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Investigative analysis to determine safety priority levels for power distribution equipment using Infrared Thermography: The case study of related ancillary equipment located within selected substations in Kumasi Metropolis.

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Abstract: *The study focused on the identification of priority levels for power distribution equipment in selected substations in Kumasi, Ghana.So many times in the event of safety disasters in substations, engineers do not normally know which power distribution equipment to address and isolate. The determination of priority levels for the various equipment help mitigate such dilemma and prevent huge power losses. The selected substations included a 33kV Substation H at Edwenase, a 33kV Nsuta Substation and a Station A, 33kV Substation at Adum, all located in Kumasi Metropolis. The power equipment under study in the various substations included an 11kV busbar, a cable/overhead jumper on a transmission pylon, a 33kV cable end isolator, a 33kV jumper located in-between an overhead transmission line, a busbar and isolator joint, a series of busbar bushings, a terminated cable housed in a distribution panel, and a high voltage terminated cable. A 41-day infrared thermography was conducted on all selected equipment to ascertain their 'health'. The survey was all conducted in the evening where maximum, actual and measured temperatures were recorded with thermographic cameras. A severity index was applied to these forms of temperature which comprised the difference in temperature between the maximum (max) and measured (msd) temperature of the equipment and between the ambient (amb) and measured (msd) temperature of the power equipment. The safety priority levels of the max/msd were always considered ahead of the amb/msd temperature in the event they reflected different priority levels.In the analysis of the Delta-T criterion, the delta-T criterion value for similar components under similar loading always override that value obtained between the components and the ambient air temperatures.*

Keywords: *Hotspot, Infrared Thermography, Severity Index, Thermographic Camera*

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I. Introduction

At a specific temperature above absolute zero (-273ºC), every object emits energy as a form of electromagnetic waves which may vary in their frequency and wavelength depending on the temperature, emissivity and the radiating region of the object[1]. With regards to the electromagnetic spectrum, the radiated energy can be grouped based on the wavelengths and the frequencies of the electromagnetic waves. The wavelength band of electromagnetic radiation that can be perceived by naked human eye varies from 400nm (violet) to about 700nm (red) [2]. This range is termed as the visible spectrum. The term "infrared" emanates from Latin, which means "below-red." The frequency spectrum of infrared region extends from (3 x 1012) Hz to (4 x 1014) Hz (red) which is the low frequency portion of the visible spectrum [3]. Thermography is the process in which heat emitted by an object is transformed into a visible image. One of the most widely used applications for infrared thermography is for electrical applications. The temperature of electrical components and associated connections are indicative of their robustness and health. Excessive heat as a result of electrical resistance will be generated by faulty components, loose and deteriorated conditions, short-circuit, overload, mismatched or improperly installed components. Most equipment running hot can also be attributed to load imbalances and failure of cooling methods. Deteriorating and unwanted materials, faulty installation or inadequate material usually causes anomalies in any insulation system. To begin with, it is imperative to know the problems that may occur in electrical apparatus due to faulty installation, improper usage, deteriorating or surrounding conditions to enable us better appreciate the importance of infrared thermography. Every electrical/electronic device usually has its own power rating specifications which indicate the amount of energy the device can operate without any damage or the tolerance levels the device can work with. If the device uses power exceeding its ratings, the excess power causes the atomic materials in the device to resonate and oppose the flow of electricity. The resistance generates heat which subsequently overheats the device and with time reduces the efficiency and lifecycle. Another problem is the loose connection of electrical components. It is a major problem that affects electrical equipment as a result of changes in the electrical resistances of the equipment. Loose connection increases resistance by making the area of the defective connection used by electricity smaller than required. The increasing resistance in turn overheats the connection. Any problem generating a change in resistance of the equipment causes the equipment to utilise more power than the intended load requirements.For electrical installations, infrared thermography as a condition monitoring technique is used for remotely gathering thermal information for monitoring the condition of practically all electrical components on an entire system. The mode of operation of a thermal imaging camera is as follows:

1. All equipment operating under regular conditions have normal operating thermal signatures characteristic of the specific component being investigated. This infrared thermography normally presents this normal signature or baseline.
2. As the baseline is drawn, infrared thermography reveals the thermal variances deviating from the norm. The localized deviation is generally as a result of an overheated condition or absence of heat.
3. The information is accessed and decisions are made for repair or to plot the temperature change over time. The information can also be used in repairing the component at an opportune time and can be stored and analysed at any point in time.

1.1 Infrared Thermography on Power Generation Equipment

Temperature and the thermal characteristic of power generation and distribution equipment as well as individual electrical systems and processes are some of the most critical factors in the reliability of any facility. Monitoring the thermal operating conditions of electrical equipment is paramount to minimising electrical losses and increasing operational efficiency and reliability in a power plant installation. Energy Audit of Electrical Installations is an essential part of the overall energy audit of complex technical systems, and infrared thermography is one of the non-destructive testing (NDT) methods for that type of power distribution subsystems analysis. Electrical systems typically suffer from problems such as loose connections, corrosion and load imbalances and these problems can cause an increase in impedance to the current, resulting in resistive heating which if left undetected and worked upon can build to a point at which connections can create fires. Power line and utility infrared inspection services assist in locating potential electrical problems and eliminating failures in the transmission and distribution systems of electrical utility companies. The use of thermography cameras for power line infrared inspection provides the fastest and most accurate method of survey which quickly locates hot spots and determines the severity of the problem and how quickly the equipment should be repaired. When these problems are addressed, there is reduction in utility maintenance costs and the increase in system reliability. The infrared thermography investigations in the thesis are presented in two main ways:

1. The inspection and identification of 'hot spots' and other deficiencies in distribution systems such as voltage insulator breakdown, transformer connections overheating, ground current leakage and fuse connection heating.
2. Identification of irregularities via inspection in overhead transmission lines brought about as a result of faulty electrical connections which heats up several equipment such as non-tension sleeve and disconnecting switch.

