Thermography

1st Process Control & Electrical Circle India

9.-12. August 2011

Cement Manufacturing Services

Electrical and Process Control Technology

Agenda

- Principle of operation
- Software and data handling
- Limitations, source of errors
- Equipment selection
- Implementation

Objective

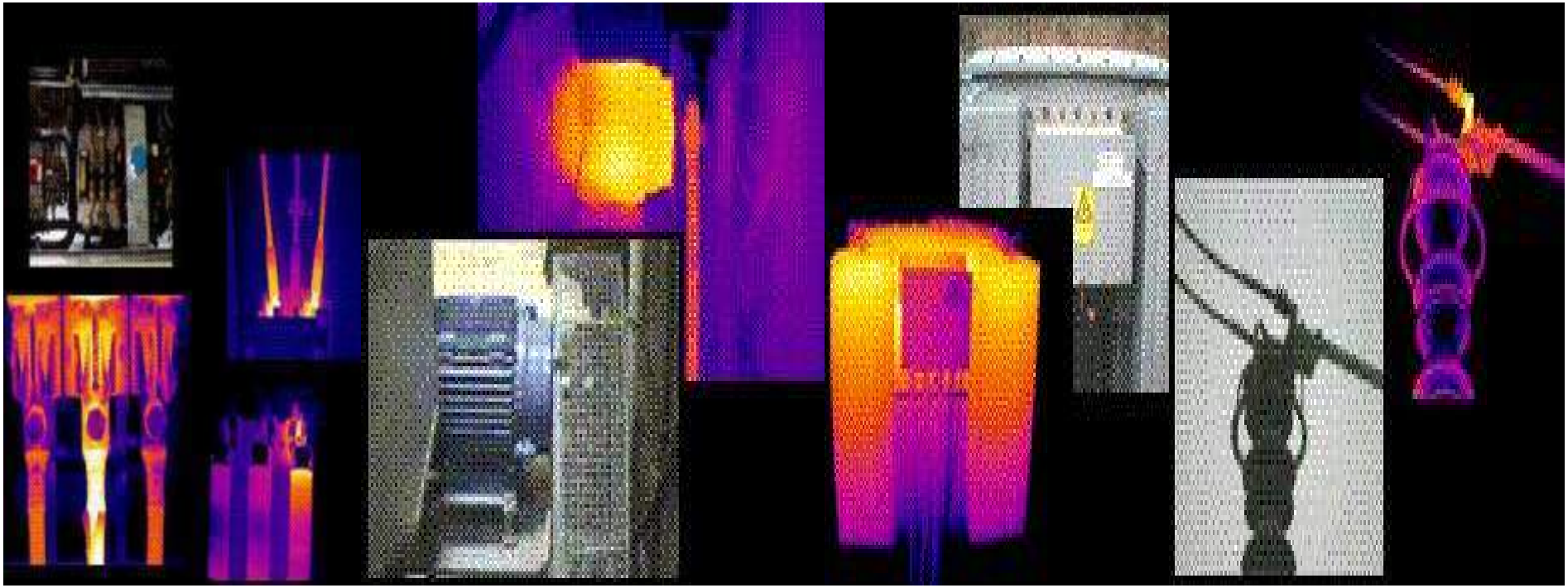
- To familiarize with the application, use and limitation of thermography

Safety First

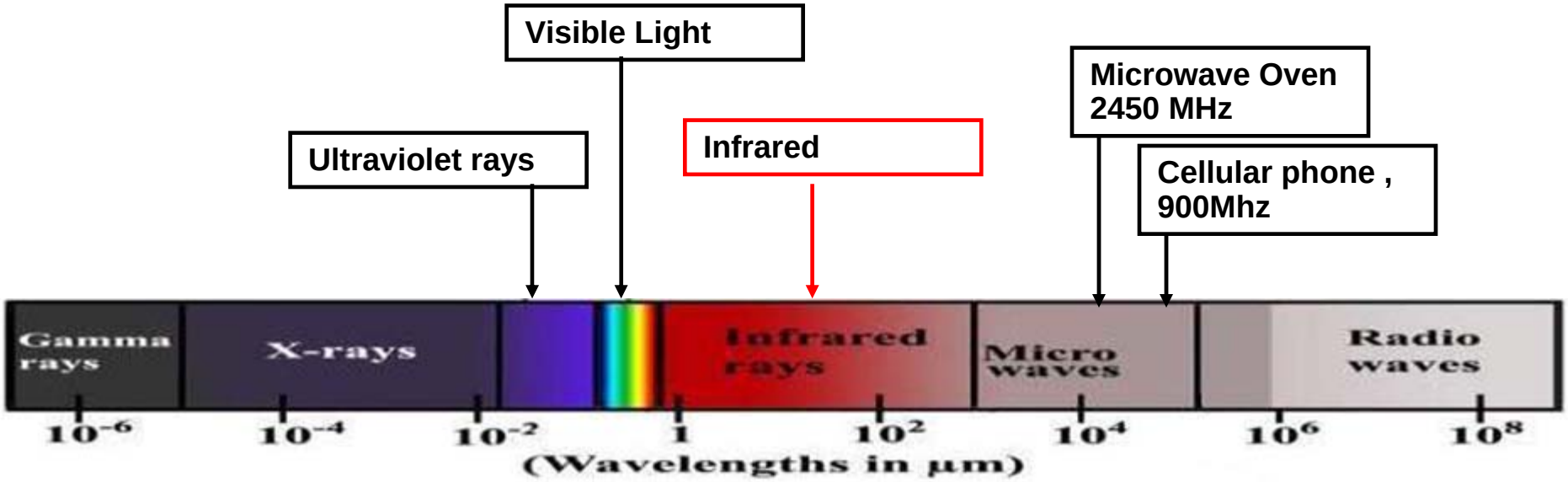
When doing thermal scanning

- Take all necessary precaution when scanning near high voltage panels, **always be aware of your distance**
- Wear PPE when scanning running machineries
- Only certified personnel are allowed to do thermography on electrical equipment
- Many electrical panels cannot be opened during operation

