1

Predictive Maintenance Part Two: The Application of Condition Monitoring

Thursday October 10, 2019
1:00 – 3:00 PM ET

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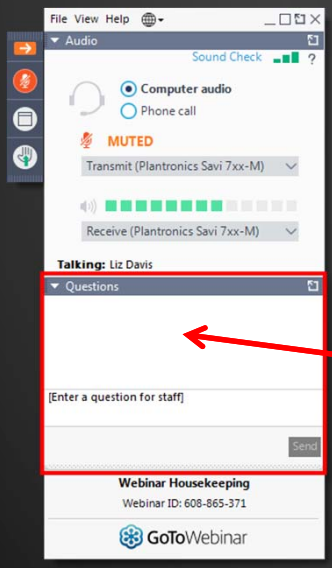
How to Participate Today



- **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.**

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Today's Speakers

- Fred Edgecomb *(moderator)*
- Matt Blaschke, Allied Reliability
  - Condition Monitoring – Predictive Maintenance Technologies
- Eric Stevens, MSDGC
  - Asset Condition Monitoring at MSDGC

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Our Next Speaker

Matt Blaschke, CMRP, CRL
CBM Professional, Trainer
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

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Condition Monitoring

Predictive Maintenance Technologies

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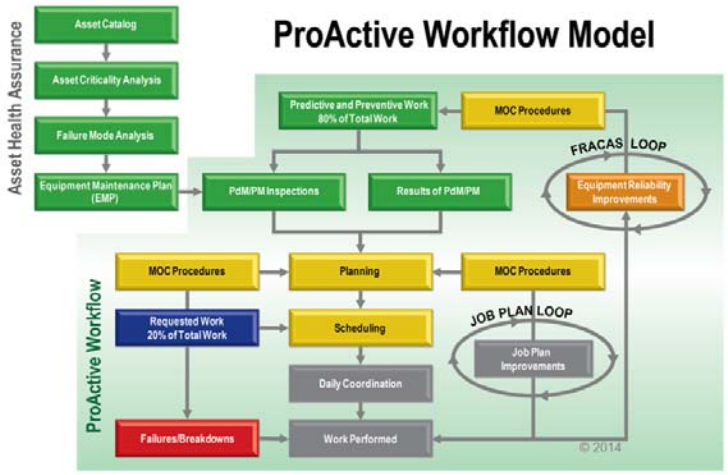
ProActive Workflow Model



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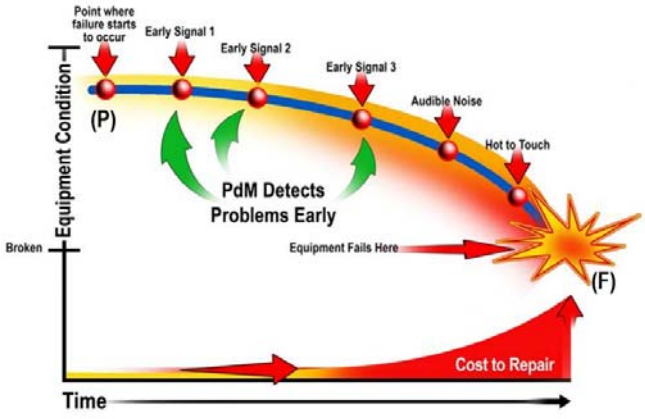
How PdM Works - Early Identification of Defects



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Asset Health

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

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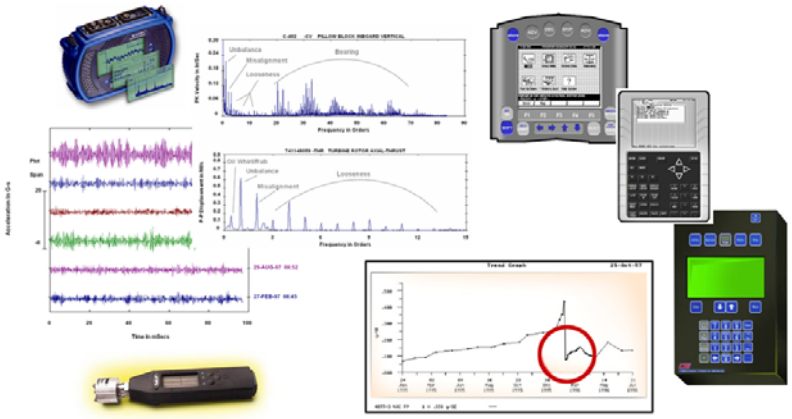
Vibration Analysis Failure Modes and Technologies



