Five uncommon component anomalies.

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ABSTRACT

During scheduled IR thermographic surveys with an IR camera of electrical substations, transmission lines, underground transformer enclosures, distribution lines and air conditioner air handler cabinets. Five anomalies are identified in this paper:

1) Control panel failure on a substation voltage regulator;
2) Transmission line wedge connection failure due to improper installation of wedge connector
3) Underground secondary compression connection failure due to copper connector splice to aluminum wire
4) Internal failure to a current transformer on a distribution line
5) Air condition belt failure on air handler motor and fan.

This paper presents the problems connected with the findings of these hot spot anomalies and the corrected action taken to avoid costly outages due to equipment failure.

Keywords: Thermographic surveys, IR camera, electrical substations, enclosures, air handler

1. INTRODUCTION

With the implementation of an infrared program on a proactive basis, at Sumter Electric Cooperative we are able to scan all transmission lines connected to our system. The substations are scanned on a monthly schedule. All substation feeder distribution lines are also inspected with in an eighteen-month period of time. Also included in are services with the infrared camera is an inspection to our key account customers. The anomalies presented in this paper are not seen on our system regularly.

2. CONTROL PANEL FAILURE ON A SUBSTATION VOLTAGE REGULATOR

On an infrared inspection of one of forty distribution substations one of three voltage regulators showed a thermal signature to the top of the oil level down about a foot. A regulator is in all reality a step transformer. This means there are a number of taps into the coil that are utilized on demand, to rise or lower a base line voltage. This is accomplished basically with a tap changer board, a motor, and a control panel. With the demand for a change in voltage the sensing section of the control panel calls for the motor to move the tap changer. This will pick up the available points of voltage on the tap changer board. Thus causing the voltage to change up or down which ever demanded on the distribution line.

Inspection by a service tech found that the voltage regulator would not step to raise or lower the voltage. A faulted component inside the electronic control panel had failed. This failure sent a mixed signal to the stepping motor to raise and lower the voltage at the same time. Thus the motor became overheated and non-functional and non-stepping causing the oil to heat which produced this thermal signature.

The importance of this regulator on the system made it imperative to replace this piece of equipment in order to keep the voltage stable to the customer. This problem with the regulator could also lead to other problems with a possible lose of the regulator it self. The valued cost of this regulator is $16, 830.00. **Figure 1** displays the thermogram (left) and the photo (right) of the regulator in question. **Table 1** lists the parameters of the thermogram.

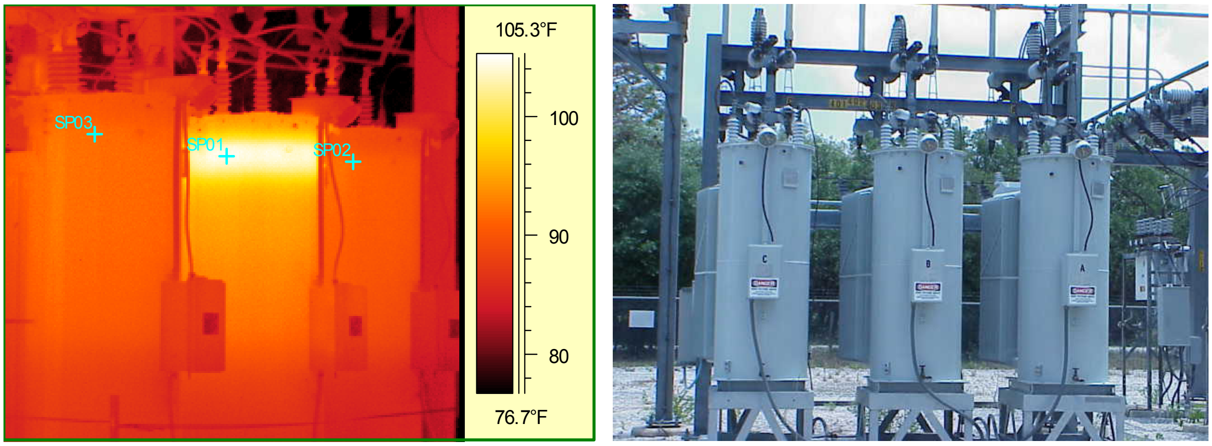

Figure 1 Thermogram (left) and photo (right) of three regulators. The motor in the middle regulator is overheating.

