	German guideline	February 2016
BUNDESVERBAND FÜR ANGEWANDTE THERMOGRAFIE E.V.	**VATh-Guideline: Electrical Infrared Inspections ▪ High Voltage** **Planning, execution and documentation of infrared surveys of electrical systems and components >1kV**	

VATh- Directive: Electrical thermal imaging

Planning, execution and documentation of infrared inspections of electrical systems and components > 1kV.

Directive du VATh: Thermographie électrique

Pour la planification, réalisation et documentation de mesures infrarouges d'installations et d'équipements électrotechniques > 1kV

High voltage

(higher than 1 kV AC or 1,5 kV DC)

Haute tension

(Tension supérieure à 1 kV ca et 1,5 kV cc)

Annotations:

This guideline is intended as assistance and directive for the planning, realization and documentation of thermographic inspections on electrical systems and components with high voltage.

This guideline represents the current state of technology.

Explications concernant la directive:

Cette directive sert de support, d'aperçu et de guide pour la planification, la réalisation et la documentation des mesures infrarouges d'installations et d'équipements électrotechniques dans le domaine Haute-Tension (HTA et HTB).

Cette directive est la version de l'état actuel de la technique.

This guideline comprises 9 pages

Am Burgholz 26 - D - 99891 Tabarz - Tel: + 49 36259 - 311444; Fax: + 49 36259 - 311445

VATh- Guideline: „Electro-Thermography, Part A: High Voltage (HS)“

Version from February, 2016

Editor:

Bundesverband für Angewandte Thermografie e.V.

Am Burgholz 26

D-99891 Tabarz

Tel: + 49 36259 - 311444

Fax: + 49 36259 - 311445

All statements are based on the current standard of knowledge. The Bundesverband cannot accept any responsibility or liability. Recommendations or objections for upcoming versions should be addressed to the office of the Bundesverband.

In the case of disputes the German version of this guideline is relevant.

Table of contents

1. Educational prerequisites and skills

The following formation bases must be present and outline the formation basis:

a) A completed apprenticeship in the field of electrical engineering with the skill of a journeyman, foreman or engineer. Engineers, who graduated from a college or technical college without having completed an apprenticeship as an electrically qualified person must produce a certificate in accord with DIN VDE 1000-10 / 4.2.

b) At least two years of professional experience in the field of Electro-Thermography and perennial experience in the field of electronic engineering according to VDE1000-10 / 4.2 is required (Annotation: perennial experience in the regarding the field of activity).

Generally, at least the achievement of level 1 according to DIN EN ISO 9712***** is to prove along with a training course in the field of electrical components including a thermographic evaluation. According to the guideline for personnel of the non-destructive testing, only those persons are allowed to run an inspection and evaluation without supervision of a level 2 or 3 certified person, who are certified according DIN EN ISO 9712* to level 2 or 3 (sector: Electro-Thermography).

Due to the generally increased fire risk in companies, the person running the inspection must be able to assess the temperature rise accurately. Therefore, only persons should be inspecting electrical systems who can possess the certificate “Electrical Thermographer, level 2” in accordance with DIN EN ISO 9712***** or “VdS acknowledged specialist for Electro Thermography” (VdS = German association of property insurance companies) in order to meet the requirements of the insurance industry.

***: has displaced DIN EN 473 and DIN 54162!**

2. Health

The presentation of a certificate proofing the visual capacity according to DIN EN ISO 9712* is indispensable and must be renewed annually.

Also it should be acknowledged that the work in the field of Electro-Thermography is associated with increased health risks. Especially, people with pacemakers or a disposition for dizziness and epileptic seizures need to be aware of that.

3. Safety distance

By definition conducting an electrical inspection is considered to be included in the category "working in hazardous electrical energized areas". As a consequence of working close to electrically energized components an electrically qualified person or a person working under the supervision of an electrically qualified person must pay attention sticking to the safety distance from the operating voltage. Therefore, a nominal voltage of 30 kV requires a safety distance of 1,5 m. The nominal voltage of 30 kV till 110 kV already requires a safety distance of at least 2,0 m. The voltage levels of 110 kV – 220 kV and 220 kV – 380 kV require compared to the just named safety distance of 2,0 m one additional meter of safety distance.