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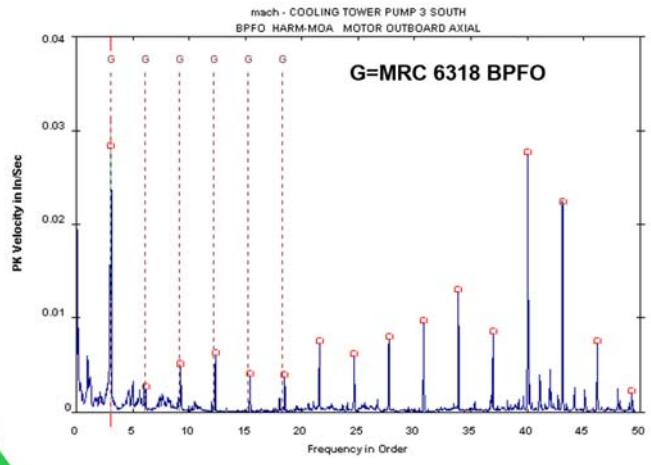
Bearing Defect Frequencies



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Vibration Analysis Common Traps

- Try to use vibration analysis to predict actual life of mechanical drive train
- Use of overall measurements as primary defect indicator
- No comprehension of the difference in low-frequency and high-frequency energy
- No detailed fault frequency information
- Poor follow up with craft skills and operators about machinery repairs and operating characteristics

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Airborne/Structure-borne Ultrasound Failure Modes and Technologies

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Types of Tools

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Ultrasound Failure Mode Effects Detected

- Leaks in pressure / vacuum boundaries (turbulence)
  - Compressed gas systems (air, oxygen, hydrogen, etc.)
  - Heat exchangers
  - Boilers and condensers
  - Tanks and pipes
  - Valves and steam traps
  - Autoclaves and forms

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Ultrasound Failure Mode Effects Detected, cont'd

- Arcing, tracking and corona within electrical assets/components switchgear
  - Transformers
  - Insulators
  - Potheads
  - Junction boxes
  - Circuit breakers
  - Overhead Splices
  - Switchgear
  - Starters
  - VFDs
  - >1000V Motors
  - Disconnect Switches

Scanning module 40 kHz
Contact module 25 kHz

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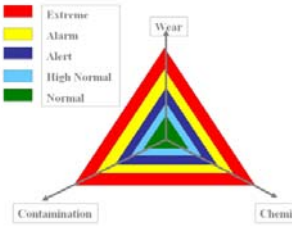
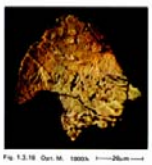
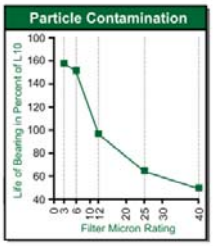
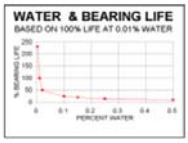
Oil Analysis Failure Modes and Technologies









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Oil Conditions and Chemistry Tests

	Viscosity	Dielectric Strength	TAN	TBN	FTIR	Spectroscopy
Mixed Different Oils	X	X				
Oxidation	X		X		X	
Sulfation					X	
Nitration					X	
Additive Depletion	X	X		X	X	X
Water	X	X	X		X	
Fuel	X	X			X	
Glycol	X	X			X	

