
Thursday, August 8, 2019
1:00 - 3:00 PM ET
How to Participate Today

- Audio Modes
  - Listen using Mic & Speakers
  - Or, select “Use Telephone” and dial the conference (please remember long distance phone charges apply).
- Submit your questions using the Questions pane.
- A recording will be available for replay shortly after this webcast.

Today’s Moderator

Fred Edgecomb
Today’s Speakers

• Andy Page
  • Condition Monitoring: An Introduction to Reliability Concepts and Predictive Maintenance

• Tacoma Zach
  • Predictive Maintenance: Supporting Asset Management

• Theresa Bruton
  • Establishing a Foundation for PdM Technology: A Case Study

Allied Reliability

• Broad focus across a wide variety of machinery and end-markets
  • Over 1,400 benchmarked sites
  • 16 industry verticals
  • Combined 5,000 years of experience in maintenance and reliability
  • Led the Reliability Journey for over 400 clients, including 20 Fortune 500 companies

• Approximately 350 employees throughout North and South America

Andy Page, Ph.D.
Vice-President, Operations
Allied Reliability
Condition Monitoring
An Introduction to Reliability Concepts and Predictive Maintenance

Best Practice Behaviors
- Asset Health Management
- PdM / Condition Monitoring
- Lubrication Management
- Materials (MRO) Management
- Planning & Scheduling
- Vibration Coverage
- Less Preventive Maintenance

Best Practice Results
- 25% Reduction in Annual Maintenance Spend
- 20% Increase in OEE in 3 years
- 30% Reduction in Parts Inventory
- 9% Increase in OEE in 4 years
- 100% Increase in Productivity over 3 years
- Asset Utilization equivalent to adding an additional plant to the system

Best Practice firms score significantly higher in the execution of these key areas.

*Performance data represents a multitude of plants, across different industries and scopes of work.
Asset Health

- A metric showing the % of machines in the plant that are defect free
- True “leading indicator” of Maintenance Costs and Emergency Downtime

How Much PdM?
100% Coverage Model

<table>
<thead>
<tr>
<th>Equipment Type Versus Technology Application(s)</th>
<th>MECHANICAL</th>
<th>ELECTRICAL</th>
<th>STATIONARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chiller</td>
<td>XX X</td>
<td>XX</td>
<td>X</td>
</tr>
<tr>
<td>Centrifugal Pump</td>
<td>XX X</td>
<td>XX X</td>
<td>X</td>
</tr>
<tr>
<td>Air Compressor</td>
<td>XX X</td>
<td>XX X</td>
<td>X</td>
</tr>
<tr>
<td>Tank</td>
<td>X</td>
<td></td>
<td>X X</td>
</tr>
<tr>
<td>Evaporator</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
100% Theoretical Model

<table>
<thead>
<tr>
<th>Coverage by Technology</th>
<th>Vibration</th>
<th>Mech UE</th>
<th>Elect IR</th>
<th>MCA Offline</th>
<th>MCA Online</th>
<th>Oil Analysis</th>
<th>Mech IR</th>
<th>Elect UE</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% Theoretical</td>
<td>3.400</td>
<td>3.076</td>
<td>5.016</td>
<td>2.839</td>
<td>2.939</td>
<td>2.069</td>
<td>4.179</td>
<td>5.016</td>
</tr>
<tr>
<td>1st Quartile</td>
<td>2.720</td>
<td>2.158</td>
<td>4.815</td>
<td>1.470</td>
<td>1.470</td>
<td>1.492</td>
<td>2.925</td>
<td>4.815</td>
</tr>
<tr>
<td>2nd Quartile</td>
<td>2.312</td>
<td>1.603</td>
<td>4.364</td>
<td>1.176</td>
<td>1.176</td>
<td>1.000</td>
<td>2.298</td>
<td>4.364</td>
</tr>
<tr>
<td>3rd Quartile</td>
<td>1.530</td>
<td>1.077</td>
<td>3.862</td>
<td>0.882</td>
<td>0.882</td>
<td>0.717</td>
<td>1.463</td>
<td>3.862</td>
</tr>
<tr>
<td>4th Quartile</td>
<td>0.680</td>
<td>0.369</td>
<td>3.290</td>
<td>0.588</td>
<td>0.588</td>
<td>0.344</td>
<td>0.501</td>
<td>3.260</td>
</tr>
</tbody>
</table>

