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TECHNICAL REPORT

"THERMOGRAPHIC ANALISYS AS APPLIED TECHNIQUE OF PREDICTIVE MAINTENANCE IN THE ELECTRICAL INSTALLATIONS OF MEDIUM AND LOW VOLTAGE OF THE PUMPING SYSTEMS SECTOR URBAN EMAPA-I"

AUTHOR: **VÁSQUEZ PAREDES DIEGO JAVIER**

DIRECTOR: **ING. MAURICIO VÁSQUEZ**

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Diego Vásquez Paredes
Author
North Technical University
djvasquez777@gmail.com

Ing. Mauricio Vásquez
Professor
North Technical University

SUMMARY

This paper focuses on the thermographic study of electrical installations of medium and low voltage of the pumping systems sector urban EMAPA-I, with the goal of reducing the percentage of failures by anticipating them and increasing operational reliability through a predictive maintenance plan based on thermography.

KEYWORDS: thermography, predictive maintenance, operational reliability.

I. INTRODUCTION

The increase in the percentage of faults in electrical installations of pumping systems in the urban sector of the EMAPA-I, has caused the suspension of drinking water for long periods of time, causing economic losses and inconvenience both the company as users of drinking water.

These power problems have generated frustration on the part of the technicians of the company, as it had not been able to predict failures, only performing corrective maintenance, also do not have exists a plan of predictive maintenance that allows the status of operation of the equipment.

Infrared thermography is a fault predictive techniques that provide insight into the operational status of the electrical and mechanical elements when they are in operation, by analyzing the infrared radiation emitted from the surface of its components, verified the existence anomalies.

Therefore, this technique is one of the best options to consider to develop a predictive maintenance plan.

This research was conducted with the objective of reducing the percentage of failures of electrical systems that make pumping systems in the urban sector of the EMAPA-I to increase the operational reliability.

II. CONTENT DEVELOPMENT

INTRODUCTION TO INFRARED THERMOGRAPHY

Infrared thermography is the science of using electronic optical devices to measure radiation, and from this to know the temperature of the bodies (Fluke Corporation & The Snell Corporation, 2009).

The importance of measuring the temperature, because there is no single process in the world, in which the temperature is indifferent, for this reason, when there is an increase in temperature of an electrical or mechanical component may indicate the existence of an abnormality to be analyzed.

The reason why thermography is a useful tool, firstly, is because it makes no contact, thus the risk of electrical accidents is reduced, and is a non-intrusive technique which does not affect the equipment under study.

Secondly, thermography to measure the temperature between two areas or points within the same image, that is used to compare the temperature of similar components, and thirdly, thermography is done in real time, allowing a rapid visualization of the temperature distribution of the components.

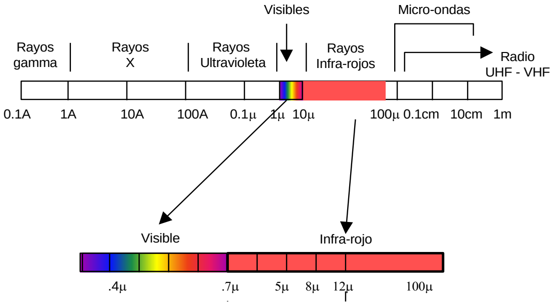
ELECTROMAGNETIC SPECTRUM

The electromagnetic spectrum is the range of all types of electromagnetic radiation is classified by wavelength (Fluke Corporation & The Snell Corporation, 2009).

The part of the spectrum was studied in this project was the area corresponding to infrared. This area is invisible to the human eye, for that reason an infrared camera was used to detect and analyze the points of greatest radiation, and from this make the temperature in degrees Celsius.

The chart below shows the range of the types of radiation:

Graphic 1. Electromagnetic Spectrum



Source: Kurt (2006). Termodinámica.

INFRARED RADIATION BODIES

The electrical components are considered opaque, i.e., only have the ability to emit and reflect infrared radiation, for that reason which is measured by the camera is the portion of radiation emitted by the body itself and reflected by objects in front of it.

Radiation corresponding to the body temperature is the emitted radiation. In the components studied, radiation reflector bodies not found, which affect the temperature measurement, therefore it is offset 20°C the reflected radiation, this being the average room temperature.

DESCRIPTION OF THE INFRARED CAMERA

The infrared equipment that was selected was a thermal imager that uses analysis software for thermal imaging, and allows the inspection of electrical installations, due to the following characteristics:

- Object temperature range: -20°C to +250°C
- Field of view (FOV): 45° (horizontal) x 34° (vertical)
- Minimum focus distance: 0,5m
- Spatial resolution (IFOV): 10.3mrad
- IR resolution: 4800 pixels (80 x 60 pixels)
- Digital camera: 640 x 480 pixels
- Analysis software: FLIR Tools, available www.flir.es
- Image storage capacity: 500 images thermal and visual.
- Battery operating time: ~4 hours

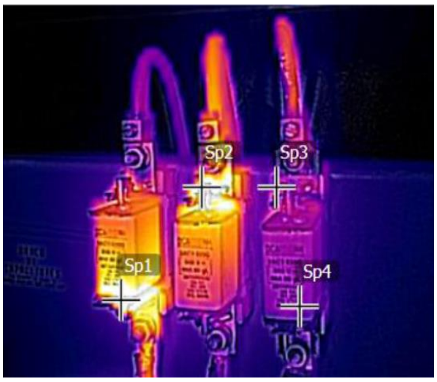
METHODS OF INSPECTION

Inspection methods used to detect and quantify the components in hot spots.