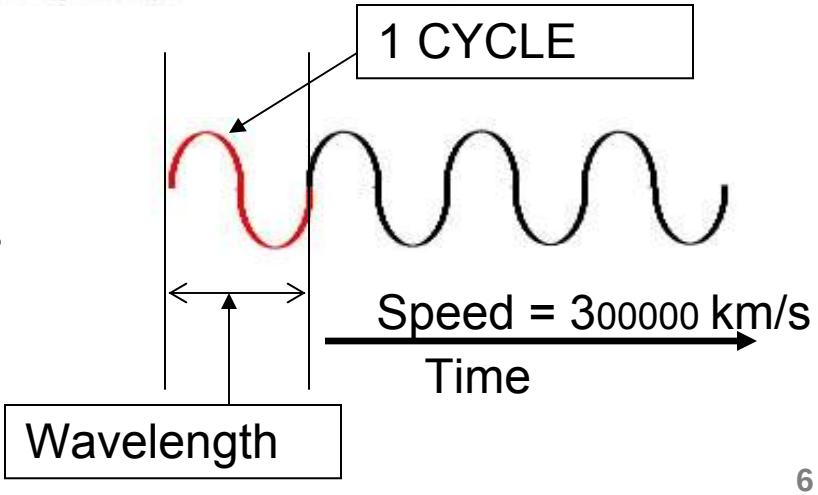
Making the invisible visible



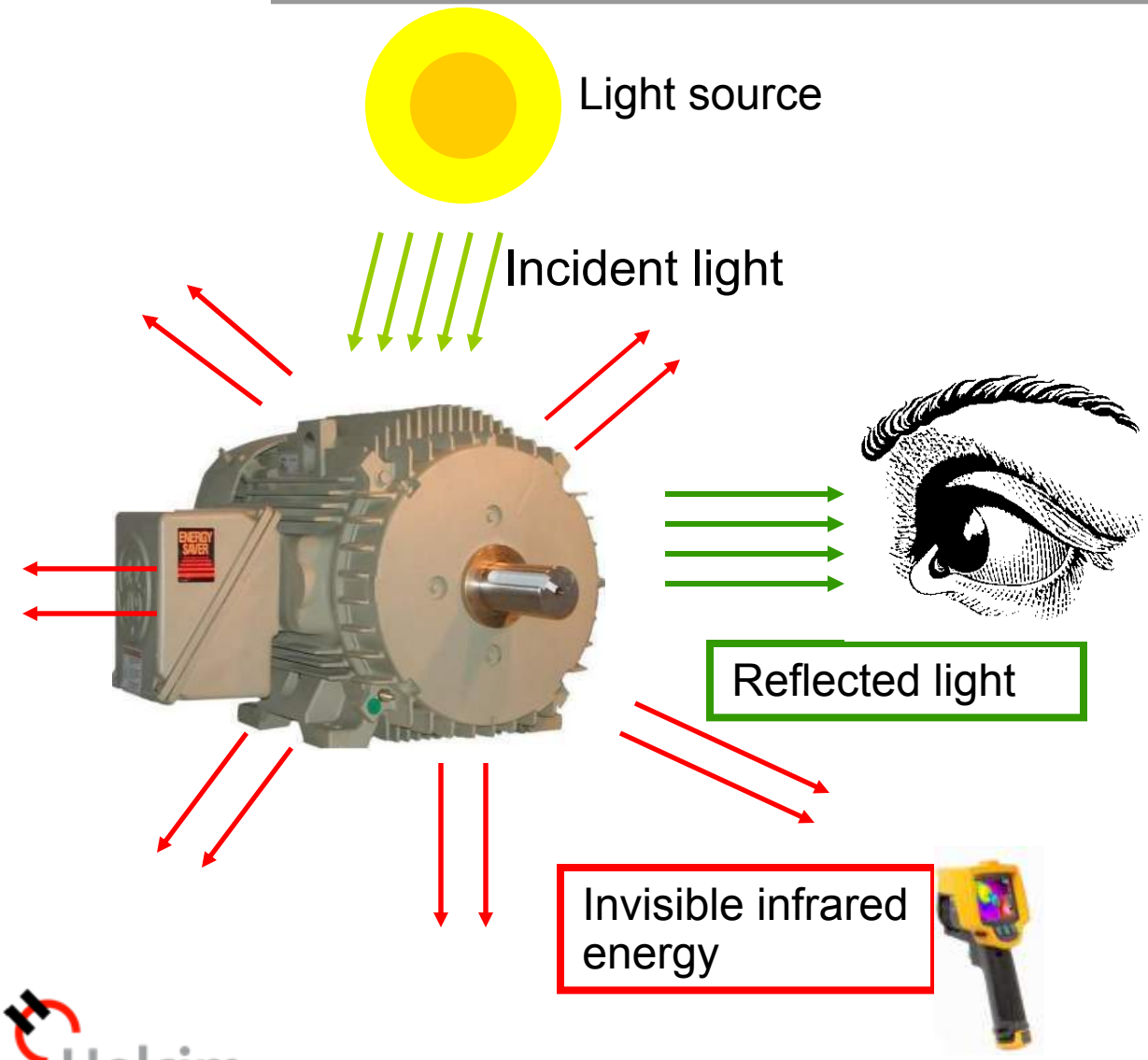
Wavelength - electromagnetic energy spectrum



