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Day and Night Thermal Analysis of a Low, Medium and High Load

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Abstract: Thermal scanning in electrical maintenance is an important method for calculating temperature and heat transfer within and between electrical system components and their surroundings. Black box or pole fuse switch is ranked as having the second-highest breakdown due to the delay in recognizing that there has been a temperature change occur. The inspection procedure is usually conducted solely in accordance with the schedule and does not include a set period of time for thermography scanning. The objectives of this project is to determine the best time for thermography scanning of low voltage poles by measuring temperature differentials and simulating the results with the Fluke SmartView software. The data is collected in three categories of load (low, medium, and high) and measured in degrees Fahrenheit using a thermal imaging camera. The collected data is analyzed to provide guidance for efficient scanning. Data was gathered using a thermography scanner, and Smart FlukeView software is also used for simulation. The proper time, either daytime or night, for thermography scanner thermal analysis of low voltage poles is established after analysis of all data collected during thermal analysis to ensure the correctness of each inspection condition. The results of thermography scanning for thermal inspection for black box or pole fuse switch is suggested to be done at night. Thermal analysis results found that all the results' accuracy ranges from 87.7% to 97.4%. Furthermore, the inspection results are 93.9% accurate overall. Lastly, this project can assist in doing preventative maintenance earlier and avoiding consumer brief power outages.

Keywords: Smart FlukeView, Thermal Analysis, Thermal Scanning, Thermography Scanning

1. Introduction

The development of thermal analysis can be dated to the eighteenth century, when temperature was made an observable and experimentally significant quantity, making it a parameter that could be monitored experimentally and serving as the foundation for the field of thermodynamics that followed [1][2]. Thermal analysis can be utilized for equipment troubleshooting, pre- and post-outage thermal

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comparisons, successful setup or repair confirmation, and equipment trouble prediction [3]. The system is used and operated at a low load during a thermal inspection, also known as "scanning" or "surveying," to avoid interrupting machine operation and minimize the need for outages.

For determining temperature and heat transfer within and between electrical system components and their surroundings, thermal scanning is a crucial technique in electrical maintenance. Thermal scanning will assist in identifying unusual thermal conditions or temperature variations that may support problems in their early tiers, preventing major disasters. Because there are many variables that can lead to inaccurate temperature readings, such as the environmental conditions, it is essential to ascertain the best time to conduct thermal scanning.

1.1 Environmental Factor

Infrared thermography testing may be carried out during the day or at night depending on the environmental factors and the desired results, and the weather in general affects the timing and techniques of infrared inspections [4][5]. Results of environmental factors vary depending on the weather, location, season, time of image capture, and material surface properties [6]. Wind speed, relative humidity, and solar loading are environmental factors that affect infrared thermography inspection.

Wind speed can have a significant impact on the accuracy of temperature measurements. When the wind speed is low, the temperature changes dramatically. Convection resists radiation from the surface when the wind speed is high. Actually, the relationship between hotspot temperature and wind speed is exponential [7].

Following that, relative humidity is the amount of water in the air at any given temperature during the saturation stage. It has no effect on measuring item temperature and will rise as the temperature rises [8][9].

Finally, solar loading can affect apparent temperature, and brief solar loading (for example, passing clouds) is more difficult to deal with. Early morning, evening, or midnight inspections will provide more accurate infrared results, so there is a questionable difference between measurements taken during the day and night. However, many structures are not as heavily loaded at night or during off-height hours. All materials that absorb a lot of sunlight will warm up.

1.2 Load Classification

Load is divided into three categories: low, medium, and high. To determine the load category, load profiling is required. Of course, the load profiling for a given area will vary greatly depending on the various consumer categories, such as commercial, residential, or industrial customers. In contrast, load profiling is the most efficient method of determining equipment demands and maintenance. The percentage set by the Tenaga Nasional Berhad engineering unit determines the load rating. The low load ranges between 0% and 30%. After that, the medium load is 30-60%. Finally, the high load varies between 60% and 100%. This percentage's value is determined by the value of the fuse.

