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**ONLINE/ AUTOMATIC AND MANUAL APPLICATIONS OF INFRARED  
THERMOGRAPHY IN ELECTRICAL SECTOR**

by

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**(IN)**

**SUMMARY**

The paper presents infrared Thermography applications using handheld devices and new concept of Automatic or Inline monitoring of critical installations in Electrical sector. The paper follows below pattern of explanations:-

1. Basics- Infrared Theory
2. What Role Thermal Camera Plays
3. Basics- Understanding Thermal Image
4. Applications overview
5. Electrical Applications-
  - a) Online/Automatic Applications-
    - i) Sub Station Monitoring for Predictive Maintenance
    - ii) Coal handling in Thermal Plants
  - b) Manual Applications-
    - i) Predictive Maintenance of Critical Installations
    - ii) Inspection of Cables and Joints
    - iii) Inspection of exposed cables
    - iv) Visualisation of SF6 leakage
    - v) Inspection of Boiler Tubes in Power Station
6. Conclusion

**KEYWORDS**

Thermal Imaging Camera basics

Online monitoring of Electrical Substations with remotely controlled Thermal Imaging Cameras

Handheld thermal cameras

Visualisation of SF6 leakage

Boiler Tubes Inspection

## 1. BASICS- IR THEORY

All objects above absolute Zero emit Infrared radiations. Purpose of Infrared Camera is to convert those IR radiations to electrical signal which gets converted to picture. Hence, Thermal imaging, also called Infrared Thermography, is the production of “heat” pictures through which temperature measurements can be done accurately, without any physical contact to the object/instrument in operation

In Electromagnetic Spectrum, as explained in Fig 1, Infrared is surrounded by visible light and Microwaves, which we all understand very well. Infrared is subdivided into 3 wavelengths

1. Short Wave
2. Medium Wave
3. Long Wave

Nowadays in most of electrical Predictive Maintenance applications, Long wave ( 8-12  $\mu\text{m}$ ) is being used due to many advantages.

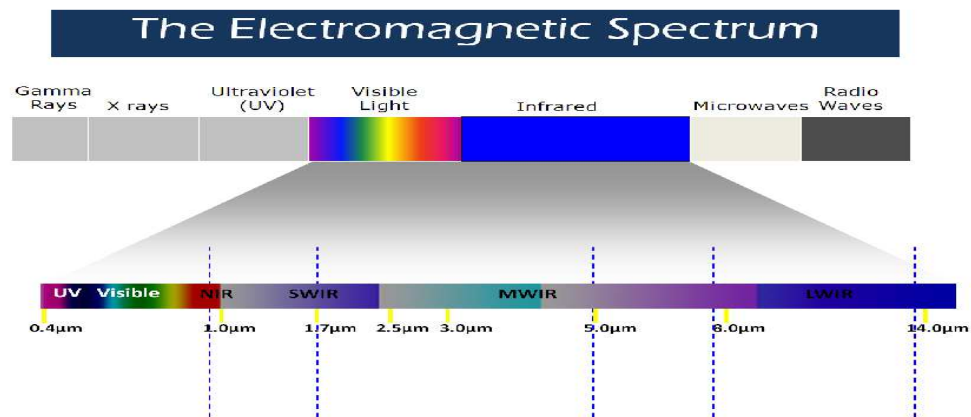


Fig 1

## 2. WHAT ROLE THERMAL CAMERA PLAYS?

Thermal Camera is a complex, very high technical device which converts IR radiations to electrical signal and these signals get processed by electronics part of this device which produces thermal Image of object seen. Complete process has been explained by way of diagram in Fig 2 below. Light is not required at all in this process.

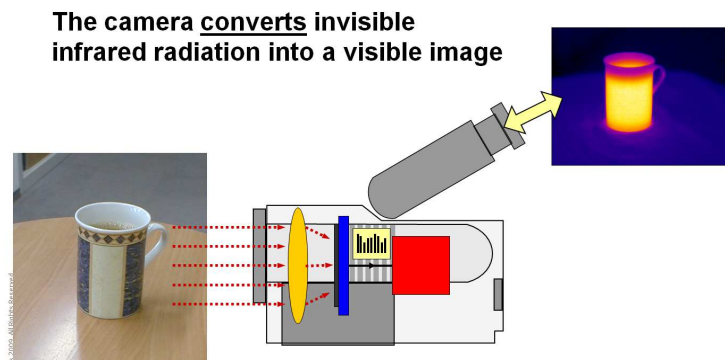


Fig 2

### 3. BASICS- UNDERSTANDING THERMAL IMAGE

Thermal image shown in Fig-3 will help to clear the concept of understanding and reading thermal image, which will help readers to get connected to images shown while explaining the application.

