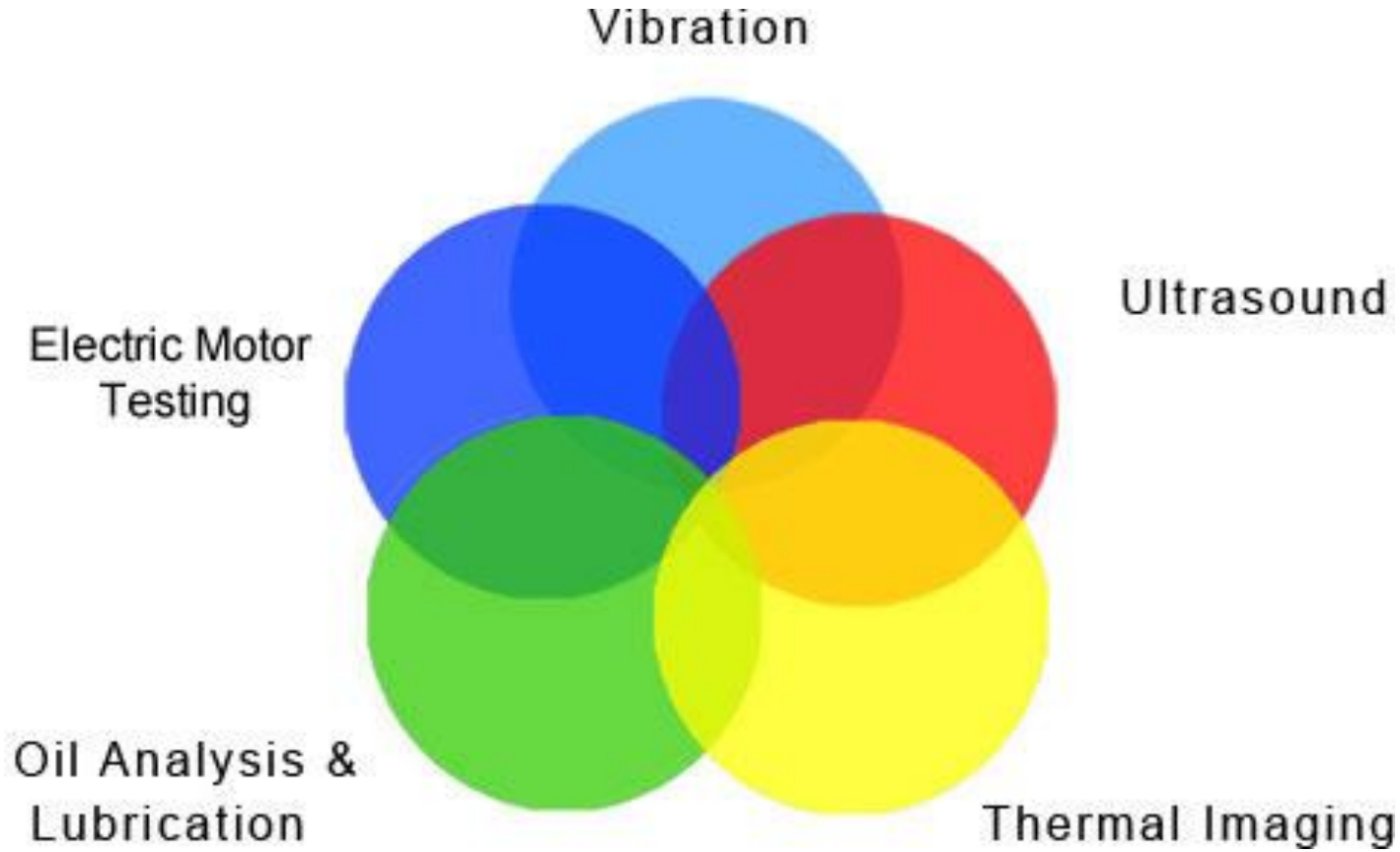


Predictive Maintenance

Basic Mechanical Maintenance Training

Course Content

- Introduction
- Maintenance
- Types of maintenance
- Predictive maintenance
- Predictive maintenance Techniques
- Practical

Maintenance

What is Maintenance?

- The work of keeping something in proper condition; upkeep
- All activities involved in keeping a system's equipment in working order

Types of Maintenance

- Preventive Maintenance
- Breakdown Maintenance
- Predictive Maintenance
- Reliability Centered Maintenance

Types of Maintenance

- **Preventive Maintenance:** Actions performed on a time - or machine-run-based schedule that detect, preclude, or mitigate degradation of a component or system with the aim of sustaining or extending its useful life through controlling degradation to an acceptable level.
  - (Routine inspection and servicing i.e. cleaning, inspection, oiling and re-tightening; to keep facilities in good working condition)
- **Breakdown Maintenance:** Repairs or replacements performed after a machine has failed to return it to its functional state following a malfunction or shutdown.
  - Wait until equipment fails and repair it. It could be planned or unplanned
- **Predictive Maintenance:** ???
- **Reliability Centered Maintenance:** a process used to determine the maintenance requirements of any physical asset in its operating context
  - It is a process to ensure that assets continue to do what their users require in their present operating context.
  - Prioritizing maintenance efforts based on equipment's importance to operations, its downtime cost in revenue and customer loss, its impact on safety, and its cost of repair

Predictive Maintenance (PdM)