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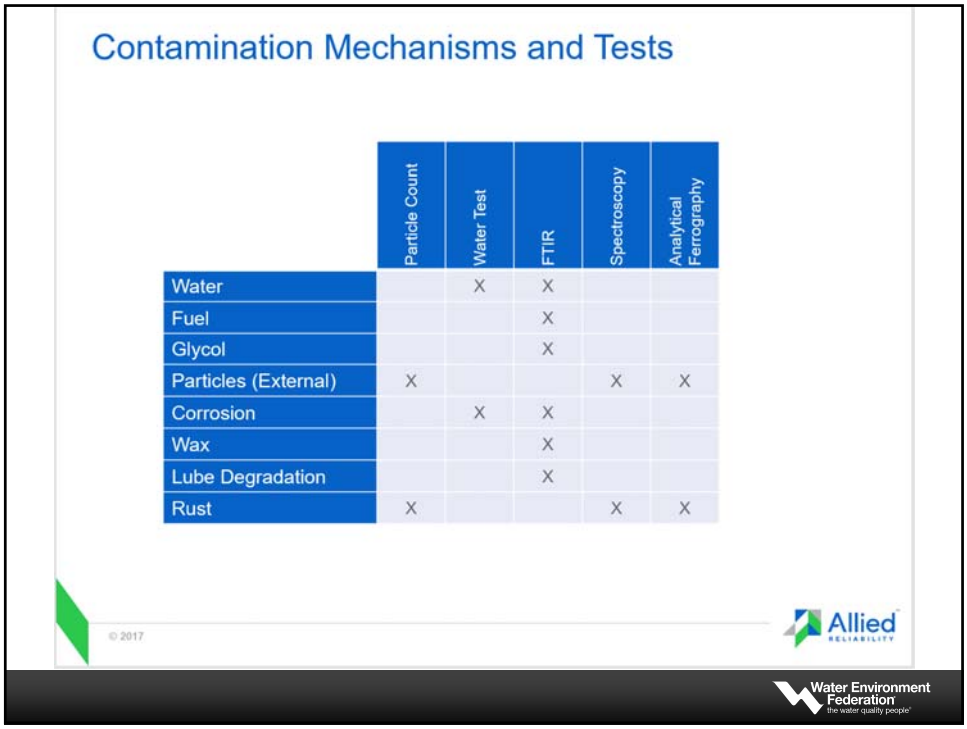
Contamination Mechanisms and Tests
Particle Count
Water Test
FTIR
Spectroscopy
Analytical Ferrography
Water
Fuel
Glycol
Particles (External)
Corrosion
Wax
Lube Degradation
Rust
X
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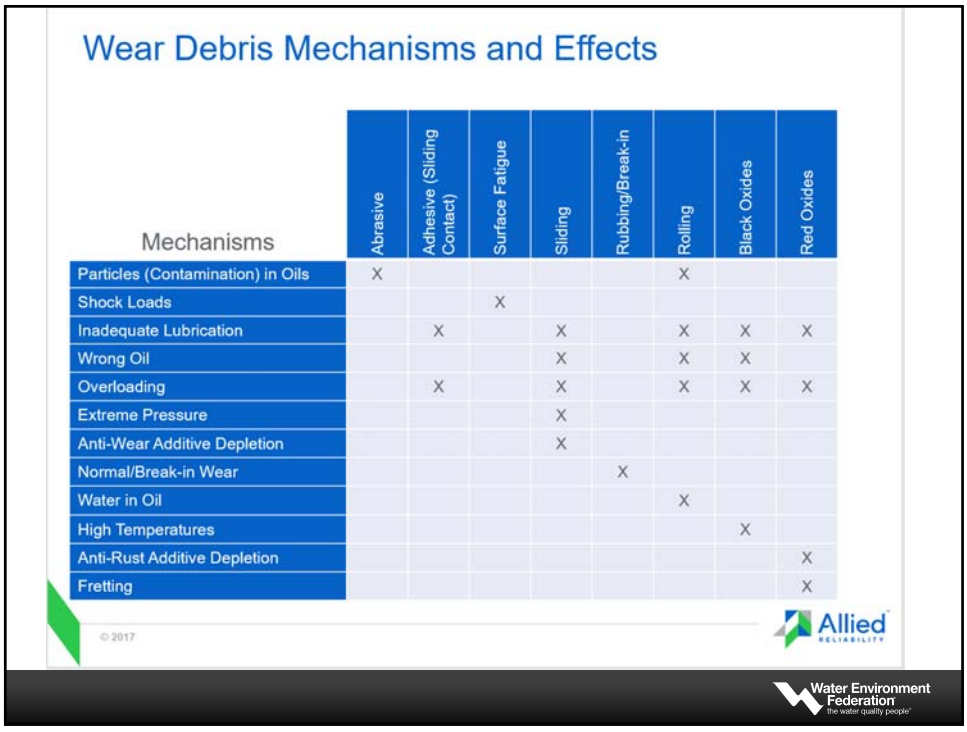
Wear Debris Mechanisms and Effects
Mechanisms
Abrasive
Adhesive (Sliding Contact)
Surface Fatigue
Sliding
Rubbing/Break-in
Rolling
Black Oxides
Red Oxides
Particles (Contamination) in Oils
Shock Loads
Inadequate Lubrication
Wrong Oil
Overloading
Extreme Pressure
Anti-Wear Additive Depletion
Normal/Break-in Wear
Water in Oil
High Temperatures
Anti-Rust Additive Depletion
Fretting
X
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Oil Analysis Common Traps