Qualitative inspection methods, which involves making a scan with the camera to check for temperature anomalies, and the second method used was quantitative, which measure the temperature of such anomalies is used.

The chart below shows the qualitative method:

Graphic 2. Qualitative method.

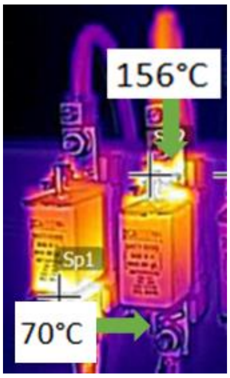


Source: The Author.

Here the existence of a temperature anomaly is detected.

The quantitative method shown in the following graph:

Graphic 3. Quantitative method.



Source: The Author.

Here the temperature is measured and compared to the inlet and outlet of the affected phase, in this case, a temperature difference of 86°C was found.

INSPECTION PROCEDURE

The inspection procedure used, according to the PPE (personal protective equipment) basic and essential to mitigate and prevent arc burns or electric shock, also it establishes the conditions in which they must perform an infrared inspection.

PPE that was used for this type of work include protection for: the head (isolated safety helmet), face (full face shield or goggles transparent), ears (hearing protection earmuff type asylee), body (sleeves and gloves dielectric), 100% cotton clothing, and feet (dielectric boots) (NFPA 70E, 2000).

The PPE stated above were chosen based on the standards shown in the following table:

Table 1. Protective Equipment Standard.

Tema	Número y título
Protección de la cabeza	ANSI Z89.1, *Requirements for Protective Headwear for Industrial Workers*, 1997
Protección de ojos y cara	ANSI Z87.1, *Practice for Occupational and Educational Eye and Face Protección*, 1989
Guantes	ASTM D 120, *Standard Specification for Rubber Insulating Gloves*, 1995
Mangas	ASTM D 1051, *Standard Specification for Rubber Insulating Sleeves*, 1995
Guantes y mangas	ASTM F 496, *Standard Specification for In-Service Care of Insulating Gloves and Sleeves*, 1997
Protectores de cuero	ASTM F 696, *Standard Specification for Leather Protectors for Rubber Insulating Gloves and Mittens*, 1997
Calzado	ASTM F 1117, *Standard Specification for Dielectric Overshoe Footwear*, 1993
	ANSI Z41, *Standard for Personnel Protección, Protective Footwear*, 1991
Inspección visual	ASTM F 1236, *Standard Guide for Visual Inspection of Electrical Protective Rubber Products*, 1996
Ropa/Vestimenta	ASTM F 1506, *Standard Specification for Protective Wearing Apparel for Use by Electrical Workers When Exposed to Momentary Electric Arc and Related Thermal Hazards*, 1998

ANSI – American National Standards Institute
ASTM – American Society for Testing and Materials

Source: NFPA 70E, 2000.

According to the recommended in NFPA 70B, 2006 standard practices: it was determined that the frequency of infrared inspections for electrical equipment should be performed every six months.

It is also recommended infrared inspections during periods of maximum load, but not less than 40% of rated electrical equipment (NFPA 70B, 2006).

TECHNICAL ANALYSIS OF THERMAL IMAGING

Analysis techniques help to identify the point with a higher temperature comes faulty component, is performed by FLIR Tools software, and is used to identify possible causes of the defect.

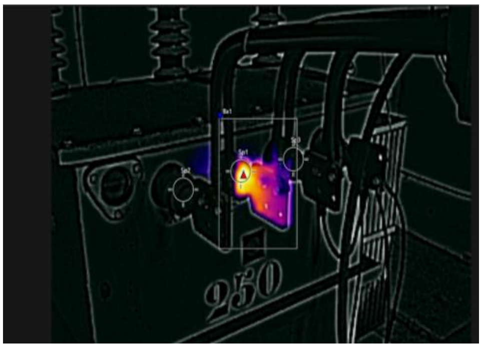
The techniques used are described below, and were performed in the following order:

1. Thermal setting

It is the scaling of the selected color palette on the component being analyzed, it was used in to point out the areas in component failure faulty.

Then a thermal image in which the adjustment was made is indicated, the problem resides in the bushing of phase 2 of the transformer:

Graphic 4. Thermal setting.



Source: The Author.

2. Measurement by areas

The measurement areas are used to identify the points with maximum temperature within a selected area, as shown in the following figure:

Graphic 5. Measurement área.

Source: The Author.

The measurement area is identified by the name Ar1.