1.2 Type of Failures

Electrical devices are often rated in strength, which shows how much energy the device can consume before becoming damaged, and resistance to electric flow generates heat, which overheats the item and reduces its life cycle and efficiency [10]. Electrical power system defects are classified into several categories, including faulty connection, short or open circuit, overload, load imbalance, and incorrect factor installation [11][12]. The most typical difficulties in electrical energy transmission and distribution lines are poor connections [13].

Thermal inspections can immediately locate hot spots, assess the degree of the problem, and assist in determining when the equipment should be repaired. Thermal imaging may detect a variety of defects in low voltage equipment, including high resistance connections, corroded connections, internal fuse damage, internal circuit breaker faults, and weak connections and internal damage.

2. Methods and Materials

The software algorithms for data collection was used in the project and an infrared thermal imaging camera was used to gather the data. The software Smart FlukeView is used to simulate the acquired image in order to analyze the outcomes. Figure 1 shows the flowchart of thermal analysis of low voltage pole during day and night on low load, medium load and high load.

2.1 Workflow of project

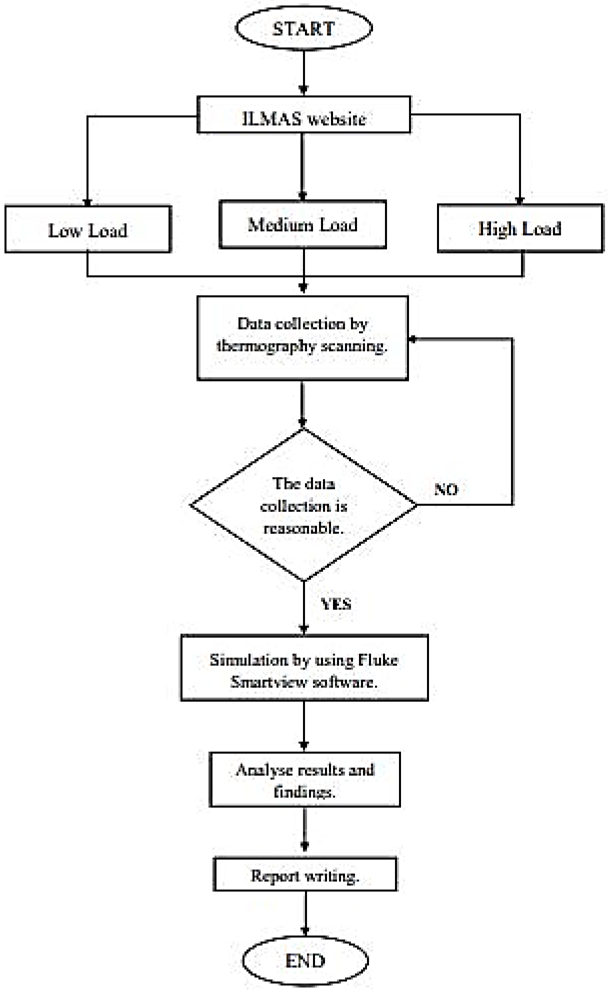

Figure 1: Flowchart of thermal analysis of low voltage pole during day and night on low load, medium load and high load.

As shown in Figure 1, the project described in the flowchart begins by load profiling to determine the load classification such as low load, medium load, and high load, using the ILMAS website. Data collection begins after the load and location are determined. If there is incorrect data, data collection is repeated. If the data is acceptable, the project moves forward with simulation using the Fluke SmartView software. Following receipt of the simulation data, an analysis is performed to determine the project's correctness and whether the thermography scanner is better at night or during the day. Finally, the report is completed, and the project is finished.

2.2 Testing Procedure

Low, medium, and high loads for low voltage poles are identified via load profiling. For each low voltage pole, a load profiling test must be conducted at the feeder pillar's incoming cable for a minimum of 48 hours. The ILMAS website offers access to all of the reading materials.

The heat from the heaters can hide hot spots in the equipment being scanned, so turn off all heaters at least three hours (if applicable) before scanning, according to the thermography scanner's instructions. Before scanning, note the voltage, amps, and breaker position (ON/OFF/ISOLATED) for each item of equipment that was scanned. Manually enter the camera's emissivity (= 1.00) and the backdrop or ambient temperature. By doing this, heat radiation from diverse materials is compensated for in terms of temperature.

