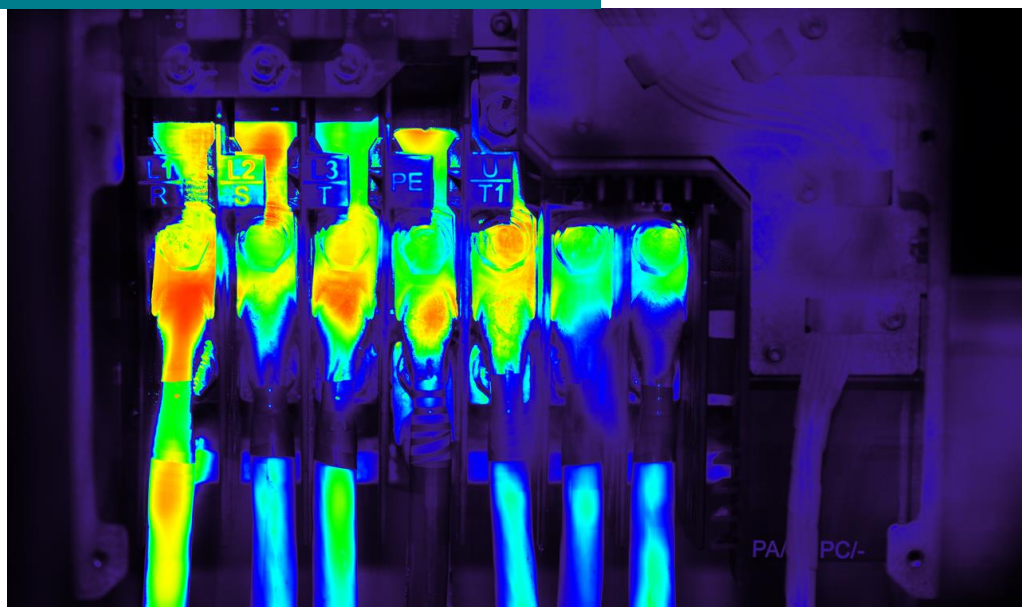
ALLIANZ GLOBAL CORPORATE & SPECIALTY SE

TECHNICAL TOPIC

VOLUME 21

INFRARED THERMOGRAPHY INSPECTIONS



Tech Top *is a series of documents developed by the ARC Mediterranean & Africa – Ibero & Latam regions for answering a question or raising a technical topic. The aim is to assist our engineers, clients and third parties involved in the property & loss control industry. It is presented through a pedagogic and understandable perspective.*

I. LET'S SUMMARIZE

A comprehensive infrared thermography (IRT) inspection of major electrical equipment should be conducted at least annually at all facilities.

IRT inspections are an important part of a preventive maintenance program that prevents electrical fires, electrical equipment failures and business interruptions.

New technology allows critical electrical equipment to be continuously monitored for overheating.

II. INTRODUCTION

According to loss statistics, approximately one third of the fires that occur in commercial and industrial facilities can be traced back to an electrical cause. The origin of electrical fires is either due to electrical overload, overheating or short-circuiting. The root cause may be:

- Inadequate design and/or installation
- Improper use
- Loose connections
- Poor maintenance
- Poor housekeeping

- Mechanical damage
- Equipment remaining powered on during idle periods
- Unauthorized equipment in electrical rooms

The vast majority of fires (estimated at 40% by the Electrical Safety Authority of Canada) involving electrical installations occur when the electrical connections overheat. Resistive heating, also known as Joule or Ohmic heating, is the process by which the passage of an electric current through a conductor produces heat. In simple terms, a poorly made, corroded or loose connection becomes a source of heat, which increases over time. For ignition to be from an electrical source, two conditions need to be satisfied:

1. First, the electrical wiring, equipment or component must have an electric charge running through it
2. Second, it must generate sufficient heat to cause ignition of an adjacent combustible material

Imperfect contact between connections means increased resistance to current flow, which in turn, generates heat. When a copper conductor is heated in the presence of oxygen, it creates a thin layer of oxide on the outer surface. As copper oxide is an electrical insulator, resistance increases. What follows is a vicious cycle of increasing heat and resistance until the heat continues to be generated but does not dissipate quickly enough. It can result in a 'glowing connection' whereby the conductor becomes hot enough to glow. If combustible materials are in close proximity to this hot spot, they can ignite. In addition, if the process continues unabated, the resulting temperatures can reach over 1300℃ (2400 °F). At this temperature, molten material may eject from the connection, igniting combustibles around it.