Infrared Thermography is not only a condition-based monitoring tool but also a valuable diagnostic tool for predictive maintenance (PM) and can help prevent electricity blackout and subsequently reduce equipment damage of both transmission and distribution systems. Usually, most electric power utility uses the thermal image camera to undertake surveys of overhead transmission lines and the overall electric distribution system for finding hotspots on non-tension sleeves and jumpers. For instance, the thermal imaging cameras can examine the damaged condition of a joint connector which has high temperature as a result of the loose contact. However, there is other equipment besides connectors such as insulators, lightning arrestors etc. that can be inspected by a thermal image camera. The benefits of using this technology include improved safety, reduced maintenance costs, increased utility system reliability, improved system efficiency, and lost production and downtime due to outages. Thermal imagers are now widely used in generating stations (whether gas, fossil, nuclear or hydroelectric), in switchyards, all types of substation and switchgear through to transformers, voltage regulators, switches, circuit breakers, power transmission lines, and capacitors[4] . They are also used to monitor pylon connections, to detect leaks, and to check distribution panels, fuses and other piping systems. As soon as electrical equipment and components are installed, they begin to deteriorate with time. Factors such as vibration, fatigue, aging and fluctuating loads increase the probability of faults in these components. Loose connections, component deterioration, unbalanced load and overload conditions, improper and faulty insulation and component deterioration are some of the many faults arising from electrical equipment and component failure. The faults, if not addressed, can lead to catastrophic failures, unplanned shutdowns and subsequently losses in production. Over the years measures have been taken to identify the 'health' of these electrical components in the course of their operations. Continual visual inspection of faulty equipment by engineers has failed as some of these faults are well hidden from the view of the naked eye. In repair and maintenance of electrical components, there have been three different categories. These are: time-based maintenance, condition-based maintenance, and when the equipment malfunctions. Infrared thermography is an example of a condition-based maintenance technique which is widely used in several industries. One of its strengths has been its non-contact nature of assessing the integrity of a material and it has become an indispensable tool especially in the electric utility sector. Subsequently, the cost of electrical expenses can be minimised by using this method that is left undetected by the naked eye.

II. Literature Review

Energy Audit of Electrical Installations is an essential part of the overall energy audit of the complex electrical technical systems. Infrared thermography is one of the non-destructive testing (NDT) methods for the analysis of power distribution systems. Infrared thermography is a condition monitoring technique used to remotely collect and acquire thermal information for monitoring the condition of components (electrical components) in an entire system. A baseline is normally established (i.e. the operating safe temperatures of equipment is recorded) with the infrared thermography revealing thermal variations deviating from the norm[5].The localized thermal deviation could be as a result of an overheated condition or in certain cases, the absence of heat. Subsequently, repair is carried out after analyzing collected data on thermal imaging of the electrical components. Infrared thermography has evolved into a most essential diagnostic tool used for predictive maintenance, which is considered a very important task that can prevent electricity blackout in large areas as well as minimising the equipment damage of both transmission and distribution systems.A thermographic camera is sometimes termed as FLIR (Forward Looking InfraRed). Most examination of power transformers is done with the aid of thermal imaging. The Electricity Company of Ghana (ECG) carries out several maintenance duties such as inspecting power line condition, inspecting porcelain insulators, as part of predictive maintenance measures using thermal imaging. The technique offers a direct location of the overall system deficiencies and identification of potential and existing 'hot spots' in power equipment such as overhead lines, insulators, lightning arresters, transformers and switchgears. For instance, the damaged condition of a joint connector with high temperature arising from loose connection can be thermally imaged. They can be assessed during the normal working conditions. However, many defects are visible and detectable only when the power transformer is not switched off. Such parts, the overheating or cold parts are only identifiable with normal inspection methods.The selected substations where these components of the power distribution system were picked included:

1. 33kV Substation H at Edwenase in Kumasi, Ghana
2. 33kV Nsuta Substation
3. Station A at Adum Ridge 33 Station

III. Methodology and Criterion

In electrical engineering, there is not a globally accepted stringent method of safety assessments based on infrared survey. In the IR practice, the delta-T criterion is used to assess the state of electrical apparatus and equipment. The figure(2) is a maintenance testing specification by the National Electrical Testing Association NETA MTS-2005 suggesting the series of actions to be taken based on the temperature difference between similar components. It is also based on the difference in temperature between the component and the ambient air temperature.

Table 1. The Severity Index System-Priority Level Table

Priority	The temperature difference (Delta-T) based on comparisons between		Recommended action
	Similar components under similar loading	Components and ambient air temperatures	
1	> 15 °C	> 40 °C	Major discrepancy; repair immediately
2	-	21 ÷ 40 °C	Monitor conntinuously until corrective measures can be accomplished
3	4 ÷ 15 °C	11 ÷ 20 °C	Indicate probable deficiency; repair as time permits
4	1 ÷ 3 °C	1 ÷ 10 °C	Possible deficiency; warrants investigation

