The Reality of Implementing Infrared Practices and Techniques into a Maintenance Reliability Program

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Abstract
This paper briefly discusses a list of program elements needed to measure, optimize and maintain an effective infrared program. While selecting the right infrared equipment for the appropriate applications and conducting scheduled, route-based inspections per written procedures are important examples of a few of these elements you will see in the second part of this paper it takes more than a list of elements to implement a successful infrared program as part of an effective reliability initiative.

What is Infrared Thermography?
This remarkable technology utilizes electronic imaging cameras that detect emitted heat, or infrared radiation, in much the same way, that conventional video cameras see visible light. Infrared is radiated by all objects above absolute zero and is also reflected by many types of surfaces and transmitted by a few. For the most part, we see surface thermal patterns only and must interpret their meanings based on internal and surrounding thermodynamics. It is vital to understand that thermal imaging cameras do not “see” inside components as an X-ray might. Surfaces emit with different efficiencies, termed their emittance (emissivity) unpainted metals are inefficient and have low emissivity values. In addition, low emissivity surfaces are typically highly reflective of the radiant energy of their surroundings thus making it extremely difficult to make accurate, repeatable temperature measurement of unpainted metal surfaces under field conditions.

Condition Monitoring of Assets:
In order for thermal images of assets to have diagnostic value, it is necessary to (1) know how the asset is constructed and its function, (2) to understand how it fails and what the thermal signatures of those failure modes are, and (3) to understand how the assets operational and environmental conditions will affect the thermal signature.

Infrared Reliability Programs:
As students complete our courses, they typically fall into one of two groups. Those returning to an established or mature infrared program at their facility, and those expected to create, administer and maintain/manage a full infrared inspection program. In both cases, there will be opportunities and challenges. The student who is returning to an existing program has the opportunity to audit the existing program and the student tasked with developing an infrared program should be assessing the opportunities. The following is a list of program elements needed to measure, optimize and maintain an effective infrared (or other condition monitoring) program.

- Program Foundational Elements
- PdM (Infrared) Equipment
- Applications
- Training
- Safety
- Methodologies, Procedures, Analysis, Reporting
- Routes and Scheduling
- Performance: Metrics, Continued Improvement, Communication, and Audit
Program Foundational Elements:
The foundational elements are just that the components necessary to build your program. Unfortunately, they are beyond this discussion, but we want to list a few essential pieces worth consideration.

- Maintenance/Reliability/Engineering/Technicians Roles and Responsibilities
- Asset Hierarchy
- Asset Criticality Ranking
- FMEA
- RCM
- PM Optimization supported by CBM
- Effective Planning and Scheduling

Infrared Equipment:
Selection of the correct infrared equipment to support your applications is crucial. Understanding camera performance specifications such as: temperature ranges, thermal sensitivity, spatial and measurement resolution, frame rate and any special performance features like filtering or high contrast are vital to quality data collection. And don’t forget about additional peripheral equipment like an anemometer for wind speed, a computer and software for analysis and reporting, and possibly additional lenses, if needed.

Applications:
Initially infrared programs start with electrical applications and effective programs strive to achieve 100% coverage. But well-rounded programs quickly expand to include mechanical applications including rotating equipment, storage tanks, steam systems, hydraulics, refractory, valves and more. Building envelope performance or roof moisture inspections round out the typical applications. Additional applications may include but are not limited to nondestructive testing, gas leakage, solar panels and mobile equipment.

Training:
Training requirements may differ depending on your applications and a company’s required level(s) of qualification. Companies following ASNT (American Society of Nondestructive Testing) may require Level 1 and/or Level 2 compliant training, testing and experience. The following is a suggested thermographer career development path and timeline:
Safety:

In thermography there are some avoidable risks. The thermographer needs to understand what the risks are and conform to standards, guidelines and procedures to eliminate or minimize them! For example, NFPA 70E (or CSZ Z462) Standard for Electrical Safety in the Workplace, should be read, understood and followed for anyone conducting electrical inspections. Key components of this document discuss approach distances, labeling, PPE (Personal Protective Equipment) and incident energy. Additional electrical safety considerations include infrared windows, continuous monitoring, as well as pre-scanning enclosures with infrared and ultrasound. And while we’ve emphasized electrical inspections, special precautions are needed for rotating equipment, confined space, elevated work areas and intrinsically safe equipment requirements.

