NONDESTRUCTIVE INVESTIGATION METHODS FOR MECHANICAL EQUIPMENT: THERMAL & ULTRASOUND

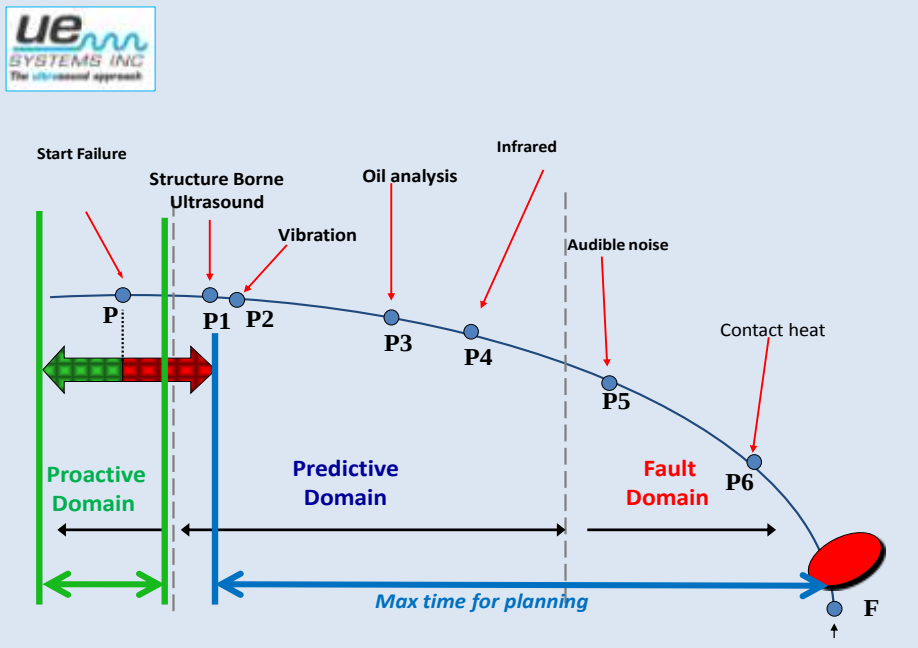
Ing. Marius **POPOVICI, General Manager**, MICRONIX PLUS SRL,
mpopovici@micronix.ro

Abstract. *Maintenance of mechanical equipment based on NDT methods has seen unprecedented development in recent years due to the many advantages these methods: investigations are done remotely, without putting the operator at risk and monitoring mechanical equipment can highlight potential problems that can be detected long before they escalate into serious fault. Well-regarded inspection tools include thermal inspections, vibration analysis, oil and ultrasound analysis.*

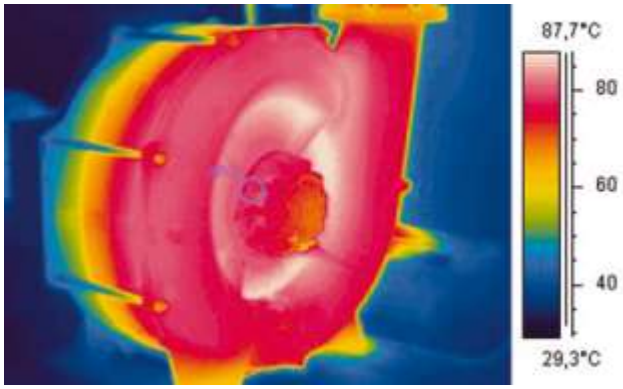
Keywords: infrared cameras, thermovision, thermography, ultrasound, maintenance of mechanical equipment

MICRONIX Plus, FLIR Systems and UESystems representative for Romania, offers a full range of thermal cameras and equipment for ultrasonic non-destructive investigation of mechanical installations.

The chart below illustrates the defect moments that can be highlighted by using different inspection technologies. As shown, ultrasonic technology can be used both in the PROACTIVE (before the advent defect due to improper use) and in prediction with infrared scanning technology (IR).



Any body with temperature above the 0Kelvin will emit IR radiation. The energy emitted depends on the temperature and the emission properties of the examined body.

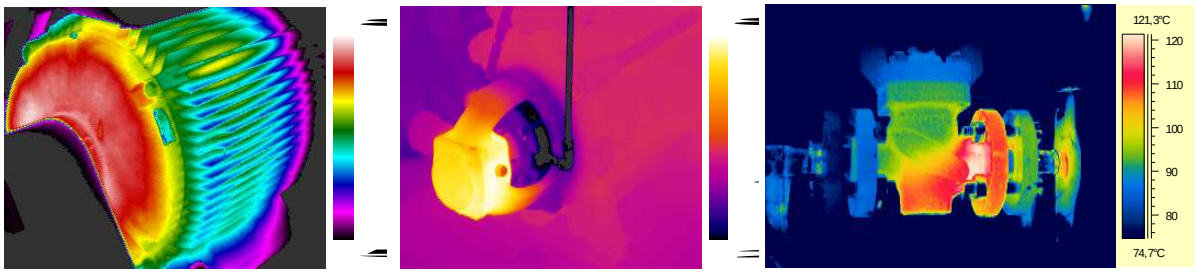


In the case of mechanical equipments, failure is usual inside of the housing and the infrared camera can "see" the thermal pattern at the body surface due to heat transfer by conduction. This is essential in the analysis because the operator must take into consideration that temperature value measured on the outer surface may be a few tens of degrees lower than the real temperature of the mechanical problem.

