

# RISK ENGINEERING GUIDELINE

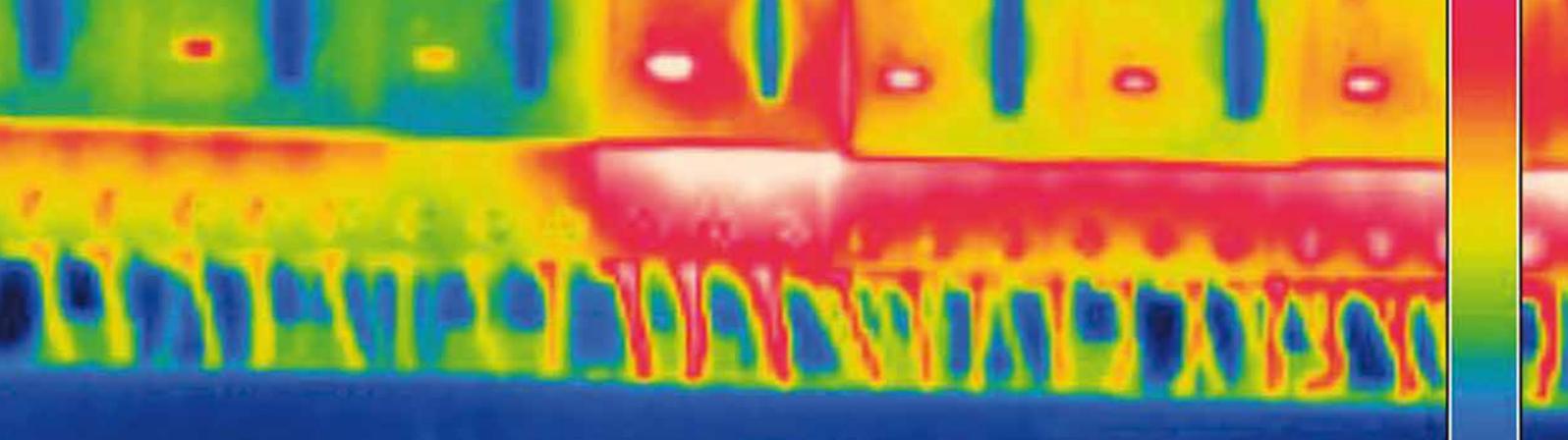
THERMOGRAPHY

HDI Risk Consulting

Property

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Today, thermography is part of the standard measuring methods for testing, inspecting and servicing technical systems and installations.



## 1 What is thermography?

Thermography is a method for the contactless measurement and representation of surface temperatures of components, buildings and plant parts. Infrared cameras record thermal radiation that is invisible to the human eye and convert it into visible thermal images (thermograms). A qualified evaluation of these thermograms provides important information for assessing the inspected or examined objects.

## 2 Where is thermography used?

Thermography, for example, is used for analysing whether the approved surface temperatures have been complied with. Surface temperatures that are higher (rarely lower) than the specified surface temperatures indicate the existence of weaknesses or faults.

### Thermography is used

- in electrical installations (e. g. wear and tear of electrical contacts, overload of electrical equipment, faults or incorrect dimensioning of equipment),
- in the construction and testing of machines and systems (e. g. furnace insulations, ball bearings, welds etc.),
- for inspecting the insulation of buildings and pipe systems (e. g. humidity pockets)
- and as early fire detection system (e. g. in waste bunkers in waste incineration plants as stationary thermographic systems).

Thermography is highly effective for monitoring electrical switchgear which will be explained in more detail later.

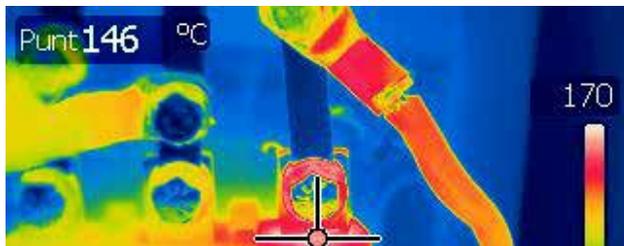


Fig. 1: Terminal of a power circuit breaker, inappropriate connection



Fig. 2: Noticeable warmed-up appliance plug with connecting cable

### 3 What are the benefits of thermography?

Thermography is an efficient tool for evaluating the state and the risks of mechanical, electrical and power plant installations. Depending on the measurement task, thermography is used alone or in addition to other measuring methods.