4. Safety equipment

According to valid accident prevention regulations and other valid regulations the thermographer has to wear personal safety equipment for his own safety.

5. Regulations

Thermographic personnel inspecting electrical systems should generally be independent (no in-house personnel). This ensures that neither superior nor the company management has influence on the inspection. Safety and fire prevention always comes first.

6. Procedure

The certified thermographer runs the inspection if possible accompanied by an electrically qualified employee of the mandating company / power supply company.

The infrared-thermographic inspections of the electrical systems is to be considered a snap shot. The electrical systems should run at minimum 10% workload by the time of inspection. If only low load conditions are given it is possible risk that not all errors can be detected. To improve the statistic certainty the inspection should be done regularly. As a result of the infrared-thermographic inspection the risk assessment of the employer is advised.

7. Infrared Camera Equipment

The infrared imaging system beeing used has to meet the following requirements:

Spectral Range:	Cameras working in the MW (Mid-Wave: 3-5 µm) or LW (Long-Wave: 8-12 µm) spectral band can be used.
Measurement Temperature Range	-20° to +500°C (or higher)
OperatingTemperature Range	-10° to +40°C (or higher)
Basic Type:	A split camera/controller concept (monitor and remote control unit separated or alternatively a turnable monitor) is necessary in order to run the inspection also in areas with difficult access. The camera should be equipped with an optical viewfinder to be able to identify even small indications when inspecting high-voltage systems outdoors under bright sunlight.
Lenses:	Usually a lens out of the available standard lens set must be used - Wide angle lens - Standard angle lens - Tele lens depending on the particular scope. When inspecting high voltage systems telephoto lenses with horizontal field of views between 7° and 12° are mandatory due to the object size at long measuring distances (depending on the infrared detector pixel resolution)
Thermal resolution:	≤ 100 mK @ 30°C recommended: ≤ 60 mK
Geometrical resolution:	≤ 1,3 mrad up to 10 m distance ≤ 0,5 mrad up to 25 m distance ≤ 0,3 mrad distance > 25 m
Detector Pixel resolution:	min. 320 x 240 Pixel
Temporal resolution:	min. 20 frames/sec
Measurement accuracy:	±2K or ±2%
Basic operating functionality:	The camera must offer the capabilities to: - focus the image precisely - freeze an image - switch between color and gray palettes

	- activate measurement functions: moveable spot and area - adjust all measurement parameters - manual scaling and display the thermogram - saving radiometric data
Power supply:	- A self-contained operation on battery power is indispensable.
Calibration:	- Periodical factory-calibrations (according to the manufacturers requirements) - Frequent automatic comparison/compensation to an internal temperature reference inside the camera A validation of the temperature calibration must be done and documented annually. It is recommended to perform a simple calibration check even more frequently.

8. Evaluation software

The expert must own or have access to a suitable software which allows processing, analyzing and reporting the infrared images afterwards. It must be possible to change the measurement parameters used to convert the measured radiation density into temperature and also labeling the results after the inspection.

9. Assessment and Reporting

The inspection report consists of a **basic document** and the actual **evaluation document page(s)**. The particular style of these documents are due to the thermographer. Nevertheless, the data and annotations listed below **must** be included.

10. Basic document

The following data has to be included on the basic document:

1. Name of the executing thermographer and accompanying persons
2. The used infrared camera system
3. Date of inspection
4. Location of the client company or else factory or power supply company
5. Scope of the inspection
6. In case of outdoor inspections the weather conditions (including air temperature [°C], relative humidity [%], wind speed [m/s], Global radiation [W/m^2])

11. Evaluation documents

Every thermal indication/anomaly should be presented on a separate page. Every of the listed items needs to be assigned to the corresponding thermogram **easily**.

