Machinery Oil Analysis & Condition Monitoring

A Practical Guide to Sampling and Analyzing Oil to Improve Equipment Reliability

Mohammed Hamed Ahmed Soliman

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CHAPTER 1
INTRODUCTION TO MAINTENANCE

Maintenance Policies and Strategies
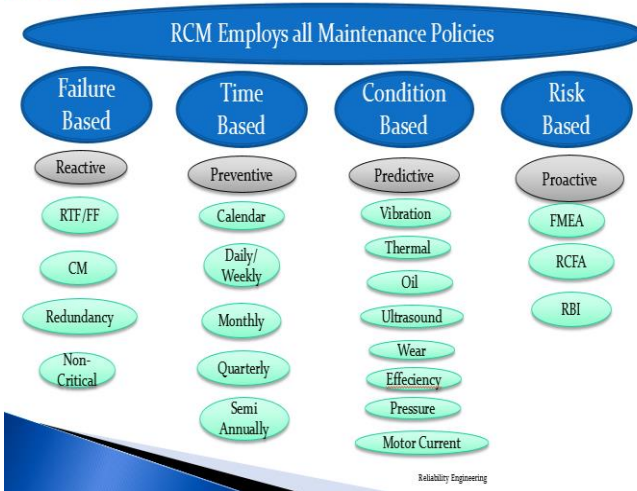
Reliability centered maintenance promotes the use of Predictive and Risk Maintenance policies for identified critical equipment

Predictive Maintenance Techniques

Predictive Maintenance Embraced by Plant Maintenance

Technique	Application	Pumps	Electric Motors	Diesel Generators	Condensers	Heavy Equipment/ Crane	Circuit Breakers	Valves	Heat Exchangers	Electrical Systems	Transformers	Tank Piping
VIB Analysis		•	•	•		•						
Oil Analysis		•	•	•		•					•	
Wear Analysis		•	•	•		•						
IR Analysis		•	•	•	•	•	•	•	•	•	•	
Ultrasound		•	•	•	•		•	•	•	•	•	
Non-Destructive testing (Thickness)				•				•			•	
Visual Inspection		•	•	•	•	•	•	•	•	•	•	•
Motor Current Analysis		•										

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Time when failure starts to occur

Change in vibration can be detected 1-9 months prior to failure

Wear particles Detectable in oil 1-6 Months prior to failure

Audible Noise 1-4 weeks prior to failure

Hot to the touch 1-5 days prior to failure

C O D I T I O N

Time

P

P1

P2

P3

P4
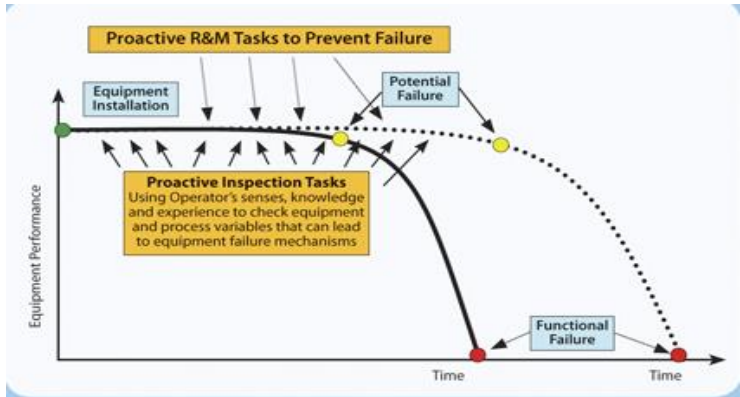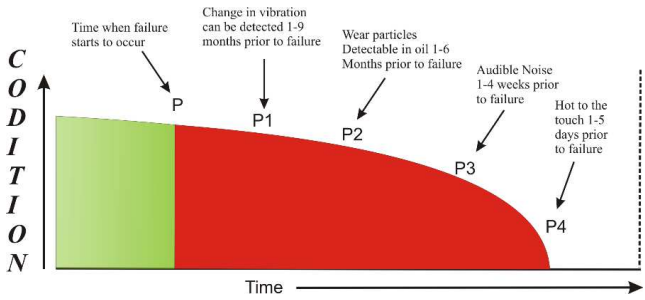
Reliability KPIs

KPI	Description
MTBF	Mean Time Between Failure
No of failures addressed by root cause analysis	>75%
Ratio of PM work orders to CM work orders generated by PdM inspection	
OEE (Overall Equipment Effectiveness)	Availability x Reliability x Quality (85%)
Percent of Faults Found in Predictive maintenance Survey (Vib, IR, UT, OA)	No of faults found/ No of devices checked (target <3%
Percent of equipment covered by condition monitoring	Target= 100%
Reliability of critical equipment	99%
Facility Availability	>98%
Availability of critical equipment	>98%
Percent emergency maintenance	<5%
Percent planned maintenance	90%