Fig.1. a section of the transmission pylon under study

Table 2. 41 day survey of infrared monitoring of power distribution equipment

				41-DAY SURVEY	
2018	5.00pm-10.00pm				
	A.T	TEMPERATURE			
		MIN(°C)	MAX(°C)	ACTUAL(°C)	POWER EQUIPMENT
1	25	-2.4	31.4	32	11KV BUSBAR
2	23	-15.5	21.9	22.3	CABLE /OVERHEAD JUMPER ON PYLON
3	24	12.3	84	120	11KV BUSBAR
4	25	19	84	69	11KV BUSBAR
5	25	12	69.5	92.8	11KV BUSBAR
6	24	28.5	32.6	87.1	33KV CABLE END ISOLATOR
7	25	2.2	81.9	155	33KV JUMPER BETWEEN OVERHEAD AND CABLE
8	25	12.8	73.5	126	33KV MAIN BUSBAR
9	25	24.3	89.7	99.3	BUSBAR AND ISOLATOR JOINT
10	25	25.7	43.2	42.3	BUSBAR BUSHING 1
11	24	25.7	43.2	57.9	BUSBAR BUSHING 2
12	25	12	38.6	68.1	CABLE /OVERHEAD JUMPER ON PYLON
13	24	22.9	144	163	CABLE BUSBAR SUBS TATION 1
14	23	11.6	56.8	77.2	CABLE BUSBAR SUBSTATION 2
15	24	25.7	43.2	50.2	CABLE BUSBAR SUBSTATION 3
16	22	25.7	43.2	56.1	CABLE BUSBAR SUBSTATION 4
17	24	15.4	63.5	110	CABLE END ISOLATOR
18	24	-2.4	31.4	32	CABLE OVER TRANSMISSION SUBSTATION 1
19	23	11.9	51.2	112	CABLE OVER TRANSMISSION SUBSTATION 2
20	24	21.9	27.5	27.6	DISTRIBUTION PANEL CABLE TERMINATION
21	24	12.4	112	165	GAS CIRCUIT BREAKER SUBSTATION SF6

4.1 Analysis of Power Distribution Equipment in Infrared Thermography

4.1.1 11KV Busbar

Two of the 11kV busbars (1 and 3) were found to be in optimum health conditions while the other two were in need of repair and replacement (2 and 4).

Table 3. 11KV Busbar

Equipment	Amb. Temp (° C)	Max Temp (° C)	Msd Temp (° C)	Delta-T (Similar Cmpnts)	P.L.1	Delta-T (Cmpnt/Amb Temp)	P.L 2	Overall Priority Level	Remarks
11kV Busbar 1	25	31.4	32	0.6	4	7	4	4	Possible deficiency; Warrants investigation
11kV Busbar 2	24	84	120	36	1	96	1	1	Major Discrepancy; Repair Immediately
11kV Busbar 3	25	84	69	-15	4	44	2	4	Possible deficiency; Warrants investigation
11kV Busbar 4	25	69.5	92.8	23.3	1	67.8	1	1	Major Discrepancy; Repair Immediately

IV. Results and Discussions

Table 4. 41 day survey of infrared monitoring of power distribution equipment

23	25	23.2	106	158	GAS CIRCUIT BREAKER SUBSTATION SF6
24	25	28.5	32.6	55.5	HV TERMINATED CABLE
25	24	21.3	59.1	94.2	CABLE /OVERHEAD JUMPER ON PYLON
26	25	28.5	32.6	78.9	BUSBAR BUSHING 1
27	25	16.5	30.5	62.1	BUSBAR BUSHING 1
28	25	17.7	39	29.4	BUSBAR BUSHING 1
29	21	22.6	31	68.4	BUSBAR BUSHING 1
30	25	14.4	37.9	27	BUSBAR BUSHING 1
31	25	-4	41.7	28.5	CABLE OVER TRANSMISSION SUBSTATION 1
32	25	25	37.3	40.2	GAS CIRCUIT BREAKER SUBSTATION SF6
33	23	9	51	63	CABLE /OVERHEAD JUMPER ON PYLON
34	23	15.2	37	29	BUSBAR BUSHING 1
35	24	22.9	80.8	96.1	CABLE END ISOLATOR
36	22	97.4	70.9	97.4	BUSBAR BUSHING 1
37	21	-6.3	29.6	41.2	CABLE /OVERHEAD JUMPER ON PYLON
38	20	2.2	81.9	155	CABLE /OVERHEAD JUMPER ON PYLON
39	23	12	38.6	68.1	CABLE /OVERHEAD JUMPER ON PYLON
40	25	20.4	114	155	GAS CIRCUIT BREAKER SUBSTATION SF6
41	24	11.9	51.2	112	CABLE /OVERHEAD JUMPER ON PYLON

