Pre Outage Inspections and Condition Monitoring Utilizing Infrared Thermography

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Infrared thermography has evolved rapidly in technology, application, and understanding. Originally, infrared thermography was used for electrical inspections. It is accurate and does not require physical contact. The older generation of cameras produced images that were fuzzy at best. Today the image quality or resolution rivals visible light imagery. Today's improved image quality has made thermography more widely accepted by industry. This article will introduce you to TFL, incorporated, some theory behind infrared thermography, reporting, application, and practical experience.

TFL's infrared thermographers are certified through The Academy of Infrared Institute and EPRI (Electrical Power & Research Institute). We employ two registered professional engineers. TFL also employs personnel certified in numerous NDE methods (ASNT Level II M.T., P.T., U.T.) and numerous ABB Boiler Inspection Schools and Seminars.

TFL's Infrared thermographers have been performing Infrared Services since 1992 with great success in power plants (electrical generation), electrical distribution (substations and transmission lines), aluminum and alumina refining industry, paper mills, steel mills, cement plants, bottling & packaging plants and commercial buildings (new construction and annual electrical inspections).

TFL uses the Amber Radiance PM Thermal Imaging System. This camera is one of the best imaging systems on the market today. It has a sensitivity of +/- 0.02 C. The sensitivity provides for highly accurate temperature readings and very clear pictures.
We use this equipment for condition monitoring of refractory lined vessels, electrical systems and mechanical systems. This system is highly portable, we provide this service throughout the US and around the world, no place is too hard to reach.

In addition to infrared, our primary business concerns are refractory engineering and design; manufacturing and engineering pre-cast pre-fired refractory shapes and the supply of refractory materials and anchors. TFL has been in the refractory business for over 20 years.

Understanding what you see in the infrared images is paramount to implementing an effective infrared program. The camera is only capable of seeing the top .001 of an inch of any surface. It, nor its operator, can tell you what is wrong on the inside. However, refractory experienced thermographers and plant personnel can work together to determine the most likely cause of a given anomaly.

Theory

Infrared thermography is a means to detect infrared energy. All matter emits infrared energy. The temperature of an object increases with an increase in stored energy. The emission of infrared energy also increases with the increase of stored energy. The detection and interpretation of infrared energy is how the infrared camera creates an image and extrapolates the temperature from the intensity of the energy being emitted. Ultimately the image produced by an IR camera can be viewed as a map. The varying colors of the image represent temperature variations in the object being viewed. If you were to view an object which ranged from 100 degrees F to 355 degrees F and the camera was set in 256 shades of gray, then every degree could be represented by a color.

If the difference in temperature is much smaller, then each color can represent small fractions of degrees and the image becomes very detailed, thermally speaking. The converse is true where the difference is great; each color may represent a number of degrees.

IR Thermography is primarily interested in comparing known or expected temperatures to actual temperatures. Elevated temperatures are generally good indicators of a problem, or at least a change, in most processes or systems. Missing refractory, channeling, flame impingement, deteriorated insulation, wet insulation, egress and ingress of gases will all exhibit a thermal profile or pattern indicative to its nature. When you are evaluating these pattern differences you will need to be aware that the camera will see both perceived temperatures as well as actual temperatures.

Perceived temperature differences may are caused by differences in:

Emissivity
Reflectivity
Difference in shape
Coatings (paints, oxidization, plastics…)

Actual temperature differences will be affected by:

Convection (by a fluid gas or liquid) Wind
Material Phase Change (solid to liquid to gas) Evaporation of Rain
Thermal Capacitance (materials ability to store or transfer heat)
Induction heating (creation of heat induced by an electromagnetic field)
Radiation (radiant heat)
Contact Heat transfer (from one material to another by contact)

Knowing what the factors are that affect your readings (perceived as well as actual) is crucial to understanding what the report is actually telling you. Your infrared report should give you the weather conditions at the time of the scan as well as the settings of the camera. The operator should be skilled in identifying the active influences during the scan and be able to neutralize or minimize their affect on the readings.

TFL Report Design

Our reports combine two sources of media. First, the entire scan is recorded on 8-mm videocassettes. The technician narrates throughout the scan giving explanation as to location and condition of what is being scanned. This video records the picture, color temperature scale, emissivity, date, current time and a profile line. The 8mm video is an excellent source of base-line data to help in predicting or forecasting of possible problems in the future. Once an anomaly is identified, a digital image is saved in the camera. Second, the digital images are printed on to hard copy in report form.

The image is printed in two color palettes, color and monochrome. This gives the reader a better understanding of temperature profiles and gradients. Also included in the hard copy report is the date and time the image was taken, point temperatures, average temperatures, location and description of the anomaly and scanning parameters.

The time the image was taken corresponds with the time recorded on the video. This enables you to locate where on the video a given anomaly was found and view what preceded and followed the area of the anomaly.

Application

We are currently using IR thermography to monitor refractory lined vessels. We typically perform mechanical and electrical surveys at the same time; however, for the purposes of this article we will remain focused on refractory lined vessels.

Refractory lined equipment is surveyed at 3 periods during its production campaign.

> ***Start Up***:
> This is a baseline scan. You need to establish the condition of your equipment after repairs or construction is completed. The equipment should be operating at target levels. This scan will be used for comparison. This scan establishes what is considered normal and acceptable.
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> ***Monitor*** (routine):
> These scans are performed at regular intervals to monitor the condition of the refractory lining during a production campaign. Frequency of the scans will be determined by the nature of the equipment. Quarterly scans are performed on severe service applications while annual scans are used to monitor milder applications. The monitoring scans are compared to the baseline or start up scan to identify changes in lining conditions. It may become necessary to monitor areas more frequently once a problem is identified.
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> ***Pre-Outage:***
> This is done just prior to bringing the equipment down for repairs. The primary focus of the scan is to identify the scope of work. The scan results are considered along with visual inspections and historical experience to define the expected scope of work. Many times the infrared survey is instrumental in establishing priorities. There are also times where infrared reports may indicate that a particular vessel can remain online for an extended period of production.

What has it done for me lately?

There are a number of interesting experiences that illustrate the value of condition monitoring with infrared. Here are a couple that will make the point.

One of our clients in South America was not using infrared thermography and was relying on other more basic forms of monitoring his lining. The unit was running for 18 months or so between major shutdowns. The shut downs would normally involve extensive refractory replacement. The scope of work and the timing of the outage were both heavily based on past experience.

This plant has now been using our service for a couple of years and according to their people, this has enabled them to increase their campaign duration to almost 2 years and it has substantially reduced the degree of repairs to be made. This is all based on more accurate and timely information. This has taken them into a predictive maintenance environment rather than responsive.

Another one of our clients took the pre-outage report along while he inspected the unit prior to tear out. He was amazed at how accurately the report depicted the condition of his refractory lining. He is much more confident in developing his scope of work with this tool now that he has first hand knowledge of its accuracy. This client now distributes our report to all of his key turnaround personnel and his refractory contractor prior to the turnaround.

The bottom line in evaluating any service or product is the answer to "can it provide tangible benefits which outweigh its cost". Infrared can! You will know when and where problems are developing before they control your next move. You will know more about your chances of extending a production run. You will be able to quantify refractory outages with better information and with a better grasp on priorities. And, you can quantify the results of repairs at the beginning of a new production run.

If you're not using infrared thermography, give us a call. We can get you going on the right track.