INFRARED THERMOGRAPHY AND DISTRIBUTION SYSTEM MAINTENANCE IN ALEXANDRIA ELECTRICITY DISTRIBUTION COMPANY

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ABSTRACT

Electrical Systems typically suffer from problems such as loose connections, load unbalances and corrosion. These problems cause an increase in impedance to current, resulting in resistive heating. If left unchecked, this heat can build to a point at which connections melt-breaking this circuit and in some cases creating fires. Power line and utility infrared inspection services are designed to locate potential electrical problems and assist utilities with eliminating failures in transmission and distribution systems. The use of thermography cameras for power line infrared inspection provides the fastest and most accurate method of survey. It quickly locates hot spots and determines the severity of the problem and how soon the equipment should be repaired. All these benefits lead to reduce utility maintenance costs and increased system reliability.

This paper describes results of the power line inspections at Alexandria Electricity Distribution Company using a thermal image camera and corrective actions taken for discrepancies found during the inspections. They can be categorized into two case studies as follows:

1) The inspections for irregularities in overhead transmission lines caused by inappropriate electrical connections which heat up several equipment such as non-tension sleeve, jumper, tongue and disconnecting switch.

2) The inspections for deficiencies and "hot spots" in distribution systems such as fuse connection heating, high voltage insulator breakdown, ground current leakage, breaker connection heating and transformer connections overheating.

INTRODUCTION

Infrared Thermography has evolved into one of the most valuable diagnostic tools used for predictive maintenance (PM) which is considered as a very important task that can prevent electricity blackout in large areas, reduces equipment damages of both transmission and distribution systems. Alexandria Electricity Distribution Company (AEDC) has carried out several maintenance activities as part of the predictive maintenance for example cutting trees around power lines, cleaning porcelain insulators, inspecting power line conditions, etc. Normally, the inspection of power line conditions is visually carried out using primary equipment which is not efficient enough. Therefore, AEDC has decided to use thermal image camera to inspect the power lines. This technique offers a

pinpoint location of system deficiencies and "hot – spots" in transformers, switchgears and overhead lines. Usually, AEDC brings a thermal image camera to survey both the overhead transmission lines and the electric distribution system for finding hotspots on non tension sleeves, jumpers, and switches. For example, it can examine the damaged condition of a joint connector which has high temperature from the loose contact. However, there are other equipment besides connectors such as insulators, lightning arrestors, crossarms, etc. that can be inspected by a thermal image camera together with a new analytical technique for inspection results. This new technique that will be presented in this paper can prevent damages of power transmission lines as well as to the power distribution lines..

BASIC CONCEPT OF THERMAL IMAGE CAMERA

The operation of thermal image camera can be explained by a nature phenomenon; every object always radiates infrared energy. The amount of energy radiated from an object is dependent on its temperature and its emissivity. An object which has the ability to radiate the maximum possible energy for its temperature is known as a black body. Hence, emissivity is expressed as:

$$Emissivity = \frac{Radiation\ emitted\ by\ an\ object\ at\ T}{Radiation\ emitted\ by\ a\ black\ body\ at\ T}$$

Where: T refers to the temperature.

Emissivity is therefore an expression of an object's ability to radiate infrared energy. The value of emissivity tends to vary from one material to another. With metals a rough or oxidized surface usually has a higher emissivity than a polished surface. Here are some examples which are shown in table 1.