- Expecting results the oil program was not designed to deliver
- No understanding of the limitations of each testing technique
- Only sampling on an “as needed” basis
- Extended time interval between sampling and analysis
- Lack of understanding how poor management of chemistry impacts wear
- Lack of understanding how poor management of contamination impacts wear
- Blind faith in quality of lubricant from supplier

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Infrared Thermography Applications

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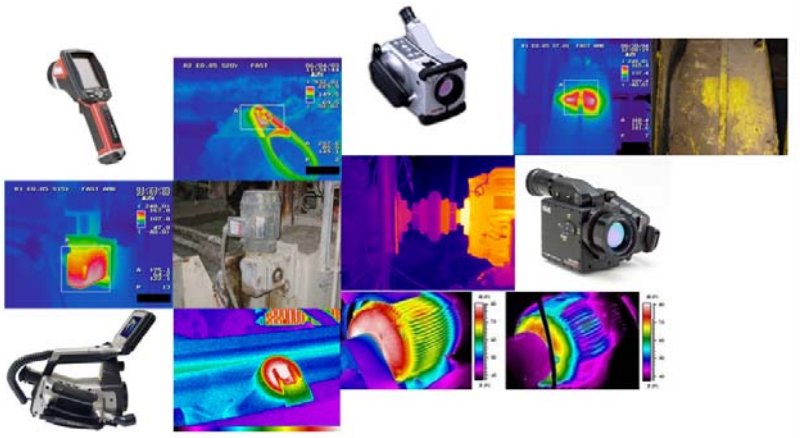
Infrared Thermography Failure Modes and Technologies



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Thermography Failure Mode Effects Detected

- Mechanical Part / Component
  - Motors
  - Bearings
  - Belts
  - Mechanical Seals
  - Rollers / Conveyors
  - Gearboxes
  - Dryers
  - Boilers
  - Tanks
  - Steam Traps
  - Buildings

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Thermography Failure Mode Effects Detected

- Electrical Part / Component
  - Utility Feeds
  - Transformers
  - Switchgear
  - Bus
  - MCC
  - Disconnects
  - Fuses
- Low Voltage Applications

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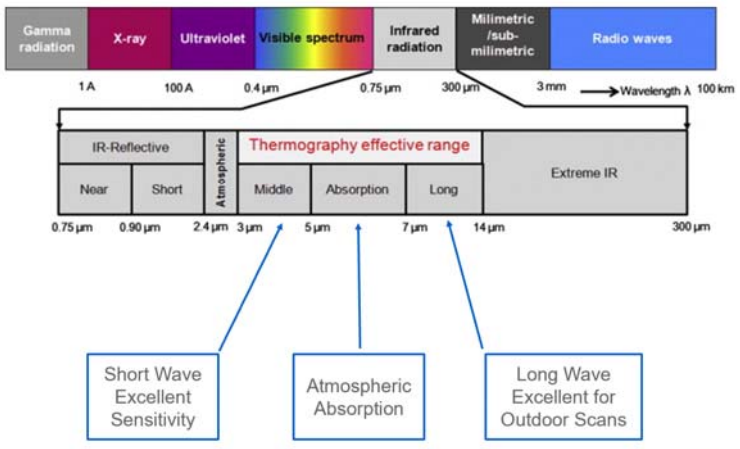
Electromagnetic Spectrum



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Infrared Thermography Common Traps

- A general lack of understanding of basic IR camera parameters like emissivity, spot size, focus, range
- Lack of equipment familiarity: do not know what should be hot and what is *normal*, fluid levels, bearing types, etc.
- Not comparing "like" equipment or even "like" components
- Not understanding the plant processes or parameters – at certain times/conditions, does this machine run hot?