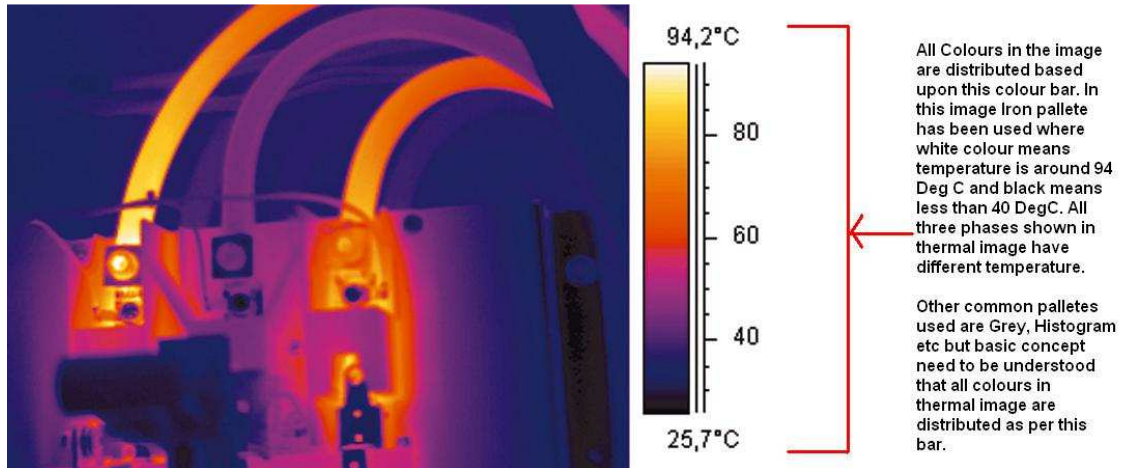


Fig. 3

### 4. APPLICATIONS OVERVIEW

Thermography is having numerous applications and few broad applications are listed below:-

- Electrical Sector- Predictive Maintenance
- Medical Imaging
- Veterinary Applications
- R&D- NDT
- Building
- Gas Leakage

### 5. ELECTRICAL APPLICATIONS

- a) Inspection of Critical Installations in Substations / Transmission Lines ( Online/Manual)
- b) Remote Monitoring of substations. ( Online/Automatic)
- c) Coal Handling in thermal Plants ( Online/Automatic)
- d) Inspections of Critical Installations- Transformers, Bushings, Insulators ( Manual)
- e) Cable Terminations, joints and cables on Racks ( Manual)
- f) SF 6 Leakage ( Manual)

## **Explanation of applications:-**

### **A) ONLINE/AUTOMATIC APPLICATION IN ELECTRICAL SECTOR.**

#### **i) Predictive Maintenance**

Transmission Companies and Electric power utilities are faced with an aging infrastructure, increasing risk of blackouts , costly unplanned maintenance, security threats to remote facilities, and rising costs. Solution to these problems has been found recently through online use of Thermal Imaging cameras, based upon IP. This will improve the reliability of electric power delivery while reducing costs.

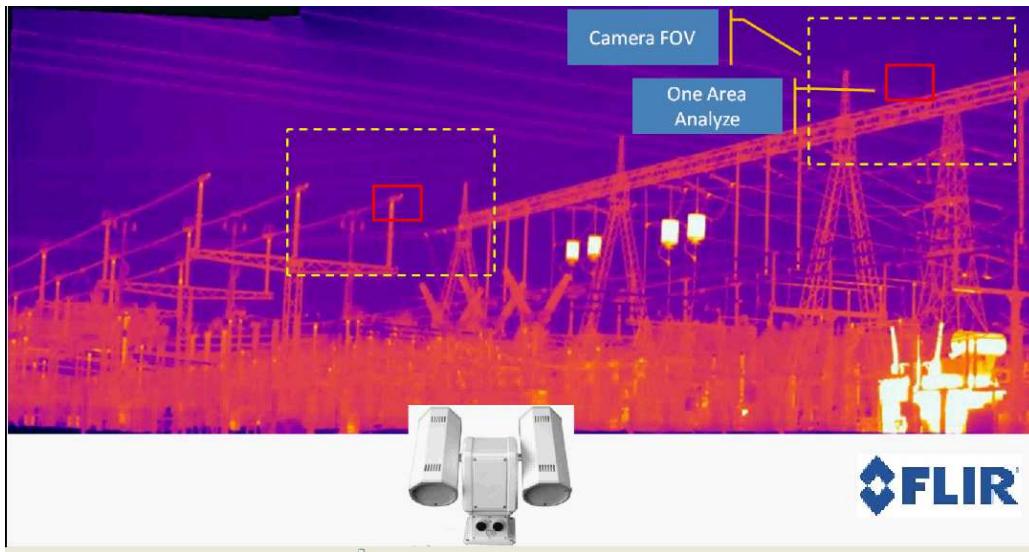
The use of infrared cameras for fault detection is becoming a common practice in the maintenance routines of different substation components. The infrared camera mounted on the gantry / pole, can be installed and moved inside the substation and positioned for collecting images of possible critical points. This real time monitoring system inside the substation aiming at safety during operation and diagnosing the failure at much early stage with an added feature of asset management.

