Preface

All scientific measurement must be accurate. And to deliver an accurate temperature measurement, there are two important factors to be considered: (1) the selection of measuring tool which measures standard (2) sufficient user knowledge to eliminate measuring error.

Therefore this guidebook is designed and published for FLIR customers who demand to understand the concept and basic of IR Thermography applications in temperature measurement. In addition, this book explains the important functions should include in an Infrared camera which improve the measuring results and maximum comfort.

Enjoy!

Lars Lidman
Vice President Sales & Marketing Asia Pacific
FLIR Systems Co., Ltd.

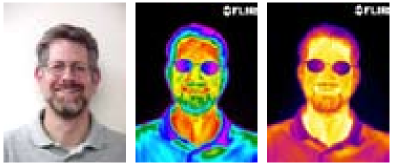
Table of Content

- end -

1.0 Introduction

1.1What is IR Thermography?

Thermography is a technology that actually allows us to see thermal energy or heat! If you saw the movie “Predator” or “Predator 2”, you saw real infrared video footage! Thermography can be used in any circumstance where the identification of thermal patterns can be used to find something (such as a missing person) or diagnose a condition (such as a poor electrical connection). If you think about all the heat related activities in our lives, you will see the application possibilities are huge!



Graph 1.1 Visible photograph and two infrared thermograms, one with a rainbow palette and the other with an iron bow palette.

Infrared thermography has been in the news recently because of its ability to detect and display a thermal map of people’s heads in a few seconds. Doing this can provide a screening function for SARS as one of the symptoms is a fever.

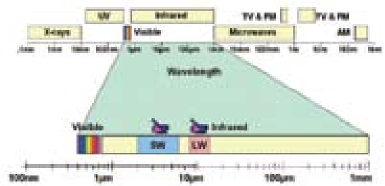
Infrared thermal imaging is also used to locate victims in fires by firefighters. Black smoke makes finding your way through a burning building virtually impossible. Firefighters use infrared imaging to be able to see through the smoke to find and rescue trapped or disabled victims.

2.0 Theory of thermography

The subjects of infrared radiation and the related technique of thermography are still new to many who will use an infrared camera. In this section, the theory behind thermography will be given,

2.1 What is Infrared?

Infrared energy is part of the electromagnetic spectrum and behaves similarly to visible light. It travels through space at the speed of light and can be reflected, refracted, absorbed, and emitted. The wavelength of IR energy is about an order of magnitude longer than visible light, between 0.7 and 1000 μm (millionths of a meter). Other common forms of electromagnetic radiation include radio, ultraviolet, and x-ray.



Graph 2.1 The electromagnetic spectrum

2.2 What is the electromagnetic spectrum?

We know that infrared radiation is a form of electromagnetic radiation, which is longer in wavelength than visible light. Other types of electromagnetic radiation include x-rays, ultraviolet rays, radio waves, etc. Electromagnetic radiation is categorized by wavelength or frequency. Broadcast radio stations are identified by their frequency, usually in kilohertz (kHz) or megahertz (MHz). Infrared detectors or systems are categorized by their wavelength. The unit of measurement used is the micrometer, or micron, (mm, where m is the Greek letter mu) which is one millionth of a meter. A system that can detect radiation in the 8 to 12 mm band we usually call "longwave." One that detects radiation between 3 to 5 mm is termed "shortwave." (A 3 to 5 mm system can also be classified as "midband," because there are systems, which can detect radiation shorter than 3 mm.) The visible part of the electromagnetic spectrum falls between 0.4 and 0.75 mm. We can see colors because we can discriminate between different wavelengths. If you have a laser pointer you may have noticed that the radiation is specified in nanometers; usually about 650nm. If you examine a chart of the electromagnetic spectrum at 650nm (.65 mm) you will see that it is the radiation of red light.

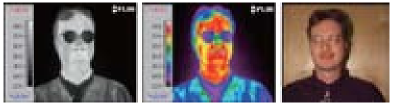
2.3 Where does infrared energy come from?

