# Predictive maintenance using thermography in industrial environments and the effect on revenue protection

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**Abstract**

Temperature is a key condition indicator which is the most frequently made measurement as the temperature measurement indicates the state of "health" of machinery and the human body. By periodically measuring these temperature indications we are able to set up a thermal profile which in turn allows us to predict an impending failure before it happens and prevents the cost of downtime. This paper will look at some older techniques of maintenance used and the benefits of predictive maintenance using thermography in industrial environments and the effect on revenue protection.

## 1. Introduction

Maintenance costs are normally a major portion of the total operating cost in most industries. A major factor to these high costs was the misuse of the expenditure due to lack of factual information that quantifies when and what kind of maintenance is required to either repair or replace critical machinery or equipment.

Typically the equipment was not monitored to gain knowledge of performance, failure history and any other symptoms that would lead to premature failure. In many cases the maintenance staff would get the blame for a poor installation and the cost of replacement or repair would be greater than the maintenance budget.

The general feeling has been that maintenance is a necessary evil and that nothing could be done to improve maintenance costs. The most common maintenance programs employed in the past were: run to failure management and preventive maintenance.

## 2. Run to failure management

This program was simple, the equipment fails, you fix it and it would seem to be the most cost effective method as no money was spent on maintenance; this however would have the greatest effect on the bottom-line as the following expenses would be incurred:

- Downtime
- Low production
- Poor quality

This reactive maintenance has further disadvantages such as the requirement of carrying spare equipment and a high inventory of spares, the expense incurred on this form of maintenance can be three times more than a scheduled or preventive repair.

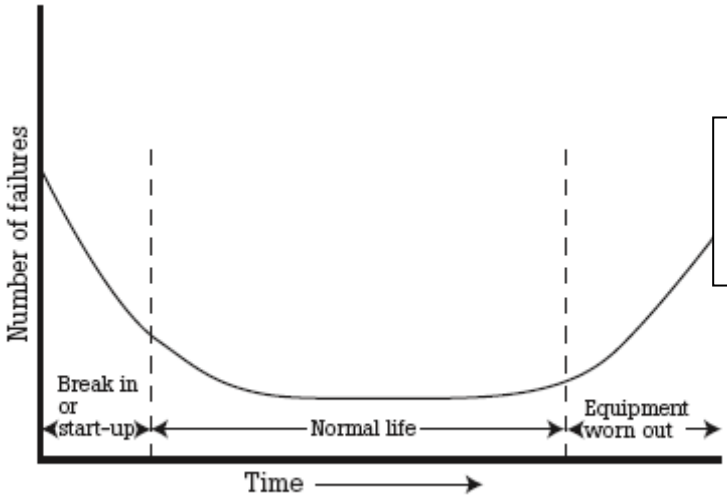
**3. Preventive maintenance**

This form of maintenance is time driven and relies on historical data of equipment as it involves statistical data and hours of operation.

In most cases preventive maintenance uses the MTTF statistic and an illustration of this is represented below as figure 1.

MTTF The mean time to failure: Bath tub curve

Indicates that a new machine has a high probability of failure during the first few hours or weeks of operation due to installation or manufacturing problems. Following the initial period the probability of failure is relatively low for an extended period of time. Following this normal machine life period, the probability of failure increases sharply with elapsed time or hours of operation.




There are actually 6 failure patterns including the conceptual curve described by you including (Reliability Centred Maintenance, Moubray, 1991, Butterworth

**Figure 1. Bathtub curve.**

This raises further factors on the quality of maintenance as all preventive maintenance programs assume that machines will degrade within the statistical time frame typical for its particular classification. For example a piece of equipment will normally run 18 months before it should be replaced. Using preventive management techniques, the equipment would be removed from service and rebuilt after 17 months of operation. What if this equipment failed before the 17 month period? We would resort to run to failure techniques and we have seen how this form of maintenance impacts on the bottom-line.

Preventive maintenance is very costly as in some instances it is very similar to run to failure maintenance and from this form of maintenance the information is not always factual.

If only we had a crystal ball that could tell us if something was about to fail.

## 4. Thermography

Thermography is a non contact technology that measures infra red wavelengths to determine an object's thermal radiation distribution at a safe distance and in real time. In other words we are measuring the thermal representation of an object as well as 1000's of temperature points in real time.