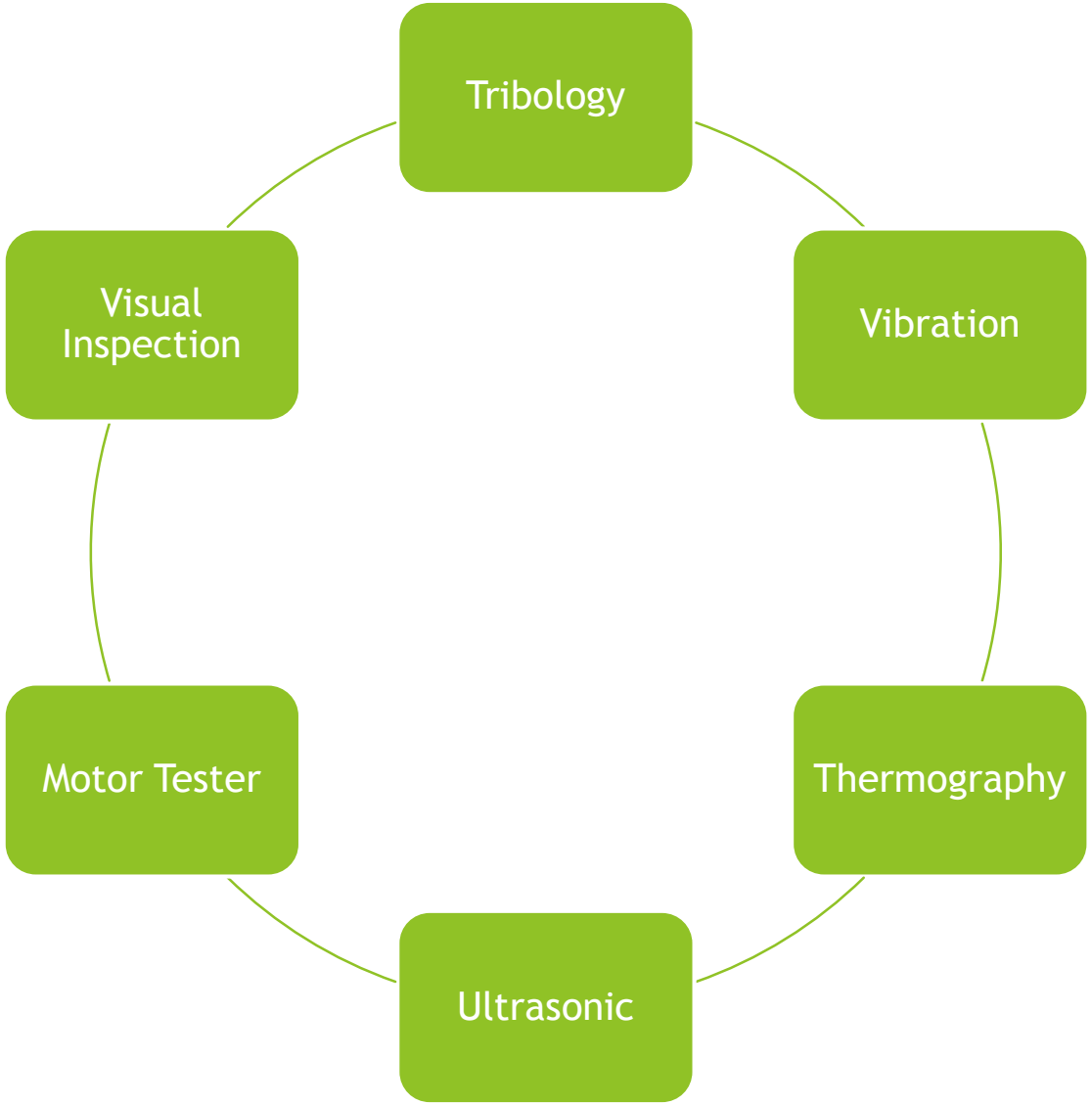
- Predictive maintenance attempts to detect the onset of a degradation mechanism with the goal of correcting that degradation prior to significant deterioration in the component or equipment

- Predictive maintenance techniques are designed to help determine the condition of in-service equipment in order to predict when maintenance should be performed