**Why Using Condition Monitoring Programs (Predictive Maintenance)?**
Benefits of setting up a Predictive Maintenance (PdM) program:
1. To detect what is out of the human sense.
2. To discover hidden failures.
3. To detect early failures & monitor the machine   health condition.
4. To reduce Maintenance Costs.
5. As a useful tool to improve the machine reliability.
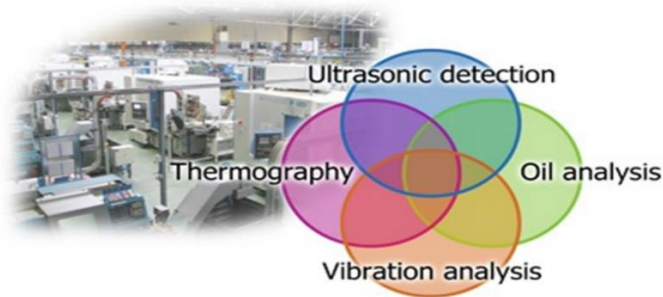
Four tools make up 85% of any PdM program
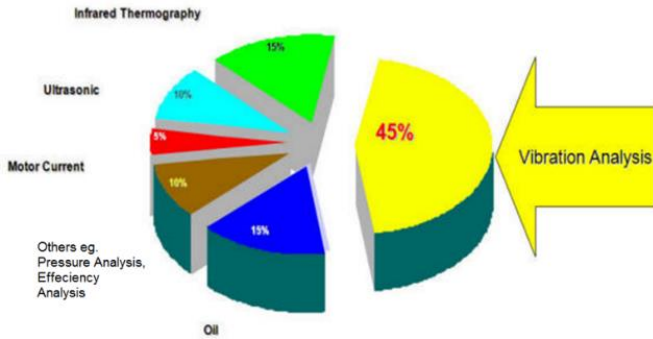
Vibration present 45% of PdM programs, oil present 15% but it can detect faults in equipment that vibration can't, e.g. electric transformers and hydraulic systems.

Equipment that fails in service can cost up to 10 times more to repair than the equipment repaired when predicted by condition monitoring.

Other PdM Techniques and Comparison
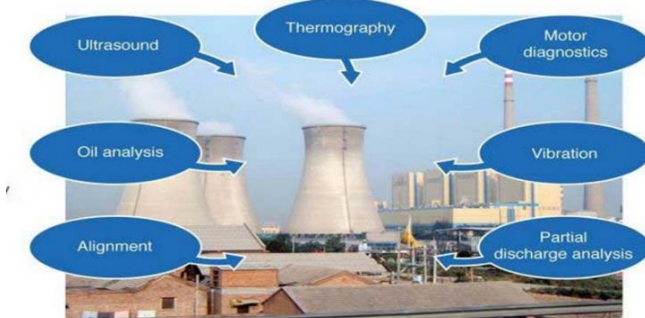
Notes:

Motor diagnosis = motor current analysis, and it's a technique involve intensive diagnosis of motor currents.

Oil Analysis involve Wear Particles Analysis for more intensive diagnosis about the sources of failure. For more information about the technique read the book: Machinery Oil Analysis and Condition Monitoring.

Thermography: involve thermal analysis using infrared camera. For more information about the technique, read the book: Industrial Applications of Infrared Thermography.

Ultrasound Analysis: is an acoustic method based on high frequencies measurement. For more information, read

the book: Ultrasound Analysis for Condition
Monitoring.

Why condition monitoring techniques?
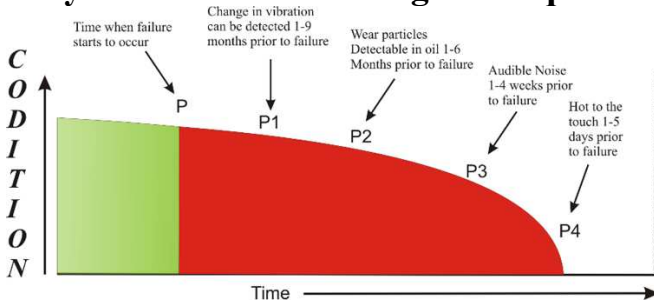
Vibration VS Thermography VS Oil Analysis

Type of fault	Vibration	Temp	Oil
Out of balance	xxx	----	----
Misalignment	xxx	x	----
Damage of bearing	xxx	xx	x
Damage of gear box	xxx	x	xx
Belt problems	xx	----	----
Motor problems	xx	x	----
Mechanical looseness	xxx	x	x
Resonance	xxx	----	----