All objects emit infrared radiation as a function of their temperature. This means all objects emit infrared radiation. Infrared energy is generated by the vibration and rotation of atoms and molecules. The higher the temperature of an object, the more the motion and hence the more infrared energy is emitted. This is the energy detected by infrared cameras. The cameras do not see temperatures, they detect thermal radiation.

At absolute zero (-273.16°C, -459.67°F), material is at its lowest energy state so infrared radiation is at its lowest level.

2.4 What is Infrared Thermography?

Infrared Thermography is the technique for producing an image of invisible (to our eyes) infrared light emitted by objects due to their thermal condition. The most typical type of thermography camera resembles a typical camcorder and produces a live TV picture of heat radiation. More sophisticated cameras can actually measure the temperatures of any object or surface in the image and produce false color images that make interpretation of thermal patterns easier. An image produced by an infrared camera is called a thermogram or sometimes a thermograph.



Graph 2.4 Black and white and color thermograms of a person; and a visible light photograph. Note the glasses appear cool because they are cooler than the skin and longwave infrared energy will not pass through glass. You can see the temperature patterns on the face, reds are warmer, yellows and greens are cooler. Thermal patterns on the skin surface can be indicative of disease and are sometimes used to aid medical diagnoses.

2.5 How is thermal imaging different from "Night Vision" goggles?

Night vision goggles amplify small amounts of visible light (and sometimes near infrared light) thousands of times so objects can be seen at night. These only work if some light is present ie. moonlight or starlight. Thermal imaging works by detecting the heat energy being radiated by objects and requires absolutely no light. One advantage of thermography over night vision technologies is that night vision goggles can be easily blinded just by shining a flashlight at them. Since thermal imager only look at the heat they are totally unaffected by light sources.

Visible light — *Near infrared "Night Vision"* — *Thermal infrared*

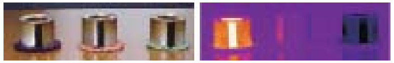
Graph 2.5 Night vision goggles amplify small amounts of visible light (and sometimes near infrared light) thousands of times so objects can be seen at night.

2.6 If IR cameras don't see temperature, what am I seeing on an IR image?

The IR camera captures the radiosity of the target it is viewing. Radiosity is defined as the infrared energy coming from a target modulated by the intervening atmosphere, and consists of emitted, reflected and sometimes transmitted IR energy. An opaque target has a transmittance of zero. The colors on an IR image vary due to variations in radiosity. The radiosity of an opaque target can vary due to the target temperature, target emissivity and reflected radiant energy variations.

The accompanying figure shows three metal cans, one hot, one ambient and one cold (left to right). Upper image is visual, lower image is infrared. There is a piece of electrical tape on each can. The can surface and the electrical tape are at the same temperature for each can. But in the infrared images, the tape looks hotter than the metal surface on the hot can, colder on the cold can and the same on the ambient can. What is going on?

The electrical tape has a higher emissivity than the metal. This means the tape has a higher efficiency as a radiator than metal. The metal has a higher reflectivity than the tape. It is more efficient as an infrared mirror. Thus, the tape will indicate the target temperature more closely. The metal will indicate the background temperature, or that which is reflected off the can. So, if the can is hotter than the background, the tape looks hotter than the metal. If the can is colder than the background, the tape looks colder than the metal. If the can is the same temperature as the background, the tape and the metal will look the same.



Graph 2.6 Three aluminum cans with partially oxidized surfaces and a strip of black electrical tape. The can on the left is hot, middle can is ambient and right can is cold.

2.7 Basic Concept

Thermographers see targets exhibiting this emissivity contrast behavior every day. It could be an insulated electric cable with a bare metal bolted connection. It could be a bare metal nameplate on a painted surface such as an oil filled circuit breaker or load tap changer. It could be a piece of electrical tape placed by the thermographer on bus bar to enable a decent reading.