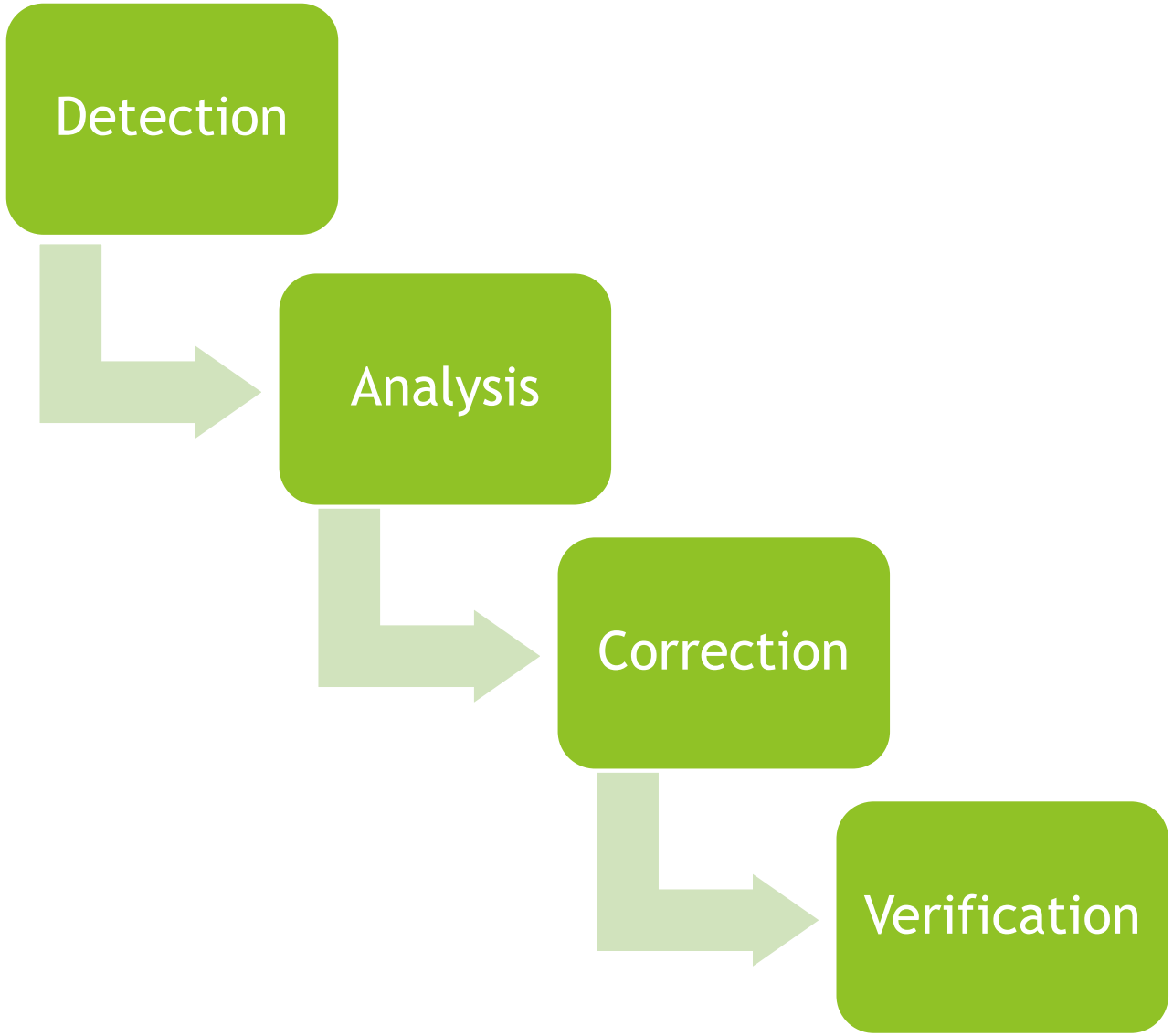
- It is condition based maintenance. It manages trend values, by measuring and analyzing data about deterioration and employs a surveillance system, designed to monitor conditions through an on-line system

- Basically, predictive maintenance differs from preventive maintenance by basing maintenance need on the actual condition of the machine rather than on some preset schedule

Predictive Maintenance Techniques



Basic steps of Analysis in PdM



Analysis of PdM Data

- Compare with Standards
- Compare with other machine operating under the same condition
- Check data trends over time

Visual Inspection

Visual Inspection

Visual inspection was the first method used for predictive maintenance during the industrial revolution time

Method

- Maintenance technicians will perform daily/scheduled “walkdowns” of critical production and manufacturing systems in an attempt to identify potential failures or maintenance-related problems that could impact reliability, product quality, and production costs

Ultrasonic

Ultrasonic

- **Ultrasonic, or ultrasounds, are defined as sound waves that have a frequency level above 20 kHz.**
- **Basically ultrasonic tool can be used to monitor Sound waves in the frequency spectrum of 20kHz to 1MHz which are higher than what can normally be heard by humans**
- **These higher frequencies are useful for detecting leaks that generally create high-frequency noise caused by the expansion or compressed of air, gases, or liquids as they flow through the orifice, or a leak in either pressure or vacuum vessels**
- **These can also be used in measuring the ambient noise levels in various areas of the plant**
- Ultrasonic leak Detector is the tool we use for ultrasonic inspection/analysis

Ultrasonic ../2

Tribology

Tribology

Definition

- **Tribology** is the science and engineering of interacting surfaces in relative motion. It includes the study and application of the principles of friction, lubrication and wear
- It is a branch of engineering that deals with the design, friction, wear and lubrication of interacting surfaces

Techniques

- lubricating oil analysis
- Spectrographic analysis
- Ferrography
- Wear particle analysis