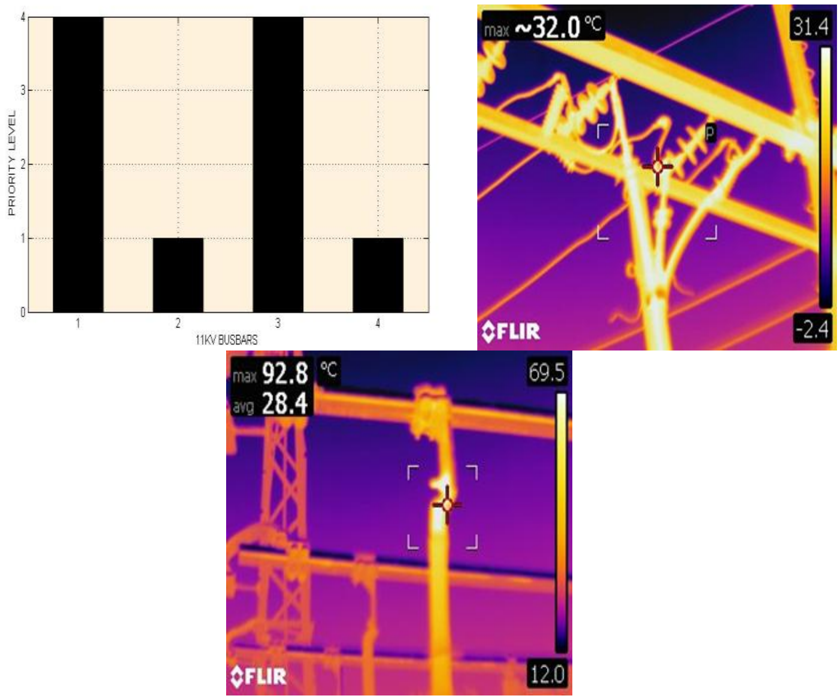


Fig.2. 11KV Busbar Assessment

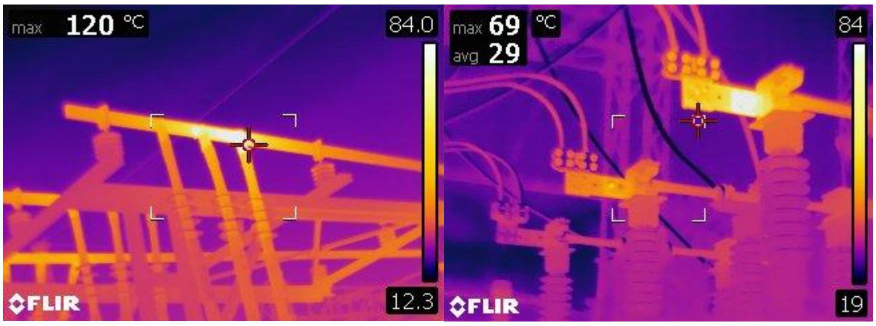


Fig.3. 11KV Busbar Assessment

4.1.2 Cable/overhead jumper on pylon (COJP)

The cable/overhead jumper (COJP) needs to be treated with urgency as almost all the components need some form of immediate attention. COJP 1 is in perfect condition while COJP 4 and 5 needs some time for repair. The rest needs immediate attention.

Table 5 Cable/overhead jumper on pylon

Equipment	Amb. Temp (° C)	Max Temp (° C)	Msd Temp (° C)	Delta-T (Similar Cmpnts)	P. L.1	Delta-T (Cmpnt/Amb Temp)	P.L 2	Overall Priority Level	Remarks
COJP 1	23	21.9	22.3	0.4	4	-0.7	4	4	Possible deficiency; Warrants investigation
COJP 2	25	38.6	68.1	29.5	1	43.1	1	1	Major Discrepancy; Repair Immediately

COJP 3	24	59.1	94.2	35.1	1	70.2	1	1	Major Discrepancy; Repair Immediately
COJP 4	23	51	63	12	3	40	2	3	Indicate probable deficiency; repair as time permits
COJP 5	21	29.6	41.2	11.6	3	20.2	3	3	Indicate probable deficiency; repair as time permits
COJP 6	20	81.9	155	73.1	1	135	1	1	Major Discrepancy; Repair Immediately
COJP 7	23	38.6	68.1	29.5	1	45.1	1	1	Major Discrepancy; Repair Immediately
COJP 8	24	51.2	112	60.8	1	88	1	1	Major Discrepancy; Repair Immediately

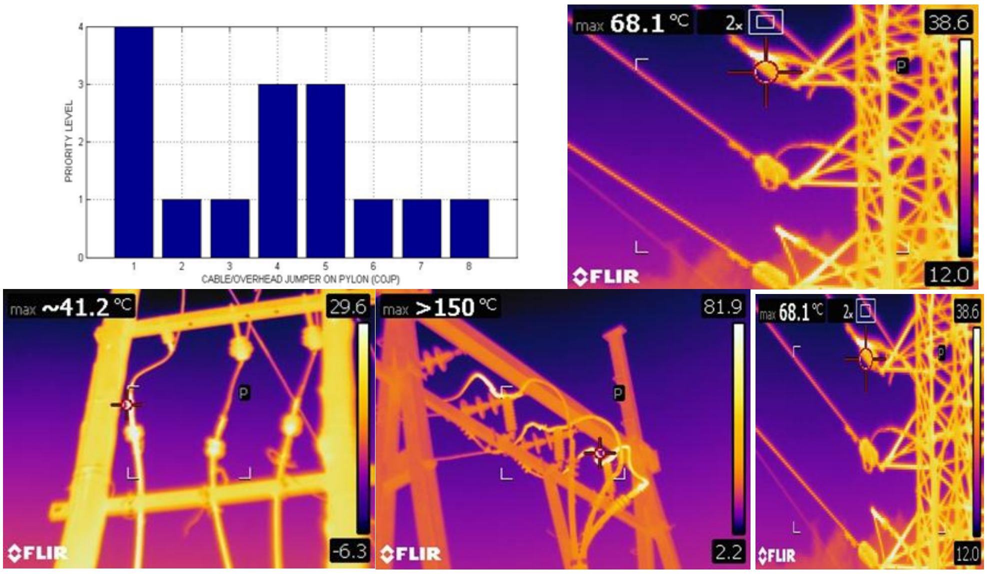


Fig.4. Cable/overhead jumper on pylon Assessment

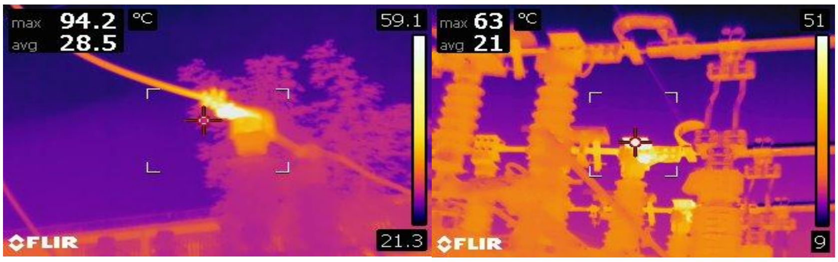


Fig.5. Cable/overhead jumper on pylon Assessment

4.1.3 33KV Cable end isolator (CEI)

All the cable end isolators need immediate repair.