All energies are in the form of waves



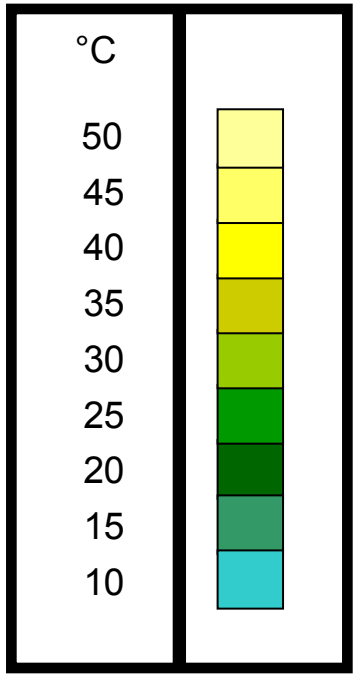
Principle of operation

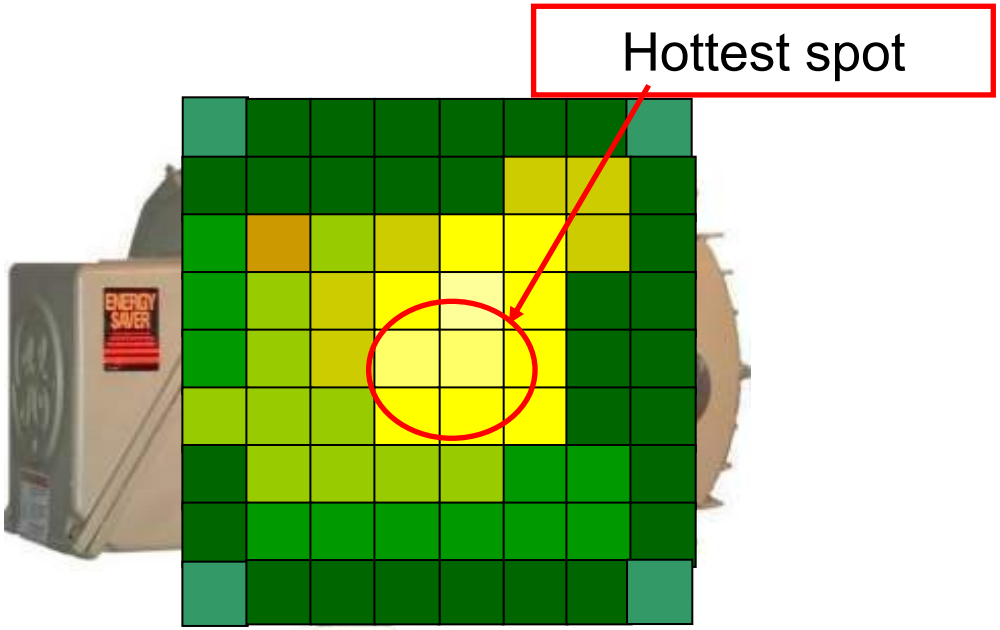


- All visible objects reflect light
- We see objects because of the reflected visible wave from a light source
- Human eyes are sensitive only to visible lights
- All objects that are above absolute zero, -273 °C, emit energy in the region of the infrared wavelength
- Human eyes are not sensitive to infrared energy

Concept

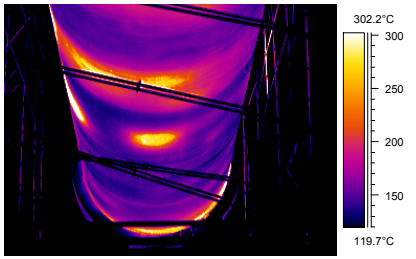
- The temperature values are represented by a range of colors called pallet for easy visualization or interpretation
- A thermal imager does this in real-time (at least 15 times per second) and up to 320 x 240 grids (or elements) = 78’800 individual spots