While oil analysis can't detect various faults like vibration, but it's a less expensive technique, and doesn't require intensive training and practice like vibration.
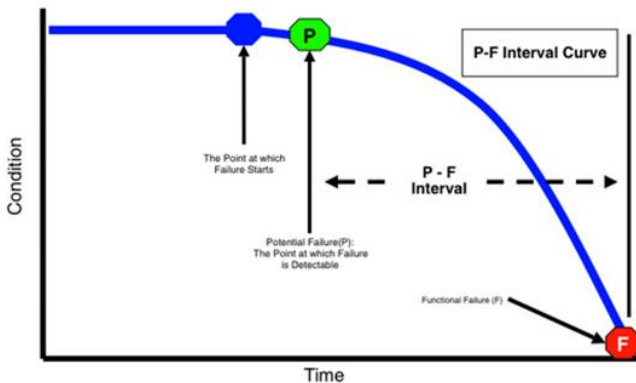
One of the most benefits of a condition monitoring program is to detect potential failures at early state.
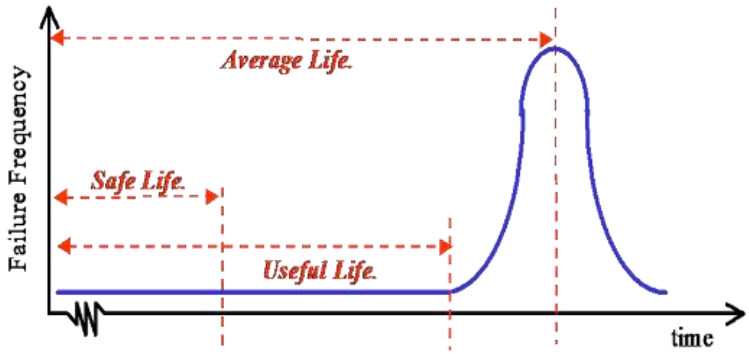
Determine the PM Interval Using Reliability Data
from PdM Programs.

CHAPTER 2
INTRODUCTION TO OIL ANALYSIS DEFINITION AND PROCEDURES

Oil analysis involves sampling and analyzing oil for various properties and materials that indicate wear and contamination in an engine, transmission or hydraulic system.

Oil Analysis is the use of various laboratory tests to monitor lubricant health, equipment health and contamination.

Oil analysis (OA) is the sampling and laboratory analysis of a lubricant's properties, suspended contaminants, and wear debris. OA is performed during routine preventive maintenance to provide meaningful and accurate information on lubricant and machine condition.

Oil Analysis as a Part of Predictive Maintenance Programs PdM

Oil analysis technique utilize 15% of condition monitoring programs. Oil analysis
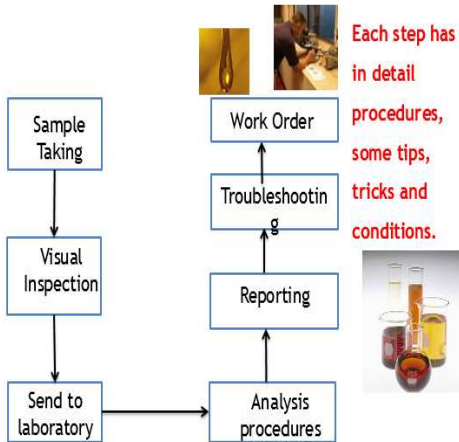
is a long-term program that, where relevant, can eventually be more predictive than any of the other technologies. It can take years for a plant's oil program to reach this level of sophistication and effectiveness.

Analytical techniques performed on oil samples can be classified in two categories:

- ➤ Used Oil Analysis
- ➤ Wear Particles Analysis

Used oil analysis determines the condition of the lubricant itself, determines the quality of the lubricant, and checks its suitability for continued use. While **Wear Particles Analysis** determine the source of the wear by analyzing the metal contents. For example, spotting which sprocket inside gearbox is wearing.

Oil Analysis procedures

Sample Taking → Visual Inspection → Send to laboratory → Analysis procedures → Reporting → Troubleshooting → Work Order

Each step has in detail procedures, some tips, tricks and conditions.

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ABOUT THE AUTHOR

Mohammed Hamed Ahmed Soliman is an industrial engineer, consultant, university lecturer, operational excellence leader, and author. He works as a lecturer at the American University in Cairo and as a consultant for several international industrial organizations.

Soliman earned a bachelor of science in Engineering and a master's degree in Quality Management. He earned post-graduate degrees in Industrial Engineering and Engineering Management. He holds numerous certificates in management, industry, quality, and cost engineering.

For most of his career, Soliman worked as a regular employee for various industrial sectors. This included crystal-glass making, fertilizers, and chemicals. He did this while educating people about the culture of continuous improvement.

Soliman has lectured at Princess Noura University and trained the maintenance team

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Soliman is a member at the Institute of Industrial and Systems Engineers and a member with the Society for Engineering and Management Systems. He has published several articles in peer reviewed academic journals and magazines. His writings on lean manufacturing, leadership, productivity, and business appear in Industrial Engineers, Lean Thinking, and Industrial Management. Soliman's blog is www.personal-lean.org.

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