Methodologies, Procedures, Analysis, Reporting:

There are a variety of inspection options available to the thermographer and the asset type and criticality may define the best methodology. Baseline and comprehensive inspections are typically applied to complex highly critical systems. Exception inspections are most commonly used for electrical systems. And trending can be applied in many situations to track or trend temperatures.

Procedures should be developed to support consistent results. They may be required for a Level 1 to conduct the inspection, for complex inspections and in any situation where safety concerns exist. Additional benefits of procedures can include program continuity (especially in a company with multiple sites), assistance for new thermographers and possible insurance benefits.

Analysis with supporting documentation or reporting is a vital component of the infrared program. All too often findings or anomalies are identified in the field and repaired without any supporting documentation. Therefore, there is no proof of the great outage that was avoided and no validation of the infrared program. Also, worth noting here is how the severity of the anomaly is determined. It is quite common that a temperature-based prioritization is utilized. We can’t emphasize enough that temperature is only one aspect of the severity and many other variables must be considered for proper repair prioritization. We suggest the use of a risk assessment approach as shown below. Where the likelihood of failure is related to the consequence of that failure.
Routes and Scheduling

Equipment lists based on asset criticality, insurance requirements, quartile coverage and industry best practices are used to establish inspection routes. These routes may be established by location, process, equipment type, availability or maybe a combination of these. Do not assume an annual scheduling and inspection frequency is adequate. Risk reduction is very different than condition monitoring for reliability. Quarterly or even more frequent inspections may be appropriate for some critical assets/systems. Stressors on a system should be considered too, not just criticality. For example, high number of start/stops cycling, an excessive thermal environment, a corrosive environment or maybe an unusual single event (ex. lightning or locked rotor).

Program Performance: Metrics, Continue Improvement, Communication

These are some crucial program components that are often overlooked. We need metrics to measure our success. We need to assess our program to identify areas for improvement. And we need to communicate for program awareness. One tool that can be utilized for these is through a program audit or assessment. Metrics of an audit can be tracked and communicated through a chart as shown below.

And as you can see, we are assessing the components of the program we just discussed.

The following section is an excellent example of the reliability journey experiences from an infrared perspective at one company.
Reliable Infrared practices
Scott James
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Abstract
Over the years, a maintenance team may take on a philosophy of “This is how we’ve always done it, or this equipment has never worked!” This philosophy must change to become a reliable maintenance team. Implementing reliable IR practices into an existing mechanical reliability program is a no brainer. Our electrical grid and equipment associated with it are vital for our plant operations and production. The plant view of reliability is important and determines the success of any program implementation. Changing the culture will be the most difficult but the most rewarding when it is accomplished.

We must first realize the importance of a successful IR program. The goal of any maintenance program must meet or exceed plant expectations. It must assist in developing and sustaining a safe, reliable maintenance team and plant operation. It must be safety driven and compliment other reliability programs already in use. If you work in a plant that is 30 years old or older, you should understand you are reaching the end of life cycle on your electrical equipment. What can you do to protect it, extend its life cycle, prevent and predict failures, and develop a plan to replace this equipment? Has it reached its end of life cycle? Infrared is a technology that can assist us in identifying these problems! We must realize that our power systems and instrumentation are essential to our plant operation and safety.

Let us begin by discussing vision. Who needs a vision? Everyone in your plant and organization! Where does it begin? It must begin at the top and work its way to the bottom. At your facility, it begins with management. Management must share and promote their vision. The next group to share and promote their vision are your engineers, then your maintenance team, followed by the process technician and control room operators, your administrative and support staff, and lastly your contractor team, service providers, and vendors. A proverb states, “Where there’s no vision people perish”. Simply put—without vision plants are not safe or reliable, without vision plants are not productive, without vision deadlines and production goals are not obtainable, without vision jobs are lost, and without vision, plants shut down. These are the factors why we must have vision! The goal of this vision is to reach complete “Buy-In”!