TABLE 1- Emissivity values

Material	Emissivity
Aluminum Weathered	0.83
Copper Polished	0.05
Copper Oxidized	0.78
Nickel	0.05
Stainless Steel Polished	0.16
Stainless Steel Oxidized	0.85
Steel Polished	0.07
Steel Oxidized	0.79

THERMAL CAMERA APPLICATIONS IN OVERHEAD TRANSMISSION LINES

Overhead transmission lines (O.H.T.L) in AEDC network are drawn across the country covering vast geographical territories with overall length 572.18 km. Overhead power transmission lines are classified in the electrical power industry by the range of voltages. Alexandria overhead transmission lines consist of two types: the first type consists of 24 overhead transmission lines at 11 k.v with overall length 194.80 km, and the second type consists of 20 overhead transmission lines at 22 k.v with overall length 307.85 km. It is therefore essential to undertake preventive maintenance activities according to a certain maintenance program using a structures method so that AEDC survey all overhead transmission lines in order to decrease the number of transmission failures that can be occurred at all connection points as follows: non-tension sleeves, sleeves, jumpers, disconnecting switches and overhead ground wires in order to improve power quality. The following are two examples of unwanted conditions that thermography can locate and provide early warning signs for maintenance departments.

CASE STUDY NO.1

A high-temperature spot is found at the connector of phase-T conductor at the jumper of the riser pole is shown in figure 1. This means that phase-T connector has high temperature due to using inappropriate equipment and tools; use of a machine bolt instead of hexagon bolt without a spring ring has caused a bad electrical connection so that it is proposed to make a replacement using the appropriate equipment and installation.

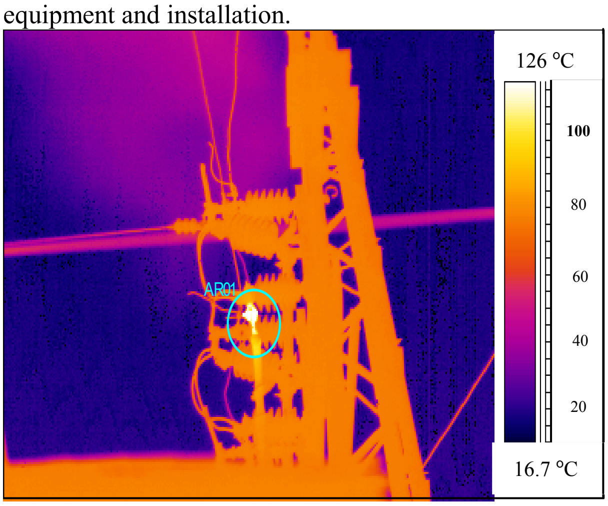

Fig.1 shows the damaged connector of phase T at EL HARES-ABIS O.H.T.L.

CASE STUDY NO.2

A high-temperature spot is detected at the top conductor is shown in figure 2 which can be caused by a loose connection.

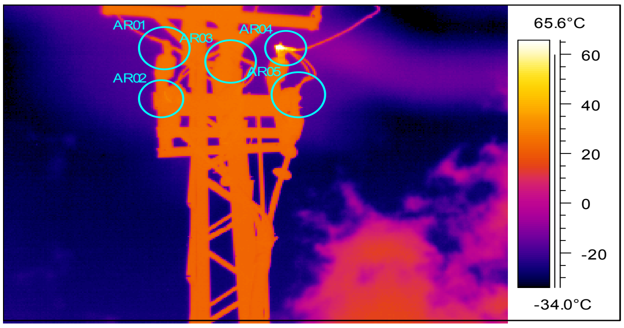

Fig.2 shows a color-infrared image resulted from a thermal image camera at MARAKIA 2 O.H.T.L.

THERMAL CAMERA APPLICATIONS IN DISTRIBUTION SYSTEMS

Infrared thermographic inspection of electrical distribution system in AEDC network which covered about 7000 transformer point (T.P) distributed on five distribution zones offers a pinpoint location of system deficiencies and "hot-spots" while at the same time remaining very affordable to company budgets. Thermal image camera has the ability to produce a visual representation of thermal patterns as heating systems components are identified and recorded. Maintenance strategies are then planned and carried out before system breakdowns occur. Heating components are generally noted as white or lighter colored areas in an infrared image. Transformer secondary connections, transformer overheating, ground currents, fuse connection or internal heating, transformer bushing heating, utility connection box break and breaker connection heating are several examples of unwanted conditions that thermography can locate and provide early warning signs for maintenance departments.