Tribology …/2

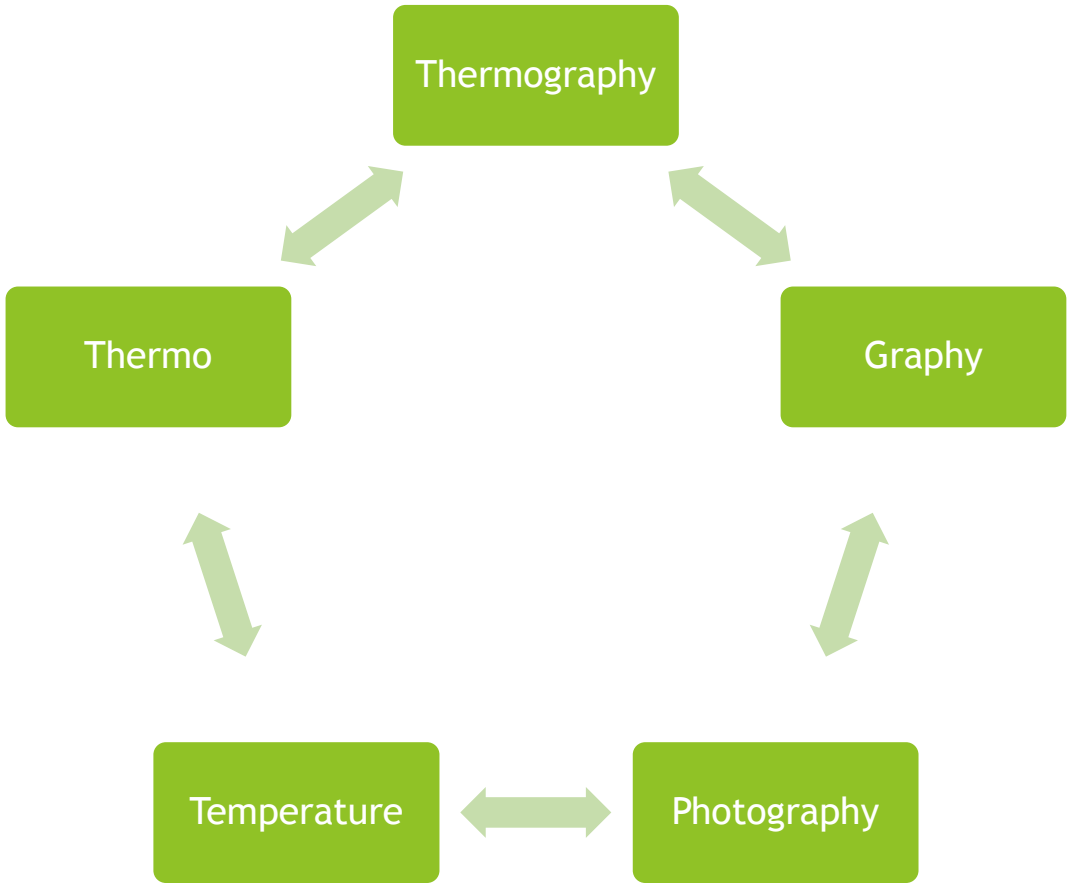
- **Lubricating oil analysis:** is an analysis technique that determines the condition of lubricating oils used in mechanical and electrical equipment.
  - Lube oil analysis test for: Viscosity, Contamination, Solids content, Particle count etc.
- **Spectrographic analysis:** allows accurate, rapid measurements of many of the elements present in lubricating oil
- **Wear particle analysis:** provides direct information about the wearing condition of the machine
- **Ferrography:** is similar to spectrography, it separates particulate contamination by using a magnetic field rather than by burning a sample as in spectrographic analysis

Thermography

Thermography: History

- Sir William Herschel, an astronomer, discovered infrared in 1800. He built his own telescopes and was therefore very familiar with lenses and mirrors. Knowing that sunlight was made up of all the colors of the spectrum, and that it was also a source of heat, Herschel wanted to find out which color(s) were responsible for heating objects. He devised an experiment using a prism, paperboard, and thermometers with blackened bulbs where he measured the temperatures of the different colors. Herschel observed an increase in temperature as he moved the thermometer from violet to red in the rainbow created by sunlight passing through the prism. He found that the hottest temperature was actually beyond red light. The radiation causing this heating was not visible; Herschel termed this invisible radiation "calorific rays." Today, we know it as infrared.

Thermography: What is?



The recording of a visual image of the heat that bodies emit as infrared / thermal radiation.

Thermography: Benefits

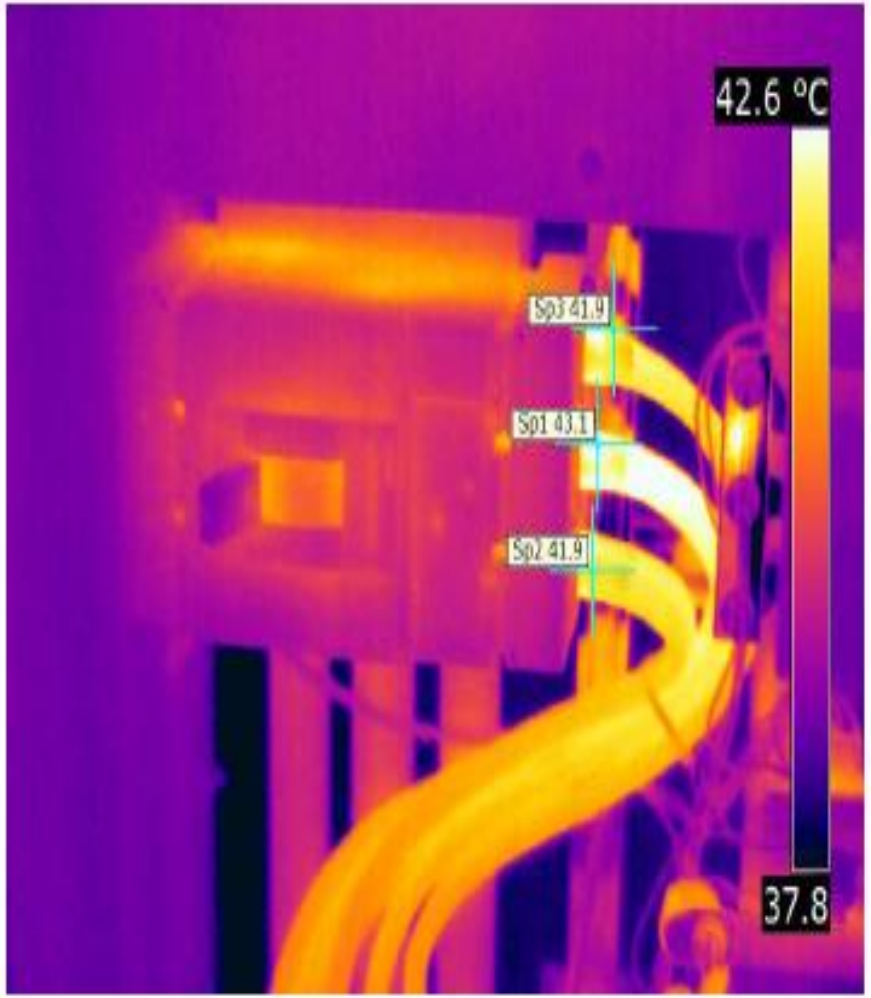
- By process or operation 99% of all plants has a Thermal profile
- Increases AVAILABILITY and RELIABILITY of plant equipment
- Thermography leads to early detection of fault conditions
- Thermography takes place under full load, no production interference
- Reduces number of unplanned shutdowns
- Safe, non-contact, non-invasive inspection
- Repeatable and a high degree of accuracy
- SAVES MONEY