**The aims of using thermographic measuring methods are:**

- reduction of fire and accident risks,
- documentation of plant conditions states and potential risks,
- identification of shortcomings during the construction and commissioning of plants,
- early detection of weaknesses and damages,
- increasing plant availability and reliability,
- preventing consequential damage.

Thermography can provide important assistance for decisions with regard to the planning and implementation of necessary measures (e. g. repairs, modernisations).

### 4 How is thermography executed?

**Thermography enables evaluating surface temperatures**

- in running operation without shutting down of the plants,
- at a distance from hazardous plant components that is safe for the inspector,
- under real operating conditions.

Usually, the measurements can only be performed on plant components that are open or visually accessible. For this, it might be necessary to remove covers or open doors, this should only be done after a full assessment of the risk to ensure the safety of personnel.

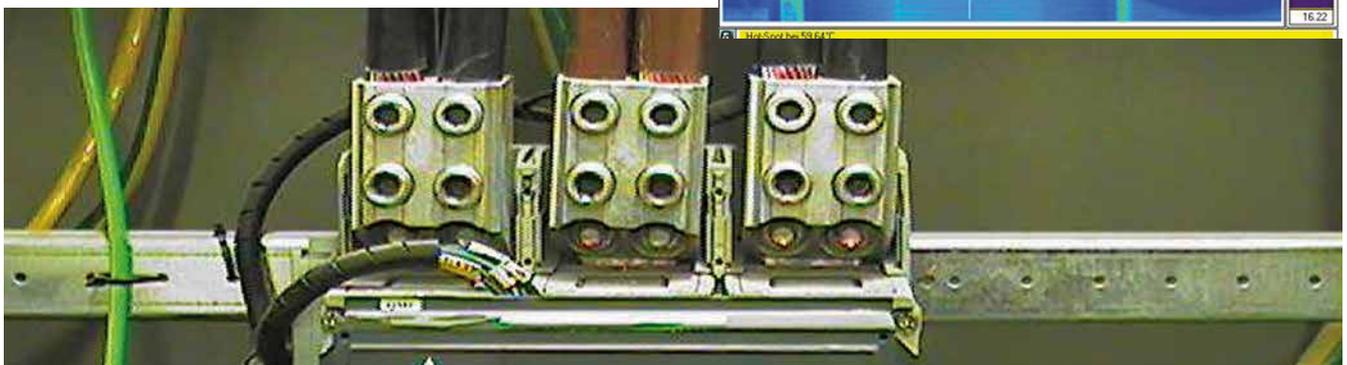
To ensure a professional analysis of the detected faults, additional measurements might be necessary (e. g. current or voltage in electrical installations, measurement of the ambient temperature, measurement of humidity etc.).