Table 6 Cable end isolator

Equipment	Amb. Temp (° C)	Max Temp (° C)	Msd Temp (° C)	Delta-T (Similar Cmpnts)	P.L.1	Delta-T (Cmpnt /Amb Temp)	P.L 2	Overall Priority Level	Remarks
CEI 1	24	32.6	87.1	54.5	1	63.1	1	1	Major Discrepancy; Repair Immediately
CEI 2	24	63.5	110	46.5	1	86	1	1	Major Discrepancy; Repair Immediately
CEI 3	24	80.8	96.1	15.3	2	72.1	1	2	Monitor continuously until corrective measures can be accomplished

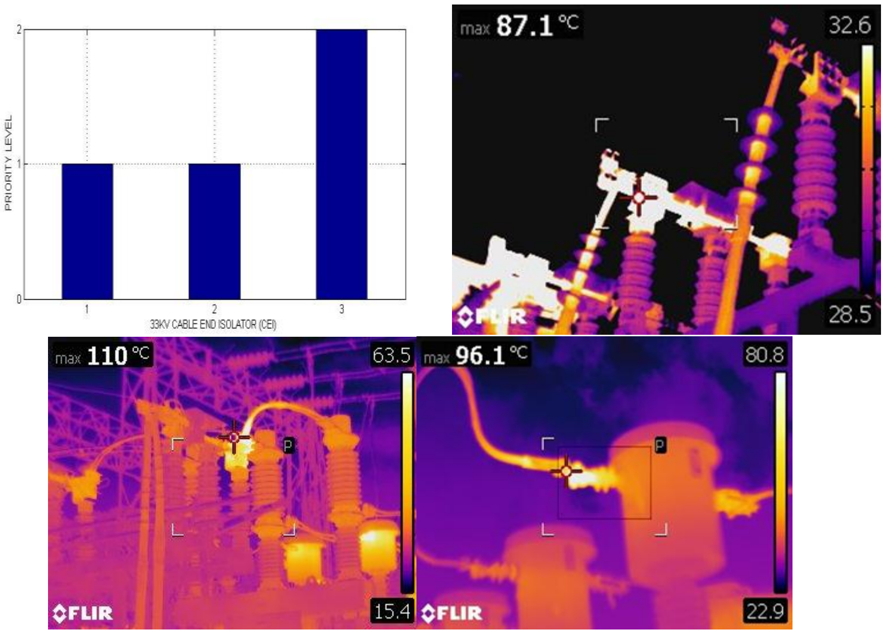


Fig.5. Cable end isolator Assessment

4.1.4 33KV Jumper between overhead and cable (JOC)

The jumper between the overhead and the cable were found to want immediate repair.

Table 7. Jumper between overhead and cable

Equipment	Amb. Temp (° C)	Max Temp (° C)	Msd Temp (° C)	Delta-T (Similar Cmpnts)	P. L. 1	Delta-T (Cmpnt/Amb Temp)	P.L 2	Overall Priority Level	Remarks
JOC	25	81.9	155	73.1	1	130	1	1	Major Discrepancy; Repair Immediately

Fig.6. Jumper between overhead and cableAssessment

4.1.5 33KV Main busbar (MB)

The main bus bar as observed needed to be worked on immediately.

Table 8.main busbar

Equipment	Amb. Temp (° C)	Max Temp (° C)	Msd Temp (° C)	Delta-T (Similar Cmpnts)	P.L.1	Delta-T (Cmpnt/ Amb Temp)	P.L 2	Overall Priority Level	Remarks
MB	25	73.5	126	52.5	1	101	1	1	Major Discrepancy; Repair Immediately

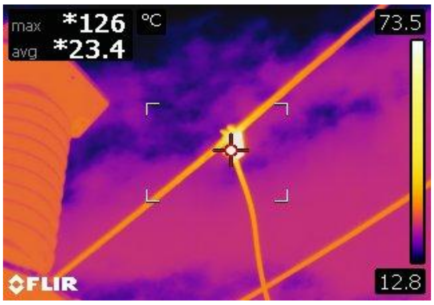


Fig.7. main busbarAssessment

4.1.6 Busbar and isolator joint (BIJ)

The busbar and the isolator joint needed a little time to repair.

Table 9. Busbar and isolator

Equipment	Amb. Temp (° C)	Max Temp (° C)	Msd Temp (° C)	Delta-T (Similar Cmpnts)	P.L.1	Delta-T (Cmpnt/ Amb Temp)	P.L 2	Overall Priority Level	Remarks
BIJ	25	89.7	99.3	9.6	3	74.3	1	3	Indicate probable deficiency; repair as

									time permits

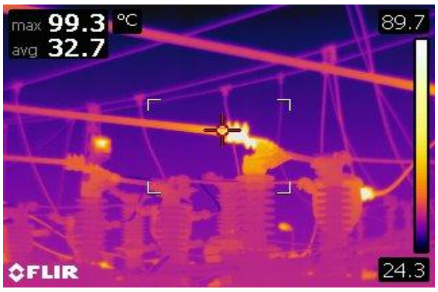


Fig.8. Busbar and isolator jointAssessment

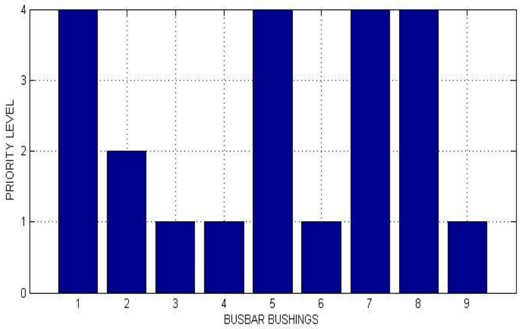
4.1.7 Busbar bushings (BB)

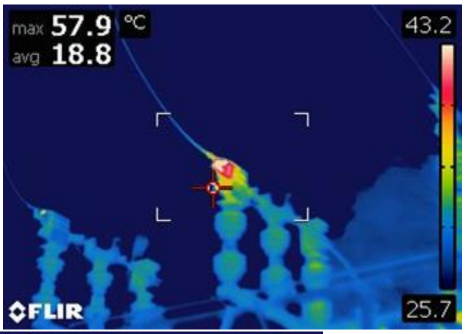
Four (4) of the bus bar bushings need immediate repair.