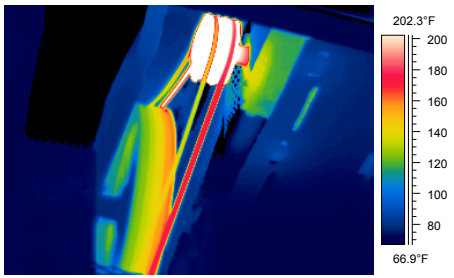


Application in cement plant

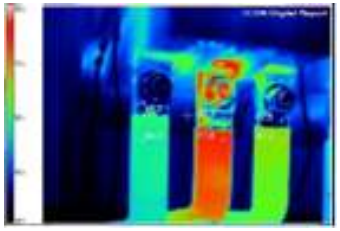
- Process optimization



- Mechanical maintenance



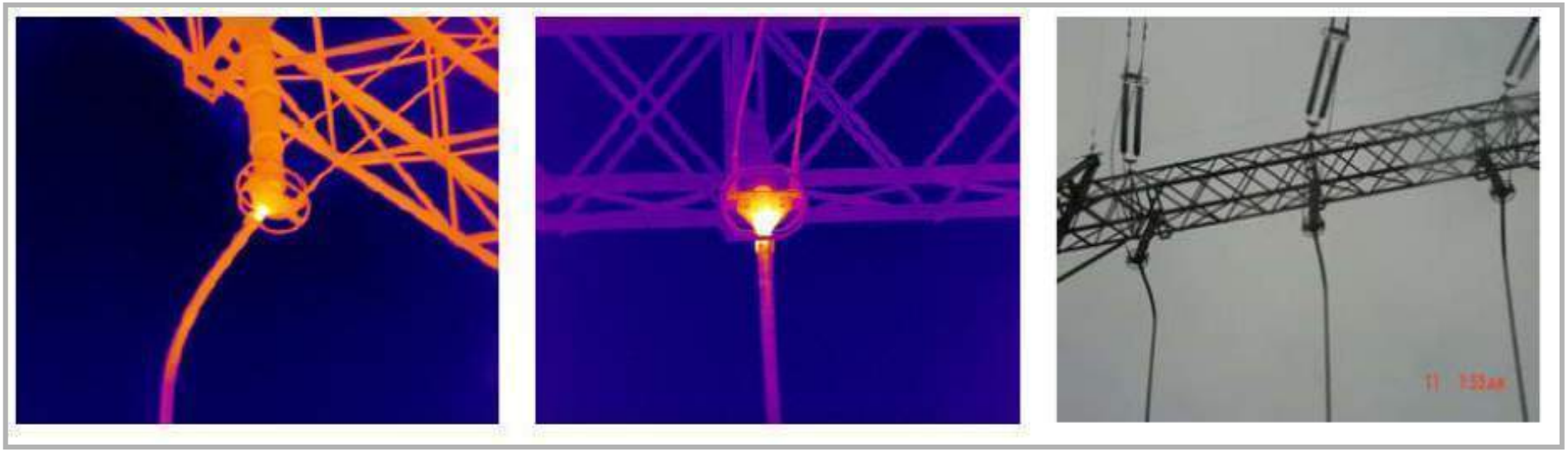
- Electrical maintenance



Thermal anomaly is almost always a sign of an impending equipment breakdown

Application: High voltage substation

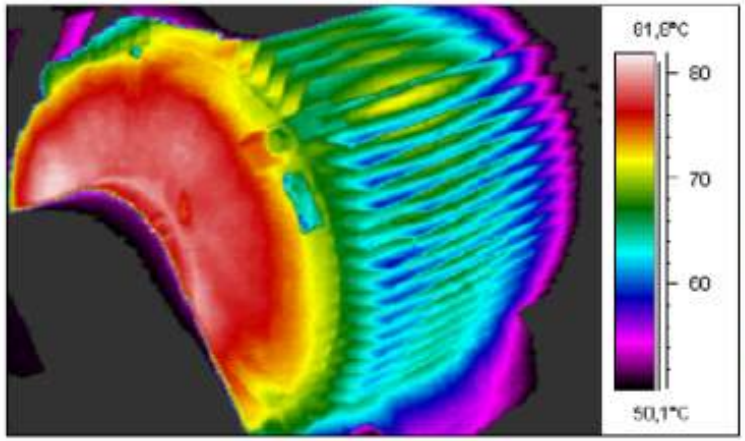
- Hot connections



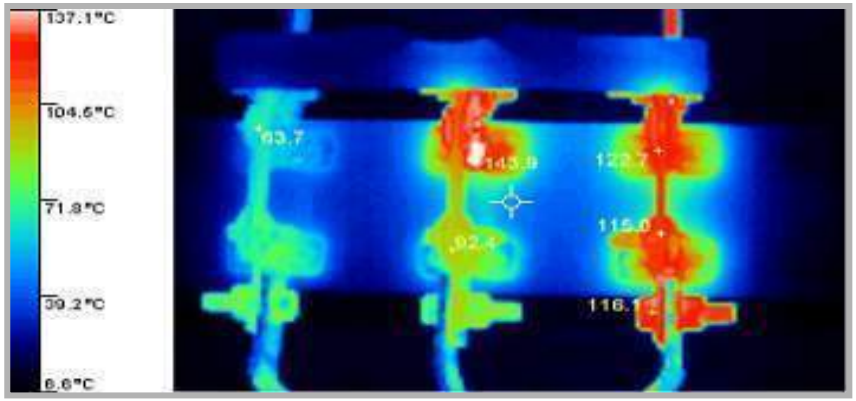
Thermal images **Visual image**

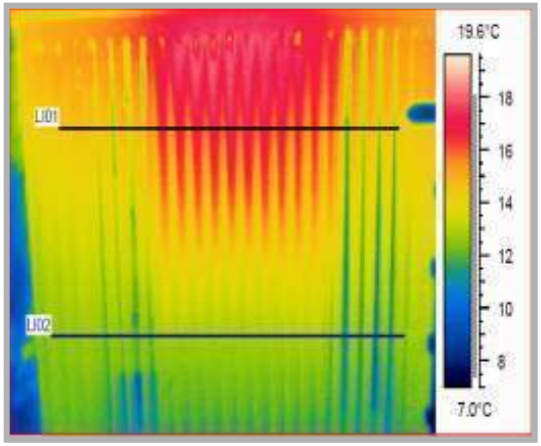
Application: Motor bearing

- Overheated motor bearing. Over 80 °C on bearing housing.