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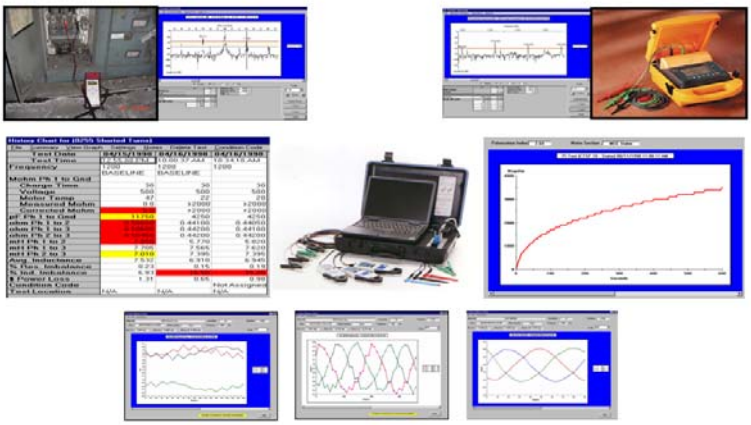
Motor Circuit Analysis Failure Modes and Technologies



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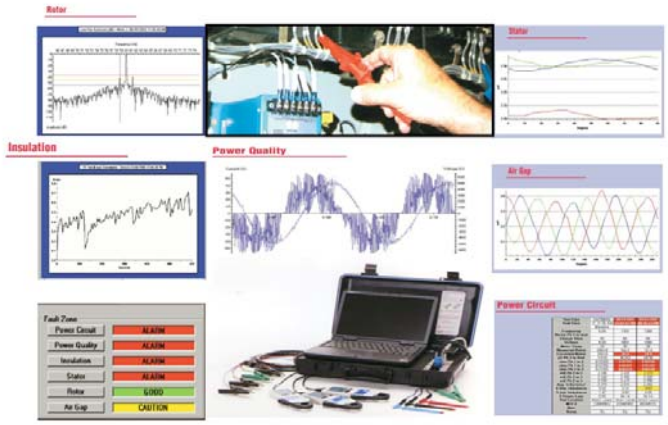
Motor Circuit Analysis Failure Modes and Technologies



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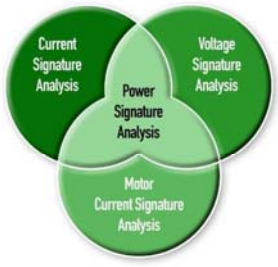
Motor Circuit Analysis Online Identifiable Faults

- Imbalance
- Shaft Misalignment
- Soft-foot / Twisted Frame
- Air Gap Eccentricity
- Bearing Fault
- Sheave and V-Belt Problems
- Gear Problems
- Mechanical Overload
- Pump Problems



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Motor Circuit Analysis Offline Identifiable Faults

- Phase Resistance and Imbalance
  - Stator and Circuit faults
- Phase Inductance and Imbalance
  - Stator, Circuit, and Rotor faults
- Capacitance to Ground
  - Insulation and Grounding faults
- Resistance to Ground
  - Insulation and Circuit faults
- Phase Angle
  - Winding faults

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Motor Testing Common Traps

- Improper analysis of data from lightly loaded motors.
- Ensure shaft is not turning during test.
- Capacitors, VFD, and surge arrestors not disconnected from circuit prior to testing.
- Failing to break connections to identify location of fault.
- Bypassing temperature reading of motor.
- Focusing too much on Polarization Index number rather than the shape of the graph.

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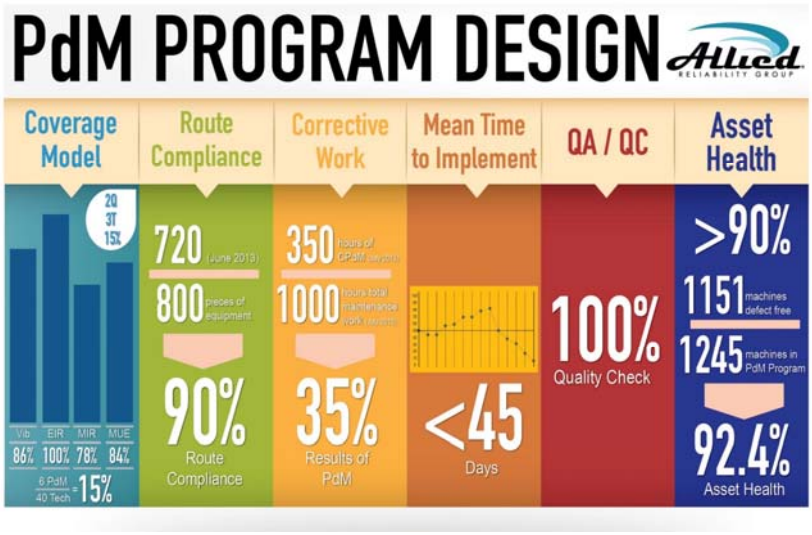