CASE STUDY NO.1

This case study shows the looseness in fuse connection as shown in figure 3. Infrared camera detects effectively loose electrical connections which generate heat and can pose serious fire hazards.

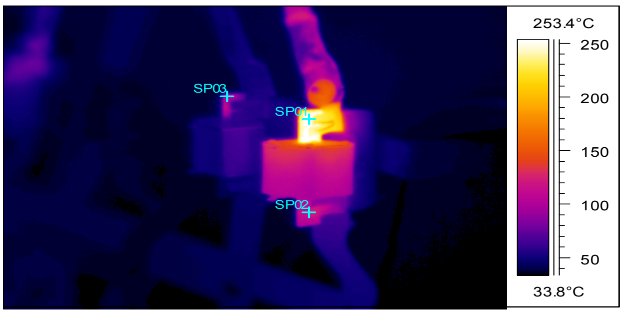

Fig.3 shows an increase in temperature in fuse connection due to the looseness in connections at T.P 784-B.

This hot spot can be prevented by keeping electrical connections tight and torque to recommended values. Also, bimetallic must be used in order to prevent looseness in connections.

CASE STUDY NO.2

This case study shows transformer insulator bushing heating which breakdown over time due to its high temperature. If it is not replaced in sufficient time, catastrophic failures can develop. Thermography can locate overheating transformer bushings to provide early warning so that repairs can be planned before failure which is shown in figure 4. This deficiency can be avoided by scheduled cleaning the equipment and also by preventing looseness in connections.

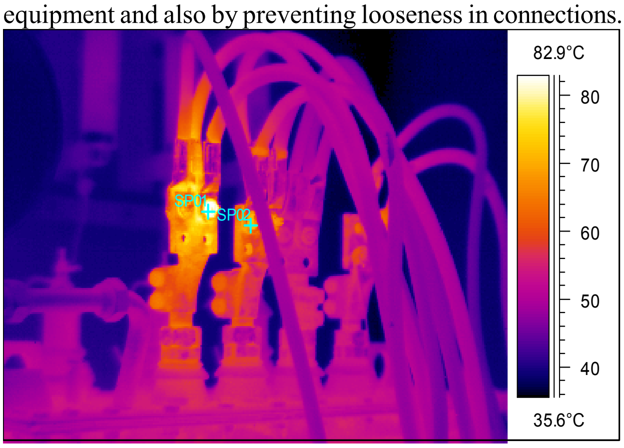

Fig. 4 shows an increase in temperature in transformer bushing due to dust and dirt accumulation at T.P 867-B.

CASE STUDY NO.3

Thermography can locate overheating transformer secondary line connections as shown in figure 5. This overheating type may be due to the presence of moisture which can cause connection failure, so precautions should be taken to minimize the entrance of moisture.

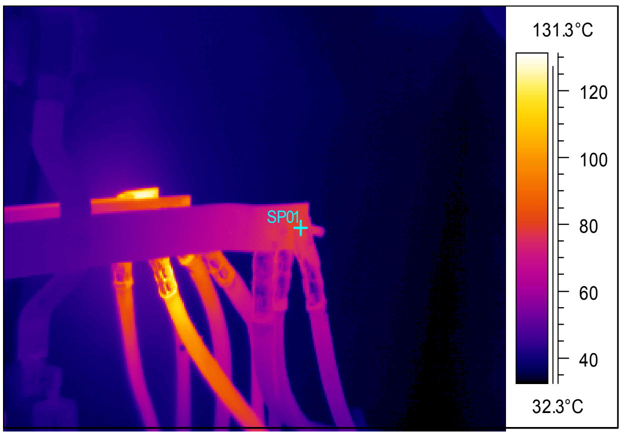

Fig. 5 shows an increase in temperature in transformer secondary line connections due to the presence of moisture at T.P 498-B.

