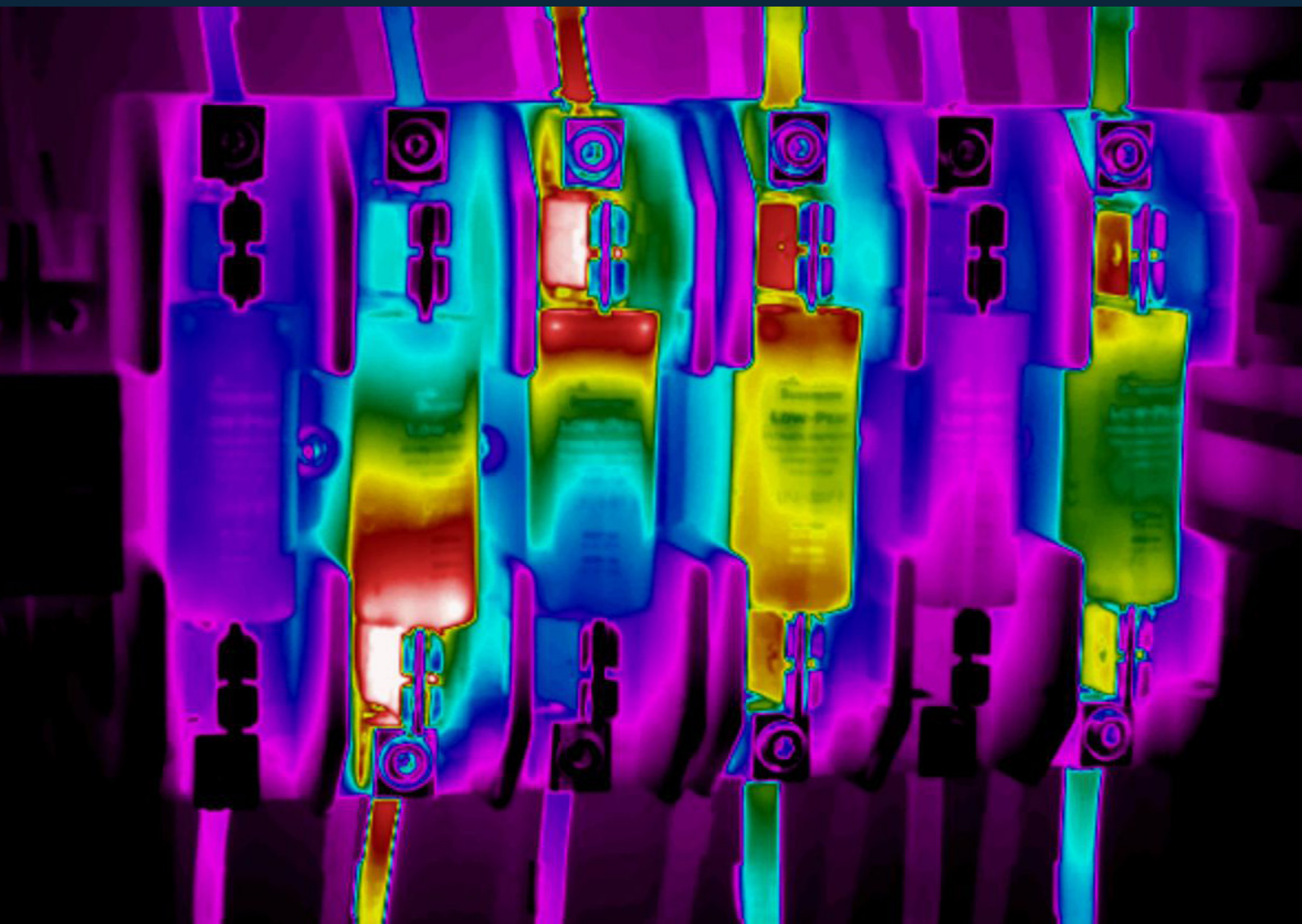
TÜV SÜD Global Risk Consultants®

Infrared Thermography

The key to identifying hidden fire and electrical hazards



What is Infrared Thermography?

When electrical problems are not identified quickly, the consequences can be dire.

Infrared thermography is the science of capturing and analyzing thermal information from machinery using infrared cameras. Every object with a temperature above absolute zero emits infrared radiation that is invisible to the human eye but can be detected by specialized sensors and cameras.

