DIAGNOSTICS OF ELECTRICAL INSTALLATIONS BY THERMOGRAPHY

Adriana Comarlă, *"Constantin Brâncuşi" University from Târgu Jiu, ROMANIA*
Francisc Comarlă, *"Constantin Brâncuşi" University from Târgu Jiu, ROMANIA*

ABSTRACT: *Thermography is a non-invasive inspection method that allows the detection of overheating in electrical equipment. These abnormalities can signal: weak connections, load imbalances or defective components. The study aims to integrate thermodynamics into thermographic analysis for effective predictive maintenance.*

Key-Words: Thermography; detection; maintenance; analysis; electrical.

1. INTRODUCTION

Infrared thermography (or thermal imaging) is one of the most effective and non-invasive methods of preventive and predictive diagnosis of electrical installations.[1]This technology uses thermal (thermographic) cameras that detect infrared radiation emitted by the surfaces of objects and transform it into visible images called thermograms, in which colors indicate different levels of temperature.

Why is thermography essential in the electrical field?

Electrical installations (electrical panels, transformers, high/medium/low voltage lines, electric motors, connections, copper bars, etc.) are subject over time to:

- overheating caused by loose contacts,
- load imbalances,
- Overloads
- corrosion
- insulation defects,
- material aging etc.

These thermal anomalies occur long before the defect becomes visible or produces a total breakdown. A local overheating may indicate an imminent risk of fire, arcing, or power failure.

Advantages of thermography in electrical diagnostics

- Inspection without stopping the installation (in most cases work under load)
- Fast detection of hot spots
- Preventing costly breakdowns and power outages
- Increasing equipment life
- Improving the safety of personnel and facilities
- Objective documentation through images and thermographic reports

Main areas of application

- Low and medium voltage electrical panels
- Power Transformers
- Overhead and underground power lines
- Electric motors and generators
- Connections and clamps
- Reactive Power Compensation Systems
- Photovoltaic installations
- Data centers and critical applications

In Romania, thermography is explicitly required in technical regulations and in many cases it is imposed by insurers or ISCIR/ANRE inspectors.

Through the systematic use of thermography, we move from corrective or fixed-term maintenance to predictive maintenance based on the actual condition of the equipment – which significantly reduces costs and risks. [2]

2. PURPOSE AND OBJECTIVES

Purpose: To identify areas with significant thermal losses in electrical installations using infrared imaging.

2.1 Thermography in electrical installations

In electrical installations, electric currents generate heat because of the resistance but also because of the resistivity of the materials. An abnormal increase in temperature in an electrical component, called a "hot spot," often signals a problem. This problem is determined with the help of thermography. Thermography allows these hot spots, invisible to the naked eye, to be visualized before they lead to major malfunctions or even fires.

Thermography or thermal vision, as it is also called, is a non-invasive inspection method that uses infrared radiation emitted by objects to detect and visualize temperature differences.

This technique is essential in the preventive maintenance of electrical installations, as it allows the identification of thermal anomalies that may indicate defects or imminent problems. [5]

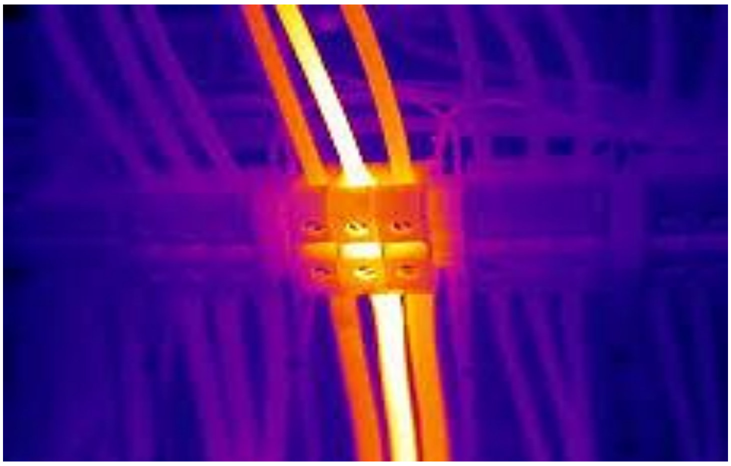

Figure 1 Thermography

This technology is a technique for measuring temperature remotely, using infrared cameras to detect thermal radiation emitted by an object. It is used in numerous applications: industrial, medical, agricultural. [4]

Thermography is applicable in all fields, but electrical installations are the field in which it brings the greatest benefits. Thermography has thus become a common practice in both the industrial and commercial fields, being the most appropriate investigation/diagnostic tool.