When establishing an IR program, you must have a leader who can bring energy to the team. The team will feed off their energy and culture will begin to change. The effort or work involved in developing it must continue even after you begin to see results. You should never stop doing what helped you obtain results. A leader must be enthusiastic. Boredom is a killer to anything in life. Enthusiasm is contagious and it breeds excitement. You must have realistic expectations and develop your team to succeed. We must expect results and successes but realize that we do not work in a perfect environment. Failures will happen but how we recover and learn from those failures will determine your future successes! Every team member involved must have a purpose, a direction, a sense of worth, and a measure of hope to make a difference. Others in your plant will begin to feel a sense of accomplishment and want to be a part of this culture. Every great movement that has ever started throughout time began with one person’s idea or invention. Are you the one that will make the difference at your plant?

Technology has changed through the years and can play a big part in identifying potential failures. Infrared technology can be cost-effective and useful to your success. If there is one thing that I have learned from experience is to find a technology that works for your plant and develop it with training, on job experience, and reporting before you try another technology. You don’t want this old wise tale statement to be implied,
“A jack of all trades but a master of none!” We should all be conducting electrical testing methods and have a plan in place to conduct them and report the results. However, plant production goals can make it hard to implement this valuable practice especially if your plant runs 24/7 and 365 days of the year. Infrared technology/practices require no downtime and have the least impact on production, therefore making it a perfect technology to spearhead your reliability efforts.

Here are some real-world case studies to review:

**Case study #1: IR Scan**

*Here is an example of plant-wide “Buy-In”:*

On a scheduled bi-annual IR route, a hot spot developed on US RF1 Line side Bus breaker stabs. As seen in Case Study #1, the IR scan showed a rise of 130F above ambient temperature @ bus stab. This required a Priority 1 report to be issue and scheduling of repair to be discuss. The IR tech recommended scanning the equipment daily to see if temperature had stabilized or was in a failure state. After 3 days of scanning the IR, tech concurred that the temperature was rising while ambient temperature and amp load had decreased. This meant that the condition was unstable. The tech met with the Maintenance manager to discuss his findings. After reviewing the images, the Maintenance manager presented facts to upper management. Based on the findings, management decided to take Refinery down to make repairs to avoid a catastrophic failure, an unsafe condition, Arc blast, fire, and destruction of equipment and lengthy downtime (24-36hr).

Refinery process technicians began controlled shutdown of refinery and E/I technicians along with contractors staged materials and discussed potential hazards. The electrical shutdown and repair of bus work took about 5.5 hours. The repair showed damage to line side bus stab from loose bolts @ stab connection from heat expansion of metals or construction. We disassembled bus work on the line and load side, replaced damaged bus stab to breaker, replaced 3200La main breaker due to heat damage @ contact fingers, cleaned all connections, and tightened all bolts to specifications. The next day the IR tech rescanned bus work repair and found an average of 85F temperature decrease on bus connections and only a 15F rise from ambient temperature.
Case study #2: IR image of RTO (Regenerative thermal oxidizer)

IR scans reveal hot spots and refractory issues – predicted a potential failure and allowed planned maintenance and repair.
Case study #3: IR image of starter bucket

Loose connection@ line side - c phase
Case study #4: IR reference image for quality of bag seal

Good seal vs Bad seal
Case study#5: IR image of Feed dryer (Johnson Joint)

Thermal efficiency of newly installed Johnson joint
Case study #6: IR image of steam trap

Verifying steam trap

Case study #7: Main Yard Fence

Grounding
**Scott James**

Scott has been an electrician for over 29 years. During those years he managed multimillion-dollar jobs, supervised and trained electricians, started an electrical company, and is presently dedicated to electrical maintenance and reliability at Tate and Lyle. Over the past 7 years they have experienced a reliability culture change in their electrical and instrumentation group by adding an electrical reliability technologist role. This role has allowed Scott to implement different technologies, methods, and programs to improve production up time and increase sustainability. Scott has obtained the following certifications: Thermography (Level 2), Transformer Maintenance Specialists, and Power Quality Technician.

**Roy Huff**

Roy is Vice President of The Snell Group with a demonstrated history, 38 years, of working in the professional training & consulting industry. Skilled in Aerospace NDT, Power Generation, Petrochemical, CBM, RCM, FMEA. He has a Bachelor of Science (BS) focused in Electrical Engineering from University of Missouri-Columbia, ASNT Level 3 Certificate #81115 T/IR, CMRP, NAS410 Level 3 TIR.