A thermal imaging camera is then used to gather the data, which is subsequently simulated using Fluke SmartView software from the Fluke maker. The ideal time of day and night to scan is determined by analyzing the findings.

2.3 Fault Classification

The level of significance of the allegedly electrical equipment in the concrete structure is described in [14]. Table 1 shows the motion that must be handled in accordance with its priority level. These classifications are based on observed temperature increases, and the timing of corrective action must take the significance of the item involved in the operation into account. Additionally, the load on the equipment has an impact on the temperature rise; a minor finding on lightly loaded equipment may become a more serious finding when fully loaded. The fact that outdoor components are impacted by environmental factors means that there are no standards for evaluating excess temperatures measured on indirectly heated surfaces.

Table 1: Fault Classification [15]

Priority	Category	Delta T, ΔT	Action	Recommended Period to Repair
4	MINOR	1°F to 50°F	Corrective measures should be taken at the next maintenance period.	6 month
3	INTERMEDIATE	>50°F to 68°F	Corrective measures required as scheduling permits.	6 month
2	SERIOUS	>68°F to 104°F	Corrective measures require immediately	6 month
1	CRITICAL	104°F (>40°C)	Corrective measure required as soon as possible.	As soon as possible

3. Results and Discussion

This section focuses on the result of a low voltage pole's day and night thermal analysis for a low, medium, and high load. The final results is derived from simulations run using Fluke SmartView software for each load category.

3.1 Simulation Results

For simulation results using Fluke SmartView Software will obtain differential temperature, Delta T (ΔT) and background temperature. Table 2 tabulates the summary simulation results for thermography scanner for low load, medium load and high load during day and night. According to the thermography scanning results for daytime and nighttime at the first location, Jalan Cemara 11, $\boldsymbol{\Delta T}$ during the day is 26.5°F and 47.3°F at night, based on the final results obtained for low load, which is 0% to 30%. ΔT is less than 50°F, in the Minor category, which is given priority 4. Therefore, corrective maintenance must be performed within six months of the next maintenance period. The second location, which is different from the first, is Jalan Cengal 11, where the daytime $\Delta\boldsymbol{T}$ is categorised as Serious, is priority 2, and is 74.3°F. In spite of this, $\Delta\boldsymbol{T}$ at night is rated as Intermediate, which is priority 3, and has a temperature of 52.2°F. The suggested action plan should be taken in response to the overnight results that the necessary corrective measures necessitate as time permits.

Table 2: Summary Results for Low Load (0% to 30%)

Location	Day	Background Temperature	Delta T, (ΔT)	Night	Background Temperature	Delta T, (ΔT)
Jalan Cemara 11	9.40 a.m.	90.3°F	26.5°F	9.20 p.m.	85.6°F	47.3°F
Jalan Cengal 11	2.00 p.m.	88.5°F	74.3°F	11.10p.m	83.7°F	52.2°F

Table 3 summarizes the medium load results ranging from 30% to 60%. It is observed that the $\Delta\boldsymbol{T}$ at the first location, Jalan Jambu 28/9, is 72.1°F during the day and 49.3°F at night. Additionally, it was discovered that the fault category during the day is Serious, which has priority 2, and the fault category during the night has priority 4. The suggested course of action should be taken in response to the overnight results, and corrective action should be taken at the subsequent maintenance appointment within six months. Due to $\Delta\boldsymbol{T}$ 54.6°F, the daytime fault in the second location, Jalan Anggerik 9/7, was elevated to Intermediate, which is priority 3. However, the Minor fault, which has a priority level of 4, occurs at night with $\Delta\boldsymbol{T}$ 47.4°F. The suggested course of action should be taken in response to the overnight results, and corrective action should be taken within six months.

