization of goals

# Maintenance Philosophy

- There are four major classes of maintenance work activities.
  - Reactive or Breakdown Maintenance
  - Preventive Maintenance (PM)
  - Predictive Maintenance (PdM)
  - Pro-Active Maintenance (Pro-M)

# Reactive or Breakdown Maintenance

- Reactive or Breakdown Maintenance is performed to reinstate equipment that had operated up to expectations until a point in time when the equipment quit functioning.
  - No monitoring system was available or used to indicate degradation or imminent failure.
  - No process data was available or used to indicate degradation or imminent failure.
  - The component just quit functioning properly.

# Reactive or Breakdown Maintenance

- Reactive or Breakdown Maintenance Events
  - Concerns for this type of event are:
    - Unexpected loss of production and sales
    - Possible safety risks
    - Possible loss of containment

# Preventive Maintenance (PM)

- Preventive Maintenance (PM) is performed on a scheduled basis to confirm equipment is suitable to continue service.
  - Schedules are derived from OEM input or historical data
  - Generally, readings or findings are pass fail criteria, or activity is replacement of components
  - Time based check or replacement of parts or fluids
  - Life limited parts are replaced based on time in service

# Preventive Maintenance (PM)

- Concerns
  - Equipment may need to be taken offline.
  - Cost and schedule impact of PM can be substantial.
  - PM findings may require break down maintenance activity. (Inspection of coupling shim packs may reveal cracked or warped shims requiring shim pack replacement)

# Predictive Maintenance (PdM)

- Predictive Maintenance (PdM) diagnostics are performed to measure and monitor the rate of degradation of equipment, parts, or systems.
  - Degradation is suspected or known to be a part of the equipment's use.
  - Measurable parameters exist to quantify the rate of degradation.
  - Rates of change can be linear or non-linear.

# Predictive Maintenance (PdM)

- Concerns:
  - Diagnostic activities need to provide useable data.
  - PdM measurement data needs an economic cost component related to the loss of the performance due to degradation.
  - Cost and timing of overhauls need to coordinate with other unit equipment maintenance needs.
  - PdM scheduled maintenance activities need to be supported with parts and maintenance personnel at the scheduled time.

# Predictive Maintenance (PdM)

- The choice to improve the equipment in a facility can be approached from different directions.
  - Component Reliability Improvements
  - Unit Availability Improvements
  - Plant Deliverability Improvements
- Each maintenance improvement approach has application in a complex plant with multiple process systems.

# Tracking Maintenance Activities and Events

- Maintenance Management Systems – These systems are used to plan and schedule all types of maintenance activities, and to document the findings for future interrogation.
  - Computer Database Systems
    - Sophisticated software to plan, schedule, and document the activities.
    - Usually has “check the box” type data records keeping options. Needs ability to add text descriptions of findings.
  - Paper based systems
- Text based data needs to be added to either system to describe findings from each event.

# Tracking Reactive or Breakdown Maintenance Events

- Review the data
- Analysis of data to develop information
- Analysis of information to develop knowledge
- Analysis and review of knowledge to make decisions for improvement

# Tracking Preventive Maintenance Events

- Perform the scheduled event and log the activity and any findings.
- Analyze the condition found during the PM activity.
- Shorten the PM activity duration if conditions found are worse than expected.
- Lengthen the PM activity duration if conditions warrant to save costs.
- Replace PM activities with PdM diagnostics when degradation can be used to better schedule the maintenance activity. (oil condition monitoring rather than periodic oil changes)

# Tracking Predictive Maintenance Events

- Maintenance activities are scheduled to correct the state of degradation at an economical time with consideration for production, TAR plans, and risk.
- Analyze the diagnostic data for trend information.
- Analyze the trend information in conjunction with production efficiency to determine economical time to overhaul the equipment back to peak performance.
- Analyze the economic knowledge derived to decide the timing for corrective intervention.
- Confirm the overhaul intervention achieved the peak performance expected. This analysis will provide the baseline for future PdM measurement activities to establish rate of degradation.

# Improving Reactive or Breakdown Maintenance Impacts

- Improve process excursion limits and equipment component reliability improvements to reduce unexpected breakdowns.
- Evaluate component replacement costs to confirm component improvements are justified. (toaster)
- Consider system sparing philosophy when evaluating component improvement activities.
- If the Reactive Maintenance event repeats and costs are unacceptable, consider evaluating a PM or PdM method for intervention.

# Improving Preventive Maintenance Impacts

- Conditions found during a PM activity should be analyzed to determine duration to next PM activity cycle.
- Extend or reduce PM intervals based on the condition assessment at previous PM activities.
- Establish teams that perform plant wide PM's for the efficiency and cost savings.
- Evaluate where PdM diagnostic activities and analysis to schedule needed maintenance can replace scheduled PM's.

# Improving Predictive Maintenance Impacts

- Evaluate the PdM rates of change and intervention limits for suitability to the specific equipment. (ESMP's)
- Establish formal diagnostic procedures, protocols, and tools to achieve data accuracy.
- Establish calibration PM's for diagnostic tool data accuracy.
- Schedule the timing of the overhaul to get cost effective productivity from the equipment without risk of a catastrophic or costly failure.
- Establish procurement of replacement parts and scheduled service based on historical needs, and diagnostic data interrogation.
- Coordinate the scheduled overhauls with planned TAR's and when maintenance staffing is available.