2.2 Installations and equipment to be checked by thermography

The main installations and equipment that need periodic measurements and checks being affected by the Joule effect are the following:

- power stations, transformer substations;
- general circuit breakers, load separators;

- general electrical panels;
- lighting panels and sockets;
- control panels for various machines, engines, etc.;
- UPS;
- AARs;
- capacitor batteries;
- stationary batteries.

3.THERMOGRAPHY-DETECTABLE CONDITIONS

- loose or damaged connections;
- overload of circuits or equipment;
- imbalances in the three-phase electricity grid;
- defective protective devices;
- inductive heating;
- the presence of harmonics.

By monitoring electrical panels, defects can be identified such as:

1. **Imperfect contact**. Unlike overload operation, where the temperature of the circuit is constant along its entire length, when we have an imperfect contact, a hotter point will appear on the infrared image which is the source of the defect, and as we move away from it, the temperature will decrease. Causes: loose connections (electrical slippers, loose screws, deformed string clamps, unused flexible conductor pins)
2. **Overheating of switchgear**. The internal contacts of switching equipment oxidize with the passage of time. Thus, they no longer work within normal parameters (they heat up). Through infrared scanning we can see their working temperature, and depending on this it will be decided if an intervention on them is necessary. Causes: overloads, advanced wear of mobile or fixed contacts, imperfect contact between them, sections that do not comply with the electrical load of the conductors, cables of the installation.