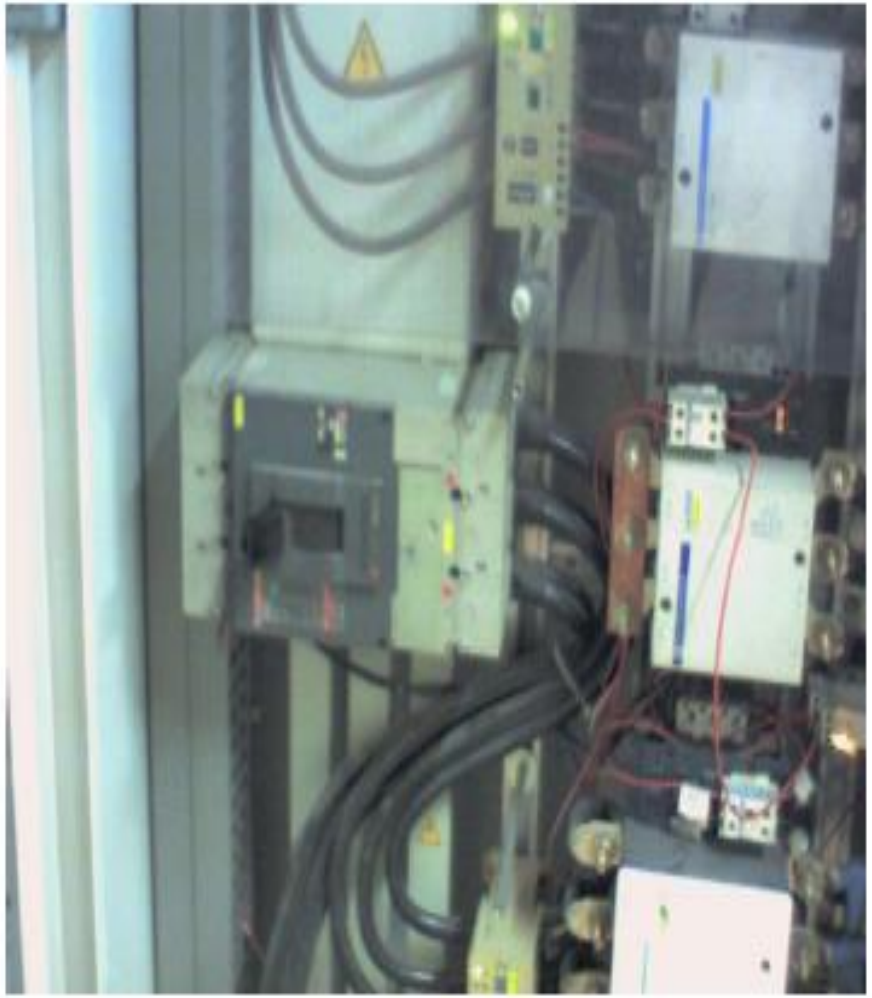
Thermography: Application

- Electrical Reticulation Equipment (HT and LT)
- Pyrotechnical such as specialized furnace inspections, kilns, incinerators
- Rotating / Moving Mechanical Machinery such as electrical motors, bearings, gearboxes
- Petrochemical such as refractory linings, piping insulation and blockages, valves
- Environmental such as underground fires, water pollution, sinkholes
- Medical

Thermography: Accuracy Contribution

- Reflected Apparent Temperature
- Emissivity
- Contrast / Focus
- Distance from Target
- Field of View
- Instantaneous Field of View
- Ambient Temperature
- Noise
- Vibration





An Infrared Image of a circuit breaker which has a heat concentration on the yellow phase

Inspection Report

Report Date	10/24/2014		
Company	FLOUR MILLS OF NIGERIA PLC	Customer	FLOUR MILLS OF NIGERIA PLC
Address	2, OLD DOCK ROAD, APAPA	Site Address	2, OLD DOCK ROAD, APAPA
Thermographer	PREDICTIVE MAINTENANCE TEAM	Contact Person	MR ALEX , MR JUDE , MR FRANK

Image and Object Parameters

Camera Model	ThermaCAM P640 West	Description	Suspected burnt insulation at the red phase terminal
Image Date	10/23/2014 11:45:09 AM	Building	D and G mills ,2nd floor electrical panel room
Image Name	IR_4415.jpg	Devices	Contactor 5-M006 Yellow phase cable Terminal
Emissivity	0.98	Priority	3- Critical
Reflected apparent temperature	35.4 °C	Recommendation	Check and rectify ,possible change the red phase terminal cable
Object Distance	1.5 m	Panel number	+M51 Door A

Text Comments

Description

The infrared thermography inspection carried out at G-Mill Electrical panel room 2nd floor contactor 5 -M006 , Red phase terminal shows heat concentration at the Red phase cable terminal of the contactor .The maximamum temp at106.6*C.