Key features of these online IP based Thermal Cameras are listed below:-

- 24 X 7 Maintenance Monitoring of Substations.
- Remote monitoring of critical substation components
- Automated Surveillance Solution with geospatial positioning.
- Multiple Infrared Cameras can be controlled remotely.
- Integration/Additional New Substation in a Network.
- Monitor Critical Temperature Areas.
- Graphical Display of Temperature Data.
- Automatic Analysis of Defined Zones.
- Automatic Pan/Tilt Control.
- Marking Of Critical Zones With Zone Mapping Functions.
- Database Management.
- Helps increase reliability without adding personnel.
- Ethernet and wireless connections to a central control room.
- See intrusions with live images on TV, PC monitor.
- Obtain temperature readouts of overheating components.
- Spot non-functioning equipment with low temperatures.
- Instantly trigger audible and visual alarms.
- Works day or night in any weather – 24/7 operation.

Fig 4 below explains the functionality of the individual Online Thermal Camera. Rectangle with Yellow dotted line shows the Field of View of the camera and Red box informs the area of interest. Camera on Pan and Tilt platform normally rotates at 360 Deg horizontal and 45 Deg vertical and monitors the temperatures of critical areas defined on continuous basis. Typically, different areas with maximum and minimum temperature can be defined during one complete circle. Every area defined can have different defined temperature limits. The moment there is any deviation in temperature from defined values in any defined area; system will give desired form of alarm informing the actual temperature of spot.

This superb technology and feature involving Thermal Imaging Cameras, if used systematically, can do wonders for maintenance.



**Fig 4**

## ii) Coal Handling in Thermal Plants

Coal and organic wastes, are stored as large piles in open yards. Air and moisture promote decomposition and exothermic reactions that raise the pile's temperature. Self-ignition usually starts within the pile's lower layers, a full-blown fire can develop later.....An incident, nobody wants !

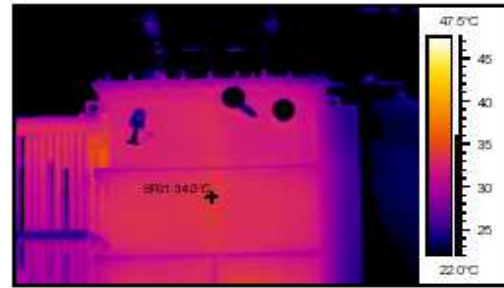
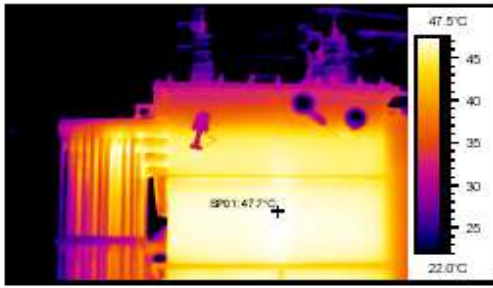
An IR Camera can prove to be very helpful tool for this problem by constantly monitoring the situation online. There are Thermal Cameras available with individual IP address which can be connected to server and hence monitoring can be done.

## B) MANUAL APPLICATIONS OF THERMAL IMAGING CAMERAS IN ELECTRICAL FIELD

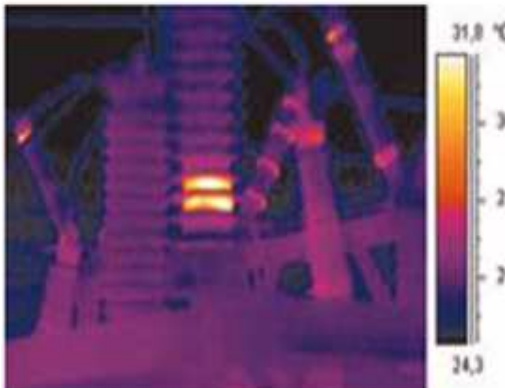
### i) Predictive Maintenance of Critical equipments in Electrical field

There are many critical equipment which can be maintained properly, without taking any shutdown, if Thermal Camera is used regularly for inspections. Few images shown below ( Fig 5,6 and 7) explain application on Transformers, Bushings, Insulators and critical connectors in Substations.