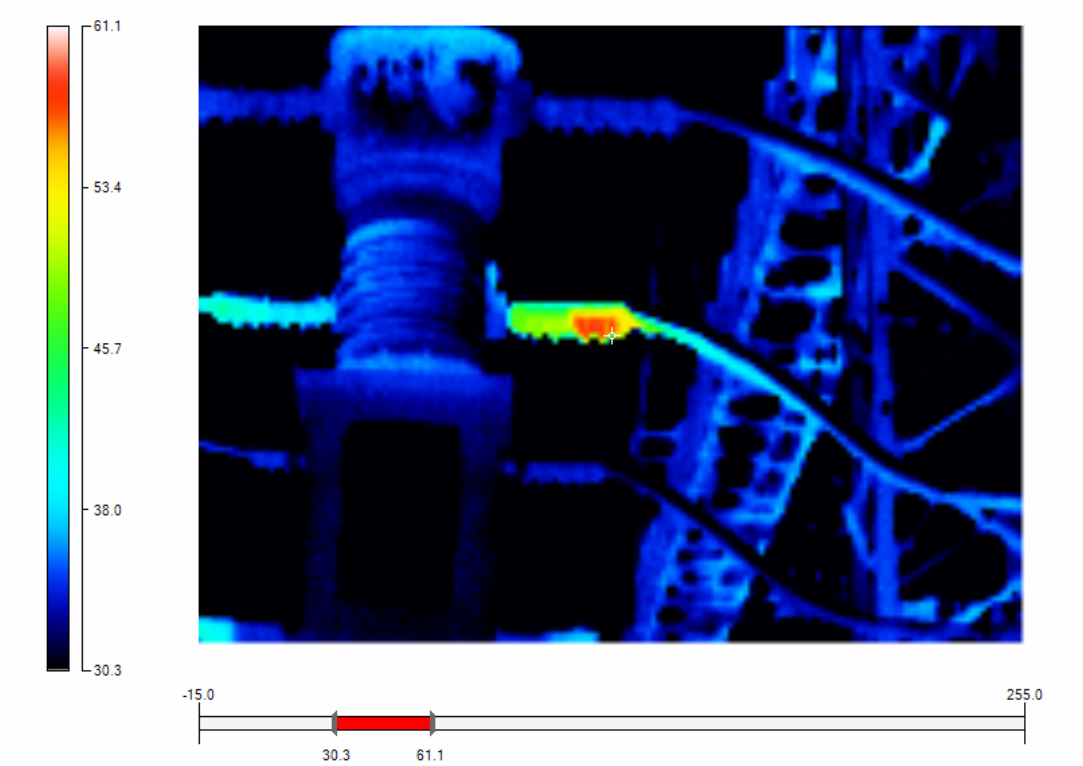



**Figure 2. Thermal image**

## 5. The Electromagnetic spectrum

The electromagnetic radiation spectrum is the complete range of the wavelengths of electromagnetic radiation, beginning with the longest radio waves (including those in the audio range) and extending through visible light (a very small part of the spectrum) all the way to the extremely short gamma rays that are a product of radioactive atoms.

The entire range of radiation extending in frequency from approximately $10^{23}$ hertz to 0 hertz or, in corresponding wavelengths, from $10^{-13}$ centimetre to infinity and including, in order of decreasing frequency, cosmic-ray photons, gamma rays, x-rays, ultraviolet radiation, visible light, infrared radiation, microwaves, and radio waves.

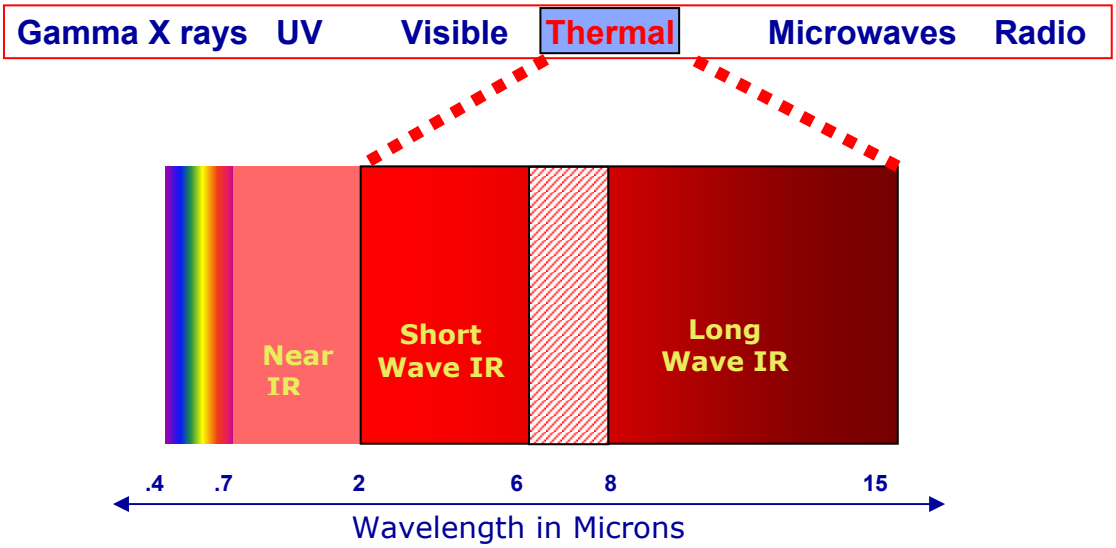



**Figure 3. Electromagnetic spectrum [Snell Infrared Training Manual Level 1]**

Most thermal imagers use the 8-14 micron range due to higher sensitivity to ambient temperature, reduction in reflected sunlight and good transmittance.