Infrared thermography cameras capture this emitted radiation and convert it into a thermogram, or visual image, representing the temperature distribution across the object's surface. The amount of infrared radiation emitted by an object increases as it's temperature increases. Infrared thermographic scanning can measure these emissions across a surface making it possible to form a thermal map of that surface and identify any areas of concern.

Infrared scanning is fast, accurate, and non-destructive. It helps risk managers and company leaders better understand fire and many potential failure risks in electrical, mechanical equipment, production machinery and within many other applications. Infrared thermography inspections and thermographic scanning/testing are best carried out by a certified Thermographic Consultant with a state-of-the-art camera and other predictive instrumentation (i.e. airborne ultrasound) to show a piece of equipment's progression toward failure.

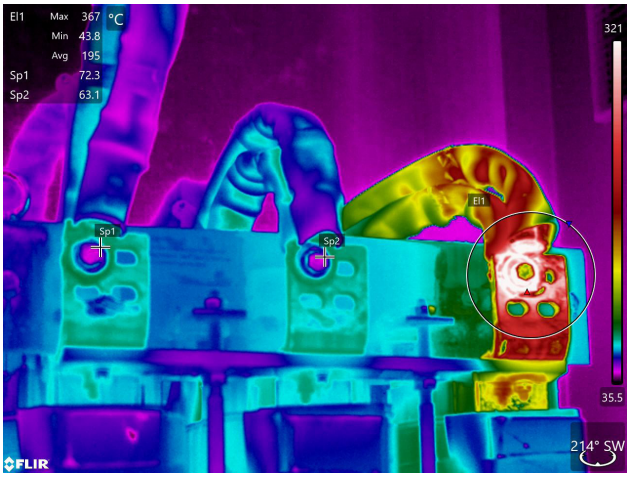
How Infrared Thermography Works

Trained professionals use properly calibrated infrared thermal imagers to detect abnormal thermal patterns, hot spots and other problems in equipment or electrical components. Infrared cameras are typically equipped with a lens, thermal sensor, processing electronics, a mechanical housing, and an LCD display.

The thermal sensor has multiple detectors, which are sensitive to infrared radiation. When pointed at an object or area:

- The infrared camera detects radiation emitted.
- The detected radiation is then converted into electrical signals.
- These signals are processed to create thermographic images (thermograms) with varying colors or intensities corresponding to different temperatures.

For example, in a color thermogram, warmer areas might be represented in red, while cooler areas appear in blue. Advanced cameras can also provide quantitative data, enabling precise temperature measurements from the captured image.



Infrared in action. These thermographic images taken by Global Risk Consultants show a deep well injection pump VFD reactor cabinet with a c-phase lug in the connection block that had heated to 360 degrees Celsius – almost 700 degrees Fahrenheit due to a loose cord and deteriorated component. Such a high temperature showed this was an imminent fire risk that needed to be mitigated quickly.

Main Use Cases for Infrared Thermography

Predictive maintenance: Thermal imaging is used to detect abnormalities in equipment, such as overheating components, which can signify impending failures.

Building inspections: Thermographic images can identify heat losses, moisture intrusion, and structural issues by visualizing temperature differences in walls, roofs, and floors.

Electrical systems: By monitoring electrical cabinets and components, thermography can detect hot spots caused by loose connections or overloaded circuits, preventing potential failures or fires.

Fluid systems: Infrared cameras can detect blockages or leaks in pipelines by observing temperature variations.

Roofing: Infrared imaging helps identify wet insulation in flat roofs by spotting areas of heat retention.

Risk management strategies: By understanding vulnerabilities in infrastructure displayed by infrared imaging, risk managers can implement predictive and preventative maintenance plans to reduce the risk of serious issues like fire, leaks, or machinery breakdown.

Accuracy of Infrared

The accuracy of infrared thermography depends on the expertise of the thermographer and the quality of thermographic imaging camera used. Cameras can range from a few hundred dollars to the tens of thousands.

High-quality cameras can measure temperature with an accuracy of ±2% or better. The range of accuracy, spot size, and resolution between high-end and low-end cameras is astronomically different.

Expertise is also a critical factor in the accuracy of infrared thermography. It's important that thermographers and professionals have proper training.