Thermal Imaging Inspections are being carried out globally at large scale and utilities all around the globe are saving money by carefully implementing IR Surveys. One such example is TVA of North America who have 18 survey teams. During one of the surveys they found low oil level in 500KV bushing which saved more than USD 3 million for their organization.



**Fig 5- Transformer Inspection**



**Insulator defect**

**Fig -6**



**Incorrectly secured connection**

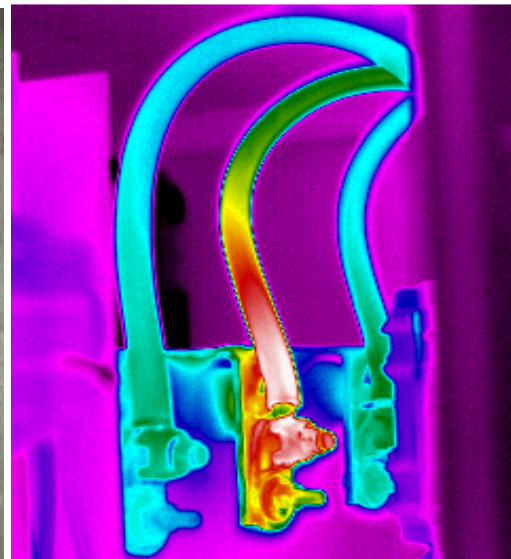
**Fig 7**

**ii) Inspection of Cable Terminations, Joints**

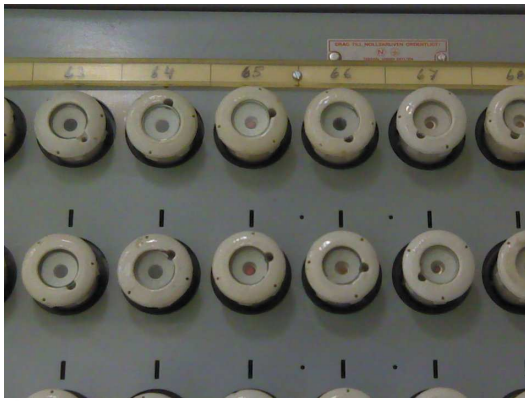
The weakest link while using cable for transmission of power is 'Connectors' and these parts require real care during installations and need regular maintenance. With the help of Thermal Imaging Camera, it becomes very easy to observe the healthiness of these connections over time. We can easily explain the same with the help of images shown below. Fig 8 and 10 are visual images and Fig 9 and 11 are corresponding Thermal images.