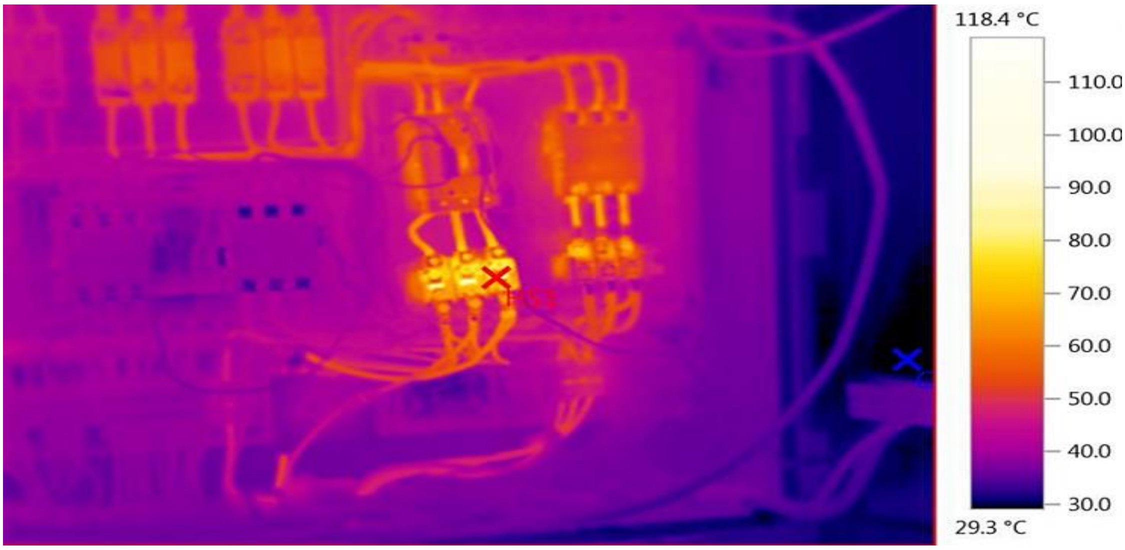

Figure 2 Imperfect contact

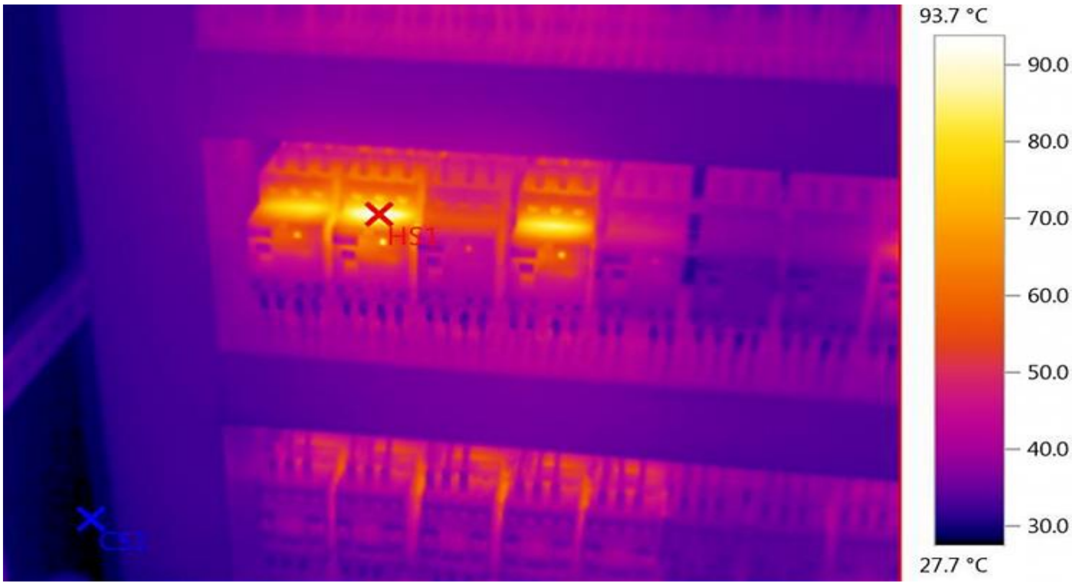

Figure 3 Overheating of switchgear

4.THERMOGRAPHY FOR MONITORING THE TEMPERATURE OF DRIVE SYSTEMS

By monitoring drive systems, defects such as:

- Overheating of the motor winding;
- Overheating of the engine bearing;
- Lack of lubrication of moving systems.
- Unbalanced rotor
- Lack of ventilation