Circuit breakers cannot prevent fires starting. While this equipment monitors the current flow, it is primary a life-saving device. Breakers protect the electrical circuit from damage caused by excess current from an overload or short circuit. They prevent very few fires because they do not respond to excessive heat.

The causes of ignition in the case of resistive heating include short-circuiting, overloaded circuits, overloaded utilization equipment, poor connections, high resistance faults and open neutrals.

This document will focus on IRT inspections for electrical equipment, as well as overheating issues that can affect electrical equipment.

III. INFRARED THERMOGRAPHY (IRT)

Infrared thermography (IRT), sometimes called infrared scanning or thermal imaging, is one application of infrared imaging science and is used to detect infrared energy emitted from an object, converting it to a temperature scale, and displaying the result as an infrared image. There are various applications for this technology. Two important applications include:

1. Firefighters use IRT to identify people and find the seat of a fire in smoky environments.
2. Maintenance technicians use IRT to locate overheating electrical equipment.

All fires are preventable, and one of the best ways to prevent electrical fires is to regularly perform IRT inspections.

IV. WHY PERFORM IRT INSPECTIONS?

There are various methods for inspection, testing and maintenance of electrical equipment. IRT inspections are one of the most important as they can identify overheating, which could lead to:

- Damage to electrical equipment

- Short-circuit
- Fire
- Untimely breakdown of equipment
- Production shutdown

IRT inspections help determine whether electrical installations require any corrective or preventive maintenance. The inspection first looks for hotspots and then determines the temperature of the overheated areas. The IRT operator will define the level of risk and identify the corrective and/or preventive action required.

IRT inspections are independent of the periodic statutory inspections of electrical equipment, which may be required in some countries on various frequencies.

V. IS A THERMOGRAPHY INSPECTION SUFFICIENT?

IRT inspections are necessary but cannot prevent all fires. The following losses illustrate this point:

- **Example 1:** At a 20,000 m² combustible constructed dairy plant, a fault appeared in the connection of a 40-amp circuit breaker during an idle period. The defect was electrical heating. After this first short-circuit occurred, a fire started, followed by the projection of molten copper in the electrical cabinet. Smoke and fire spread causing new short circuits. The horizontal bus bar at the top of the cabinet was impacted. The heating of the air reduced the electrical resistance, and electric arcs occurred at the end of the copper bars. Due to the lack of fire detection, the fire was not detected at an early stage. Because of the lack of segregation, the fire spread outside the electrical room. A large part of the plant was damaged by fire, mainly because of the presence of combustible construction, moderate combustible loading and the lack of segregation. Loss amount: EUR 56 mn. (90% PD / 10% BI). The client conducted annual IRT inspections.
- **Example 2:** At a 650 m² supermarket, the fire detection system was activated. The public fire service was called, arriving on site 10 minutes later and began to fight the fire. Around 3 hours later, the fire was extinguished. The fire started at an electrical panel. It is known that adequate IRT was performed. Total loss: EUR 2 Mn
- **Example 3:** At this 40,000 m² pharmaceutical location, a fire started in the control panel of one of the filling lines. The line stopped automatically, but the control panel continued to be supplied with power. Soon after, the employees discovered smoke billowing from the control panels. Upon opening the panels, they saw flames and the employees used an extinguisher to extinguish the fire. The loss is estimated to constitute 36 hours of business interruption and the loss of the batch production, but this was lower than the deductible. Total Loss: EUR 1.7 Mn. IRT was performed on site.

These three losses illustrate that IRT inspections are sometimes not sufficient to avoid a loss. It reduces the frequency but doesn't eliminate the capacity of a loss to occur. IRT inspections do not provide continuous measurement. Furthermore:

- IRT requires sufficient current flow through the circuit in order to be able to see overheating. Inspection during low load periods might be not very effective.
- Configuration of inner space of electrical panel might be complicated and restrict visibility of IRT and not allow to get full picture of equipment condition. It's even more serious issue when it comes to MV equipment, because normally doors of panel are closed to prevent occasional opening during live operation. They might be equipped with special infrared window mounted in door, but the viewing angle through such window is very limited.

VI. WHAT CAN CLIENTS DO TO PROTECT THEIR ASSETS?

A number of solutions are available to protect assets depending on one's objectives, ranging from segregation and space separation, to detection and protection systems. Both clients and risk engineers are aware of these options, but extra care should be taken when selecting the solutions to be implemented. The cost of protection measures should be considered as well as the expected loss.