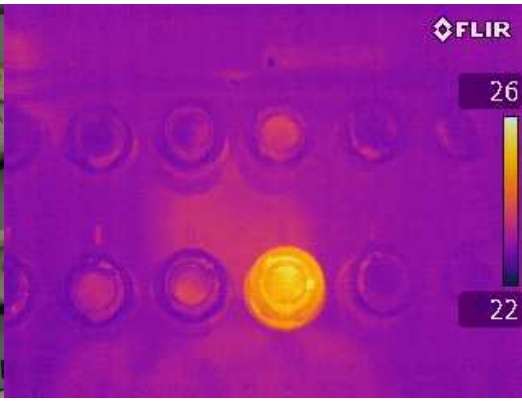
**Fig 8**



**Fig 9**



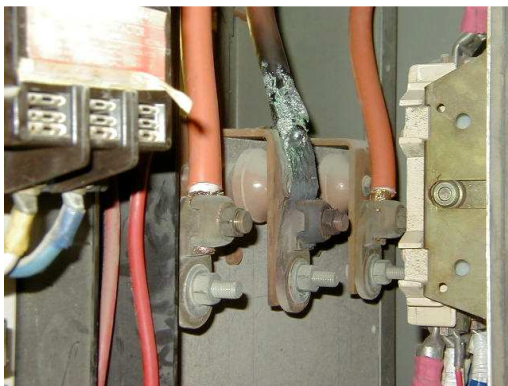
**Fig 10**



**Fig 11**

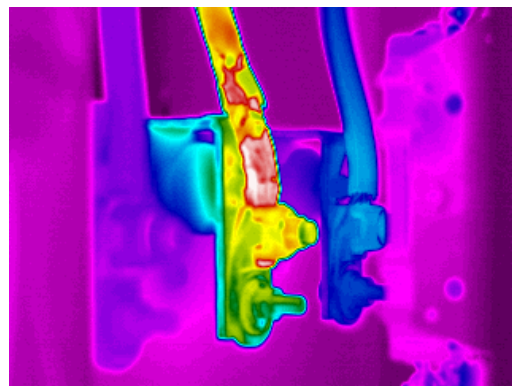
Applying the method explained above for understanding the Thermal Image, Fig 9 clearly shows Middle cable termination has a connection problem and in Fig 11, third point from right in last row is getting heated up.

Without Thermal Imaging Camera, such problems will not come under notice till visual deterioration/breakdown takes place. This clearly signifies the importance of this tool. If thermal Camera is used regularly to check healthiness of connections, we can avoid situations as shown in pictures below in Fig 12 and Fig 13.



**Fig 12**

iii) Inspection of Exposed Cables

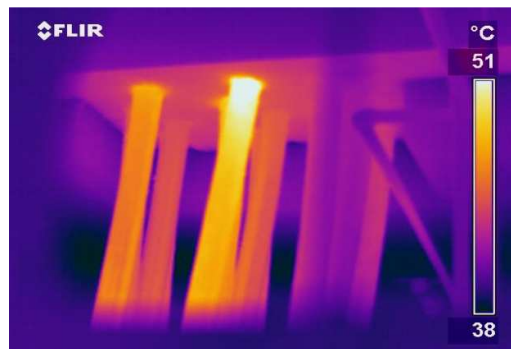


**Fig 13**

Thermal Imaging Camera is very effective tool to check condition of exposed cables due to its capability to just visualize heat. Fig 14 and Fig 15 shown below are self explanatory.



**Fig 14**



**Fig 15**

iv) Visualisation of SF<sub>6</sub> Leakage

Many chemical compounds and gases are invisible to the naked eye. Earlier methods of gas detection required close or near contact using “sniffer” technology and probes. The limitations of these methods are that they are time consuming and run a risk of missing gas leaks. They may expose inspectors to invisible and potentially harmful chemicals.

The Gas Detection cameras are infrared cameras which are able to visualize gas. The camera produces a full picture of the scanned area and leaks appear as smoke on the camera’s viewfinder/screen. The image is viewed in real time and can be recorded in the camera for easy archiving

SF<sub>6</sub> is as an electrical insulator in equipment that transmits and distributes electricity. SF<sub>6</sub> has a very high potential for global warming. This potential is 23 900 times bigger than carbon dioxide, CO<sub>2</sub>. Hence, even a relatively small amount of SF<sub>6</sub> can have a significant impact on global climate change. Fig 16 and 17 explains the application in field. What our eyes cannot see ( Fig 16), Thermal Camera ( Fig 17) can show.



**Fig 16**



**Fig 17**

v) Inspection of Boiler Tubes in Power Station

Conducting Thermography with the right boiler conditions enables a high thermal contrast between the escaping water/steam and the external tube surface temperature. This allows the location of leaks to be pinpointed early and prevents many hours of manual searching that may involve the building of complicated scaffolds for boiler access.

**Fig-18**

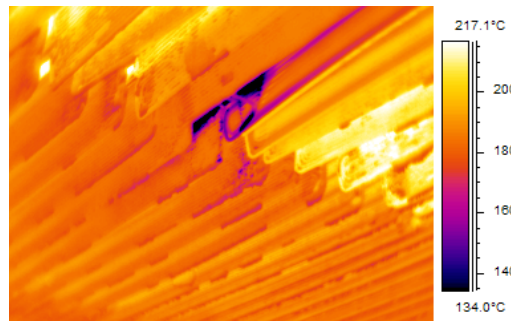


Figure 18 show what turned out to be very small holes located in Boiler Super heater tubes.



## **6. CONCLUSION**

Thermal Camera due to its vast applications and advantages can be used almost everywhere saving millions of Dollars, if utilized intelligently. The best part of this tool is the usage of the same under online conditions without any shutdowns. Applications of this fantastic tool are increasing day by day.

## **BIBLIOGRAPHY**

FLIR database of Thermal images and videos

Data of Mr. AK Mittal, NTPC CENPEEP, Delhi

ITC Level 1 Course material