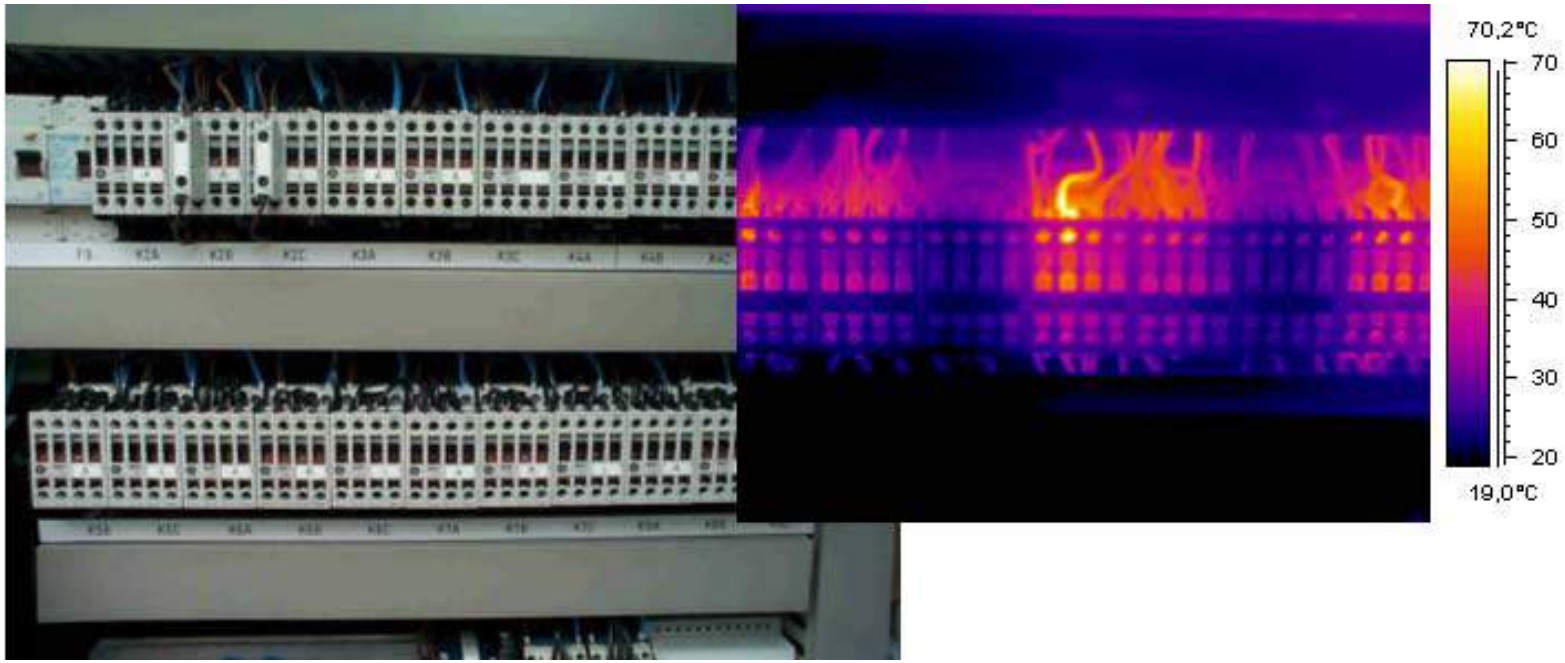
Application: Connection, Flow



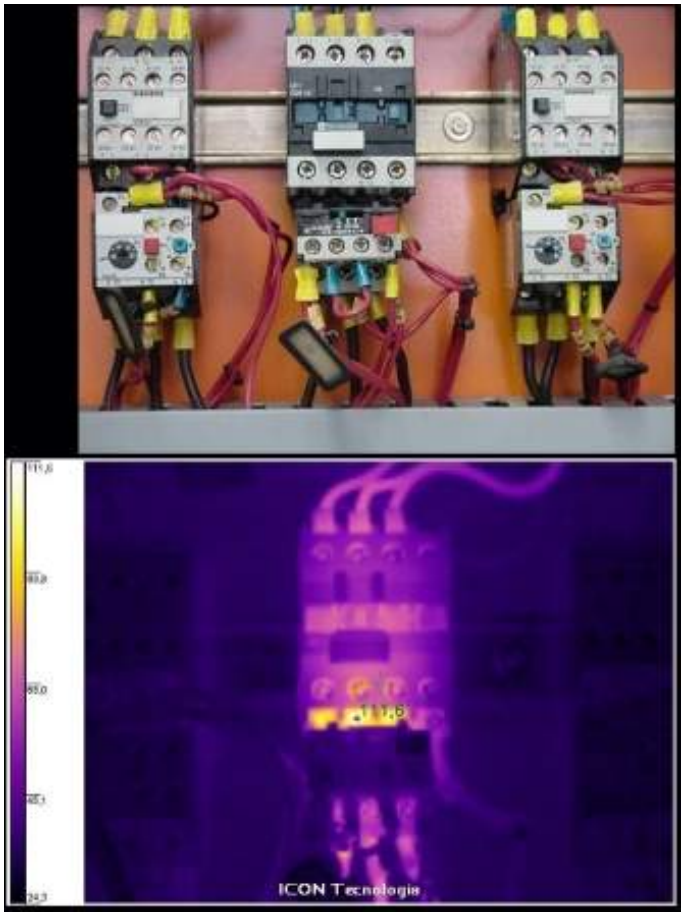


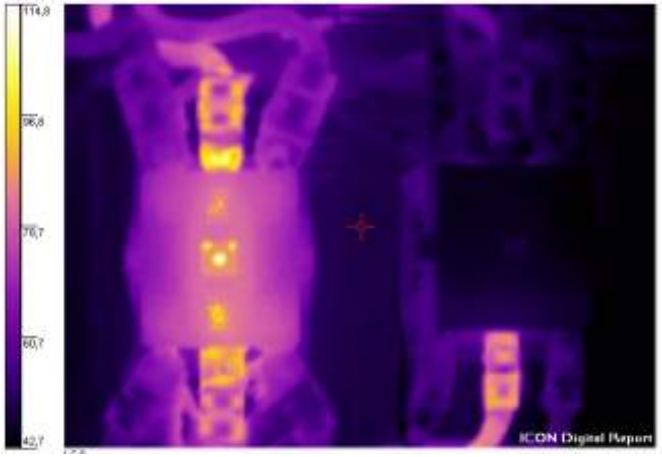
Application: Low voltage indoor

- Finding problems about hundreds of cables



Application: Contactors

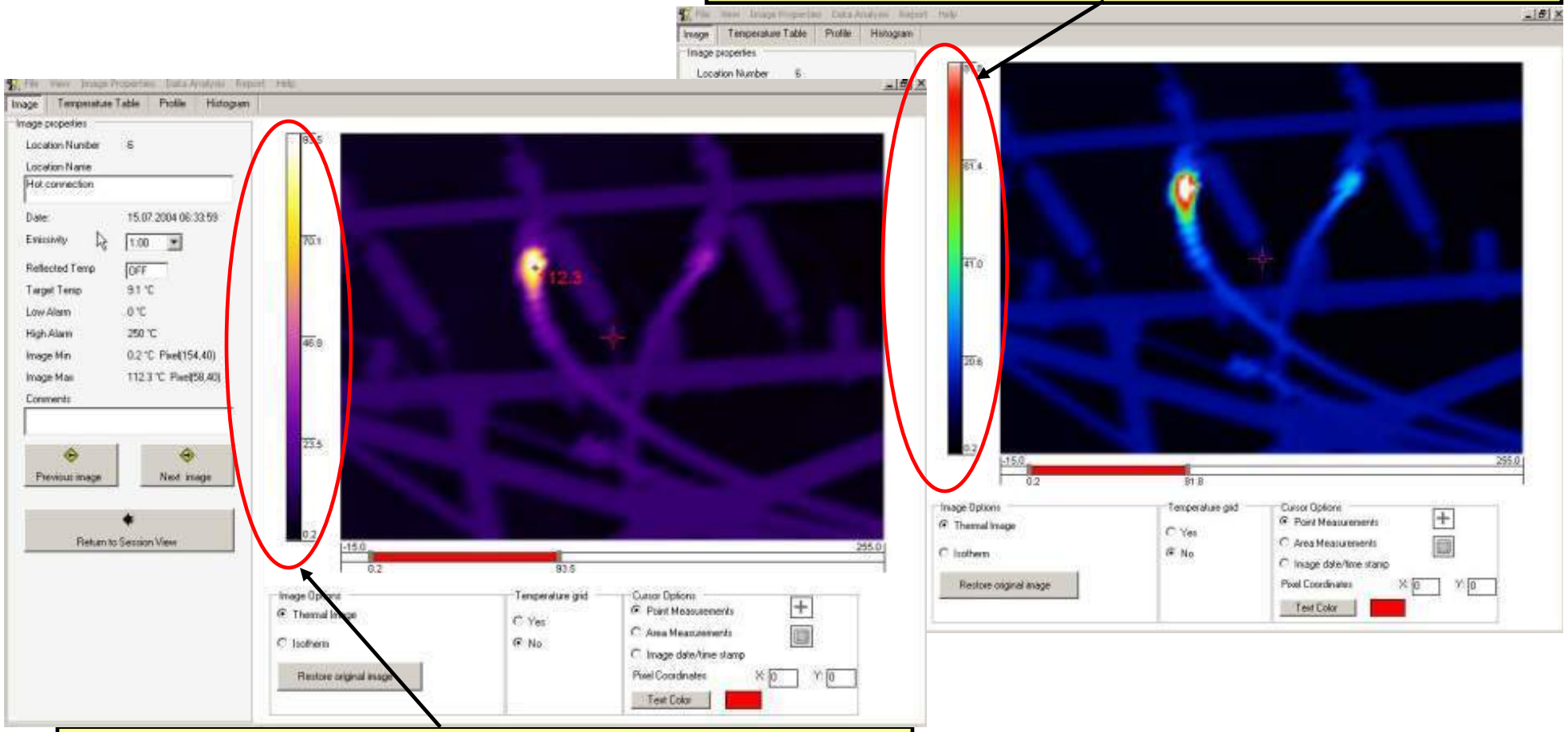




New options – Mix of thermal and normal picture

Software: Data Acquisition & Interpretation

Color palette and data type



Software: Reporting

THERMOGRAPHIC REPORT

Company	Volks Cement
Problem #	First Scan,K7&8

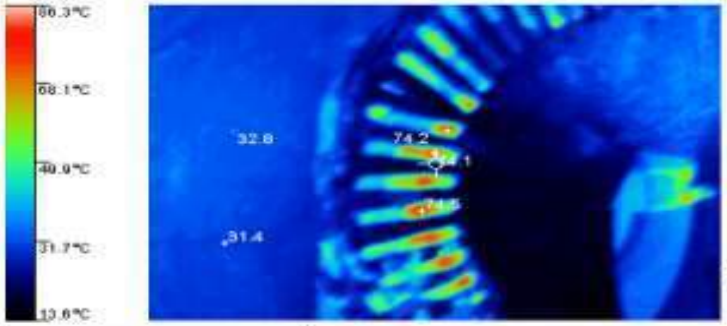
IDENTIFICATION

Location Name	Kiln 8 Main drive A Slip Ring
Equipment	

PROBLEM DESCRIPTION

Heating due to resistance / loose connection

THERMOGRAM



TEMPERATURE MEASUREMENTS

Image Date	01/01/2000 23:48:28
Target Temperature	74°C
Emissivity	0.98
Reflected Temp	OFF

WEATHER

Air Temp	
Sky	
Wind Speed	
From	

Distance	**Rated Load**	**Meas. Load**	**% Load**
0.6 meter			

MAINTENANCE ACTION

Description	**Repaired by**
Moderately Critical, monitor after 1 week, inspect as soon as possible.	

REPAIR PRIORITY

Subj. Rating	
Temp. Rating	

REINSPECTION