Even the most sophisticated cameras will only provide the right accuracy if the right input data is loaded by the thermographic consultant. Some additional factors can influence accuracy (all not included) are:

Distance: The farther the camera is from the target, the more potential there is for measurement errors.
Emissivity: Different materials emit infrared radiation differently. Ensuring the correct emissivity setting on the camera is crucial.

Atmospheric conditions: Factors like humidity, air temperature, and intervening obstacles can influence readings.

Camera calibration: Regular calibration ensures the camera maintains its accuracy.

Infrared means ROI

Every dollar spent on infrared thermography studies yields cost avoidance of five dollars, according to recent studies.

That return-on-investment jumps to 1 to 20 when considering factors like reduced downtime, business interruption avoidance, and other expenses.

Benefits of Infrared Thermography

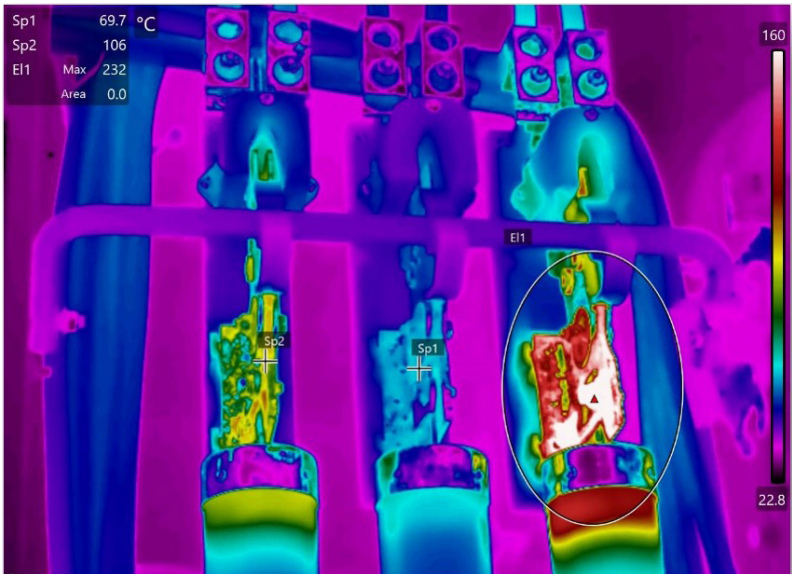
Electrical and mechanical infrared thermography inspections are the single most preventative/predictive measure a business can implement. Here are just some of the benefits of using the technology:

Non-destructive testing: As a non-contact, non-invasive method, infrared thermal imaging (scanning doesn't interfere with the operation of equipment, ensuring there's no downtime during inspection.

Cost-effective: By identifying potential problems early, thermal imaging can prevent expensive breakdowns and maintenance, bottleneck disruptions, and unplanned outages. In most cases, infrared thermography delivers savings many times greater than initial investments.

Comprehensive visualization: Infrared thermography provides a visual representation of temperature discrepancies. This visual aid makes it easier for technicians and maintenance personnel to locate and address problem areas.

Quick and efficient: Thermographic inspections cover large areas in a short time, making it possible to assess multiple systems or vast facilities quickly.



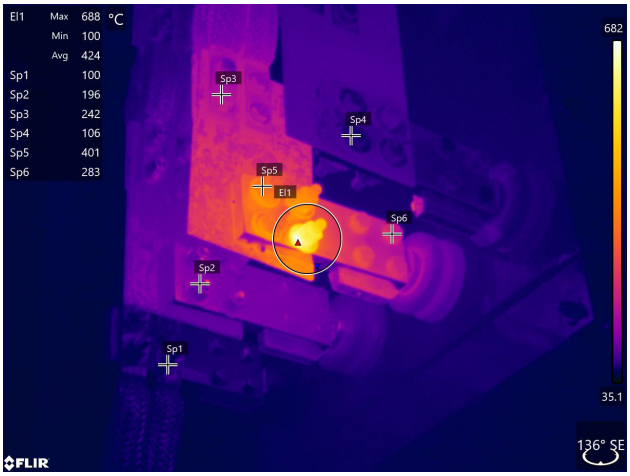
Infrared in action: Global Risk Consultants discovered this loose, deteriorated connection on a fuse clip with a very high temperature. The compressor was near failure which would have led to a long downtime for the company had it not been identified and mitigated.

