RELIABILITY MAINTENANCE
IS GOOD MEDICINE

HECO
All systems go

About the Author

Tom Spettel is a Sr. Engineer at HECO. He is an ANSI/ISO Certified, Category IV Vibration Analyst.

Tom was an US Army Medical Specialist, running diagnostic tests for a MASH unit in Vietnam. He then worked in a chemical plant/refinery supervising annual teardown inspections on large steam turbines, compressors, and pumps. He realized this was essentially performing surgery on the machines (even if they showed no signs of distress). Later, he became a vibration analyst, where he saw the similarities to previous medical job. The examples in this paper are meant to help predictive maintenance "practitioners" increase the reliability and extend the useful life of plant equipment.

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Overview

Just as advances in medicine have more than doubled human life expectancy, the application of reliability technology to maintenance has brought similar results to industry. The similarities between medical diagnostic testing and industrial reliability testing are remarkable. For example, think of blood testing and oil analysis, or ultrasonic testing for heart valve leakage and ultrasonic surveys for steam/air leaks. The application of these and other predictive maintenance tests will be discussed and examples of each technology provided in this eBook.

The practice of medicine (I always wondered why we say that Medical Doctors "practice" medicine) has resulted in a significant increase in life expectancy. Much of this increase is due to the ability to diagnose illness and disease at early stages of development and take appropriate action. Preventative medicine relies heavily on the use of diagnostic testing (being proactive).

If we in the maintenance field apply a similar proactive approach, can we not expect a corresponding increase in the life expectancy of our plant machinery? Recent experience in multiple industries shouts YES! This eBook will show the parallels between medical diagnostic testing and industrial predictive technologies currently being applied as part of a comprehensive reliability program. I hope the examples in this paper will help predictive maintenance "practitioners" increase the reliability and extend the useful life of plant equipment.

Temperature Measurements

One of the first medical diagnostic tests used was the measurement of body temperature. Elevated body temperature is a primary indicator of infection. Recently, medicine has adopted the use of thermal scans (thermography) to help diagnose specific diseases such as breast cancer.

Likewise, measurement of temperatures on industrial equipment is a technology that has been used for a long time. Elevated bearing temperature is a strong indicator of damage to the bearings or poor lubrication; and higher than normal temperatures in electrical circuits can indicate immanent failure. Recently, the use of thermal cameras has developed the field of thermography.

Ultrasonic Testing

Ultrasound tests are performed routinely to look for abnormalities during pregnancy or find tumors without resorting to surgery. They use high frequency sound waves to penetrate tissue and show a picture of underlying structures without using x-rays.

Ultrasonic testing is used in industry to:

- Detect air leaks in piping and machinery.
- Detect steam leaks (high temperature/pressure steam leaks are invisible).
- Determine flow in pipes.
- Detect tank and pipe wall thickness for pressure vessel calculations.
- Detect roller bearing damage.
- Detect corona discharge in electrical circuits and generators.

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Electrocardiogram (EKG) and Vibration Analysis

An electrocardiogram is a noninvasive, painless test used to monitor your heart. Each beat of your heart is triggered by an electrical impulse. An electrocardiogram — also called an ECG or EKG — records these electrical signals. Your doctor can use an electrocardiogram to look for patterns among these heartbeats to diagnose various heart conditions. Many doctors are recommending capture of an non-emergency EKG to use a a baseline for comparison when a possible cardiac event occures.

Vibration analysis is the industrial coorelation to the EKG. Vibration analysis is a noninvasive test that seeks to determine the mechanical condition of various components in rotating machinery. Vibration analysis is the most useful of the predictive technologies for rotating machinery.