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Eric Stevens

METROPOLITAN SEWER DISTRICT of greater CINCINNATI

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Asset Condition Monitoring at MSDGC

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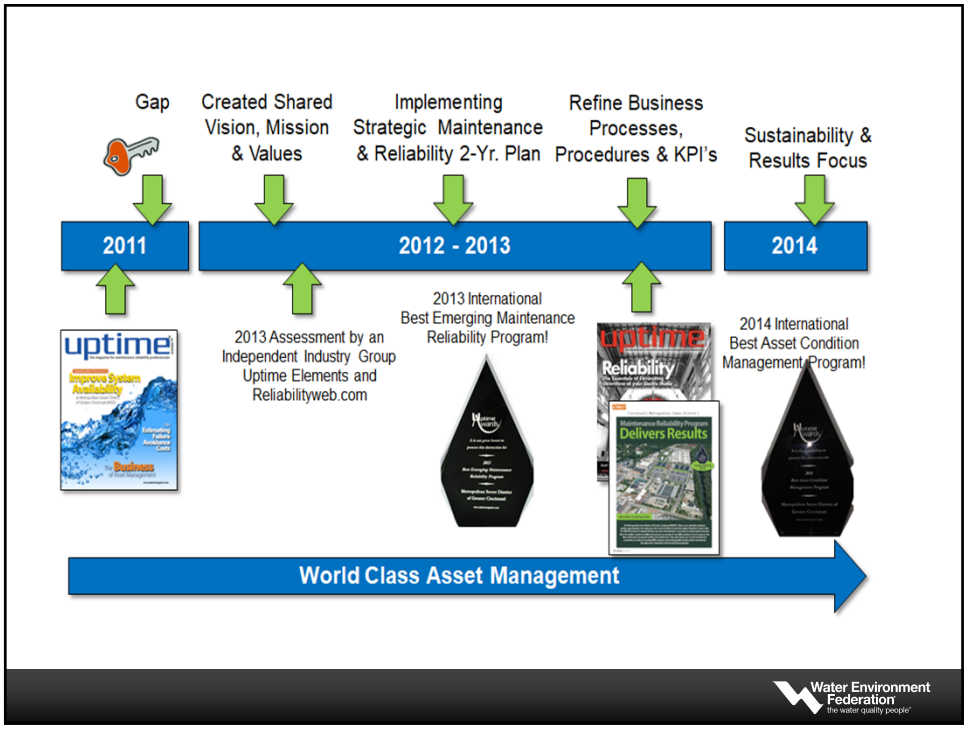

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Desired Maintenance and Reliability Outcomes

- Increase Proactive Maintenance
- Shift from reactive to a more proactive culture
- Improve System Availability/Reliability
- Avoid forced outages
- Reduce Downtime
- Develop internal predictive maintenance skills
- Improve planning and scheduling process
- Improve Safety
- Reduce Reactive Maintenance Cost

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Asset Condition Monitoring

- **5-Year PdM Master Plan**
  - 2-Day Workshop (O&M Staff)
  - Supported by Subject Matter Expert
- **Centralized** - Predictive Maintenance team
  - Focused on Analysis and Correlation
  - Focused on High-Tech Predictive tools
- **Decentralized** – Predictive Maintenance
  - Focused on Lower-Tech Predictive tools
  - Post Maintenance Testing, Follow-up Repairs
- **Benefits:**
  - Reduce Life Cycle Cost
  - Reduce Downtime
  - Longer Usable Asset Life

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Multi- Tiered ACM/ PdM Program

- Concept developed when MSD Decided to enhance our PdM programs performance
  - Right PdM technologies already being Employed
    - Vibration and Infra-red by contractor
    - Ultrasonic analysis, off-line, on-line motor circuit analysis internally but decentralized.
    - Lubrication & wear particle analysis with commercial lab support

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Conversion to an internal two-Tiered ACM/PdM Program

Done after assessment (including 2-day workshop)the following was determined that there were:

- Problems with the way the PdM services contract was managed, particularly for Post Maintenace testing.
- Problems with PdM data collection, feedback, follow-up and data correlation
- PDm technologies assigned to an in-house Maintenace personnel not being used to full potential

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ACM/Pdm Program related issues

- Rotating machinery alignment was limited to initial installation only
  - By machine shop or new installation contractors.
  - No in-service checks
  - Lubricant & wear particle analysis program was working well but was understaffed and not full equipped for best practices.