# Pro-Active Maintenance (Pro-M)

- Pro-Active Maintenance (Pro-M) is performed to change the equipment or conditions with the goal of interrupting the repeated failures of a component or system, or to change the rate of degradation. Pro-M is applied to:
  - Repeat failures that reduce or stop production
  - Repeat failures that expend significant funds for reinstatement
  - Repeat failures with unknown timing that can affect Safety and Environmental Compliance

# Pro-Active Maintenance (Pro-M)

- Tools to use to rank Pro-M
  - Worst Actors List
  - Unspared Equipment Philosophy
  - Single Point of Failure Analysis
  - RCFA
  - Deliverability Models
  - Future Production Requirements
- Pro-M usually requires engineered changes to the design of components and systems.
- Pro-M also requires MOC review and risk mitigation.

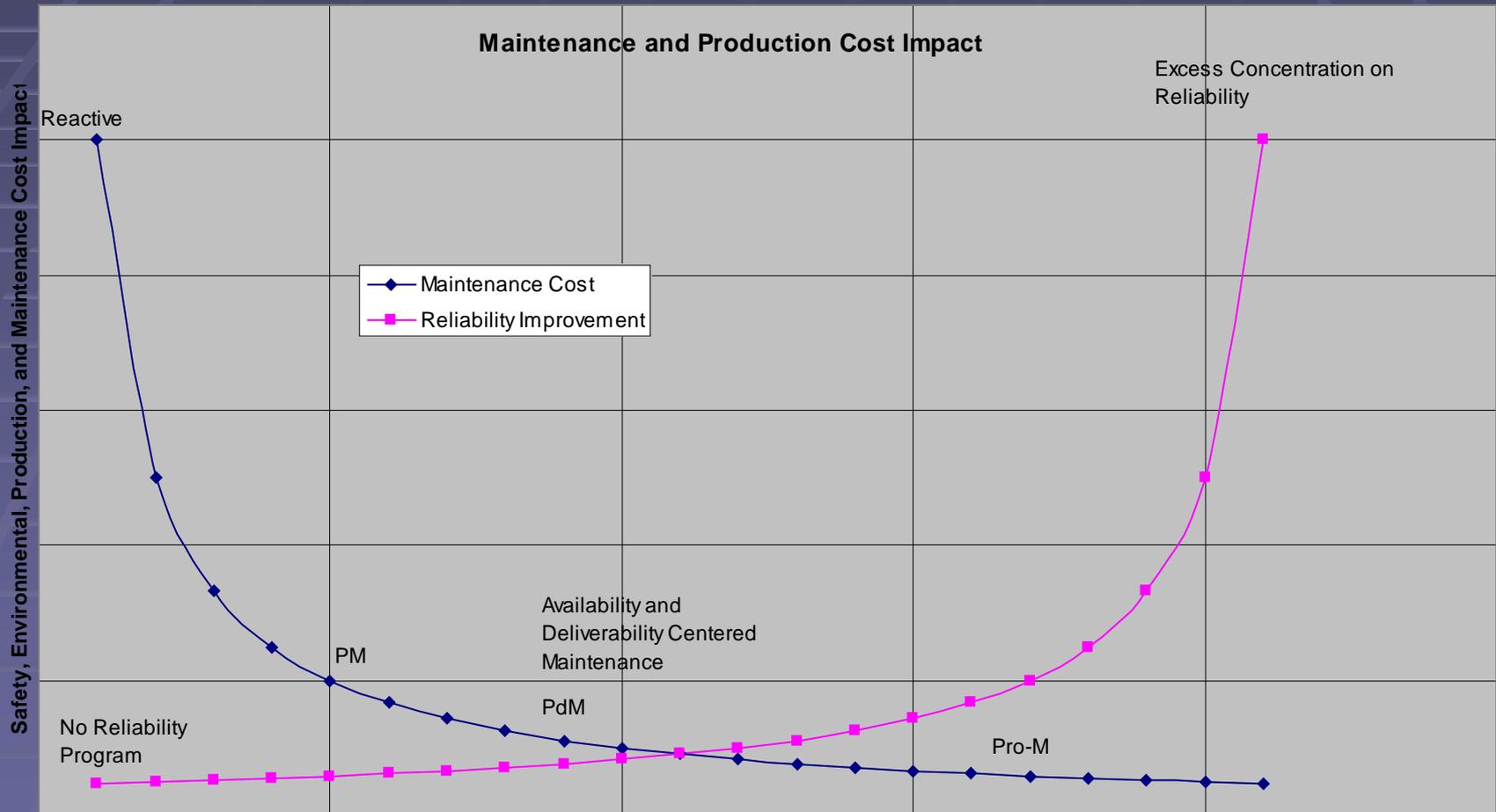
# Tracking Pro-Active Maintenance Events

- Predict the safety and environmental improvements expected from Pro-M activities and the risk to success, along with cost to implement compared to expected cost savings.
- Predict the operational improvements expected from Pro-M activities and the risk to success, along with cost to implement compared to expected cost savings.
- Compare historical intervention intervals and maintenance costs with the duration and costs after the Pro-M is performed.
- Confirm the Pro-M applied to a worst actor eliminates the equipment from the list.
- Reorder the ranking of the worst actors list after Pro-M activities remove a piece of equipment.

# Improving Pro-Active Maintenance Impacts

- Analyze the Pro-M effort on a plant wide and corporate wide basis to develop improvements to the methodology while publishing the successes.
  - Safety
  - Environmental
  - Profit

# Maintenance Philosophy Cost Impact



# Additional Areas of Savings

- Shared Equipment Philosophy
- Commonality of Design
- Spare Parts Philosophy
- Staffing Philosophy
- Procurement Programs with Preferred Vendors
- With all of these, the need exists to continually evaluate the cost benefit ratio with production losses included.

# The Beginning

Questions and Comments