Electrocardiogram (EKG) and Vibration Analysis *(continued)*

Some of the problems that can be detected are:

- Imbalance
- Misalignment (coupling, pulley, shaft, bearing)
- Looseness (structural and/or looseness in the rotating assembly)
- Bearing race/roller defects
- Flow (process) related
  - Pump cavitation
  - Pump flow away from the pump curve
  - Fan or compressor surge
- Electric motor related
  - Rotor bar
  - Stator eccentricity
  - Motor soft foot
  - Rotor eccentricity
- Resonance (natural frequency

Vibration diagnostic plots include the time-waveform (very similar to the EKG) and FFT (frequency).

Current medical practice suggests that a baseline EKG be obtained before any heart conditions are suspected and periodically as aging occurs. This provides the medical specialist with the ability to compare EKG results over a period of time and trend changes. Predictive maintenance using vibration trending has proven to be an equally powerful technique.

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Blood Testing and Oil Testing

Blood testing is used to detect a broad spectrum of illnesses and medical conditions. It has become a routine test performed at annual health check-ups and as a first level of diagnostic analysis. Blood testing can include tests to determine the "quality" of the blood (i.e. red blood cell concentration) and the presence of foreign substances (drug test).

Oil testing should include measurements to check the "quality" of the lubricant and to look for foreign substances. A complete oil analysis should include testing of:

- Oil chemistry
  - Viscosity
  - Additive package
  - Oxidation
  - Nitration
- Foreign substances
  - Water
  - Particulate
    - ISO index
  - Wear debris
    - Ferrous
    - Non-Ferrous
  - Solvents

Oil testing can also be used as a preventative tool, much as blood analysis. If doctors find an abnormally low or high level of something in your blood, they may prescribe a diet supplement or medication. Likewise, if a tribologist (oil doctor) finds a lower than desired quantity of a substance in the lubricant, an additive may be prescribed. If high levels of contamination are found, filtering may be recommended.

Electromyogram (EMG) and Modal Analysis

An electromyogram measures the electrical activity of muscles at rest and during contraction. Nerve conduction studies measure how well and how fast the nerves can send electrical signals. The delay between a nerve impulse and muscle contraction is measured.

Modal analysis cross-channel vibration tests can measure the phase delay between an input force and the resultant vibration motion. This information can be useful in diagnosing complex motions of machines.

Other Technologies

Several other crossover technologies that come to mind are:

Medical

X-rays sends individual x-ray particles through the body. The images are recorded on a computer or film. Structures that are dense (such as bone) will block most of the x-ray particles, and will appear white. Fractures will appear a dark spots.

Industrial

X-rays are used to detect cracks in shafts, piping, and structures.

Blood pressure measures the pressure in blood vessels. The systolic (low) pressure represents the inlet pressure to the heart, the diastolic pressure measures the output pressure from the heart. Blood pressure measurements can detect heart damage.

Measurement of the suction pressure and discharge pressure on pumps, compressors, and blowers are used to determine if the machine is “pumping” efficiently. Rotor damage or process issues can be diagnosed.

Fiberoptic Scopes are used for various medical inspections. They allow doctors to observe internal organs without major surgery.

Fiberoptic inspections of the internal components in machinery allow visual inspections without disassembly of the machine.

Looking ahead

Medical and industrial technologies provide powerful diagnostic information that, in the hands of highly skilled professionals, can positively affect the life of machines (human and mechanical). Continued improvement is essential for both technologies.

One area where improvement is required (and much effort is being applied) is in the field of “prognostics”. Prognostics are an engineering discipline focused on predicting the time at which a system or a component will no longer perform its intended function. Anyone working in the predictive field for even a short time knows that once a defect is reported, the next question is “How long will it last”. As we learn more about machine failure mechanisms, the answer to this question will become clearer.

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WHAT is the problem
vs.
WHY did it occur

HECO is the industry's "why" company. We specialize in custom systems that optimize the performance of the entire electric motor-driven powertrain.

When you tell HECO you're having a motor problem, we want to find out why. Why did a failure occur? Why didn't you know about it ahead of time? Why can we make sure it doesn't happen again?

Then we use our problem solving and engineering expertise to keep your plant up and running.

To learn more about what our "All Systems Go" approach can mean to you, please contact:

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