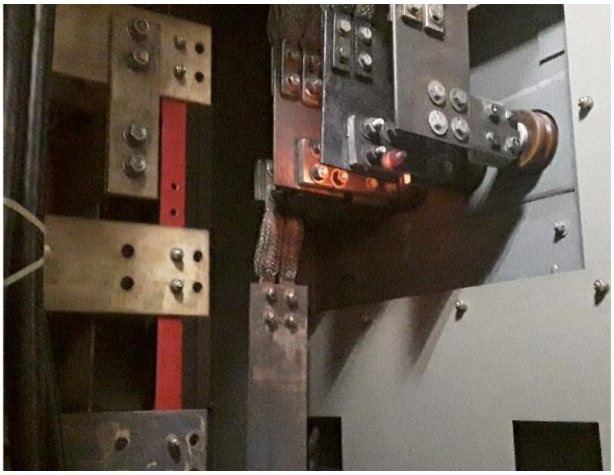
Improved safety: By detecting issues like overheating early, it can help prevent unplanned disruptions, electrical/mechanical equipment from breaking down, failure, or fires.

Enhances preventive maintenance: With the ability to detect issues before they escalate, infrared thermography complements preventive maintenance strategies, ensuring the longevity and optimal performance of assets.

Versatility: Infrared imaging can be applied to a myriad of scenarios, from checking the insulation in buildings to monitoring the health of electrical circuits or even assessing human body temperature in medical applications.

Eco-friendly: By aiding in the detection of energy wastage due to poor insulation or system inefficiencies, thermography inspections can contribute to more energy-efficient operations, reducing the carbon





Infrared in action: When Global Risk Consultants examined this switchgear, we noticed an imminent failure with muti-million-dollar damage potential. The bolted bus bar registered a temperature of 688°C which means that the equipment was near failure and almost led to a near total plant shutdown.

Finding Invisible Threats

Not only can modern thermal imagers see in real-time, but they can also record infrared images and measure the temperatures of target objects with overall precision. Points of possible concern show up clearly as hot or cold spots in relation to their surroundings and other similarly loaded objects.

One of the first indications that an object is trending to failure is a change in a readily-observable physical condition: temperature. Operating an electric motor at 10°C rise above the specified normal ambient operating temperature specified by the manufacturer, may reduce its lifespan by approximately 50%. This reduction in the expected life of the motor repeats itself for every 10°C, a phenomenon also known as the "motor half life" rule. Approximately 30% of all motor failures are the result of insulation breakdown or failure, caused by excessive heat inside the motor.

A temperature increase can result in electrical connections becoming loose, leading to an increased flow of electrons to the point that it manifests a change in resistance. A high contact resistance loss within an electrical circuit resulting from a loose electrical cable lug will operate with higher than normal energy consumption losses. Similarly, an increase in friction on a bearing, belt, or conveyor can be identified quickly with the help of an infrared imager, and a repair can be scheduled immediately.

What Do Infrared Surveys Include?

1. Consultations with business owners
Problem areas are diagnosed, and their severity in electrical systems, mechanical equipment are determined.

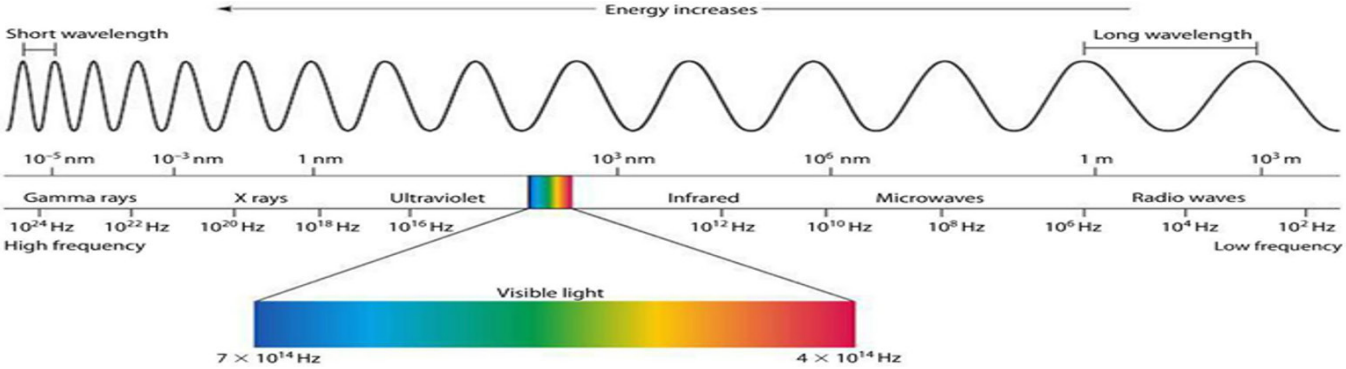
2. Visual examination
Variances and deficiencies are addressed by identifying sources of non-uniformity of temperature within process applications.

