Operations & Maintenance

Key Steps to Implementing a Robust Maintenance Program

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Agenda

- Define O&M
- Value of a Robust Maintenance Program
- Identify Criticality & Priorities
- Maintenance Philosophies (TPM/RCM/sRCM)
- Maintenance Strategies (PM/PdM/CM/RTF)
- Scheduling & Managing (CMMS)
- Assess & Analyze (KPIs)
- Q&A

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Operations & Maintenance

- Operations – The operating of systems in accordance with their purpose
  - Efficient use of resources
  - Cost-Effective
  - Productivity & Costs
  - Occupant Comfort - Production
  - Customer Perception

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Operations & Maintenance

- Maintenance – Keeping systems in adequate working order
  - Scheduled Maintenance
  - Emergencies & Repairs
  - Service Requests
  - Minimize Impact to Productivity
  - Mitigate Risks

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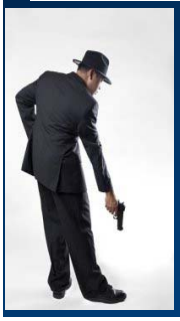
Our Own Worst Enemy



- Most maintenance organizations operate between 10% to 40% efficiency (MT-Online)
- Nearly 70% of failures are self-induced (MT-Online)
- Most spend >50% time on emergency work (FacilitiesNet)

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No More Firefighting

Cost of Reactive Maintenance

- RM Costs 3X to 5X more than PM (MT-Online)
- DOT Study found 8X higher costs
- Downtime/Business Loss
- Customer Satisfaction
- Employee Retention/Burn-Out
- Lost Productivity?

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Value of a Robust Program

- Increase Production by 28% (IFMA)
- Double Productivity of Staff (IFMA)
- Reduce Maintenance Costs by as much as 50% (Piper/FacilitiesNet)
- Reduce Energy Use by 15% - 20% (Piper/FacilitiesNet)

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What is a Robust Program?

- Equipment in CMMS
- Maintenance Scheduled
- Target PM/CM Ratio – 80/20
  - 90/10 for Critical Environments
- PM Completion % by Priority
- Maintenance Backlog
- Percent Staff Utilization
- Capital Replacement Program

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How do you measure up?

- Benchmarking Cost Data
  - O&M $/SF
  - Maintenance Staff/SF
  - Janitorial Staff/SF
  - Industry/Geography/Size
- Resources
  - IFMA's BEX
  - IFMA Store
  - Industry Specific (APPA, ASHE)

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Developing a Program - Overview

- Determine System Criticality
- Identify Maintenance Strategy
- Develop Job Plan & Frequency
- Identify who performs maintenance
- Schedule & Assign Maintenance
- Manage Performance
- Assess & Analyze
- Adjust & Improve

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Determine Criticality

- Understand Business & Priorities
  - Vision/Mission/Goals
  - Disaster Recovery & Business Continuity
- Identify Critical Systems
- Evaluate System Function & Components
  - Reliability Centered Maintenance (RCM)
    - Failure Modes & Effects Analysis (FMEA)

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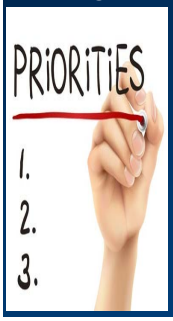
Assign Criticality



- Location
- System
- Equipment/Asset

Example

1) Life Safety / Regulatory
2) Direct Production
3) Indirect Production
4) Support

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Maintenance Philosophies - TPM

Total Productive Maintenance (TPM)

"A holistic approach to equipment maintenance that strives to achieve perfect production."

- Emphasizes proactive & preventive activities to maximize production*
- Involves operators in simple, daily/weekly maintenance

*Leanproduction.com

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Maintenance Philosophies - TPM

Five Pillars*

- Focus on Results
  - OEE – Overall Equipment Effectiveness
    - OEE = Availability x Performance x Quality
- Involve Operator in Maintenance
  - Rounds & Readings (R&R) – Use Senses
- Improve Maintenance Efficiency & Effectiveness
- Training of all Parties Involved
- Lifecycle Management

Five Pillars from MTONline.com

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Maintenance Philosophies - RCM

Reliability Centered Maintenance (RCM)

Employ maintenance strategies that maximize production and operational efficiency at a system and component level

- Minimize downtime
- Minimize/eliminate intrusive maintenance
- Leverage technology & data analysis

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RCM Approach

Failure Modes & Effects Analysis

- What is the purpose of the asset?
- How could it fail? – Failure Mode
- What would happen if it failed? – Effect
- What can we do to prevent failure?