CASE STUDY NO.4

Thermal image camera can also identify overheating components such as transformers as shown in figure 6. Transformer overheating increases transformer losses , weaken the insulation and may result in reducing transformer life. The principal reasons for transformer overheating are classified as follows:

- Excessive transformer loading.
- Excess current in the neutral of the transformer.
- Problems in the cooling system.
- High harmonic content in the power supply.
- Sustained overvoltage which exists for a long period of time.

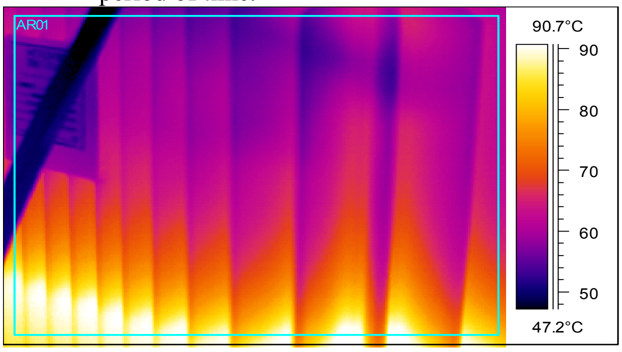

Fig. 6 shows the transformer overheating which reduce the transformer life at T.P 695-B.

Since transformers are a critical and expensive component of the power system so that it must be protected against faults and overloads. The type of protection used should minimize the time of disconnection for faults within the transformer and to reduce the risk of catastrophic failure to simplify eventual repair. Any extended operation of the transformer under abnormal condition such as faults or overloads compromises the life of the transformer, which means adequate protection should be provided for quicker isolation of the transformer under such conditions.

CASE STUDY NO.5

A large ground current which may trip the protective devices is detected in figure 7.

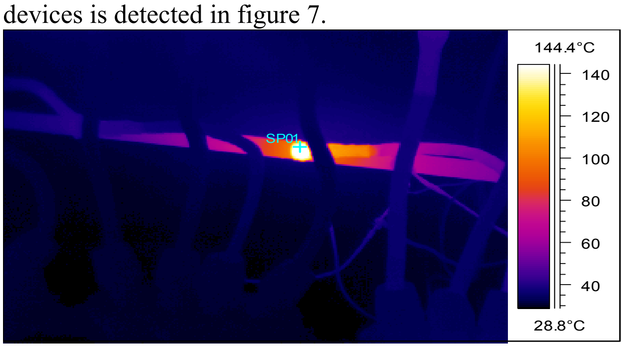

Fig. 7 shows a large ground current due to the unbalanced loads between the three phases R,S,T at T.P 322-B.

This is considered as a sign of the unbalanced loads between the three phases R, S, T. This phenomenon is very dangerous since the system power quality is affected. For example, the unbalanced loading causes unbalanced voltages even the voltage at source is balanced. Lower, higher, or unbalanced voltage can reduce efficiently and may damage appliances. Furthermore, this phenomenon must be prevented by balancing loads in distribution systems.

CONCLUSION

Enhancing and preserving system reliability and reducing maintenance costs are top priorities for electric utilities today. AEDC has used the thermal image camera to inspect the system deficiencies for both overhead transmission lines and distribution systems by detecting the high temperature normally caused by the heat due to bad contacts or high resistance of connection points. Since Alexandria is a mediterranean city that is characterized by its high humidity which oxidizes the electrical connection terminals. These terminals consist of several materials such as copper, aluminum and steel that has various coefficient of thermal expansion. This oxidization leads to increase the material resistance resulting in high temperature or hot spots that can be prevented by using a bimetallic in order to prevent the looseness in connections.

Concluding, infrared inspections of electrical systems are beneficial to reduce the number of costly and catastrophic equipment failures and unscheduled plant shutdowns leading to the improvement of system efficiency and power quality.

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