Date of creation: 10/9/2001	IR information
Time of creation: 12:34:40 PM	
Label	Value
SP01	105.2°F
SP02	91.4°F
SP03	92.0°F
Delta – T	13.80

Table 1. Parameters of the thermogram of figure 1

3. TRANSMISSION LINE WEDGE CONNECTION FAILURE DUE TO IMPROPER INSTALLATION OF WEDGE CONNECTOR

During a routine monthly infrared inspection of a distribution substation, a wedge connection appeared as a hotspot on the incoming 69 kV transmission line to the power substation. A 2/0 jumper from the 69 kV disconnect switch to the incoming 1/0 line was connected by a 2/0 to 2/0 wedge connector. This type of connection is a common connector used for this kind of application. The problem being is the use of a wrong size connector. A 2/0 to 1/0 connector is the proper connector, which at a later date replaced the improper connection, caused a loose fit of the jumper wire connection to line.

If the problem were not corrected the jumper connection could burn up. This could cause the substation to single phase with only two phases serving power, as this was a 69kV-fused substation. This would cause an unbalance condition to the consumers until the main 69 kV breaker feeding the transmission line relayed open. This breaker serves other substation on this transmission line, if opened this would be considered a large outage of power to the consumers. This is shown to be an improper installation with the wrong size wedge connector with a connector cost of $1.98. **Figure 2** shown below shows the wedge connector anomaly. **Table 2** lists the parameters of the thermogram.

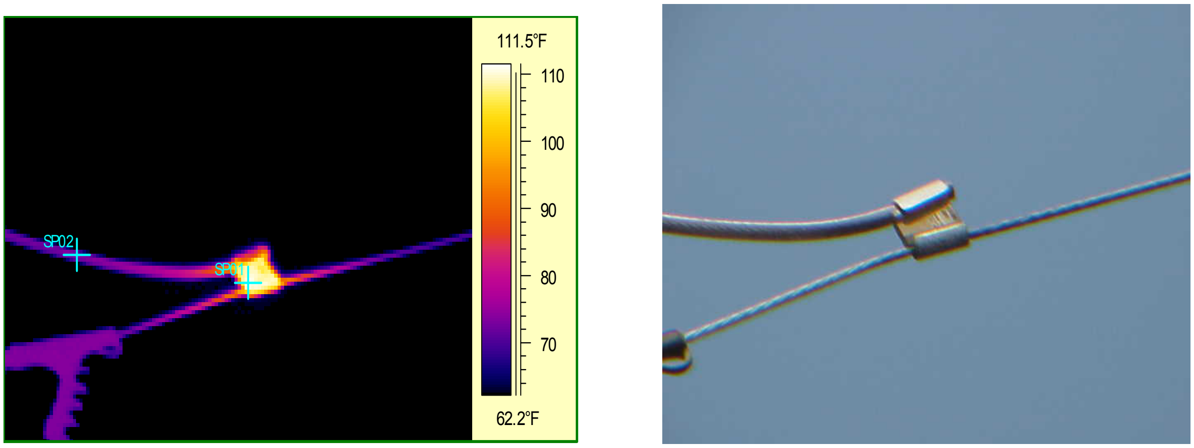

Figure 2, Thermogram (left) and photo (right) of a failing wedge connector

Date of creation: 7/12/2001	**IR information**
Time of creation: 3:323:58 PM	
Label	**Value**
SP01	**111.4°F**
SP02	**74.8°F**
Delta – T	**36.6°F**

Table 2. Parameters of the thermogram of figure 2

4. UNDERGROUND SECONDARY COMPRESSION CONNECTION FAILURE DO TO COPPER CONNECTOR SPLICE TO ALUMINUM WIRE

During a routine infrared inspection of a padmount transformer, the secondary side of the transformers 4/0 jacketed wire conductors showed a hotspot at a compression splice. Upon visual inspection it was noticed that another splice had been overheated. The anomaly (shown in the thermogram of **figure 3**) is due to the amount load on this wire at the time also the failure of the compression splice. The compression splice is copper with a plated coating. The coating more than likely deteriorated due to the crimping and the load heat on the wire conductor. At this point corrosion began to build up between the copper splice and the aluminum wire causing a poor connection in the splice. **Table 3** lists the parameters of the thermogram.