3. Airborne ultrasound inspection
Supplementary to Infrared Thermography, Airborne Ultrasound Inspections detect potential acoustic emissions which cannot always be detected thermally.

4. Comprehensive reports and critical sharing of anomalies
Businesses are immediately informed through reports and critical sharing of anomalies requiring attention to allow for swift remediate action to be taken.

5. Notification of severity and impact ratings
Businesses are notified of the severity and impact ratings for each finding, with the summary of findings, equipment inventory listing, trending and business impact.

6. Personnel training
In-house Thermographic Consultants are trained to ensure they're familiar with the knowledge required to identify anomalies and technological advances in infrared.



NFPA 70B: New Infrared Requirements

Electrical equipment inspections now mandatory at least every 12 months.

National Fire Protection Association (NFPA) standards are typically updated within annual cycles, with review by committee members representing professionals from industries like insurance and loss prevention – including Global Risk Consultants. During the review cycles, the committee members assess the standards for proposed enhancements, changes, annex updates, and more to benefit facilities impacted for property and life safety protection.

Every three to five years, the NFPA 70B standards committee provides updates for creating effective Electrical Preventive Maintenance (EPM) programs commonly used in industrial manufacturing, commercial and large residential complexes. NFPA 70B drives the electrical inspection types and frequencies for all aspects of electrical preventive/predictive maintenance, what should or must be inspected and who is qualified to inspect.

In 2023, NFPA 70B standard now makes the inspection of ALL electrical equipment mandatory at least every 12 months if it meets the following two conditions.

Condition 1 - 9.3.3.1
1. The equipment appears in like new condition.

2. The enclosure is clean, free from moisture intrusion, and tight.

3. No unaddressed notification from the continuous monitoring system has occurred.

4. There are no active recommendations from predictive techniques.

5. Previous maintenance has been performed in accordance with the EMP.

Condition 2 - 9.3.1.2
1. Maintenance results deviate from past results or have indicated more frequent maintenance in accordance with manufacturer's published data.

2. The previous maintenance cycle has revealed issues requiring the repair or replacement of major equipment components.

3. There have been notifications from the continuous monitoring system since the prior assessment.

4. There are active recommendations from predictive techniques.

Some Equipment Must be Inspected Every 6 Months: Equipment classified under the Equipment Physical Condition requires thermographic inspection at least every six months.

Condition 3 – 9.3.1.3

1. The equipment has missed the last two successive maintenance cycles in accordance with the EPM.
2. The previous two maintenance cycles have revealed issues requiring the repair or replacement of major equipment components.
3. There is an active or unaddressed notification from the continuous monitoring system.
4. There are urgent actions identified from predictive techniques.
5. This enhanced focus on condition-based maintenance in the 2023 edition of NFPA 70B reflects the increasing importance of preventive and predictive maintenance in the electrical industry. By closely adhering to these updated guidelines, facilities can reduce electrical failures, enhance personnel safety, and maximize the lifespan of their electrical equipment.

7 Takeaways on NFPA 70B

The updates to the NFPA 70B in 2023 have significant implications for risk managers, facilities engineering managers and environmental health & safety managers. Here are some key takeaways:

1. Increased Inspection Frequency: NFPA 70B now mandates inspection of all electrical equipment at least every 12 months, with certain equipment requiring even more frequent inspections. This shift means risk and facilities managers will need to review more closely and likely increase their inspection schedules, along with maintain proactive management of their EMP programs.

2. Condition-Based Maintenance: The introduction of the equipment physical Conditions (1, 2, and 3) indicates a shift towards condition-based maintenance, requiring managers to be more proactive and attentive to the current state of their equipment. That requires careful monitoring and updating based on changes in equipment status and operation.