Reinspected by	
Date	

Comments

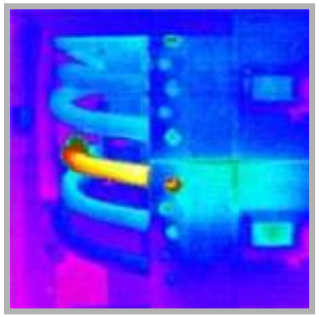
Absolute Measurement

Severity criteria: How hot is “HOT” ?

- The temperature of the equipment or parts of the equipment is measured and compared to its normal temperature rating
- A base or reference should be available to analyze the image
- Examples:
  - Cable operating temperature as indicated in the cable specification

Relative Measurement

Severity criteria: How hot is “HOT” ?



- The temperature of the target is measured and compared to the other phases
- The temperature of the target equipment is compared to other targets having similar type and load
- Difference in temperature or ΔT is the basis of the corrective action to be taken

Temperature limits

Severity criteria: **How hot is “HOT” ?**

Delta –T or Temperature increase	Action
10° C - 24 ° C	Advisory
25 ° C - 39 ° C	Intermediate
40 ° C - 69 ° C	Serious
>70 ° C	Immediate

US Navy

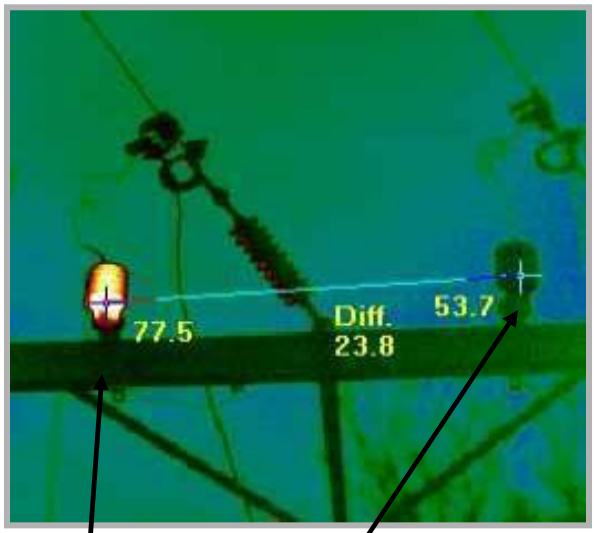
Delta –T or Temperature increase	Action
0.5° C - 8 ° C	Advisory
9 ° C - 28 ° C	Intermediate
29 ° C - 56 ° C	Serious
>56 ° C	Immediate