### 5 What is the test scope of a thermographic inspection?

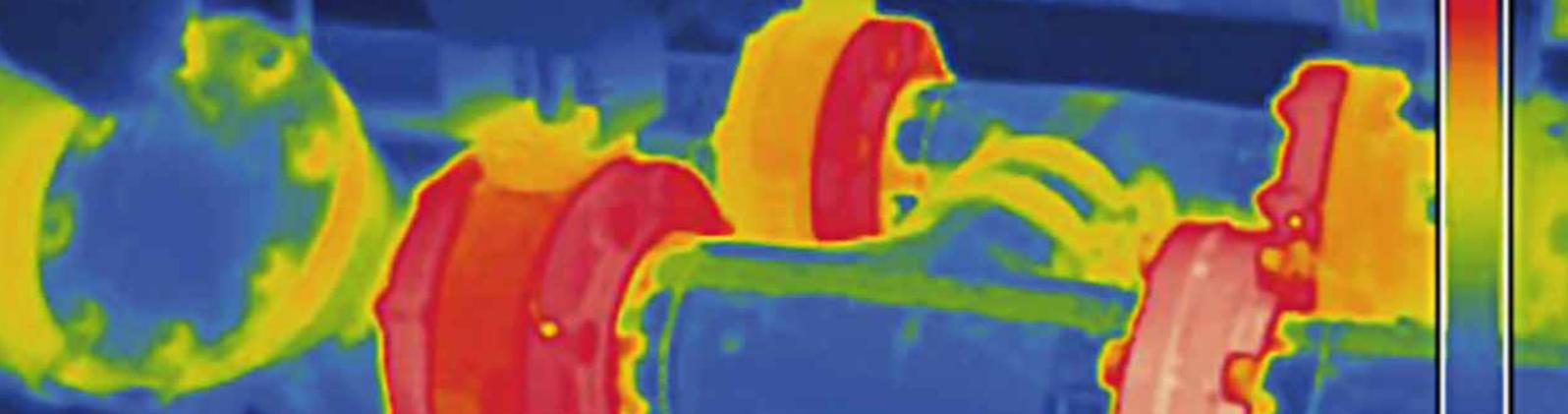
When inspecting machines, plants and buildings, the inspection scope must be defined individually with the operator.

**A systematic inspection of the electrical installation of a company will comprise, for example:**

- transformer stations including the medium and high-voltage switchgear and the respective transmission lines,
- main low-voltage distributions,
- compensation systems including inductors, central network filter systems etc.,
- conductor rail systems and cable ducts (bundling),
- switch and control cabinets, fuse boxes,
- electrical machines and drives including the terminal clamps,
- electrical equipment and installations in that, according to experience, hazardous heating can be expected.



**Fig 3:** Noticeable temperature difference between inlet line L1 and L3 to inlet line L2. Temperature at outlet lines L1, L2 and L3 is evenly distributed. The location of the thermal peculiarity indicates that a contact between wire terminal and power switch fails to close. If there was a switch contact fault (L2), more noticeable heating of the power switch and inhomogeneous temperature at outlet line L2 could be expected.



## 6 What cameras are suitable?

The used thermographic camera systems must be suited for the measuring task and must produce reproducible measurement values (thermograms). The camera systems must allow for reliable detection and unambiguous allocation of noticeably increased surface temperatures. The use of the camera systems in electrical installations must not produce any accident risks for the thermographer and for third parties.

### Two camera types are used in practice:

- scanning camera systems,
- FPA (focal plane array) systems, camera systems with a detector matrix.

Scanning systems were the first systems available on the market. Due to their very good measurement accuracy, they are particularly suited for long-term measurements. On the other hand, for (quick) successive inspections, e. g. on control cabinets, machines etc., FPA systems are normally used, which provide sufficient measurement accuracies, depending on the design.

It must be considered on an individual case basis whether the purchase of a camera is worthwhile since extensive training and a lot of experience are required for carrying out the measurement (qualification of suitable staff). It might be more sensible to entrust a qualified and experienced thermographer with the inspection.

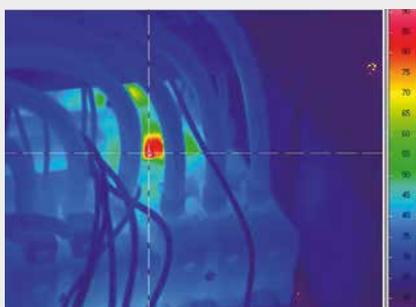
Inspections of electrical installations place very high demands on the thermographic cameras in terms of measurement accuracy and, in particular, the resolution.

They should therefore feature at least the characteristics given in the table on page 5.

## 7 When and how often should thermography be executed?

If possible, thermographic inspections in electrical installations should be performed in connection with the specified repeated inspections of the electrical installation. The in-

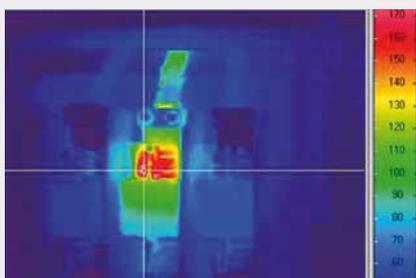
## Examples.