Mech = Mechanical  UE = Ultrasound  IR = Infrared Thermography  Elect = Electrical  MCA = Motor Circuit Analysis

Defect Severity

P-F Curve

Low                  High
Critical             Catastrophic Failure
Mechanically Loose   Auxiliaries Damage
Hard to Touch        Oil Analysis Detected
Aviable Noise        Fault Detection
Ultrasonic Energization Analysis
Failure Identified

Equipment Condition

Time

Precision              Predictive              Preventive              Run to Failure

Urgency

Failure Modes for Bearings

Bearing Failure Categories and Common Causes

Improper Installation
- Bad Shaft Fit
- Bad Housing Fit
- Improper Handling
- Hammer Rush
- Wrong Clearance
- Dropped Syndrome
- Wrong Type
- Wrong Place
- Cage/Seal Damage

Inadequate Lubrication
- Wrong Type
- Too Little
- Too Much
- Wrong Relube Frequency

Operating Conditions
- Misalignment
- Imbalance
- Belt Tension
- Overload
- Overspeed

Adverse Environment
- Improper Seals
- External Vibration
- Electrical Current
- Contaminants
Root Causes of Bearing Failure

Vibration Analysis Failure Modes and Technologies
Airborne/Structure-borne Ultrasound Failure Modes and Technologies

Oil Analysis Failure Modes and Technologies
Motor Circuit Analysis Failure Modes and Technologies

Motor Circuit Analysis Failure Modes and Technologies
Secret to Reliability

• Early Identification and Early Elimination of Machinery Defects
  ▪ For the applicable failure modes...no inspection method is more effective than PdM

Uses of PdM

• Enhance failure modes analysis
• Enable development of Equipment Maintenance Plans
• Enhances Root Cause Analysis
• Drives Maintenance Planning by means of identification of known defects
Tacoma Zach, P.Eng.

- President of Uberlytics
- Experts and Innovators in
  - Risk Based Decision Support and Criticality Analysis
  - ISO55000
  - Asset Management
- Senior Fellow of the Asset Leadership Network and Training Provider Co.
- Institute of Asset Management Certified Training Provider Co.
- Formerly Area Manager and Vice President with Veolia with P&L West
- BASc. & MASc. in Chemical Engineering University of Toronto
- P.Eng. Canada

Predictive Maintenance: Supporting Asset Management
Guided by Criticality & Failure Modes
Valhalla

- Everyone’s Budget is unlimited
- Everything is equally critical, no need to prioritize
- Everything fails the same way, one size fits all
There is way to really FOCUS the resources to pick the right PdM

Deals with efficient: Budget, Focus, Tactical

4 Pillars of Asset Management

Derive maximum value from assets

Lowest Spend for LOS

Risk Based decisions

LOS Assurance

Have corporate line of sight to the field level

Alignment (often misunderstood)

Have executive support and sponsorship

Leadership
Means...

• Discover When & Where Your Mission is at Risk
  • What impacts your Level of Service, and how badly

• Manage Assets Appropriately
  • Based on Criticality and Risk
  • Correct Asset Strategy per asset
  • R.R.R.R.

• Minimum spend to maintain LOS
  • Maintain/refurbish/replace

MENTORAPM PLAYBOOK

A Plan for Managing Assets within Asset Management

Asset Management is doing the right things, in the right order, for the right reasons, to get the right results.

This pyramid shows an outline of activities in a sequence that drives you toward the aim of service, asset and fiscal sustainability.

To begin, you need to understand why you exist.

Figure out What is most important

Select the right Asset Strategy for each asset
Corporate Line of Sight

Executive
Strategic Direction

Establish Mission & Objectives
Why

Identify Values
How

Specify Overall Level of Service
Macro Asset Portfolio Plant Network

Specify Systems Level of Service
Asset Portfolio Systems that collectively support the mission

Select Appropriate Asset Strategies

Uberlytics’ Criticality Analysis uses these to align Focus

Field Level
Tactical Execution

Little about Criticality and How to do it “Smart”
Criticality vs Risk: there’s a difference

- **Criticality**: “Is a measure of the relative importance of something, usually a tangible system or asset, to the corporate mission, objectives and values of the organization”, (incl. minimum acceptable Level of Service (LOS))
- **Risk**: The likelihood of an event X the criticality of the event.