Vibration

Vibration

- Vibration is a mechanical phenomenon whereby oscillations occur about an equilibrium point
- Changes in the health, or condition, of a machine often produce changes in the machine's vibration.
- Even a perfectly healthy machine produces some degree of vibration.
- Condition monitoring monitors for change in the vibration that a machine problem normally produces.
- Vibrations felt in the steering wheel can be an indicator of an out-of-balance wheel or looseness in the steering linkage
- Vibration analysis could be used to detect unbalance, misalignment, bend shaft, looseness, bearing defect in a machine

Vibration: Magnitude of Vibration

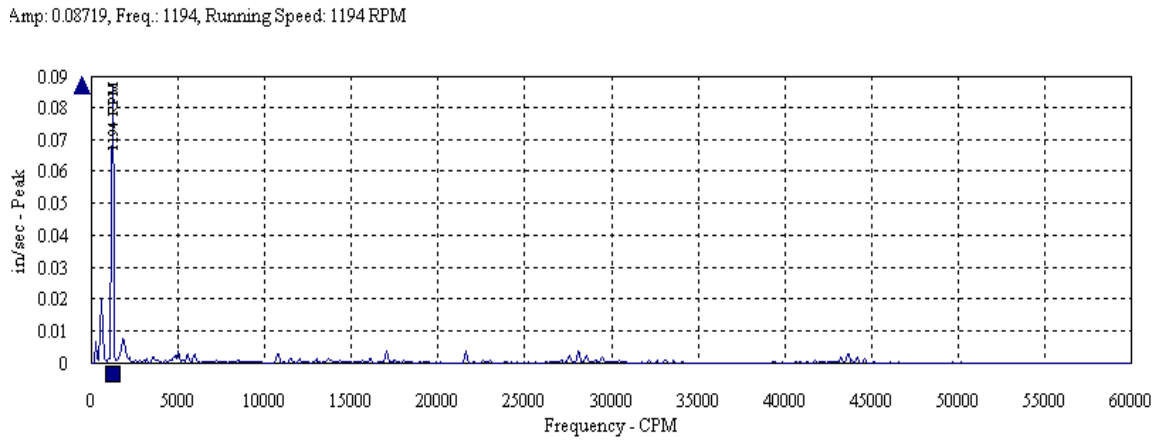
- **Displacement:** The total distance traveled by the vibrating part from one extreme limit of travel to the other extreme limit of travel. This distance is also called the “peak-to-peak displacement.”

- **Velocity:** A measurement of the speed at which a machine or machine component is moving as it undergoes oscillating motion

- **Acceleration:** The rate of change of velocity. Recognizing that vibrational forces are cyclic, both the magnitude of displacement and velocity change from a neutral or minimum value to some maximum. Acceleration is a value representing the maximum rate that velocity (speed of the displacement) is increasing

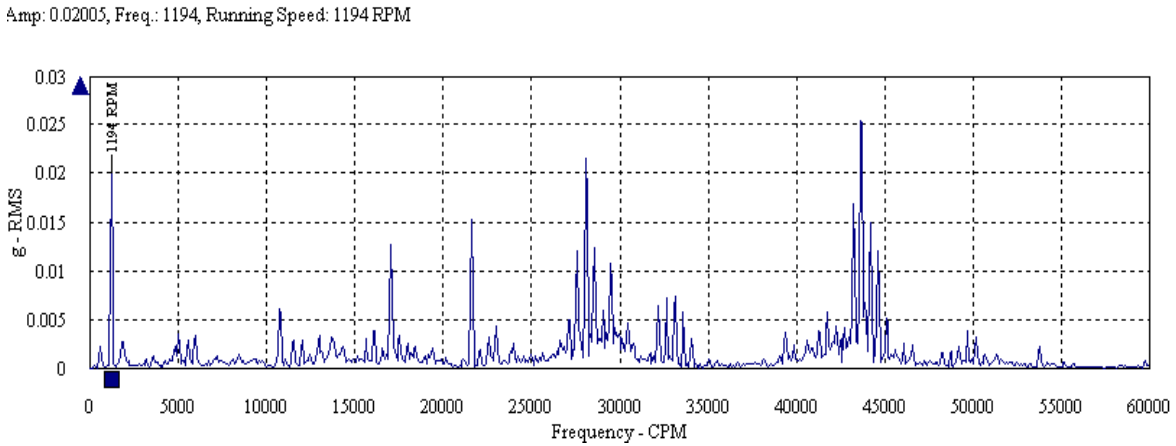
Vibration: Measurement Selection

Velocity spectrum



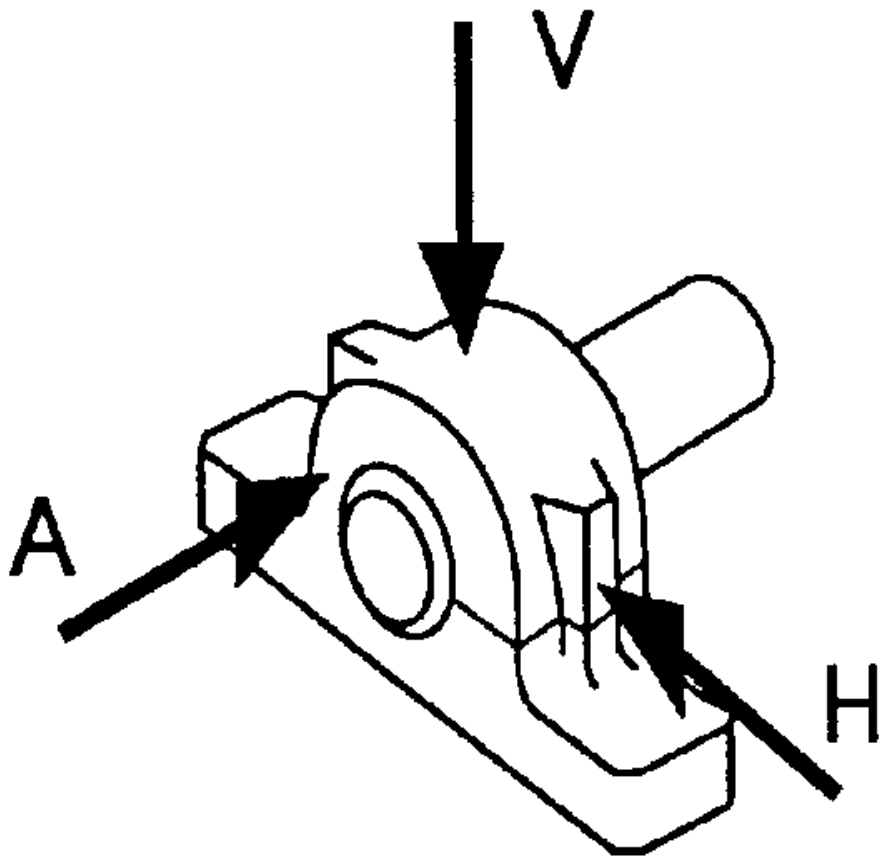
- Low frequency events show best in the velocity spectrum
- High freq. events show best in the acceleration spectrum