Nuclear maintenance application centre

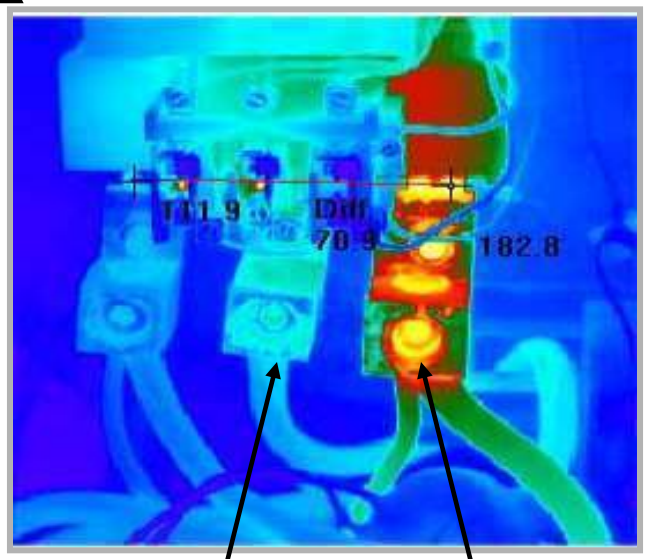
Maintenance: Condition monitoring

Severity criteria: **How hot is “HOT” ?**

Temperature difference, ΔT



25 °C	12 °C
ΔT = 13 °C	
Priority low	



43 °C	84 °C
ΔT = 41 °C	
Priority high	

Limitations and source of errors

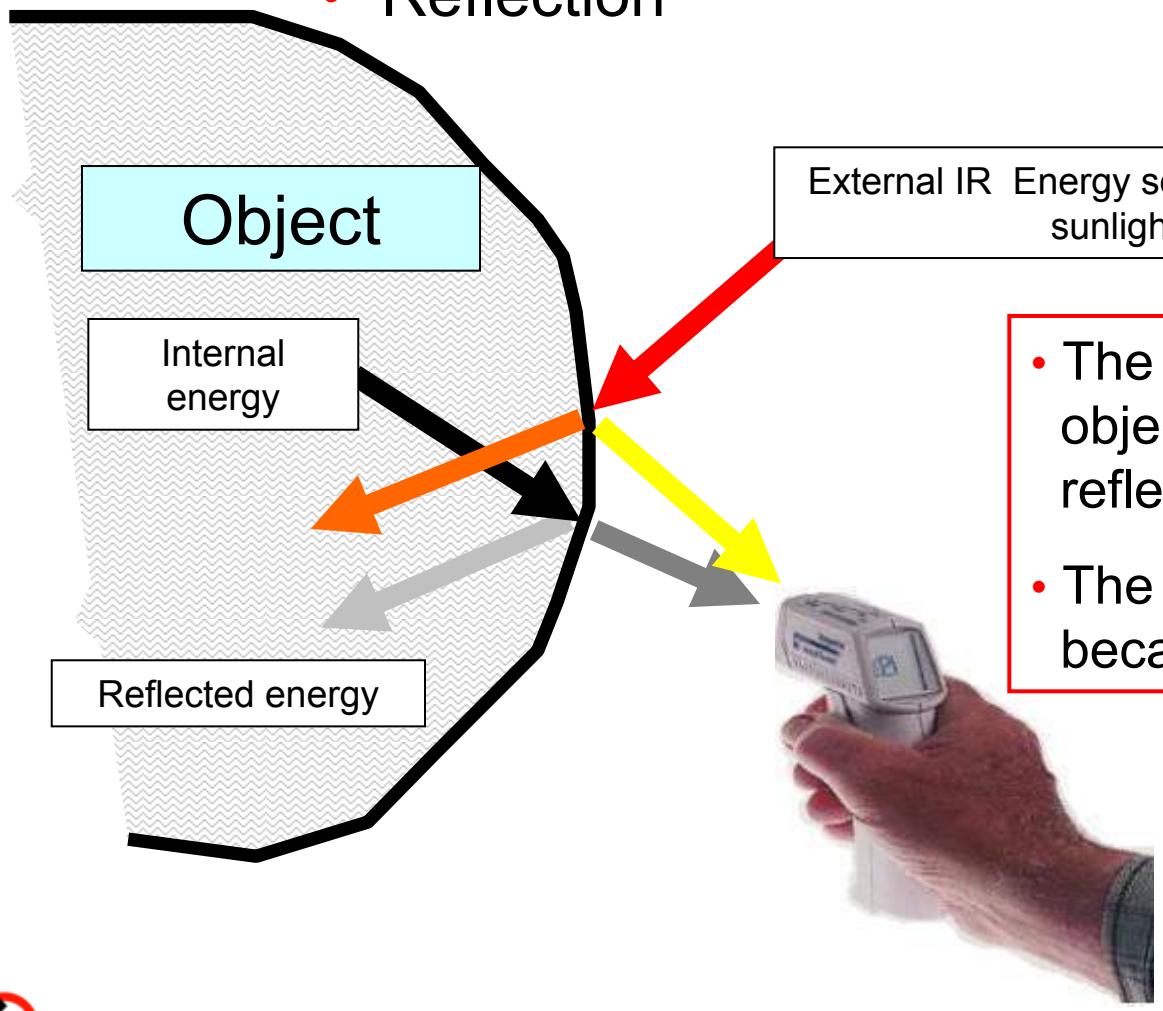
- Emissivity

Black Electrical tape on Aluminum heatsink

- The black tape appear to be hotter than the aluminum
- The same effect can happen on 3-phase cables having different colors