1. The date and exact time the image was taken and the name of the recorded infrared image file.
2. An accurate object description (building, hall, switchboard, control panel, component of the building or else).
3. It has to be guaranteed that the customer can recognize and assign the fault to his equipment
4. A photo with the same image content taken from the same position.
5. The temperature of the thermal anomaly with the exact location and/or the temperature difference between the fault location and an identical faultless component. The given information must be clear enough that the client can retrace the shown temperature values, resp. temperature.

An evaluation should also include a listing of all inspected devices, a listing of all found anomalies or faults, a description of the inspection procedure as well as annotations and recommendations of the thermographer.

In any case at least those systems or components must be documented which shows thermal anomalies.

12. Classification of thermal anomalies

The classification of thermal anomalies needs to be done under consideration of the actual load! The ΔT is in accordance with the comparison between the temperature of the anomaly and a proper working component.

Defect severity classification of high voltage systems after recalculation the detected temperature, resp. temperature difference ΔT up to nominal load (switch field load, shortage load, limting current)

	Defect severity classes based on the measured overtemperature ΔTafter recalculation to the the nominal load			
Temperature difference	**ΔT < 10 K**	**10 K < ΔT < 35 K**	**35 K < ΔT < 70 K**	**ΔT > 70 K**
Classes	**Class 1**	**Class 2**	**Class 3**	**Class 4**
Recommen-dation	**No immediate action required, further observa-tion of the sus-picious compo-nent**	**check probable cause Repair at the next planned shutdown**	**check probable cause Repair at the next planned shut-down, at most within 1 month**	**Short –time shut-down, check probable cause and repair as soon as possible; alternatively reduce load**

Fault Classification with a known current load related to the nominal load:

Screwed connections in air made of copper, aluminum and other alloys, no matter if they are silver-coated, nickel-plated or tinned

Ratio of known load to nominal load (in %)	Defect classes based on overtemperature ΔT = suspect temperature – normal operating temperature in K Depending on the actual load			
	0 K < ΔT < 10 K	**10 K < ΔT < 35 K**	**35 K < ΔT < 70 K**	**ΔT > 70 K**
up to 50 %	**1**	**3**	**4**	**4**
50% to 75%	**1**	**2**	**3**	**4**
75% to 100%	**1**	**1**	**2**	**4**

Flexible connections in air made of copper, aluminum or other alloys, no matter if they are silver-coated, nickel-plated or tinned

Ratio of known load to nominal load (in %)	Defect classes based on overtemperature ΔT = suspect temperature – normal operating temperature in K Depending on the actual load		
	< 10 K	**10 K < ΔT < 35 K**	**> 50 K**
up to 50 %	**1**	**3**	**4**
higher than 50%	**1**	**2**	**4**

Connections in closed devices in oil or SF_6

For closed devices the measured surface temperature can be considered as an rough indication for the temperatures inside

Generally applies:

1. The absolute temperature of the oil must not exceed 90 °C
2. The pressure of the SF_6- gas* must be under the upper limit
3. The lower the operating load and the higher the surface temperature is, the more urgent are corrective activities

*: SF_6-Gas is a gas extremely harmful to climate. Therefore the location of leakage(s) must be detected as fast as possible if a leakage is found. Highly specialiced infrared-cameras, developed for this purpose, can help to locate the leakage(s) accurately.

Limiting temperatures of insulating material

For insulating material, which is located inside of electrical system components or electrical machines, the class of insulating material of the concerned object can be consulted in order to evaluate the measured surface temperature or else the distribution of the surface temperature. Thermic classes of insulating material are coded with letters labeled Y – A – E – B – F – H – N – R in the order of rising temperatures. The lowest temperature limit of 90°C is presented by the class of insulating material named Y. The temperature limits of the next classes A and E are15 Kelvin higher. While the classes of insulating material called B and F have temperature limits of 130°C and 155°C, the class of insulating material named H has a temperature limit of 180°C. The temperature limits of the following classes increases in 20 Kelvin steps compared to the preceding class.