This problem could have been avoided if an aluminum splice had been used at a cost of $31.00 per splice. This consumer's problem cost $4500 to replace all bad wires with splices from the secondary side of the transformer to their main panel boxes with new wire thus eliminating all splices

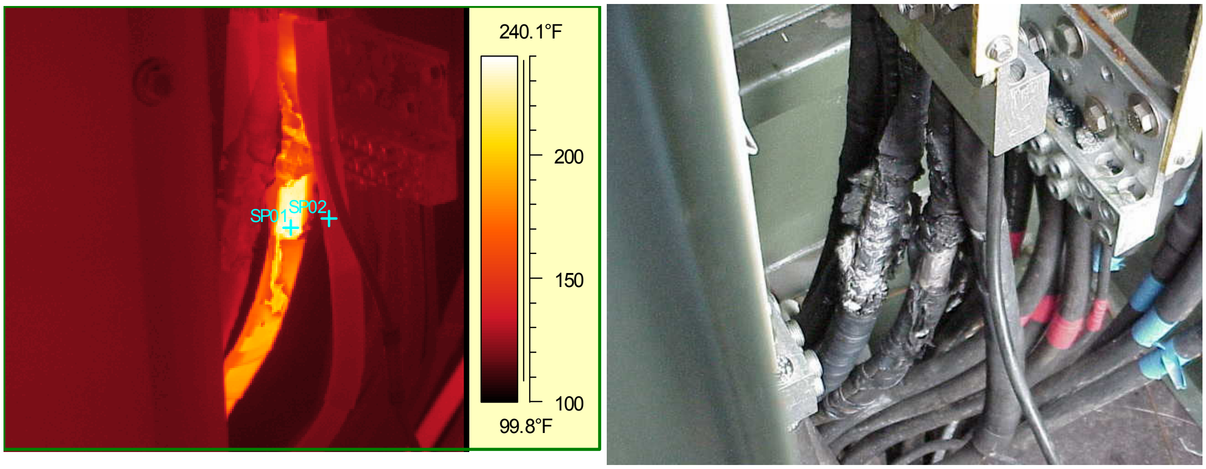

Figure 3. Thermogram (left) and photo (right) of a copper connector splice to aluminum wire

Date of creation: 3/29/2002	**IR information**
Time of creation: 2:39:50 PM	
<u>Label</u>	**<u>Value</u>**
SP01	**239.3°F**
SP02	**128.0°F**
Delta – T	**111.3°F**

Table 3. Parameters of the thermogram of figure 3

5. INTERNAL FAILURE TO A CURRENT TRANSFORMER ON A DISTRIBUTION LINE

On a yearly infrared inspection on a feeder circuit line one of the current transformers on a three-phase service to a sandmine appeared to be hot as can be seen in the thermogram of **figure 4**. There are three current transformers one for each phase serving this sandmine. A Current Transformer or CT as they are sometimes called monitor the amount of amperage or load per phase a customer is using. These are a necessity in order to bill a customer for electricity usage. **Table 4** lists the parameters of the thermogram.

By locating this problem we were able to schedule a time to remove the bad current transformer due to a probable internal failure. This averted an outage due to a complete failure to this current transformer cluster mount. The cost of a 600:5 ratio current transformer is $177.00.

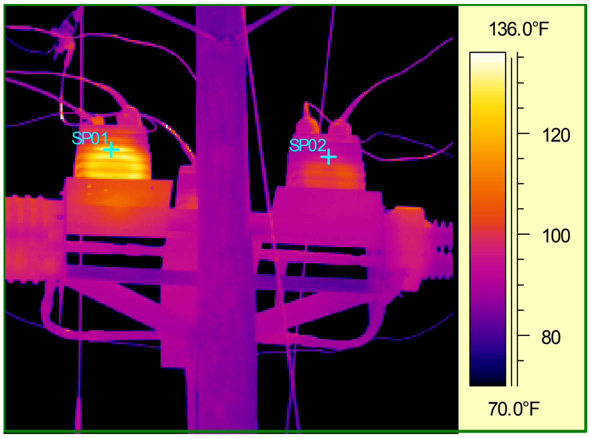

Figure 4. Thermogram (left) and photo (right) of an overheated current transformer (left of picture)

Date of creation: 4/11/2002	**IR information**
Time of creation: 11:28:22AM	
Label	**Value**
SP01	**136.0°F**
SP02	**96.0°F**
Delta – T	**40.1°F**