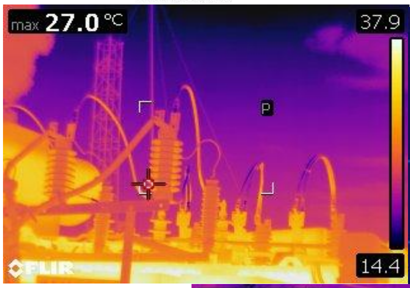
Table 10. Busbar Bushings

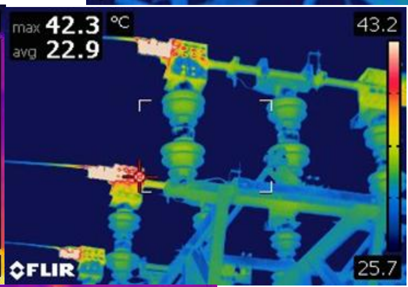
Equipment	Amb. Temp (° C)	Max Temp (° C)	Msd Temp (° C)	Delta-T (Similar Cmpnts)	P.L.1	Delta-T (Cmpnt/ Amb Temp)	P.L 2	Over all Priority Level	Remarks
BB1	25	43.2	42.3	-0.9	4	17.3	3	4	Possible deficiency; Warrants investigation
BB2	24	43.2	57.9	14.7	2	33.9	2	2	Monitor continuously until corrective measures can be accomplished
BB3	25	32.6	78.9	46.3	1	53.9	1	1	Major Discrepancy; Repair Immediately
BB4	25	30.5	62.1	31.6	1	37.1	1	1	Major Discrepancy; Repair Immediately
BB5	25	39	29.4	-9.6	4	4.4	4	4	Possible deficiency; Warrants investigation
BB6	21	31	68.4	37.4	1	47.4	1	1	Major Discrepancy; Repair Immediately
BB7	25	37.9	27	-10.9	4	2.0	4	4	Possible deficiency; Warrants investigation
BB8	23	37	29	-8	4	6	4	4	Possible deficiency; Warrants investigatio

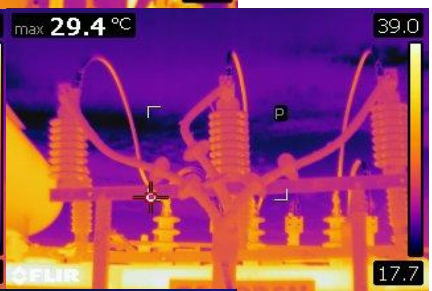
									n
BB9	22	70.9	97.4	26.5	1	75.4	1	1	Major Discrepancy; Repair Immediately











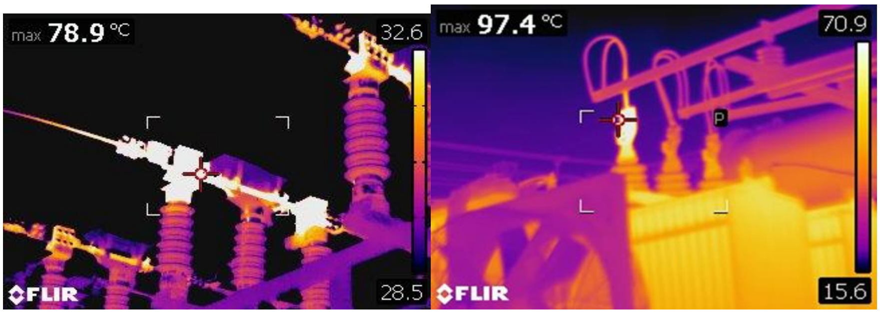


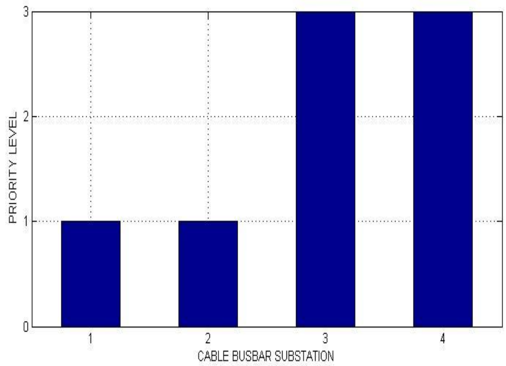
Fig.9. Busbar bushings Assessment

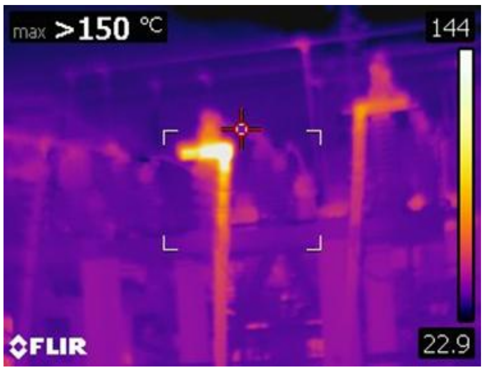
4.1.8 Cable busbar substation (CBS)

Two of the cable busbars in the substations need immediate attention.

Table 11. Cable busbar

Equipment	Amb. Temp (° C)	Max Temp (° C)	Msd Temp (° C)	Delta-T (Similar Cmpnts)	P.L.1	Delta-T (Cmpnt/Amb Temp)	P.L 2	Overall Priority Level	Remarks
CBS 1	24	144	163	19	1	139	1	1	Major Discrepancy; Repair Immediately
CBS 2	23	56.8	77.2	20.4	1	54.2	1	1	Major Discrepancy; Repair Immediately
CBS 3	24	43.2	50.2	7.0	3	26.2	3	3	Indicate probable deficiency; repair as time permits
CBS 4	22	43.2	56.1	12.9	3	34.1	2	3	Indicate probable deficiency; repair as time permits