On the other hand, the cost is not always justified, and the protection measures insufficient. Clients and engineers often raise two questions when looking at the loss history:

- **Question 1:** What about locations with a low total sum insured which suffer a 100% loss? The typical industries concerned by this issue are the retail, hospitality, and office industries.
- **Question 2**: What to do if any electrical equipment incident will create business interruption? This question is typically raised by those who cannot afford any fires to start, such as pharmaceutical locations which require approval.

New solutions to manage resistive heating are being developed and may be cost effective solutions for specific applications. These technologies can monitor and detect any overheating of electrical equipment. They do not prevent fires from happening but add an extra level of safety by either alerting occupants or automatically disconnecting circuits when excessive heat is detected. Miniature thermal sensors are used to continuously monitor electrical connection points. If excessive heat is detected, they can send a warning notification to the site manager or the maintenance manager. This extends the principle of thermal imaging by offering continuous heat monitoring. As such, the response then becomes one of investigation and maintenance, instead of an emergency.

EPI-TAG by mesafox Handelskontor GmbH ©

These devices make sense in very specific cases such as those listed above. Overall, they can be considered as providing a very cost-effective solution that monitors for thermal events 24 hours a day and not just during an IRT inspection.

As with many innovations, these devices can be connected by wire or wirelessly to existing fire alarm or building management systems or, in the case of some devices, via a dedicated Internet of Thing (IoT) device, which is Lora, Bluetooth, and GPS enabled.

The installation of this device does not replace the need or frequency of IRT inspections

Another solution is mostly for larger LV and MV electrical panels (distribution boards, switchgears, capacitor panels etc.). It uses special sticker with encapsulated signal gas inside, which is glued close to each concerning contact connection. As soon as contact connection gets overheated to abnormal temperatures (80-130 degrees), the sticker releases the signal gas, which is being detected by selective gas sensor, installed in the same volume. After detection it sends an alarm to maintenance personnel via Modbus, discrete output or SMS. These notifications may allow service personnel to be aware of an evolving overheating problem before a hazardous situation occurs to the equipment.

FIPRES © by Streamer Electric AG ©

VII. ARC GUIDANCE

a) **Perform visual inspections** of all electrical equipment on a regular basis (e.g., monthly or quarterly) depending on the environmental conditions. Verify the electrical equipment is operating in a clean, dry, cool and tight condition with no unusual heat, odors, noises, or vibrations. An IRT inspection should be conducted as soon as possible if any unusual conditions are observed.

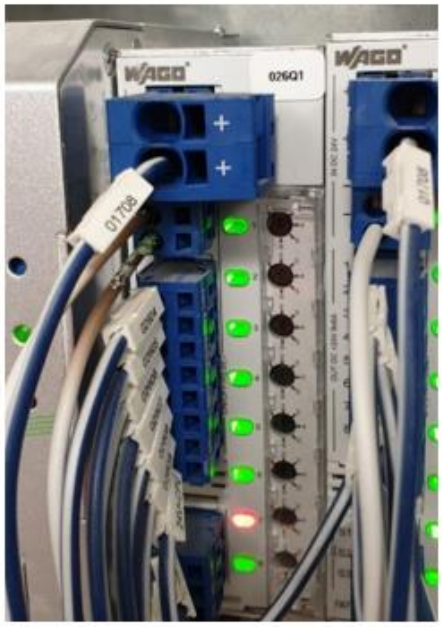
b) **Perform IRT inspections after an installation is commissioned (full or partial) and then annually thereafter.**

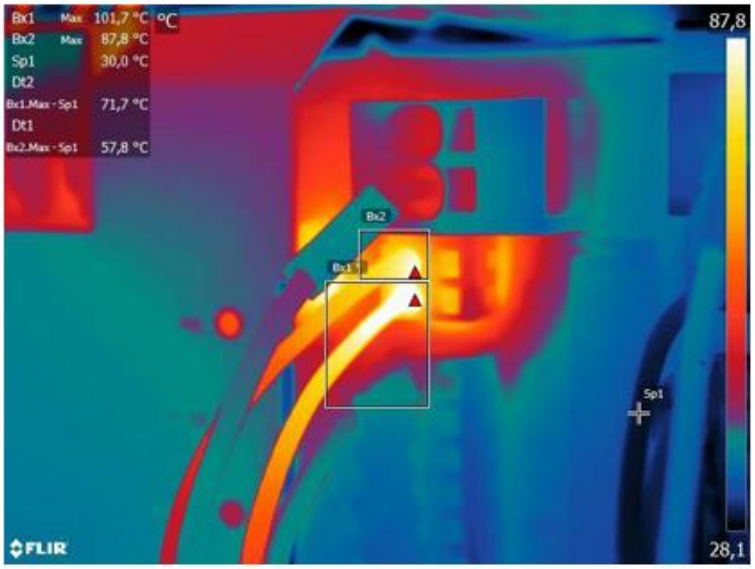
- The IRT inspection frequency should be based on previous results with more frequent inspections (e.g., quarterly, semiannually, etc.) conducted for equipment with a history of deficiencies.
- If any event is observed (increase of consumption, disturbances, etc.), an intermediate IRT should be conducted instead of waiting for the annual IRT inspection.
- Whenever an installation is commissioned (partial or otherwise), an initial IRT inspection should be performed.