Temperature of the RC link: approx. 95 °C.

Fire risk potential: Critical; thermal decomposition (pyrolysis) may cause coking of the synthetic materials of the equipment. Under additional thermal load, this could result in possible ignition.

Plant hazard potential: Exists; if the equipment fails and a fire starts, this might also result in contamination of additional plants and systems (e. g. additional compressors) in the compressor room.



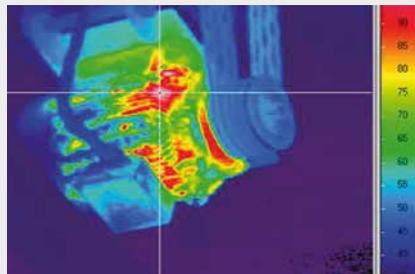
Measured temperature at the top blade contact of the HRC fuse of external conductor L2: approx. 183 °C.

Strong thermal decomposition of the insulation materials at the connected lines.

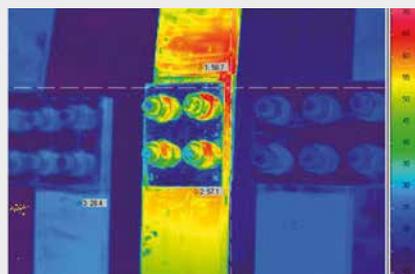
Fire risk potential: Potential ignition risk of the insulation materials.

Plant hazard potential: In the event of a fire, production loss for several weeks.

Characteristic		Recommended values
1	Ambient temperature (area of use)	-10 °C to +40 °C
2	Temperature measuring range	-20 °C to +500 °C
3	Accuracy/measurement value	+/- 2 % or 2 K
4	Spectrum	MW 3-5 µm oder LW 7,5-14 µm
5	Geometric resolution at IFOV 20° to 25°, IFOV (Instantaneous Field of View - spot size)	IFOV ≤ 2 mrad, and a factor for the real optics of ≤ 3. Spot size = distance * IFOV * real optics factor or resolution at minimum 500:1 Thus, for a typical measuring distance of 0.6 metres, an IFOV of 2 and a real optics factor of 3, the spot size must have a surface of at least 3.6 mm * 3.6 mm. When scanning very small spots (e. g. contact on a series terminal), camera systems with a higher resolution are therefore recommended. Alternatively, the measuring distance can be reduced, which, however, is not always feasible due to the local measurement situation (occupational safety, plant situation etc.).
6	Thermal noise, thermal resolution	NETD at 30 °C from 0.08 K
7	Internal calibration (stability)	Yes, according to the manufacturer's specifications
8	Accuracy check (entire system)	Annually, according to the manufacturer's specifications, with documentation (e. g. factory certificate)
9	Image	Pseudocolours
10	Image resolution at an angle of 24°	At least 240 x 320
11	Refresh rate	> 20 Hz
12	Adjustable measurement parameters	Emission ratio, reflected ambient temperature
13	Measuring function	Temperature range scale, 1 spot, 1 isotherm, automatic hotspot search function, image freeze function
14	Measurement value management	Digital storage, evaluation of radiometric IR images
15	Handling	External display (hand-held)
16	Lenses	Wide angle + telephoto Note: The use of a telephoto lens is purposeful so that even small objects (e. g. series terminals) can be inspected. Wide-angle lenses are not required for qualified electro-thermography.
17	Power supply	Mains-independent (battery powered) sufficient for a minimum use period of 2 hours



Dust deposits resulting in increased thermal load.  
If dusts are present in the environment and have accumulated on the case surface, there is a risk that the accumulated dusts might self-ignite since a temperature of approx. 101 °C was measured.



Noticeable temperature difference between busbars L1 and L3 to busbar L2 in the area of the flange connection. Decolouration of the busbar coating is clearly visible (original image).

Fire risk potential: exists, but not critical as no combustible materials in the area.