3. Predictive Techniques Importance: There's a clear emphasis on the role of predictive techniques in determining equipment condition and necessary maintenance actions. Risk and facilities managers should consider implementing or expanding the use of predictive techniques, such as vibration analysis, oil analysis, airborne/structure-borne ultrasound examination, motor circuit analysis, and particularly thermographic inspection.

4. Monitoring System Notifications: Unaddressed notifications from continuous monitoring systems play a significant role in equipment condition assessment. Ensure that these systems are functioning correctly and that their alerts are promptly addressed.

5. Enhanced Recordkeeping: With the changes in equipment conditions and inspection frequencies, comprehensive and accurate recordkeeping is more crucial than ever. This will help in tracking the maintenance history, assessing the equipment condition, and planning future maintenance cycles and activities.

6. Training and Education: Given the significant changes in this edition of NFPA 70B, training for maintenance personnel on the new requirements will be essential. This training should cover the new equipment conditions, the revised inspection frequencies, and the use of predictive techniques.

7. Increased Safety: The primary goal of these changes is to increase safety. By adhering to these new guidelines, risk and facilities managers can help prevent electrical accidents, enhancing the safety of personnel and the reliability of their facilities.

Infrared in action: High temperatures in this high-voltage switching equipment could have been catastrophic as a fire could have spread and tracked along the bus cable, easily reached the roof above. Luckily, Global Risk Consultants found the issue and alerted the risk managers.

Quantifying Infrared Findings

Organizations can interpret infrared findings in terms of both their severity and impact. Severity determines "how serious" a finding is from a thermal temperature threshold perspective. This involves measuring the actual temperature of an objective and its temperature rise against a reference point, with suggested limits and actions outlined in the indicator charts.

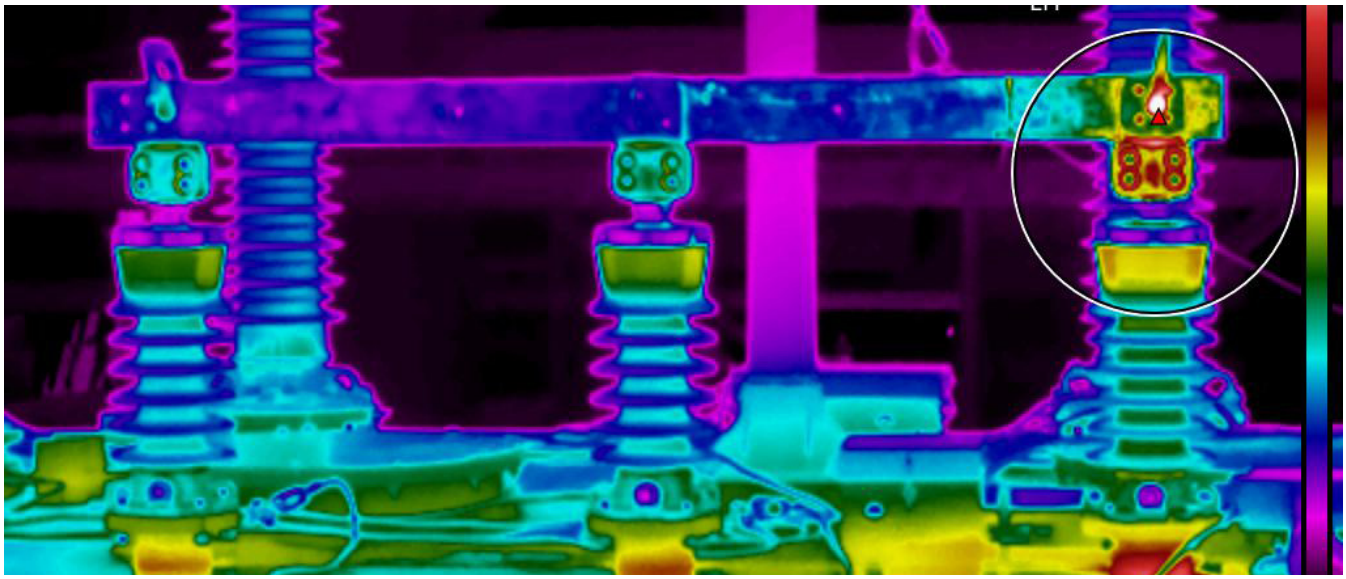
	Severity	Temp-Rise	Comments
Minor problem	*	1-9 °C	Monitor, repair as part of general maintenance. Repair in immediate future. Monitor load, watch for changes. Inspect for physical damage.
Immediate problem	**	10 - 34°C	Repair in immediate future (1-2 days). Inspect surrounding components for possible damage.
Serious problem	***	35 - 74°C	Repair immediately. Recheck with thermal imager. Inspect surrounding components for probable damage.
Critical problem	****	75°C or greater	Non-thermal finding. Observed condition poses risk to integrity of facilities, electrical, mechanical, equipment/building systems.
Notification of risk exposure	FYI	FYI	