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Conversion to a two-tiered ACM/PdM Program

- **5-Year PdM Master Plan**
  - 2-Day Workshop (O&M Staff)
  - Supported by Subject Matter Expert
- **Centralized** - Predictive Maintenance team
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- **Benefits:**
  - Reduce Life Cycle Cost
  - Reduce Downtime
  - Longer Usable Asset Life

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Centralized ACM/PdM Team and Technologies

- Team Leader
- 4 –team members
- Collect and analyze data with state-of-the art technology tools & technology tools and software:
  - Vibration analysis
  - Infra Red Thermography
  - Ultrasonic Analysis
  - On-line and Off-line Motor Testing
- Lubricant and Wear particle analysis (Initially organized decentralized, eventually merged under PdM team leadership

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Centralized ACM/PdM Team and Technologies

- Assignment of technologies
  - Based on prior experience
  - Previously held PdM technology certification
- Expectations
  - Team Members become certified in more than one and up to three technologies eventually
- Progressive process (2-years or more)
  - Level 2 in Vibration and Infra red
  - Level 1 in Ultrasonic
  - Competency in others with no established certification schemes.

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Decentralized Tier of the ACM/PdM Program and Technologies

- Local Plant Maintenance Personnel
- Primary Function is equipment preventive and corrective maintenance
- Technologies employed
  - Vibration analysis with " green, Yellow, Red, Readouts"
  - Infra Red Thermography "guns" with Integrated visual imaging and digital data transfer capability
  - Ultrasonic testing with Db readout and digital data transfer capability
  - Laser alignment equipment for rotating equipment

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Decentralized Tier of the ACM/PdM Program and Technologies

- Decentralized crew tools
  - Empower maintenance crews to determine, with more data than their five senses, when equipment condition or performance is normal or abnormal
  - Some cases what defects are developing
- Post Maintenance testing (PMT)
  - Maintenance crews conduct PMT so equipment can be turned over promptly to operations for use.

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Laser Alignment Tools at the Local Maintenance crews

- Consistent with research findings at the University of Tennessee
  - Shows shaft coupling (offset) misalignment, even when well within manufacturer allowable specifications is detrimental
  - Major contributor to bearing life reduction and premature failure
- Objectives and goals for lser alignment technologies
  - Extend bearing and coupling life and overall asset Reliability
  - Reduce the number of bearing and coupling failures "finds" reported by the PdM team

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Outside support for ACM/PdM Program

- Advising (Subject matter Expert)
  - Planning, budgeting and progress monitoring
- Predictive Maintenance Management (reporting & Communications) Software PDMMS
- PdM Services Contractor
  - Acting initially (as before) conducting periodic condition monitoring with vibration and Infra red
  - PdM team member mentoring, training, and certification
- PdM hardware and software vendors for specific training

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Benefits of a two-Tiered Program

- Local Maintenance crew personnel are empowered and equipmed to declare an asset ready for return to operational service
- A PdM capability provides maintenance personnel with their own quality assurance tools
- There is a division of labor and responsibilities in employment of predictive technologies
- A Two Tiered approach relieves the PdM team of the need to perform this Post maintenance testing task under time constraints (and pressures) needed to return the asset to service as soon as possible.\
- PdM team specialists can train novice maintenance crew PdM practitioners on use of their easy to learn instruments

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Managing & Communicating ACM/PdM Program information

- Reasons why a dedicated web based PdM management (& communications) Software (PDMMS) may be needed:
  - Wide dispersal over the geographic area many actual and potential users
  - Cyber security concerns from IT departments about allowing access by outsiders through established fierwalls into interal networks
  - Other maintenance upgrade iniatives that are in progress
  - CMMS (Maximo) Upgrade
  - Planing and Scheduling
  - RCM & ECM analysis

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Find of the Week

- Communication Process
- Supports proactive culture
- Recognizes staff
- Highlights positive results


"Find of the Week" News

Offline Motor Circuit Analysis Identifies Pump Motor Deficiency


"Find of the Week" News

Infrared Thermography Identifies Electrical Faults In Pump Circuit

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Questions?

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52