IR thermal inspections are accurate, rational, intuitively interpretable, nondestructive, noninvasive, noncontact, and fast. They provide instant images and data that are immediately usable in reports, and they can be easily archived to maintain a trending study of performance, which in turn may be used to project time-to-failure, enabling optimal scheduling of maintenance, based on actual operating condition, and preempting catastrophic failure [1].

Preventive maintenance is not just a matter of organisation: it also requires knowledge and the efficient handling of gathered information. A suitable thermal imaging camera helps in both of these areas, with an impact which makes itself abundantly clear in the cost-benefit analysis.

Thermography, among other things, reveals and measures heat generation in machines and installations. It visualises overheated components and detects and prevents "creeping" breakdowns. It has become a familiar and accepted technique for preventive maintenance. What is less well known, however, is that the consistent, large-scale use of thermography can yield impressive savings.



FLIR Series-E / Compact Infrared Cameras with On-board Visual Camera, Wi-Fi Connectivity, P-i-P and Bright LED Light

Presenting the best performance and value in compact thermal imaging cameras ever, designed to fit beautifully into your IR inspection program, budget, and the palm of your hand.

E-Series cameras offer:

- ➔ Superior Thermal Imaging – Up to 76,800 pixels (320 × 240) for better long-range accuracy and the highest level of point & shoot camera IR resolution
- ➔ Improved Digital Camera – 3.1 megapixel resolution provides clearest visible light pictures in its class and includes bright LED lamp that doubles as a fashlight (2 megapixel for E30 model
- ➔ Wi-Fi Connectivity - Send images and data to an Apple or Android mobile device to create and share reports and critical information quickly using the FLIR Tools Mobile App.
- ➔ Measure More than Temperature with MeterLink™ - Quantify the severity of electrical problems with Extech MeterLink clamp meters that use Bluetooth wireless communication to send data to the camera for annotation on stored thermal images.
- ➔ Large Landscape Touchscreen - Brighter than other brands, the FLIR E-Series touchscreen provides an intuitive interface that takes full advantage of the entire 3.5" display with no image cropping.
- ➔ Multiple Measurements - Add up to three box areas and three moveable spots using the touchscreen to gather more detailed temperature information.

FLIR T620 & T640

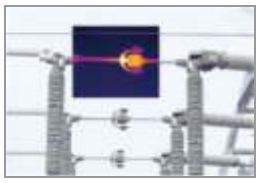
High performance thermal imaging with on-board 5MP visual camera, interchangeable lens options with autofocus, and large 4.3" touchscreen LCD

These thermal cameras combine excellent ergonomics with superior image quality, providing the ultimate image clarity and accuracy plus extensive communication possibilities:

- ➔ Highest IR Resolution in Its Class – Crisp thermal images with 307,200 pixels (640 × 480) for the best detection, pictures, and temperature measurements from long range
- ➔ New! MSX™ Enhancement – Multi-Spectral Dynamic Imaging adds visible spectrum definition to IR images in real time for excellent thermal detail that instantly highlights problem locations (T640 only)
- ➔ New! Field of View (FOV) Match – Option to match the visible camera field of view to the IR FOV for better documentation
- ➔ Wi-Fi Connectivity – Send images and data to smartphones and tablets and share critical information quickly with the FLIR Tools Mobile for

Apple® and Android™, featuring live video streaming and remote control via the mobile device

➔ High Temperature Range – measures up to 2000°C targeting applications
➔ Scalable P-i-P and Thermal Fusion – Blend thermal with visible light images on-screen; includes picture-in-picture window sizing
➔ Multiple Measurements – Report all the details with 10 measurement spots, 5 box areas, Delta T temperature differential, isotherm, and auto hot/cold markers METERLiNK®
➔ Wirelessly transmit vital diagnostic data from clamp and moisture meters directly to the camera for annotating thermal images to further support findings and decisions
➔ Annotation – Add voice comments via Bluetooth headset and text notes from the touchscreen keypad. New! T640 has image sketch feature to draw circles and pointers on IR/Visual stored images
➔ InstantReport – Create PDF document directly from the camera


Picture-in-Picture


Real image


IR image


Thermal Fusion

COMMON USES OF AIRBORNE AND STRUCTUREBORNE ULTRASOUND TECHNOLOGY [2]

Sound is not directional and penetrates solid materials, making it difficult to locate.
Ultrasound is defined from 20kHz to 100kHz and has the following advantages:

- Very directional
- Reflects on solid materials and does not penetrate
- Reduces in strength, making source locating easy
- We can use the information for condition evaluation

Applications:

Valves

Valve activity such as leakage or blockage can be accurately checked while the valve is on line. Properly seated valves are relatively quiet while leaking valves produce a turbulent flow as the fluid moves from the high pressure side through the leak to the low pressure side. Due to a wide sensitivity and ultrasonic frequency selection range, all types of valves even in noisy environments can be accurately tested.