Plant hazard potential: critical, as due to the state of the contact point, an increase in temperature for the same current flow must be predicted within the short term resulting in rapid deterioration of the contact point.

specification interval should be every 1 to 2 years depending on the operating and environmental conditions, provided that no faults have been detected.

**The following is recommend:**

- newly erected plants or plant areas should be tested as part of an initial inspection so that any assembly faults or incorrect dimensioning of equipment can immediately be detected as potential fault sources (approx. 8 to 12 weeks after start of normal operation),
- repaired plants or plant areas should be inspected to verify that the repair has been successful,
- existing plants should be inspected at regular intervals. The inspection cycle depends on the plant stress, the environmental conditions and the results of previous thermographic inspections.

## 8 Who should execute thermography?

For buildings, machines and plants, the thermographer should have a qualification according to ISO 9712 "Non-destructive testing - Qualification and certification of NDT Personnel", Level 2.

A certified expert for electrothermography is recommended for inspections in electrical installations. They should have proved their technical qualification, in particular in the area of heating of electrical equipment, and have suitable measuring instruments.

## 9 What is the importance of thermography?

Today, thermography is one of the standard measuring methods for testing, inspecting and servicing technical systems and plants. Thermography does not replace any other specified tests. However, thermography represents a purposeful addition for assessing the state of systems and plants under real operating conditions.

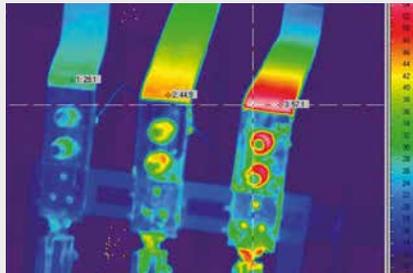
Nevertheless, thermography is a useful additional measuring method in this area and allows in particular for inspections and assessments of the state of the plant and the building, which previously had been difficult or had only been possible at major expenditure. Today, thermography thus forms part of the state of the art in safety technology.

## 10 Note.

This information is not exhaustive and does not exempt the operator from the fulfilment of legal standards as well as official regulations and requirements.

The respectively valid version of the standards and rules must be observed and applied.

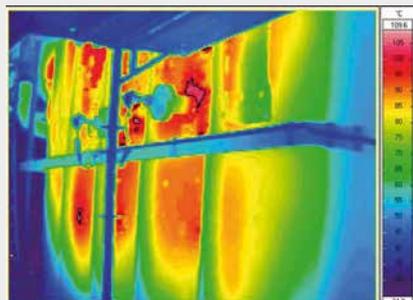
## Examples.



Significant heating at the top busbar connectors of the separator. This is caused by non contact- and force-fit connections at the contact surfaces of the busbar and the connecting flange of the separator.



Left: Deficient insulation on a bypass line at a combined heat and power plant. Heat control faults are possible.



Deficient insulation at the filter. Heat loss may unfavourably affect the effectiveness of the filter.

## 11 References.

Local standards should be complied with.

### Internationally recognised standards:

<b>CFPA Guideline No. 3</b>	Certification of thermographers
<b>DIN VDE 0100-600</b>	Low-voltage electrical installations – part 6 verifications
<b>DIN VDE 0105</b>	Operation of electrical installations
<b>EN ISO 9712</b>	Non-destructive testing – qualification and certification of NDT personnel
<b>EN 13187</b>	Thermal performance of buildings
<b>ISO 10878</b>	Non-destructive testing – infrared thermography – vocabulary