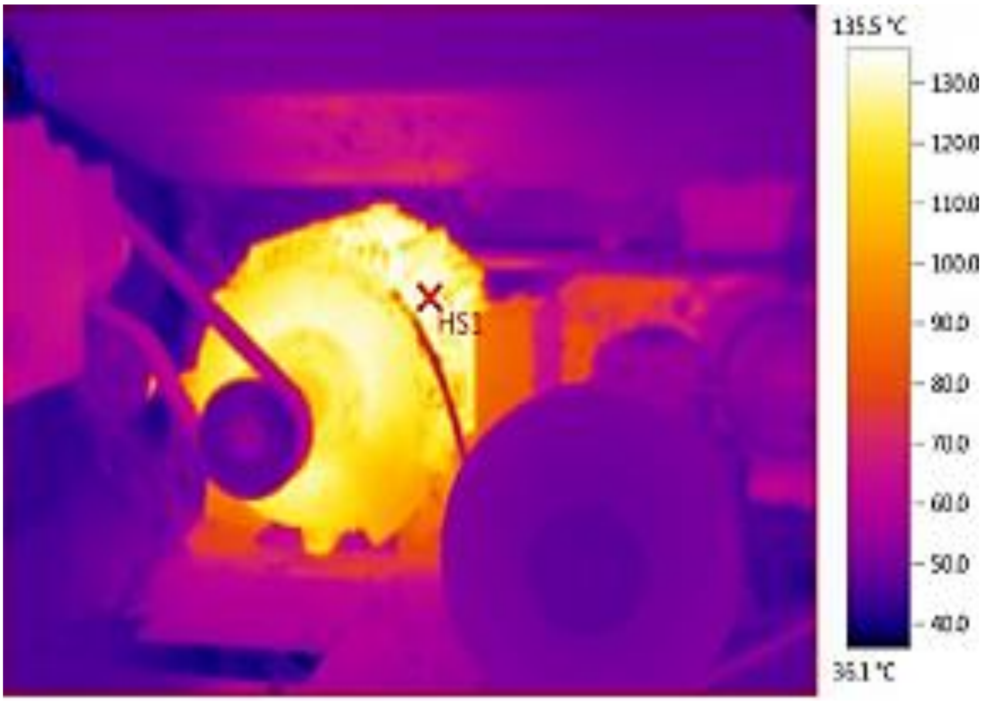

Figure 4 Overheating an electric motor

Advantages of monitoring drive systems

- The equipment used for scanning does not emit radiation that would affect the operator or personnel in the vicinity;
- To perform the infrared scan, direct contact with the live installation is not required;
- Defects are discovered in a very short time and do not require shutting down the installation;
- Allows real-time analysis;
- The scan can also be done on hot installations or in hard-to-reach places, remotely, without affecting the operator;
- The scan can be repeated as many times as the operator wishes as it does not affect the installation.

Objectives:

- Performing a thermographic inspection on an electrical panel.
- Identification of points with abnormal temperatures.
- Interpretation of results based on the principles of thermodynamics.
- Formulating recommendations for remediation and prevention.

5. MATERIALS AND METHODS

Equipment:

1. Thermal imaging camera (e.g. FLIR, Testo)

Figure 5 Thermal imaging camera

A thermal imaging camera works by detecting and measuring the infrared radiation emitted by objects, then converting this radiation into visible images, called thermograms, that show the temperature distribution. In other words, it captures heat, not visible light.

Practical recommendations for distance measurement with the thermal imaging camera

- For electrical panels: it is measured from 0.5 ÷ 2 m, depending on the resolution of the room.
- For medium/high voltage power lines: cameras with special lenses are used, from
- 10 ÷ 30 m.
- A tripod that focuses correctly is used for reliable results.
- It calibrates the emissivity and corrects the background temperature according to the material being measured.

6.CASE STUDY – THERMOGRAPHY OF ELECTRICAL INSTALLATIONS ON AN ELECTRICAL PANEL EQUIPPED WITH MPR FUSES

In order to detect any anomalies in the operation of the electricity supply, a series of scans were carried out with the thermal imaging camera on the general distribution panels and some critical points were discovered where an urgent intervention is necessary to remedy the situation and avoid a defect or accident.

Defect in the main distribution panel

- Inspection Place: General Distribution Panel
- Date and time of measurement
- Equipment inspected: TF 20 circuit + TB lighting
- Fault Location: Slipper Cable Connection Phase S
- Distance
- Ambient temperature
- Measured temperature: 272.3 °C
- Reference temperature: 30.1 °C
- Actual overtemperature: 242.2 °C
- Permissible overtemperature: 30 °C
- Load current: 10.89 A
- Maximum load current: 59 A
- Type of intervention: immediate