Pressure/Vacuum Leaks

As any gas (air, oxygen, nitrogen, etc.) passes through a leak orifice, it generates a turbulent flow with detectable high frequency components. By scanning the test area with an Ultraprobe, a leak can be heard through the headset as a rushing sound or noted on the display/meter. The closer the instrument is to the leak, the louder the rushing sound and the higher the reading. Should ambient noise be a problem, a rubber focusing probe may be used to narrow the instrument's reception field and to shield it from conflicting ultrasounds. In addition, Frequency Tuning (available in most models) dramatically reduces background noise interference to provide ease of ultrasonic leak detection as never before experienced.

Steam Trap Inspection

Major steam trap manufacturers have recommended ultrasound inspection of steam traps as one of the most reliable methods available. By converting the ultrasonic elements of a working steam trap into the audible range, Ultraprobe® allows users to hear through headphones and see on a display/ meter the exact condition of a steam trap while it is on line. Blow-by, machine gunning, oversized traps or line blockage are all easily detected. Frequency tuning enhances Ultraprobe's ability to discriminate between condensate and steam. Ultraprobe® markedly reduces confusion from extraneous sounds or from heat transfer, even when traps are extremely close together.

Bearing Inspection/Monitoring

Bearing Inspection/Monitoring Ultraprobe® detects the earliest stage of bearing failure. NASA research has demonstrated that ultrasound bearing monitoring will locate potential bearing failure long before it is detected by traditional heat and vibration methods. With the Ultraprobe, users hear the sound quality of a bearing as well as monitor amplitude changes on the display/ meter. This provides the ability to trend, trouble shoot and confirm potential bearing problems. Bearing inspection is easy with the Ultraprobe®. Requiring only one test point and very little training, users will learn to test bearings within minutes. Frequency Tuning makes it easy to tune into a bearing and isolate it for analysis regardless of competing signals. Even current vibration programs will achieve enhanced diagnostic ability with an Ultraprobe®. Most vibration analyzers are easily connected to an Ultraprobe.

Prevent over-lubrication

with the Ultraprobe® 2000 by simply lubricating only until the meter reaches as pecified level. Over lubrication is one of the most common causes of bearing failure.

Using ultrasound technology for trending bearing condition:

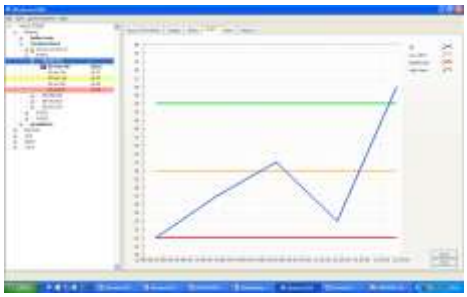
- ➔ Indicating early warning of failure
- ➔ Identifying lubrication condition
- ➔ Avoiding over lubrication

Works also on slow moving bearings or sloe bearings!

Friction between mechanical components will cause a sound energy

The dB levels can be used to evaluate condition in the route-based data colletion principle with help of DMS software:

- ➔ Baseline +8dB = Lubrication alarm
- ➔ Baseline +12dB = microscopic damage
- ➔ Baseline +16dB = visual damage



General Mechanical Inspection
of pumps, motors, compressors, gears & gear boxes: All types of operating equipment may be inspected with an Ultraprobe®. Since Ultraprobe works in a high frequency, short wave environment, problems such as cavitation in pumps, compressor valve leakage or missing gear teeth may be heard and isolated.
Ultraprobe's Frequency Tuning allows users to quickly "tune in" to problem sounds and recognize them with little previous experience due to the clarity of the heterodyned signal.

Heat Exchangers,Boilers & Condensers
In-leakage or pressure leakage can be readily located with the Ultraprobe. Fittings, valves, flanges are all easily scanned for leakage. The high frequency, short wave nature of ultrasound allows operators to pinpoint the location of a leak in high noise environments. Condenser tubes and heat exchanger tubes may be tested for leakage through three methods: vacuum, pressure, ultratone.

Vacuum. The tube sheet is scanned for the tell-tale rushing sound produced as the leak draws air into the tube.

Pressure. Additional testing may be performed when the system is off-line utilizing air pressure around the tube bundle and scanning for the rushing sound produced from the leaking tube.

Ultratone. A unique method that is also employed for heat exchangers is the "Ultratone" method in which a powerful high frequency transmitter floods the shell side of the exchanger with ultrasound. The generated sound will follow the leak path through the tube. A scan of the tube sheet will indicate the leaking tube.

REFERENCES

[1] FLIR Systems – Thermal Imaging Cameras for Industrial Applications - 2012
[2] UESystems – ULTRAPROBE® Ultrasound Applications Brochure - 2008