*SMRP for further information

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Failure Modes & Effects Analysis

- Output
  - Maintenance Strategy
  - Replacement Criteria/Planning
  - Critical Spares
  - Service Contracts with SLAs
- Downside
  - Time consuming
  - Labor Intensive
  - Overkill for most organizations

*SMRP for further i

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sRCM – a simpler approach

Streamlined RCM (sRCM)

- FMEA on select systems/assets
  - Higher Criticality/Priority
  - Complexity
- Redundancy
  - N+1 vs. 2N vs. 2(N+1)
- Balance Cost & Effect
  - Backup Power for Server Room vs. Domestic Hot Water

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Maintenance Strategies

- Run-To-Fail (RTF)
- Preventive Maintenance (PM)
- Predictive Maintenance (PdM)
- Condition-Based Maintenance (CBM)

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Maintenance Strategies - RTF

Run-To-Fail (RTF)

- "Ain't Broke, Don't Fix It…"
- Legitimate Strategy
- When to apply:
  - Low Criticality
  - Inexpensive to Replace
  - Easy to Access

Cost of maintenance outweighs repair cost and productivity/risk impact

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Maintenance Strategies - PM

Preventive Maintenance (PM)

- Calendar/Run-Time Based
- Clean/Inspect/Adjust/Replace
- Set Frequency
  - D, W, M, Q, SA, A, Bi, QQ
  - Whether Needed or Not
- Relatively routine & simple
  - Exception SA, A, Bi, QQ
- Typically requires interruption

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Maintenance Strategies - PdM

Predictive Maintenance (PdM)

- Data/Trend Based
- Identify Cause
- Right Maintenance / Right Time
- Picture of Performance
- Investment / Contracted
- Continuous Justification

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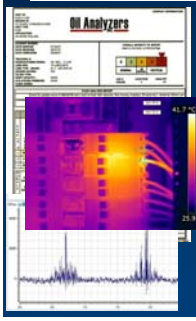
Maintenance Strategies - PdM



Technologies

- Vibration Analysis
- Infrared Thermography (IR)
- UltraSound (U/S)
- Ferrography – Oil/Fluid Analysis
- Motor Circuit Analysis (MCA)
- Laser Alignment

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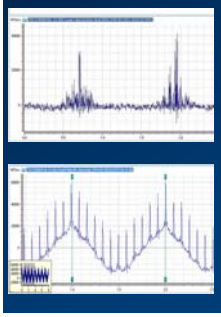
Vibration Analysis



Measures vibration to identify faults and potential failure modes

More than Bearings…

- Unbalance
- Misalignment (Coupling/Sheaves)
- Bent Shaft
- Gear/Gearbox issues
- Looseness
- Belts
- Fan & Impeller Issues
- Electrical & Motor Issues
- Resonance & Beat Frequencies

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Vibration Analysis

When to Use Vibration Analysis
- Rotating or Reciprocating Equipment
- 10HP or larger
- Critical Equipment/Systems
- Monthly to Quarterly Readings

How to Implement
- Resources
  - Tools & Software
  - Training/Certification
- In-Source vs. Out-Source
  - Overall Vibration Tester
  - Call-in Experts when Needed

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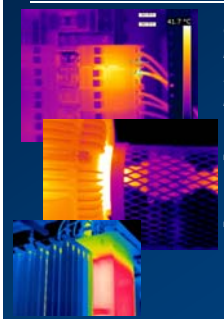
Infrared Thermography (IR)



Uses infrared imaging, detecting radiation in the infrared range, to measure and visualize relative heat of objects

- "Picture is worth a thousand words"
- Identifies but does not Specify

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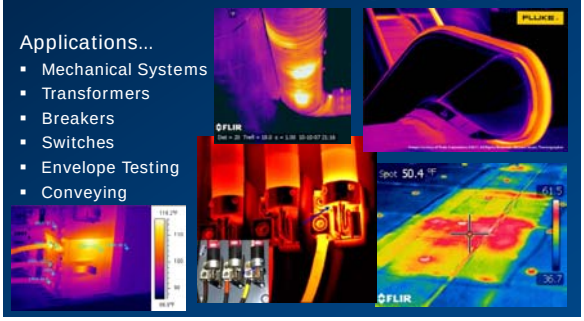
Infrared Thermography (IR)

Applications…
- Mechanical Systems
- Transformers
- Breakers
- Switches
- Envelope Testing
- Conveying



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Infrared Thermography (IR)

When to Use IR
- Annual PdM
- 200A or larger
- Troubleshooting
- Selling…

How to Implement
- Resources
  - Tools & Training
- In-Source vs. Out-Source
  - In-House Camera
  - Call-in Experts when Needed
- IR Ports