Acceleration Spectrum



Vibration: Measurement sensor orientations

- Radial
  - Vertical
  - Horizontal
- Axial



Vibration: Measurement sensor orientations

- **Horizontal:** Measurements typically show higher amplitudes since most machines are more flexible in the horizontal plane
- **Vertical:** Measurements typically show lower vibration amplitudes than horizontal due to the increased vertical stiffness and gravity
- **Axial:** Under ideal conditions, axial readings should have low vibration readings, as most forces are generated perpendicular to the shaft. However, problems such as misalignment or a bent shaft create vibration in the axial plane as well as some bearing faults

Electric Motor Testing

Electric motor Testing

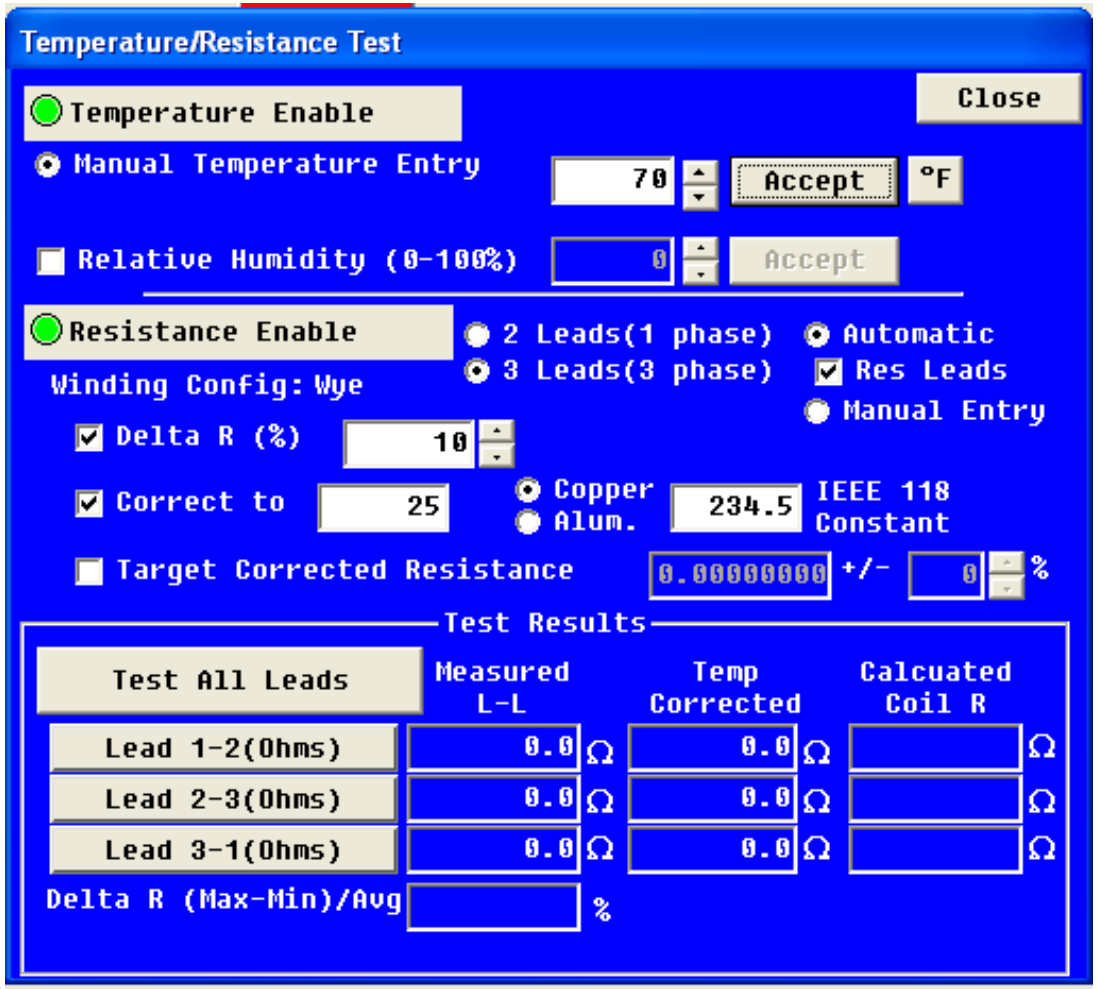
Electric motor testing can be done in two ways:

- Offline Motor Monitoring (Static Motor testing)
- Online Motor Monitoring (Dynamic Motor Testing)