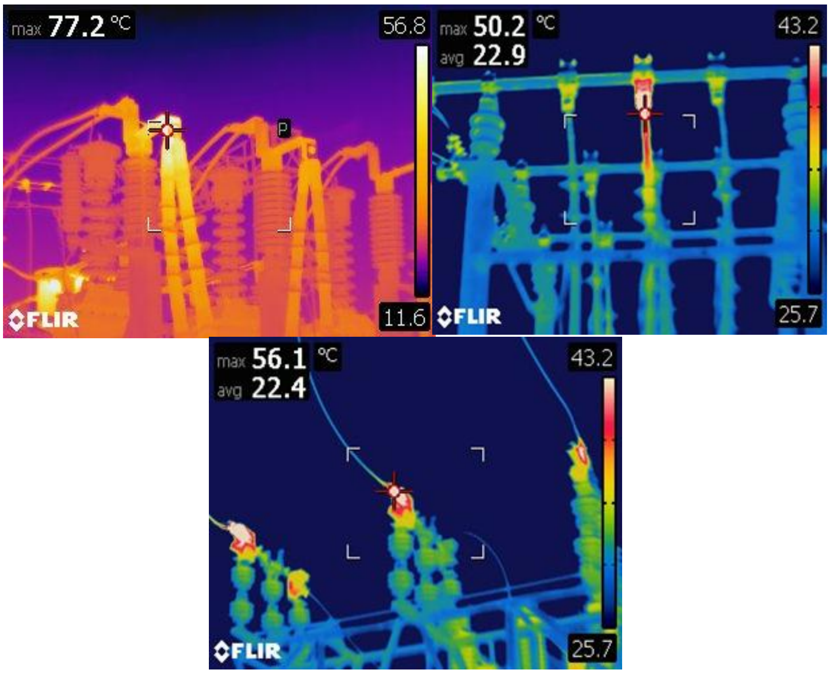


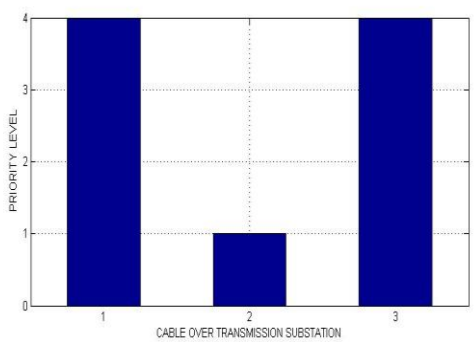
Fig.10 Cable busbar substation Assessment

4.1.9 Cable over transmission substation (COTS)

Only one (1) of the cable over the transmission substation requires immediate attention.

Table 12. Cable over transmission substation

Equipment	Amb. Temp (° C)	Max Temp (° C)	Msd Temp (° C)	Delta-T (Similar Cmpnts)	P.L .1	Delta-T (Cmpnt/Amb Temp)	P.L 2	Overall Priority Level	Remarks
COTS 1	24	31.4	32	0.6	4	8	3	4	Possible deficiency; Warrants investigation
COTS 2	23	51.2	112	60.8	1	89	1	1	Major Discrepancy; Repair Immediately
COTS 3	25	41.7	28.5	-13.2	4	3.5	3	4	Possible deficiency; Warrants investigation



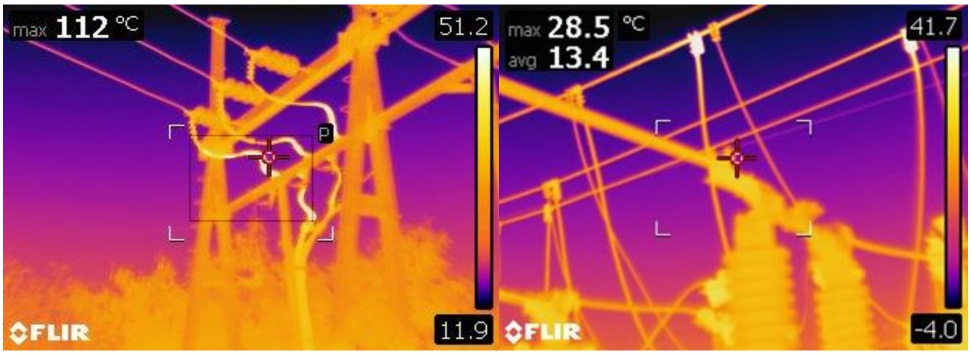


Fig.11 Cable over transmission substation Assessment

4.2.0 Distribution panel cable termination (DPCT)

Overall the cable terminated in the distributed panel was healthy.

Table 13. Distribution panel cable termination

Equipment	Amb. Temp (° C)	Max Temp (° C)	Msd Temp (° C)	Delta-T (Similar Cmpnts)	P.L.1	Delta-T (Cmpnt/ Amb Temp)	P.L 2	Overall Priority Level	Remarks
DPCT	24	27.5	27.6	0.1	4	3.6	4	4	Possible deficiency; Warrants investigation

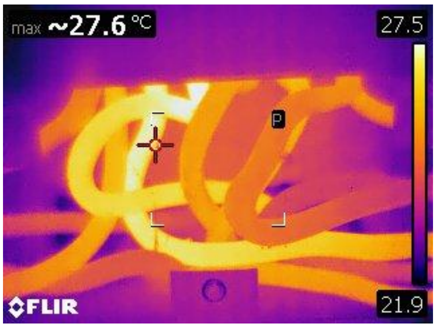


Fig.12. Distribution panel cable terminationAssessment

4.2.1 Gas circuit breaker substation sf6 (GCBS)

Only one (1) of the gas circuit breakers was deemed healthy.