How most people approach it... asset by asset
The Most Useful Level of Focus for Entire Asset Portfolio

Too Coarse a View
Asset Level too Granular

...Forest for the Trees
Rather

Functional Systems: LACSD RAS

Relate SYSTEM to:
Mission
All Values
- otherwise incomplete
Functional System Criticality

Only critical systems have critical assets
A little about ‘Order of Operation’ to save Budget

EPA 10 Steps Asset Management Plan: Make it More efficient ($)

- System Layout: Data Hierarchy, Data Standards, Data Inventory
- Condition Assessment Protocol, Rating Methodologies
- Expected Life Tables, Decay Curves
- Valuation, Life Cycle Costing
- Demand Analysis, Balanced Scorecard, Performance Metrics
- Inventory Assets
- Assess Condition
- Determine Residual Life
- Determine Replacement $ & Date
- Set Target LOS
- Assign BRC Rating (Criticality)
- Determine Appropriate Maintenance
- Determine Appropriate CIP
- Fund your Strategy
- Build the AMP
- Root Cause: RCM, PM, O&M
- Confidence Level Rating: Strategic Validation ORDM
- Renewal Annuity
- Asset Mgt Plan, Policies & Strategy, Annual Budget

FSBCA
“ARE WE THERE YET?”

Not Just Yet...
• Factors to Consider

• Cost of Failure
• Cost of Consequential Failure
• Impact of Down-time
• Impact on LOS
• Resiliency of the System
• Others...
Critical Part: Gas Conditioning
If it’s Critical, & Worth it...

- Condition Monitoring to detect early enough
  - Tailor to FM
  - Consider first the symptoms as direct result of
    the FM,
    Then indirect or secondary symptoms; as there might be
    from another FM

- Adjust PMs to catch early enough to
  minimize overall cost, and reduce Risk to
  LOS
Keep Your End Goal in Mind

AM Pillars:
- Make Risk Based Decisions
- Extract Max Value from your Assets
- Get Line of Sight and Alignment: everyone working on the right things: Define Your Mission, Values and LOS

Summarize

- Functional System CA First: brings focus
- Execute with Focus: @ risk, develop the correct strategy for each asset
Thank You

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DC Water – Blue Plains WWTP

• Asset Management and Reliability Group
  • CMMS Business Practice
  • CMMS Analysis and Metrics
  • RCM Workshops
  • Oil Analysis
  • Ultrasound lubrication and Analysis
  • Vibration Analysis

Theresa Bruton, PE, CMRP, CRL, MLT 1
Asset Manager, Blue Plains WWTP
DC Water

dc water is life®
Establishing a Foundation for PdM Technology: Case Study
Blue Plains Advanced Wastewater Treatment Plant
Background Information

- The largest Advanced Wastewater Treatment Plant (AWTP) in the world
- Design capacity of 555 mgd (4 hours) then 511 mgd. Separate wet weather plant 225 mgd
- Effluent TN 3.74 mg/L (load based) and TP 0.17 mg/L (rolling 12 month avg)
- Services 2.2 million people
- Occupies about 150 acres
- 5,000 rotating equipment and 36,000 assets

Reliability Journey: How to Start

DC Water Reliability Journey from 2004 to Today.

Start with building a good foundation

- Need a strong foundation before beginning PdM program
- Remove non-value added tasks
Building a Foundation -

- Asset Registry
- Roles and Responsibility flowchart and RASCI
- Work Execution Data Used For:
  - Planning and scheduling
  - Reliability metrics (MTTR, MTTF, bad actors etc)
  - Risk and CIP planning
  - Auditing
  - MOC documentation

Building a Foundation: Timeframe

- 2004 - Started using Maximo for work execution. Location based system
- 2005 - Started creating PMs for inspection
- 2010 - Hired EMA to coach, audit and improve Maximo. Changed to asset based approach and started using workflow
- 2013 - Hired Planners
- 2014 - Good data entered for work orders, labor, material and services
2016 Driver for Change

Building on the Foundation

- Education
- Level of Service
- Risk
- PMO
- RCM
- Work execution - continuous improvement
- PdM Program
Education/Training/Communication

- Education
  - Authority wide effort to set base understanding
  - Uptime elements (280 users; 260 finished)