Table 3: Summary Results for Medium Load (30% to 60%)

Location	Day	Background Temperature	Delta T, (ΔT)	Night	Background Temperature	Delta T, (ΔT)
Jalan Jambu 28/9	10.14 a.m.	84.1°F	72.1°F	10.40p.m	91.3°F	49.3°F
Jalan Anggerik 9/7	10.40 a.m.	95.4°F	54.6°F	12.00a.m	83.7°F	47.4°F

Table 4 tabulates the summary results for high load. It is noticed that the $\Delta\boldsymbol{T}$ reading during the day is 59.8°F, the fault is classified as Intermediate, which is priority 3 at Jalan Pertama 1. Meanwhile, the temperature at night is 45.9°F, and the fault is classified as minor, priority 4. The recommended action should be taken in response to the overnight result, with corrective measures implemented at the next maintenance period within 6 months. Meanwhile at Jalan Serunai 1, the daytime temperature of 61.9°F and a nighttime temperature of 50.3°F. As a result, the $\Delta\boldsymbol{T}$ reading is classified as intermediate, which is priority 3. The recommended action should be taken in response to the overnight result, with corrective measures implemented as soon as scheduling allows within three months.

Table 4: Summary Results for High Load (60% to 100%)

Location	Day	Background Temperature	Delta T, (ΔT)	Night	Background Temperature	Delta T, (ΔT)
Jalan Pertama 1	12.00 p.m.	83.4°F	59.8°F	12.00 a.m.	80.9°F	45.9°F
Jalan Serunai 1	2.21 a.m.	87.2°F	61.9°F	10.10 a.m.	84.6°F	50.3°F

3.2 Result Analysis

Because of the more stable weather conditions at night, scanning thermography is most effective at night. Each load has the same chance of experiencing a minor, intermediate, serious, or critical fault, whether it is low, medium, or high. Ageing installations, lack of maintenance, loose fuses, and loose jumper wires are all causes of the blackbox heating up. As a result, preventive maintenance is essential for avoiding damage. To avoid things like supply interruptions for consumers, it is critical to plan ahead of time. The accuracy results of a low voltage pole thermal analysis for various loads are shown in Table 5. It is observed from Table 5 that the accuracy of the results ranges from 87.7% to 97.4%. Furthermore, the overall accuracy of the inspection results is 93.9%. The range are acceptable since average percentage is more than 90%.

Table 5: Results Accuracy during Thermal Analysis

Location	Background Temperature (Day)	Background Temperature (Night)	Differences	Percentage Accuracy
Jalan Pertama 1	90.3°F	85.6°F	4.7	94.8%
Jalan Serunai 1	88.5°F	83.7°F	4.8	94.6%
Jalan Jambu 28/9	84.1°F	91.3°F	7.2	92.1%
Jalan Anggerik 9/7	95.4°F	83.7°F	11.7	87.7%
Jalan Pertama 1	83.4°F	80.9°F	2.5	97.0%
Jalan Serunai 1	87.2°F	84.9°F	2.3	97.4%

Temperature changes are greater at night than during the day so thermal analysis should have been performed at night. This is due to the fact that earth's surface rapidly cools at night as the sun sets and the sky clears, and rapidly heats up during the day as the sun rises and the sky becomes cloudier. At night, this results in higher temperature gradients and more pronounced thermal effects, making it ideal for thermal analysis. Furthermore, the lack of sunlight at night allows for more accurate readings.

Impact from this project, can save time during the inspection if the optimal time are determine to conduct a thermal inspection for this project. Then, knowing ahead of time about the specific temperature fluctuations that occur, preventive maintenance is vital to avoiding harm. To minimize problems like supply disruptions for consumers, it is vital to plan ahead of time.

4. Conclusion

A project involves scanning low voltage poles with infrared thermography for different loads during the day and night. The main goal is to measure the ΔT (temperature differential) at the pole during the day and at night using the same load value. To obtain the differential temperature, thermal scanning at the black box or pole fuse switch disconnector is required. Data was collected for three different types of loads. There are more faults as a result of the day inspection than at night. Finally, the results of thermography scanning during the day and night is analyzed using the results of main image markers and markers data. Overall, the accuracy of both results was acceptable, ranging from 87.7% to 97.4% with a temperature difference of up to 11.7 degrees Fahrenheit between day and night inspections.

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