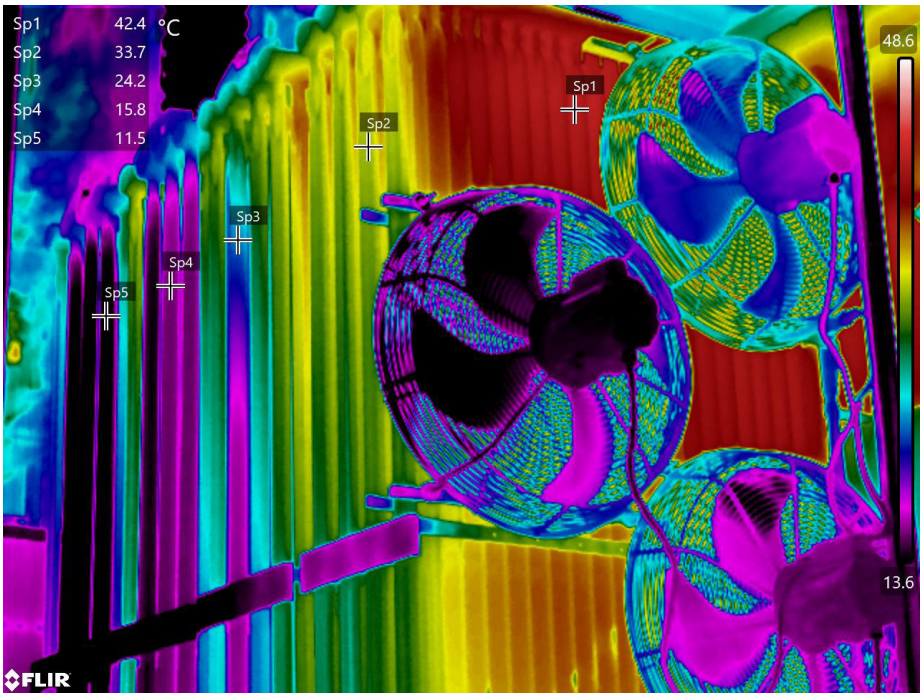
Optimizing the Effectiveness of Infrared Inspections

Infrared thermography inspections are not simple tasks to complete. In order to cover all areas of a facility, access to electrical rooms and machinery space is essential.

While there is no set "best period" for conducting IR inspections, there are many factors to take into consideration for optimizing the effectiveness of thermographic inspection work. In general, routine annual infrared thermographic inspections are recommended prior to shutdown, so any anomalies identified can be adequately repaired, and spare parts can be pre-ordered with ample time, to further prevent an unplanned shutdown, business interruption or outages.

Depending upon the facility's operations (heavy industrial, chemical, power generation, cement, woodworking, mining, semiconductor, food & grain, etc.) age of facility's electrical systems, environmental conditions, dust/contaminants control, building age and age of electrical systems, criticality of facility's operations (bottleneck potential), preventive vs. predictive maintenance programs in place, loss frequency, site specific conditions or many other factors warrant more frequent inspections may be recommended. Through the analysis of facilities' production, process, operations, and utility systems, faults and loss exposures can be identified and quantified so that measures can be implemented to mitigate them.





Additional Guidelines on Optimizing the Effectiveness of IR Inspections

Mechanical

These inspections should be conducted in conjunction with electrical thermography to include: electric motors, bearings and couplings, compressed air systems, HVAC, critical refrigeration systems, fluid systems (tank levels, pipe temps, blockages), refractory systems (boilers, ovens, furnaces, dryers), conveyor belt rollers, steam systems (i.e. traps), etc.

These inspections should also be conducted along with other inspection techniques, such as vibration and lubricating oil analysis.

A quarterly inspection program will offer the most robust results.