Limitations and source of errors

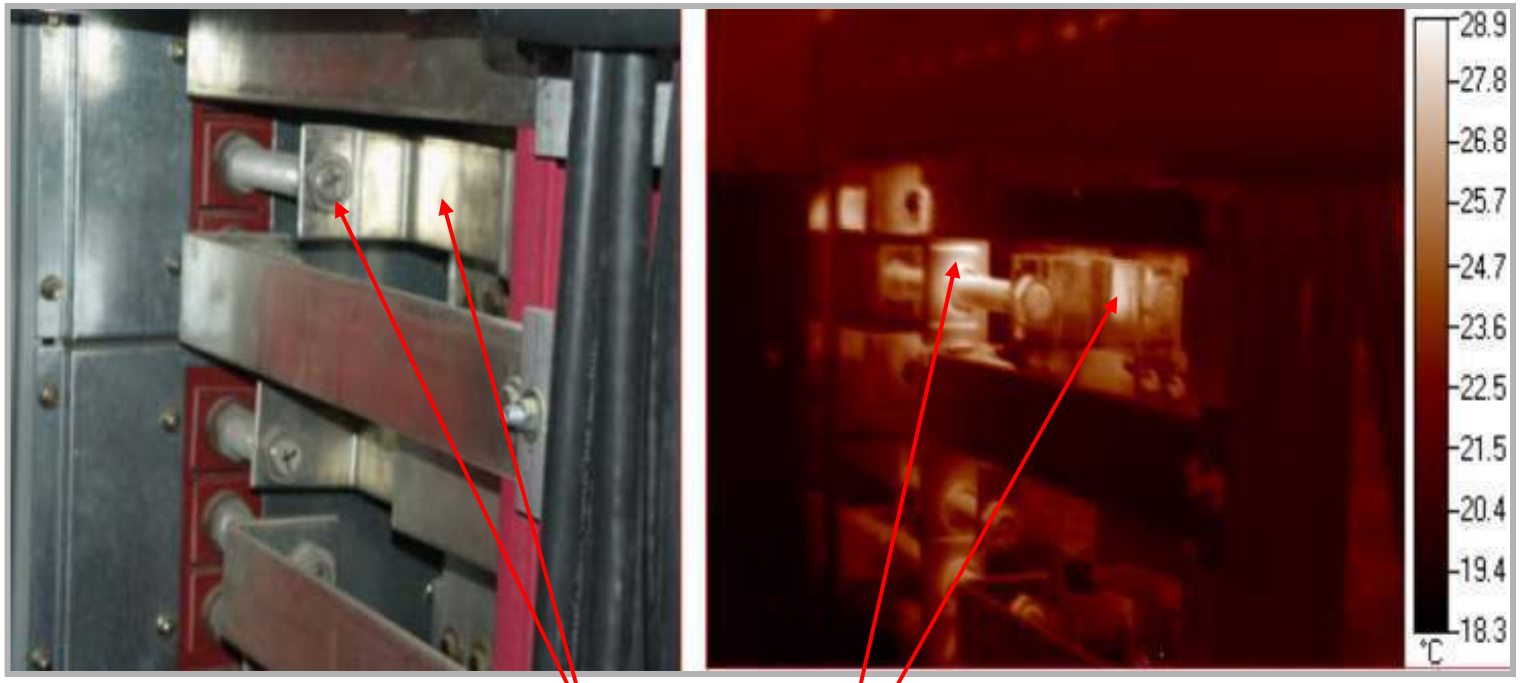
- Reflection



- The effect of reflection is greater on objects with low emissivity (highly reflective)
- The object will appear to be hotter because of the reflected infrared

Limitations and source of errors

- Reflection



Reflected Light causing a false hotspot

Suppliers






Brand	Model / Family	FPGA Resolution	Price range, $
Fluke (Formerly Raytek)	TI 30	160 x 120	10'000
Fluke (Formerly InfraredSolutions)	TI40 and TI 50 Series (Formerly Flexcam & Insight	from 160 x 120 to 320 x 240	13'000-30'000
Irisys	IRI 4010	160 x 120	8'000
Flir	P Series	from 160 x 120 to 320 x 240	30'000
Flir	Thermacam E 320	320 x 240	20'000
Thermoteknix	TI200	320 x 240	25'000

Implementation: Training

- A thermal imager is a sophisticated piece of equipment and the person that will use it will need training
- A good thermographer ..
  - Will immediately know if the temperature reading is correct or not in order to redo it
  - Can immediately judge if equipment is showing abnormal conditions to take further images

Implementation

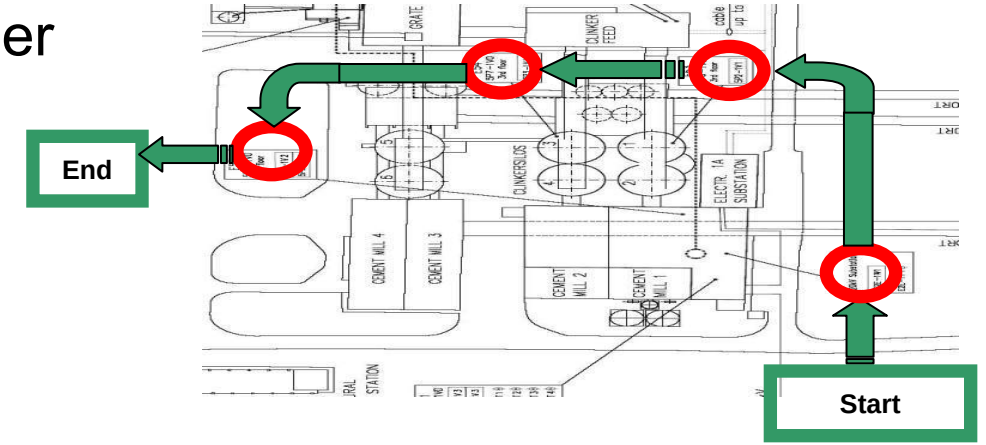
Define a schedule:

- Set the time for equipment scanning where the influence of interference can be avoided
  - On outdoor equipment such as transformer where there will be direct sunlight should be scanned where the influence is least (early morning)

- It is recommended to scan before a planned shutdown
  - Any abnormal finding can be corrected during the shutdown

Implementation

- Establish base
  - A visual picture as reference
  - Relevant data regarding the equipment
  - Equipment must be loaded
- Plan a route
  - Define a route where the thermographer can scan the equipment in one travel
  - Make sure that the equipment will be easily accessible by the thermographer



Benefit of Thermography Inspections

- *"...From a return on investment perspective, infrared inspection programs have proven that on average for every $1 spent on infrared electrical inspections, there is a $4 return on investment for materials and labor from fixing the problems before it fails..."*
  "Cost/Benefits Analysis of Infrared Programs."
- *MaintenanceTechnology Magazine*

1$ = 4$

Summary

- Each plant should have its own camera
- Thermography should be used by the preventive maintenance team as a complimentary tool
- Perform thermography at least once a year


Holcim