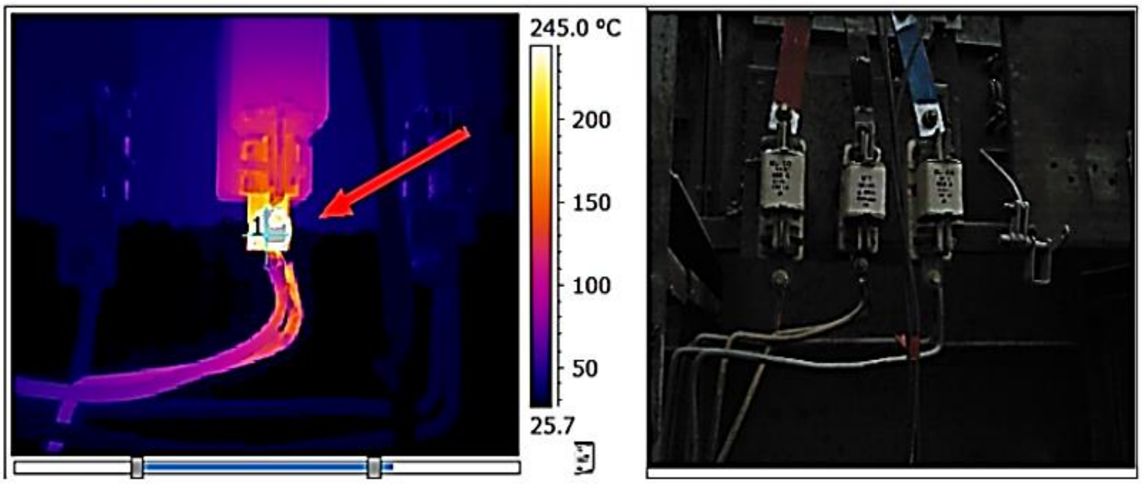

Figure 6 Defect in the main distribution panel

As can be seen, the connection slipper at the output of the S phase MPR has a temperature of 273.3 °C. This situation indicates an imperfect contact due to the oxidation of the contact that maintains electrical continuity, which leads to an increase in the electrical resistance of the current path and to the generation of heat.

This phenomenon of overheating is very dangerous because it leads to thermal destruction of the insulation and possible sources of fire if they are not discovered and remedied in time. [7] These measurements are compared with the reference temperature of the electrical installation or thermographed equipment and represent the standardized value of the temperature at which the components of the installation (cables, switching and protective equipment, connections) are evaluated and designed. This temperature serves as a point of comparison for evaluating the performance and uptime of equipment.

Defect on transformer

- Inspection Location: Transformer 1
- Equipment Inspected: Trafo 1 General Power Supply Circuit
- Fault Location: Slipper Cable Connection Phase S and T
- Distance
- Ambient temperature
- Measured temperature: 106.7 °C
- Reference temperature: 65.7 °C
- Actual overtemperature: 41.0 °C
- Permissible overtemperature: 30 °C
- Load current: 362.56 A
- Maximum load current: 610 A
- Type of intervention: immediate

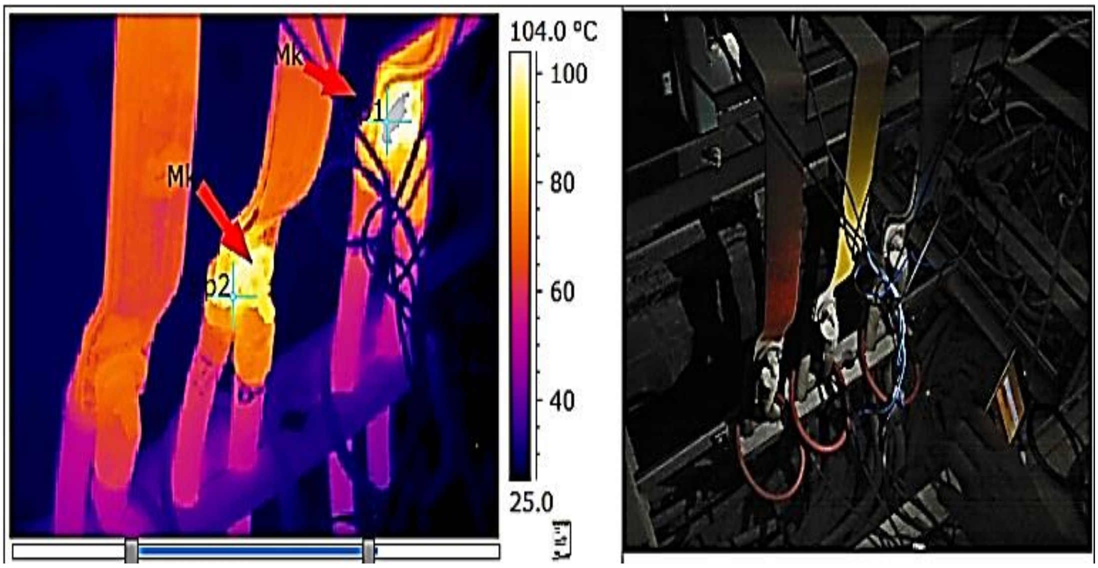

Figure 7 Defect on transformer

As can be seen, the connecting slippers between the busbars and power conductors on the S and T phases have a temperature of about 106 °C. As we are talking about the power bars on the low voltage side of the transformer, heating can lead to the interruption of the electricity supply to the entire installation, producing very large losses.