Table 4. Parameters of the thermogram of figure 4

6. AIR CONDITION BELT FAILURE ON AIR HANDLER AND FAN

We had the opportunity to do an infrared survey for the school systems in the local counties. The surveys included ten schools. We were able to look at all electrical and mechanical equipment. There were a total of 120 air conditioner air handlers and fans inspected. Each air handler consists of a motor and belt and fan unit to move the chilled air through out the school area. The problem in question is in the rubber belts that run from the motor pulley to the air handler pulley. These belts are three and a half feet long from pulley to pulley. In the visual picture of **figure 5** below can be seen notches on the inside of the belt This type of belt is made to fit better in the pulleys groove but was found to stretch more quickly. Upon further inspection it was discovered that another style of belt was also being used. This was a belt with no grooves in the belts running surface. It was found that about thirty air handlers had the grooved type of belts in service. Only one unit showed excessive heat transferred to the motor pulley by a slipping belt. The heat range of the thermogram of **figure 5** below shows this. The motor pulley is acting as a heat sink. **Table 4** lists the parameters of the thermogram.

This IR survey showed that, according to past records, this grooved type of belt has been found to be slipping and to need more adjustments in less time than the other style of belt. The school's maintenance supervisor decided to change out all grooved belts on their scheduled repair dates, even though the grooved belt cost some $3.00 less than the solid belt which cost $15.80.

If the grooved belt were left in place the efficiency of the air handler would be in jeopardy, possibly costing more money to run the air conditioners at these schools.

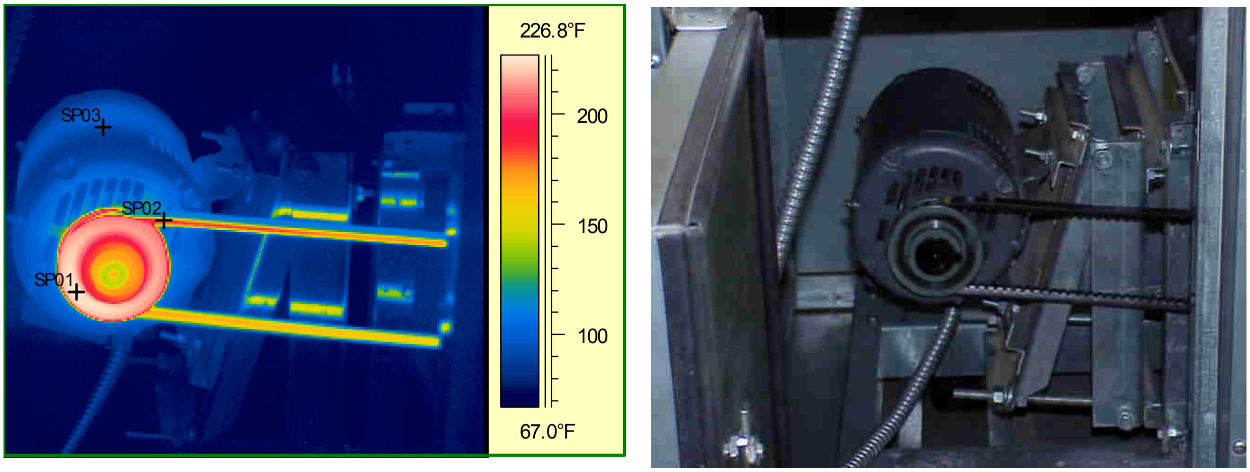

Figure 5. Thermogram (left) and photo (right) of an overheated air conditioner belt and pulley

Date of creation: 5/15/2002	**IR information**
Time of creation: 9:21:08A M	
<u>Label</u>	**<u>Value</u>**
SP01	**226.7°F**
SP02	**175.2°F**
SPO3	**94.2°F**
Delta – T	**132.5°F**

Table 5. Parameters of the thermogram of figure 5

6. SUMMARY

The five anomalies in this paper all were corrected before any catastrophic display took place. The Regulator, and the Wedge connection would have affected Sumter Electric Cooperative directly by a costly power outage due to equipment loss, revenue loss and possible man power overtime. This affects the substations involved which supply power to a possible several thousand members. The secondary underground compression connection, Current Transformer and the Air handler belt, would be a more direct loss to our key account consumers due to production loss and possible class interruption. Because we have been so pro-active with this Infrared program at Sumter Electric, reliability has improved dramatically since its implementation in 1997.

Offering this service to our key account customers has greatly improved are relationships with these people with all the help this program offers them. It is not only a money saver to Sumter Electric Cooperative, but it is also a fantastic public relations tool.