Offline Motor Testing

- Measuring and tracking the dielectric strength and integrity of motor insulation and copper-to copper potential with the motor stopped
- Testing motor components at voltage levels similar to those the motor encounters in it’s normal environment

Offline Motor Testing



- Coil Resistance
- Meg-ohm Test
- PI (polarization test)
- Hipot Test
- Surge Test

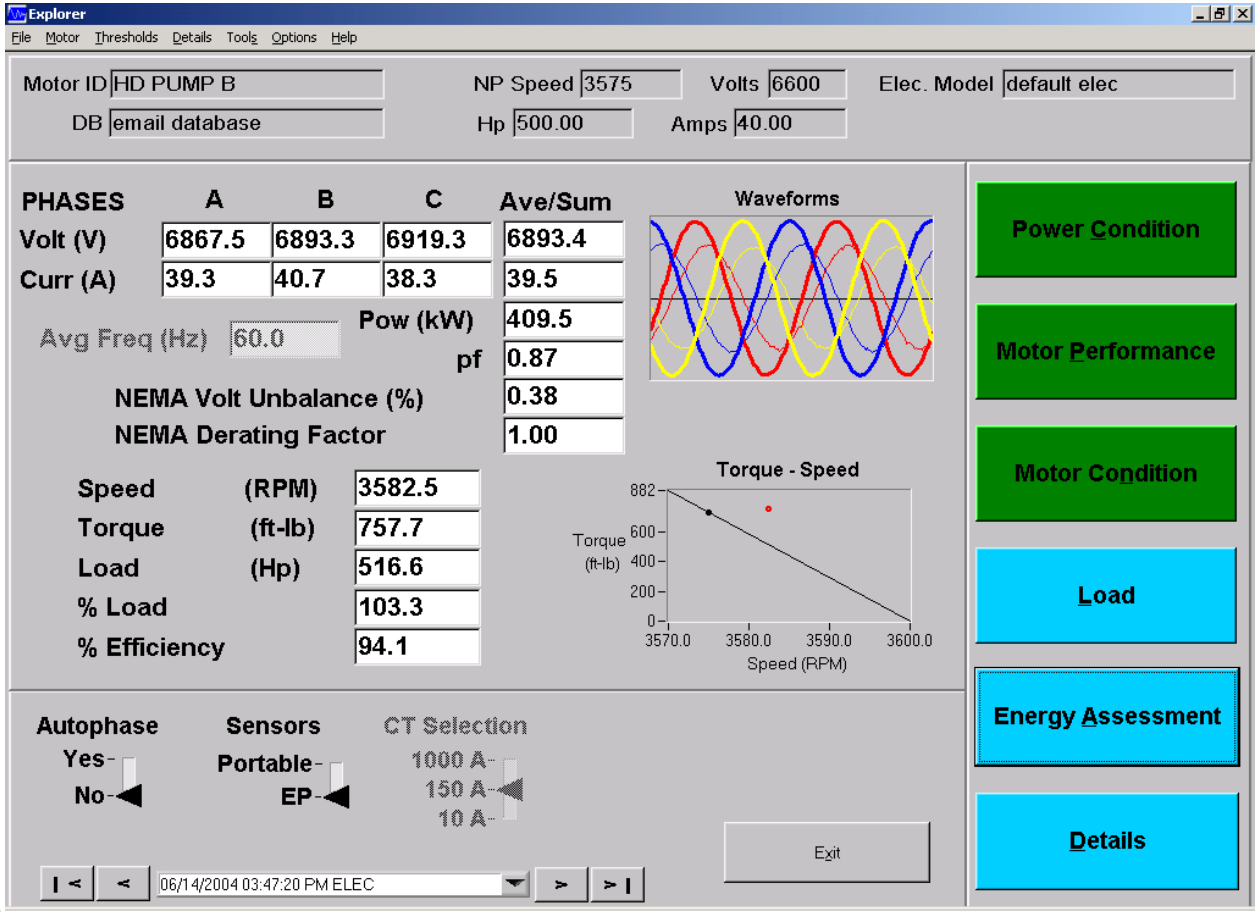
Offline Motor Testing

Resistance Test	Meg-Ohm Test	Polarization Index	High Potential Test	Surge Test
• # of Turns per phase • Diameter copper • High resistance connections • Turn-To-Turn shorts • Turn-To-Turn Opens	• Determine if the motor has failed to ground • Dirty motor (Surface leakage) • Perform a Polarization Index and Dielectric Absorption Test	• Deteriorated ground wall insulation • Dry-rotted, hard, brittle ground wall insulation, contamination	• Weak Ground wall insulation • Cable insulation	• Weak insulation • Reversed coils • Turn-To-Turn shorts • Unbalanced turn count • Different size copper wire • Shorted laminations

Dynamic Motor Testing

- A motor is only one part of a “Machine System” that includes: Power in, the Motor and the Load
- Dynamic testing diagnoses issues for all three links
- The ability to find Power Condition, Motor and Load Related issues while the motor is running under normal conditions
- We measure, analyze and trend the currents and voltages of the motor-load system

Online Motor Testing



- Power quality
- Machine Performance
- Current
- Spectrum
- Connections
- VFD details

Dynamic Motor Testing

Power quality	Machine performance	Current	Spectrum	Connections	VFD Details
• Power level • Voltage unbalance • Harmonic distortion • Total distortion • Power • Harmonics	• Effective Service Factor • Load • Operating Condition • Efficiency • Payback Period	• Over Current • Current Unbalance	• Rotor Bar • V/I Spectrum • Demodulated Spectrum • Harmonics	• Waveforms • ABC/SYM Comparisons • Phasors	• Torque and Speed vs. Time • Frequency and Voltage vs. Time