c) Consider all of the following electrical equipment as part of the IRT inspection:

- Transformers
- Switchgear and circuit breakers
- Busways and distribution panels
- Motor controllers
- Stationary batteries and chargers

- Emergency generators
- Uninterruptible power supplies (UPS)
- Photovoltaic systems
- Critical power cables
- Any other critical electrical equipment





When considering fires of electrical origin, we assume, three-phase 400 V or single-phase 230 V in Europe or 110 V in the US but rarely the control panel and very low voltages. However, this equipment is also likely to have contact resistance defects.

d) Ensure the operator is certified / qualified to operate the thermographic equipment and interpret the results.

- It can be difficult to determine the qualifications of an operator. The following are examples of regional certifications / standards related to IRT: Many European countries have implemented a course called Thermography Specialist CFPA-E, through the Confederation of Fire Protection Associations. This certification is available in France, Germany, and the UK.
- In the US , ASNT SNT-TC-1A: Personnel Qualification and Certification in Nondestructive Testing, is used as the standard to measure various levels of training for IRT.
- In regions of the world where there are no formal certification programs, suppliers of thermography cameras may offer training/certification courses.

e) Owner / Client Responsibilities:

- Assist the operator during the inspections by assigning an electrician who is authorized and qualified to work on the electrical equipment and is familiar with the facility.
- Where possible, provide a list of all the facility's electrical equipment to the contractor and the existing specifications.
- Take all necessary measures to ensure the safety of the operator, particularly where safeguards have been compromised for the purposes of the inspection.
    - Make the equipment easily accessible.

  - Maintain a safe distance between the equipment and the operator.
- Information on the statutory regulations that should be complied with

f) Contractor's responsibilities

- A detailed description of the work, in accordance with the client's requirements
- The purpose of the inspection
- The name of the qualified operator who will complete the inspection
- A copy of the certification
- A copy of the current certificate for the annual inspection of the IRT camera
- The date and expected duration of the inspection
- The inspection requirements, in accordance with the preliminary inspection (if requested), for example: access to equipment, required space, visibility, bypassing of any safeguards, etc.

g) Report to be issued by the contractor

The results of the inspection should be submitted in a report, with adequate pictures and thermographic photographs. At a minimum, the report should include:

- Criteria: the criteria used to categorize findings in the report. They are based on the potential effect that a failure would have on operations and production. The following list is provided as an example for informational purposes:
  - CRITICAL- Failure of this component will have a significant impact on operations or the facility and require costly repairs.
  - SEVERE- Failure is not expected to go beyond the component listed and would have minimal impact on operations or the facility; repair costs could be significant.
  - ALERT- Failure is of a routine nature and repairs can be made easily and at a reasonable cost. Cost is, more often than not, limited to labor and a few minor parts.
  - ADVISORY- Helpful information based on sound engineering judgment.
- The report should indicate:
  - The type and features of the equipment and software used
  - The name and the qualifications of the operator
  - The name and the qualifications of the person who has reviewed and approved the report (in case this person is not the operator).
- The report should include the list of the equipment with the following details:
  - Ideally, the building area, equipment location and equipment identification
  - The operating load rate at the time of the inspection (i.e. full load, half load, etc.)
  - For equipment that does not show any anomalies, "nothing to report" or similar wording should be indicated.
  - For equipment that does show any anomalies, a specific page should be referenced
  - A photograph with an arrow indicating the hot spot and a thermographic photograph should be provided.
- A list of the anomalies and a repair priority classification.
- During regular annual checks, this list should be updated with the result of the last inspection so that the repair of the defect can be validated. A correlation should be established, if possible, with the nominal parameters, particularly for equipment operating at high temperature under normal conditions.
- Testing of similar equipment, in similar conditions, should be detailed to serve as a reference and comparison.

h) Infrared type equipment used during the control

- The infrared camera should meet the existing standards as far as its spatial and thermal resolution, sensitivity, and accuracy.
- The camera's calibration certificate should be provided to the client.

i) Conditions of the inspection

As far as possible, the inspection should be conducted:

- with all the equipment and components being energized and loaded.
- with the electrical cabinet panels or doors open.
- without any device that could reduce the infrared signal.