Table 14. Gas circuit breaker

Equipment	Amb. Temp (° C)	Max Temp (° C)	Msd Temp (° C)	Delta-T (Similar Cmpnts)	P.L.1	Delta-T (Cmpnt/ Amb Temp)	P.L 2	Overall Priority Level	Remarks
GCBS 1	24	112	165	53	1	141	1	1	Major Discrepancy; Repair Immediately
GCBS 2	24	134	155	21	1	131	1	1	Major Discrepancy; Repair Immediately

GCBS 3	25	106	158	52	1	133	1	1	Major Discrepancy; Repair Immediately
GCBS 4	25	37.3	40.2	2.9	4	15.2	3	4	Possible deficiency; Warrants investigation
GCBS 5	25	114	155	41	1	130	1	1	Major Discrepancy; Repair Immediately

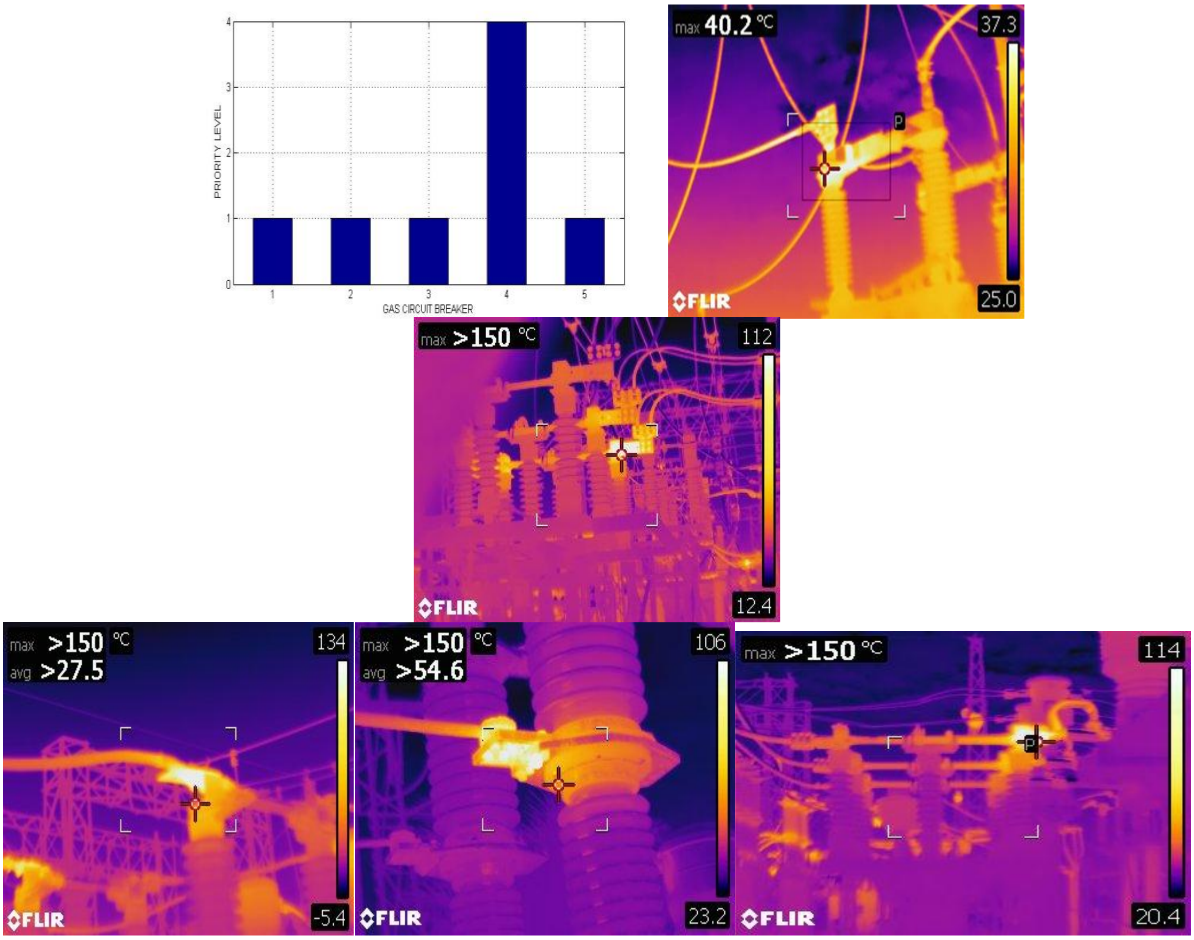


Fig.13. Gas circuit breaker substation Assessment

4.2.2 HV terminated cable (HTC)

The high voltage terminated cable has to be repaired.

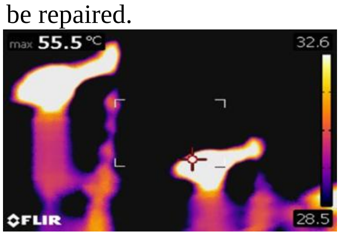


Fig.14. high voltage terminated cable Assessment

Table 15.high voltage terminated cable

Equipment	Amb. Temp (° C)	Max Temp (° C)	Msd Temp (° C)	Delta-T (Similar Cmpnts)	P.L.1	Delta-T (Cmpnt/Amb Temp)	P.L 2	Overall Priority Level	Remarks
HTC	25	32.6	55.5	22.9	1	30.5	1	1	Major Discrepancy; Repair Immediately

V. Conclusion and Recommendation

As a non-destructive method of testing electrical installations, infrared thermography is a simple way to spot the potential problems. In most cases there are two basic criteria for spotting potential problems: the criterion of absolute temperature and the criterion of temperature difference.In this work, the delta-T criterion which was used takes into account the temperature difference between similar components under similar load conditions. Based on the temperature difference the operator makes decisions based on the operating state of each component.Infrared thermography, over the years has been a very practical way for conducting energy audit and maintenance of electrical installations. The delta-T criterion was used in this work to ascertain the 'health' of several power distribution equipment within selected substations in the Kumasi Metropolis. It is highly recommended that all the power distribution equipment with the priority levels of 1 be immediately replaced. In subsequent research, there should be more thermal imaging cameras to increase the number of images and subsequently analyse other substations.It is expected that in the nearest future, virtually every electric power generation and distribution company, as well as every major manufacturing and process facility, will be using infrared thermography as a condition monitoring technique to increase reliability and decrease electric losses, or downtime.

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