Power Supply Circuit Defects:

- Inspection Location: TF4 Circuit
- Equipment Inspected: R Phase Power Supply Circuit
- Defect location: Cable crimping slipper phase R
- Distance
- Ambient temperature
- Measured temperature: 137.7 °C
- Reference temperature: 46.5 °C
- Actual overtemperature: 91.2 °C
- Permissible overtemperature: 30 °C
- Load current: 191.35 A
- Maximum load current: 259 A
- Type of intervention: immediate

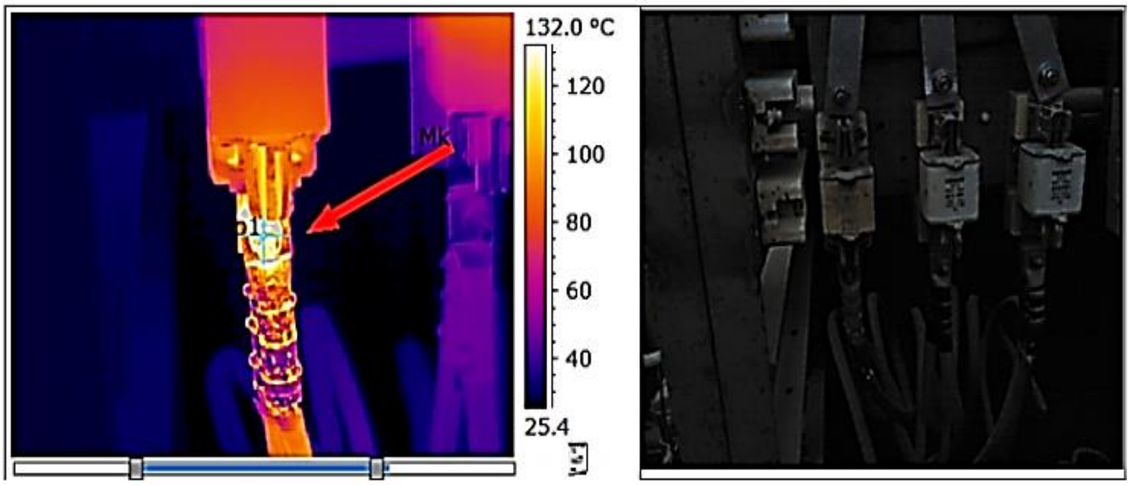

Figure 8 Defect circuit alimentation faza R

- Inspection Location: TF5 Circuit
- Inspected Equipment: S-Phase Power Supply Circuit
- Fault Location: MPR Support Input Screw
- Distance
- Ambient temperature
- Measured temperature: 132.8 °C
- Reference temperature: 46.5 °C
- Actual overtemperature: 86.3 °C
- Permissible overtemperature: 30 °C
- Load current: 191.35 A
- Maximum load current: 259 A
- Type of intervention: immediate