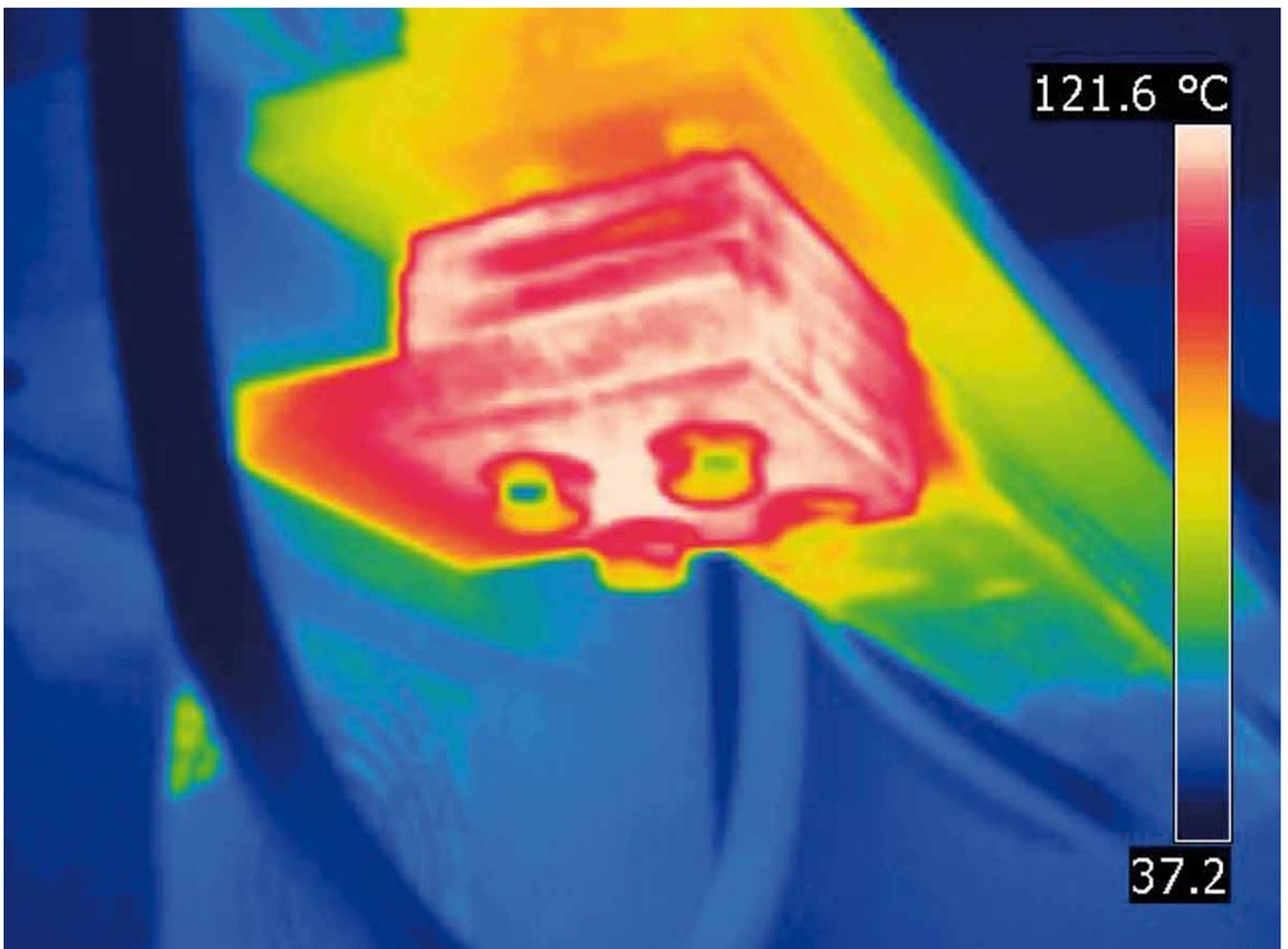
**ISO 10880** Non-destructive testing – infrared thermography testing – general principles

**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

### Specific standards (Best practice):

**Vds 2858en** Thermography in electrical installations



## About HDI Risk Consulting.

HDI Risk Consulting GmbH supports major corporations, industrial and mid-size companies with loss prevention and in establishing risk management systems.

HDI Risk Consulting offers its' customers access to some 180 engineers and experts from a wide range of technical disciplines. We aim to support companies with the management of risks and the development of individual risk-based concepts for insurance cover.

HDI Risk Consulting operates globally in the Property, Motor, Engineering and Marine markets, with particular focus on the identification and assessment of risks and the development of appropriate, individual protection concepts.

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