Electrical

Deep dive electrical studies should be conducted using infrared thermography to include the following: incoming utility services, substations, incoming primary switches, oil-filled and dry-type transformers, primary and secondary switchgear and switchboards, bus ducts and raceways, motor control centers (MCC's), production machinery control panels and cabinets, fused and unfused disconnects, capacitor banks, contactors, motor starters, variable frequency drives (VFD's), relays, etc.

Regular inspections should be conducted to ensure corrective actions to faults have been rectified.

It is ideal to have in place a minimum annual inspection program that can be increased where findings and anomaly trends identify increased risks and hazards, mean-time-between failure mode, etc.

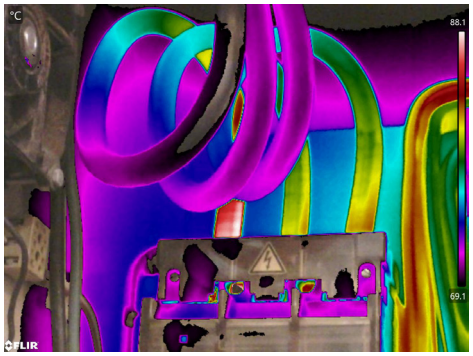
Additional electrical inspections should include onsite evaluations of critical electrical equipment, transformer oil analysis, switchgear maintenance, electrical protective device testing, arc-flash, short-circuit and protective device coordination studies, motor circuit analysis, megger testing, hi-pot (high-potential or dielectric withstand) testing, ground-fault, etc.

Process Equipment

Inspections should be done alongside mechanical inspection work as it is usually synonymous with mechanical supplies. Cursory inspections should be given to steam pipework in order to identify any breakdowns in difficult-to-reach areas of the site.

Follow-up inspections

Follow-up inspections should be done immediately upon corrective action, or as soon as possible if the condition cannot be remedied immediately due to extraneous factors. This ensures the fault is fixed and acts as quality assurance for the rectification process.



Infrared Thermography by Global Risk Consultants

Global Risk Consultants (GRC) uses the latest techniques to provide you with comprehensive reports, severity and impact ratings, ultrasonic testing, arc-flash analysis, thermographic imaging analysis and immediate delivery of findings.

Clients say our infrared thermography risk engineers are incredibly knowledgeable and provide first-rate service. In a recent client survey:

- 77% of GRC infrared thermography clients described their experience as “better than expected”
- 40% said GRC service was “much better than expected.”

Infrared and airborne ultrasound technology
GRC employs infrared and airborne ultrasound technology to detect abnormal or “invisible” threats that may cause equipment failure.

Comprehensive reports
Our formal comprehensive reports locate problems with extreme precision and recommend cost-effective solutions.

Severity and impact ratings
We provide severity and impact ratings for each finding.

Ultrasonic testing
Primarily for high- and medium-voltage systems (i.e. corona, arcing, tracking) and strategic low-voltage applications, this additional tool enables us to identify critical loss exposures that are not detectable when using infrared imaging.

Immediate delivery of findings
Comprehensive on-site reports can be accessed through our online client data management system.

Thermographic imaging analysis
This is used to diagnose problem areas and determine their impact and severity, which also enables us to pinpoint abnormal temperatures and resolve variances and deficiencies.

About Global Risk Consultants

Global Risk Consultants pioneered unbundled loss control — independent risk assessments not tied to insurance. We offer truly consultative expertise that is always independent and never bundled to underwriting. With GRC, you own your data — not insurance companies.

That empowers you to take on more risk if you desire, helps you shop for appropriate insurance coverage, and negotiate premiums with confidence.

GRC provides sound, cost-effective fire protection engineering services to some of the world’s most successful businesses.

Our worldwide staff of engineers has pioneered advances in fire protection by applying their in-depth expertise to developing new methods to address today’s escalating concerns.

Some have even been instrumental in writing NFPA standards. We work with major insurance organizations, the engineering staff of global brokers, and the engineering departments of major industrial firms.

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With GRC, you own your data — not insurance companies. That empowers you to take on more risk if you desire, helps you shop for appropriate insurance coverage, and negotiate premiums with confidence.

Global Risk Consultants is dedicated to providing sound, costeffective Fire Protection Engineering services. From arc flash to explosions, we address all potential property losses from fire, and keep you compliant with National Fire Protection Association standards.

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