With a thermal imager it is quick, easy and safe to check critical parts while the machine continues to run. An effective predictive maintenance program can add to your bottom line by using thermal imaging technology to proactively find problems before they cause an outage so you can effectively plan a shut down for repair or equipment replacement. This takes a lot of the guess work out and now you are able to predict these failures with factual information.

## 6. Electrical application.

Thermal imagers are an easy way to identify apparent temperature differences in industrial three phase electrical circuits compared to their normal operating conditions**.** By inspecting the thermal gradient of all three phases side by side you can quickly spot performance anomalies on individual phases, these temperature differences are an indication of a power quality problem that may be due to unbalance, overloading, harmonics or even open circuits.

New electrical components begin to deteriorate as soon as when we install them, vibration, fatigue, environment and age cause the loosening of electrical connections whenever a load is put on a circuit, put it this way, all electrical connections over time will fail, fortunately a loose or corroded connection increases resistance at the connection and the increased resistance results in an increase of heat which in turn has a higher consumption of energy and adds to the cost of electricity.

When using thermal imaging to troubleshoot loose, over tight or corroded connections in electrical systems first remove the panel covers and then:

- Remember safety steps
- Compare temperatures of connections within panels
- Look for connections that are hotter than others
- Look for hot spot related connections as these normally appear warmest at the spot of high resistance and cooler the further you get from the spot
- Store the relevant image for further analysis

**Other Thermal imager applications:**

- Mechanical
- Process
- Building
- Medical

## 7. Predictive maintenance

Predictive maintenance is a condition driven preventive maintenance program, instead of relying on industrial or in plant average life statistics to schedule maintenance activities, predictive maintenance uses direct condition monitoring techniques which determine operating condition, efficiency, heat distribution and other indicators to determine the actual time to failure or loss of efficiency that would be detrimental to the plant or facility.

This program now provides factual information on actual operating conditions of critical assets, including efficiency, as well as the actual mechanical condition.

Now maintenance management has the factual information to effectively plan and schedule maintenance activities.

Predictive maintenance is not vibration testing or thermal imaging, it is a philosophy or attitude that simply stated uses actual operating conditions of plant equipment and systems to optimize total plant operation.

Predictive Maintenance is an integrated approach to condition monitoring and includes thermography and vibration analysis.

A comprehensive predictive maintenance program utilizes a combination of cost effective tools, i.e. thermal imaging, vibration monitoring and some other non destructive testing methods, to obtain actual operating conditions of critical plant systems.

If we look at some of the benefits of predictive maintenance we can see that:

- We can minimize unscheduled breaks in production
- We can identify problems before they become critical
- Major repairs can be prevented if a problem is detected early
- Repaired equipment is in acceptable condition
- Could eliminate 33% to 50% of maintenance expenditure
- Improves the life span of critical equipment

**8. Maintenance routing**

Maintenance routing requires frequent inspections of equipment and this could be visual inspections or non destructive tests using various test instruments. The frequency and sequence of inspections should be predicated on the unique requirements of each system and will vary depending on the make up of facility equipment.

There are three primary criteria that should be considered when developing routes for predictive maintenance:

- Travel time
- Logical sequence of inspection
- Safety
- Criticality of machine

The best solution is to create a regular inspection route that includes all key electrical panels and other load connections such as drives and controls. This gives you a baseline to compare to what will help you to determine whether a hotspot is unusual or not and it is also helpful for verifying if repairs were successful.

You could then analyse stored images taken of your equipment and then return at regular maintenance intervals to reshoot your equipment, then using a computer compare new images with previous ones to determine any gradual changes in temperature that could signal impending problems allowing you to plan a maintenance route that can be uploaded to your imager, which gives you a description, the image and date of the image. As seen in figure 4 below:

**Figure 4. Inside IR Software**

**Conclusion**

A properly conducted predictive maintenance route will ensure longer life cycles of equipment, decrease downtime and increase profitability of production.

**References:**

Fluke-*the basics of preventive and predictive maintenance 2005*
Fluke plus-*thermal imaging preview 2006*
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*Info:snellinfrared.com www.snellinfrared.com Phone: 800-636-9820*