3. Measurement points

The measurement points are used to measure the temperatures of the phases in a single point, and present failures in a simple manner in the reports.

The following image measuring points SP1, SP2 and SP3 settled.

Graphic 6. Measurement points.

Source: The Author.

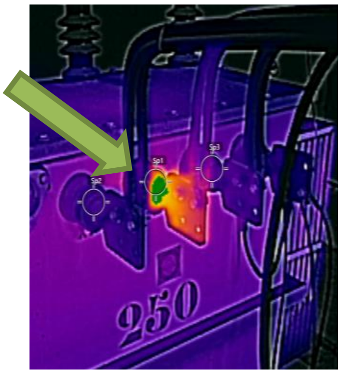
Faulty stage here compared to other phases at the same points.

4. Isotherm:

The isotherm is used to determine where the heat comes on a faulty component. This technique can be covered with high-contrast color (e.g., green) areas that are hotter inside the image.

Then a thermal image of a component to be applied to green isotherm indicated by the arrow shown:

Graphic 7. Isotherm.



Source: The Author.

Using this technique it was found that the hottest area comes from the inside of the base of the transformer bushing.

DEGREE OF SEVERITY OF POWER FAILURE BY THE STANDARD.

To set the priority and degreee of severity of defective components, indexed to 100% of rated load, the criteria table "NETA" (International Electrical Testing Association) standard is used, this rule states that temperature differences with respect to reference components, you have the following classification:

(1) Temperature differences of 1°C to 3°C indicate possible deficiency and warrant investigation.

(2) Temperature differences of 4°C to 15°C indicate deficiency, and should be made as time permits.

(3) Temperature differences of 16°C and above indicate major deficiency; repairs should be made inmediately.

PREDICTIVE MAINTENANCE STRUCTURE PLAN

The predictive maintenance plan or condition based comprises the following steps:

(a) Sets policies that serve to guide the actions according to the objectives of predictive maintenance;

(b) Develop procedures;

(c) Program activities; and

(d) Develop budgets (García, 2012).

Within the principles of predictive maintenance, root cause analysis as tool reliability was used to determine the origin of anomalies.

The procedures and the inspection program as part of the plan were developed based on NFPA 70E and NFPA 70B standards.

III. RESULTS

After conducting a study of thermography lot of components that need thermal monitoring was checked, four equipments with the highest deficiency representing 1% of the study and need to be repaired immediately found, they are: the bushing Transformer wáter well #1, NH fuses and motor type horizontal axis of the project #1 pumping station and Yuyucocha contactor Yahuarcocha treatment plant.

The causes of these hot spots were due to false contacts in terminals and in the case of the distribution transformer to a false internal contact.

The results are shown in the following table:

Table 2. Summary of results of the study of thermography.

Clasificación de los Equipos	***Porcetaje***	***N° Equipos***
Analizados	100	502
Operación Normal	90	450
Posible Deficiencia	5	25
Probable Deficiencia	3	14
Deficiencia	2	9
Deficiencia Mayor	1	4

Source: The Author.

IV. CONCLUSIONS

Field research reveals many defective components due to deterioration and lack of maintenance of pumping systems in the urban sector of the EMAPA-I.

After the analysis of thermal images, the severity of the fault is verified, four electric components found in different plants with greater deficiency, which need to be repaired immediately, and lots of deficient components that need to be repaired soon as possible.

As a result of the socialization of thermography study, the Technical Director of the EMAPA-I, decided to implement corrective actions suggested in the thermographic reports presented by each plant.

After developing the plan of predictive maintenance using thermography, it is concluded that most problems arise due to false contacts at the terminals of electrical components.

V. RECOMMENDATIONS

It is suggested to implement a predictive maintenance plan, using non-destructive testing as thermography and vibration analysis, to know the state of operation of electrical and mechanical equipment that make pumping systems.

It is suggested that an order of priority, according to the leaderboard fault ANSI / NETA ATS-2009, to be first correct the most significant failure is established.

It is recommended that defective components whith major deficient, repaired as soon as possible to avoid inoperability of plants.

Due to the high percentage of failures due to false contacts, it suggested implementing an adjustment program terminal by using torque wrench and torque tables.

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VII. BIOGRAPHIES

Diego J. Vásquez P., born in Ibarra - Ecuador on 10 November 1991. He completed his secondary education at the College "La Salle". Exit at the Technical University of the North in Electrical Maintenance Engineering. Area of interest: Equipments low and medium voltaje, electric motors, variable speed drives, non destructive testing and terotechnology. (djvasquez777@gmail.com)

Mauricio Vasquez., born in Chaltura - Ecuador on July 16 1959. He completed his secondary education at the College San Diego. He graduated in 1988 at the National Polytechnic School in Electrical Engineering. It has fourth level studies in higher education in the Unita and Business Administration at the Technical University of the North. Currently he holds the position of Director of Planning Emelnorte and Principal Professor at the Technical University of the North - Ibarra. Areas of interest: Distribution of electricity. (mvasquezbrito@gmail.com)