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UltraSound (U/S)

Acoustical analysis at the ultrasonic level - hearing things we can't…

- Steam/Air/Gas Leaks
- Steam Traps
- Transformers
- Bearings
- Lubrication
- Cavitation


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UltraSound (U/S)

Examples
- Indiana University - $300k/yr savings on ~3000 traps
- 1" pipe @10psig = $162/month

When to Use U/S
- At least Annually
- Troubleshooting

How to Implement
- In-Source vs. Out-Source
  - Size of Plant/Number of Equipment
  - Bearing Tester



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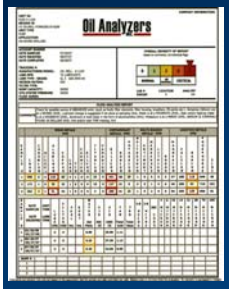
Tribology



Analyzing the particles present in fluids that indicate mechanical wear

- Oil Analysis
- Refrigerant Analysis
- Coolant Analysis

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Tribology

When to Use Tribology

- Generators
- Chillers
- Transformers
- Gearboxes
- Transmissions

How to Implement

- Collect Samples & Submit to Lab
- Most Lubrication Suppliers have Labs
- Conducted by Service Provider

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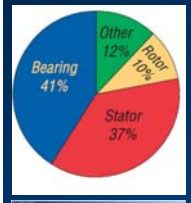
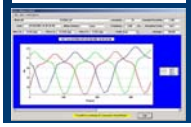
Motor Circuit Analysis (MCA)



Ascertains motor health through detection of electrical imbalances and insulation degradation

- Winding Defects
- Cable Defects
- Rotor Issues
- Integrity of Insulation
- Load Problems



- One-Time or Routine
- Online & Offline Tests
- Couple with Vibration Analysis
- Providers - Motor Shops

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Laser Alignment

Aligning rotating equipment within recommended specifications

Nearly 50% of all breakdowns in rotating machines are due to misalignment (Vibralign)

- Couplings
- Belts/Pulleys
- Example
  - 14% amp draw

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Maintenance Strategies - CBM

Condition-Based Maintenance (CBM)

- Data/Information Based
- Right Maintenance / Right Time
- Leverage All Data Available
  - PdM
  - "Smart Buildings"
  - Cx365
  - Controls System
  - Rounds & Readings
  - Meter Data
- Determine Best Maintenance

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Where are we in the Process???

- Determine System Criticality
  - Based on Priorities
- Identify Maintenance Strategy
  - sRCM - FMEA
  - RTF/PM/PdM/CBM
- Assemble Job Plan & Frequency

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Assemble Job Plan & Frequency

- Job Plan Source
  - Experience / CMMS Data
  - Service Contractor
  - O&M Manual
  - In-House vs. Out-Source
    - Prescriptive vs. Performance-Based
- Frequency
  - D-Daily, W-Weekly, Q-Quarterly, SA-Semi-Annual, A-Annual, Bi-Biennial, Tri-Triennial, QQ-Quinquennial
  - Run-Hour Based

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Common Maintenance Practices

- HVAC (Q, SA, A)
- ELEC (A, QQ)
  - Arc Flash Hazard
  - Short Circuit Coordination
- PLMB (M, A)
- ROOF (SA, A)
- FLS (M, A)
- ELEV (Q, A, QQ)

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Determine Best Provider

- In-House vs. Outsource
  - Industry Trends - specialization
  - Other Considerations – geography, response time, resources, SF
- What skills & training are needed?
  - Licensing? Certifications?
- What tools are needed?
  - Tool maintenance & calibration

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Setup Maintenance & Schedule

- Setup Job Plan in Computerized Maintenance Management System (CMMS)
  - In-House vs. Outsource
- Schedule
  - Stagger or All-at-Once?
  - Seasonal
    - Prepare for Heating/Cooling
    - Particulates & Pollen

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Execute & Manage

- Prioritize PMs, CMs, & SRs
- Target PM/CM Ratio – 80/20
  - 90/10 for Critical Environments
- Digging Out
  - Manage Client Expectation
  - Set aside PM Team/Day
  - Plan for long-haul

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Analyze & Improve

- Key Performance Indicators (KPIs)
  - PM/CM Ratio
  - % Complete
    - By priority/criticality
    - On-Time vs. Late
  - Actual Hours vs. Budgeted
    - By Staff
- Analyze – How Improve?
  - Training, tools, etc.

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Questions?

Next Sessions:

- CMMS – The Nervous System of FM

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