Survey the equipment and components under their operating conditions at the time of the inspection. The results should consider the ambient conditions (temperature, wind, moisture), especially when outdoors.

Each component showing a hot spot should be identified and the temperature directly read on the thermographic display system.

j) Complete all recommendations provided in the IRT inspection report

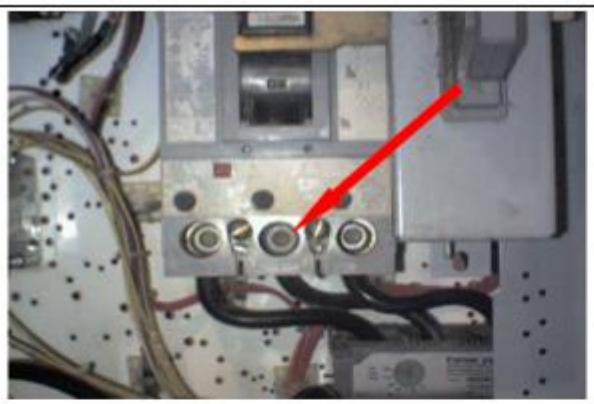
- Immediately address all deficiencies noted in the IRT inspection report that do not require cutting power to equipment.
- Plan for the work to be completed as soon as possible, depending on the severity of the deficiency, and the timing of equipment shutdowns.
- Keep records of the completed work (i.e. date, purchase order, bill, etc.) for a minimum of two years to enable review by ARC representatives.

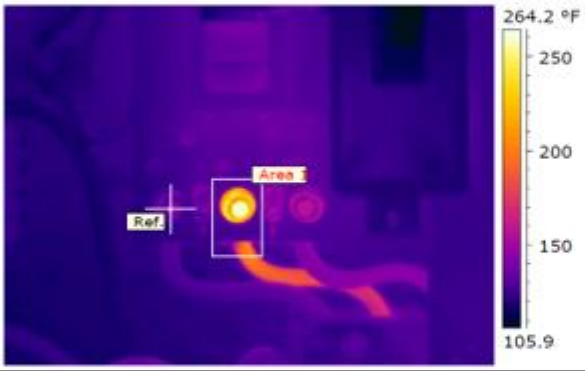
VIII. REFERENCES

- CFPA Guideline No. 3 Certification of thermographers
- EN 13187 Thermal performance of buildings
- ISO 10878 Non-destructive testing – infrared thermography – vocabulary
- ISO 10880 Non-destructive testing – infrared thermography testing – general principles
- ISO 10881 Non-destructive testing – infrared thermography – guidelines for examination of electrical installations
- ISO/CD 18251-1 Non-destructive testing – infrared thermography – system and equipment – part 1: Description of characteristics
- ISO 18436-7, Condition Monitoring and Diagnostics of Machines — Requirements for Qualification and Assessment of Personnel – Thermography
- ASNT SNT-TC-1A: Personnel Qualification and Certification in Nondestructive Testing
- VdS 2858en Thermography in electrical installations
- Référentiel APSAD D19, Thermographie infrarouge, Document technique pour le contrôle d'installations électriques
- NFPA 70B, Recommended Practice for Electrical Equipment Maintenance

IX. EXAMPLE OF A REPORT FINDING

Finding No.	1 / 5	Category	SEVERE





Location area	Raw Materials
Equipment location	Pellet Feeder
Equipment ID	Main Breaker
Est. Repair Cost Before Failure	€ 100
Est. Repair Cost After Failure	€ 4,000
Est. % of production	50 %
Est. Down Time	2 days
Ref. Temperature	140.1 °F
Area Max. Temperature	262.5 °F
Area 1: Rise	122.4 °F

Recommendation / Comments
The lug connection should be disassembled, cleaned, inspected for damage and repaired as necessary. Replace any discolored or damaged hardware and cut back the wire to sound conductor. Reassemble and torque the fastener according to the manufacturer's specifications. This is rated as "SEVERE" due to the very high temperature and potential business interruption.

Repair Notes	Signature	Date
.....		
.....		
.....		
.....	.....	...../...../.....
.....		

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