- Training
  - Work Execution
  - Predictive Technologies
  - RCM Fundamentals

- Communication
  - Operations
  - Procurement
  - Engineering
  - Finance
  - Safety
  - Facilities

Minimum Level of Service (LOS)
Risk (LOF vs COF)

- **2016** - Original COF and LOF based on tribal knowledge. Updated annually

- **2019** - Generate LOF from Maximo data
  - Proof of Concept: Convert wkly LOS and MTTF
Preventative Maintenance Optimization (PMO)

- Why Improve PMs?
  - In 2017 36% of the labor was performing PMs but only generated 7% of the CM labor, i.e. not value added
  - Duplicates had built up over time due to various projects, and some tasks did not reflect O&M changes
- CMMS Based Review
  - Removed duplicate PMs, non-value added tasks, checked consistency, and revised PM frequencies
  - Reviewed 2500 PMs on 7000 assets over 8 months
  - Modifications to over 1000 PMs or Job Plans
- Reduced the annual estimated CMMS PM labor by 58,000 hours. Potential savings of $2M. Allows better PM calendar loading. The actual PM labor was reduced from 36% to 23% with the same CM generation.
- Use RCM to replace remaining tasks with value added tasks

FMEA -> RCM

- An FMEA is a structured approach to identify failures within a system and the consequences of those failures.
  - Relies on input from trade technicians and operations staff to develop the why and how systems fail
- Done only on critical systems
Work Execution Improvements

- Coaching Users and Training
- 2019 - Scheduler
- 2019 - Mobile CMMS

Predictive Technology Program

- Oil Analysis
- Vibration
- Ultrasound Lubrication
- Thermography
Oil Analysis

- 294 units covered
- 80% of the volume of oil but only 20% of the equipment that has oil
- Significantly reduce time based oil changes
- Lubricant consolidation project 100 to 7 lubricants

Vibration Analysis

- 291 units covered
- Outside contractor analyzes the data
- Trending over time catches failures early
Ultrasound Lubrication

- 157 units covered and increasing
- Applied to rolling element bearings

Thermography

**THERMOGRAPHIC REPORT**

DC WATER/ BLUEPLAINS
5000 OVERLOOK AVE. SE
WASHINGTON D.C. 20032

**Problem Description:**
The left contactor which is #1 Sump Pump has a temperature gradient on its “C” phase indicating a possible loose connection at that specific connection point. Other possibilities could be bad wiring or windings on that phase.

**Thermograph**

<table>
<thead>
<tr>
<th>Problem Description</th>
<th>Thermograph</th>
<th>Temperature Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>The left contactor</td>
<td><img src="image" alt="Thermograph Image" /></td>
<td><strong>Emissivity:</strong> 0.95</td>
</tr>
<tr>
<td>which is #1 Sump</td>
<td></td>
<td><strong>Object Distance:</strong> 3.3 ft</td>
</tr>
<tr>
<td>Pump has a temperature</td>
<td></td>
<td><strong>Reflected Temp.:</strong> 68.0°F</td>
</tr>
<tr>
<td>gradient on its “C”</td>
<td></td>
<td><strong>Atmospheric Temp.:</strong> 68.0°F</td>
</tr>
<tr>
<td>phase indicating a</td>
<td></td>
<td><strong>Relative Humidity:</strong> 50.0 %</td>
</tr>
<tr>
<td>possible loose</td>
<td></td>
<td><strong>Sp1 Temperature:</strong> 71.9°F</td>
</tr>
<tr>
<td>connection at that</td>
<td></td>
<td><strong>Sp2 Temperature:</strong> 83.6°F</td>
</tr>
<tr>
<td>specific connection</td>
<td></td>
<td><strong>DT1 Delta T:</strong> -11.7°F</td>
</tr>
<tr>
<td>point. Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>possibilities could</td>
<td></td>
<td></td>
</tr>
<tr>
<td>be bad wiring</td>
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<tr>
<td>or windings on that</td>
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<tr>
<td>phase.</td>
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</tr>
</tbody>
</table>
Conclusions

- Patience - It takes time
- A good asset registry and risk values helps determine the PdM technologies and resources needed
- Budgets are shrinking and reliability is becoming a life line.
- Removing non-value added tasks is key

Questions?