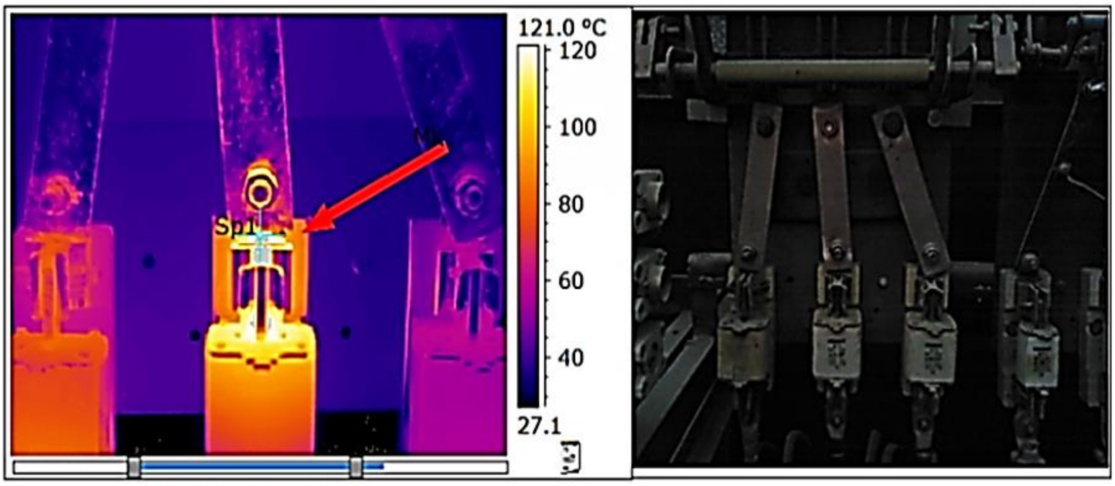

Figure 9 Defect circuit alimentation faza S

- Inspection Location: TF10 Circuit
- Inspected Equipment: S-Phase Power Supply Circuit
- Fault Location: MPR Support Input Screw
- Distance
- Ambient temperature
- Measured temperature: 148.3 °C
- Reference temperature: 42.2 °C
- Actual overtemperature: 106.1 °C
- Permissible overtemperature: 30 °C
- Load current: 251.35 A
- Maximum load current: 500 A
- Type of intervention: immediate

Most of the defects identified are related to connection elements that have imperfect contacts, but are easy to fix. By eliminating these defects, electricity losses are reduced (by conversion into thermal energy) and, at the same time, preventive maintenance eliminates the possibility of other sources of failures. [6]

CONCLUSIONS

- Thermography is an effective tool for damage prevention.
- Areas with abnormal temperatures indicate the need for rapid interventions.
- The application of the concepts of thermodynamics allows a deeper interpretation of the causes of these anomalies. [3]

Recommendations

- Periodic verification of thermography installations.
- Tightening the connections identified with high temperatures.
- Load balancing between phases.

REFERENCES

1. G Buică, R Dobra, D Păsculescu, A Tătar, Leakage current measurement of protective equipment insulating materials used in electrical installations, IOP Conference Series: Materials Science and Engineering, Vol.133, Nr.1, 2016, Pag. 012035;
2. Popescu Cristinel; Popescu Luminita-Georgeta - *Aspects concerning the influence of the temperature on the ohmic resistance of the winding*

transformers with rated power 400 MVA, 14th International Multidisciplinary Scientific, SGEM 2014, Geoconference (SGEM), Albena, BULGARIA Accession Number: WOS:000371089600003,DOI: 10.5593/SGEM2014/B41/S17.00

3. Racoceanu Cristinel, *ENERGY BALANCE MEASUREMENTS FOR AUXILIARY INSTALLATIONS OF LARGE POWER ENERGY GROUPS*, Annals of the „Constantin Brancusi" University of Targu Jiu, Engineering Series, No. 2/2017, pag. 27 -31 , ISSN 1842 – 4856.
4. Racoceanu Cristinel, STUDY ON INFLUENCE OF ENERGY EFFICIENCY OF A STEAM BOILER BENSON ON ENVIRONMENTAL POLLUTION, Fiability&Durability, no.2/2017, pag.35-40, ISSN 1844-640X.
5. Racoceanu Cristinel, *STUDY ON THE ENERGY BALANCE OF THE ELECTRO-PUMPS WITH CONDENSATION FOR THE ENERGY GROUPS IN CONDENSATION OPERATING WITH INFERIOR COAL*, Annals of the „Constantin Brancusi" University of Targu Jiu, Engineering Series, No. 3/2016, pag.19-23, ISSN 1842 – 4856.
6. Popescu Cristinel - ASPECTS REGARDING THE DIAGNOSTICATION OF THE MEDIUM VOLTAGE AFFERENT TO THE COLLECTOR BARS OF THE POWER SUPPLY SYSTEM OF OWN SERVICE CONSUMERS OF AN ENERGY GROUP WITH THE POWER OF 330 MW. Annals of the ,,Constantin Brâncuși University of Târgu Jiu, Engineering Series, No. 2/2017,pp.92-95.
7. Cristinel Popescu: ASPECTS REGARDING THE OPERATING REGIME IN CHARGE OF SINGLE PHASE ELECTRICAL TRANSFORMERS, Annals of the "Constantin Brâncuși" University of Târgu-Jiu. Engineering Series, 3 (2019), 95-98 [ISSN: 1842-4856], pp.95-98.