The list is long. It turns out that for opaque objects, the emissivity and reflectivity are complementary. High emissivity means low reflectivity and vice versa. The conservation of energy law shows us that:

$$\varepsilon + \rho + \tau = 1$$ *(Equation 2.7a)*

Equation 2.7a Greek letters for e, r and t are typically used where:
e is emissivity
r is reflectivity
t is transmissivity

For opaque targets, t = 0 and the equation reduces to:

$$\varepsilon + \rho = 1$$ *(Equation 2.7b)*

Equation 2.7b is a powerful result. In simple terms it says that a high emissivity means a low reflectivity. A low reflectivity means a high emissivity. Thermographers like the emissivity to be as high as possible. They then get the most accurate reading as most of the radiosity is due to radiant energy emitted by the target. Modern IR cameras correct for emissivity with a modicum of user input.

But the uncertainty in the measurement increases with decreasing emissivity. Our calculations show the measurement uncertainty gets unacceptably high for target emissivities below about 0.5.

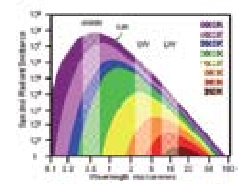
Emissivity tables abound. But emissivity is a slippery slope. Above, we discussed emissivity as a material surface property. It is that, and more. The shape of an object affects its emissivity. For semi-transparent materials, the thickness will affect emissivity. Other factors affecting emissivity include: viewing angle, wavelength and temperature. The wavelength dependence of emissivity means that different IR cameras can get different values for the same object. And they would both be correct! We recommend measuring the emissivity of your key targets under conditions they are likely to be monitored during routine surveys. A quality IR training course can teach you how. It is not difficult. Register an ITC course now by visits www.infraredtraining.com

In general, dielectrics(electrically non-conducting materials) have relatively high emissivity, ranging from about 0.8 to 0.95. This includes well-painted metals. Unoxidized bare metals have emissivity below about 0.3 and should not be measured. Oxidized metals have emissivity ranging from about 0.5 to 0.9, and are the problematic category due to the large range of values. The degree of oxidation is a key ingredient to an object's emissivity. The higher the oxidation, the higher the emissivity.

For opaque objects, if you know the emissivity and the background (reflected) temperature, an IR camera with a temperature measurement feature can give temperatures accurate to within a few percent. To get temperature, the IR camera must extract just the fraction of the radiosity due to the energy emitted by the target. Fortunately, modern IR cameras are smart and can do this. They subtract the reflected component, then scale the result by the target emissivity. The resulting value can then be compared to a calibration table and temperature extracted.

2.8 What is a blackbody, a graybody, a realbody?

A blackbody is a perfect radiator. It has zero transmittance and zero reflectance. According to Kirchhoff's law, then, the emissivity of a blackbody is one. Blackbodies were first defined for visible light radiation. In visible light, something that doesn't reflect or transmit anything looks black. Hence the name. A graybody has an emissivity less than one that is constant over wavelength. A realbody has an emissivity that varies with wavelength. IR cameras sense infrared radiant energy over a waveband. To get temperature, they compare results explained above with a calibration table generated using blackbody sources. The implicit assumption is the target is a graybody. Most of the time this is true, or close enough to get meaningful results. For highly accurate measurements, the thermographer should understand the spectral (wavelength) nature of the target.



Graph 2.8 The mathematical model for black body radiation curves by Max Planck

Max Planck (1858 - 1947) is credited for developing the mathematical model for blackbody radiation curves. The accompanying Graph 2.8 shows the magnitude of emitted radiation due to an object's temperature vs. wavelength for various temperatures. Note the sun has a peak wavelength in the middle of our visible light spectrum.

Blackbody curves are nested. They do not cross each other. This means a blackbody at a higher temperature will emit more radiation at every wavelength than one at a lower temperature. As temperature increases, the wavelength span of radiation widens, and the peak of radiation shifts to shorter and shorter wavelengths. Note, the peak of infrared radiation at 300K (about 27C, 81F) is about 10 mm. Also, an object at 300K emits radiation only down to about 3 mm. Since our eyes are not sensitive beyond about 0.75 mm, we cannot see this. But if we warm the object up to about 300C, we can just begin to see it glow faintly red.

3.0 Infrared Thermography Applications Overview

Infrared thermography is such a valuable and versatile tool that we cannot possibly list all the applications. New and innovative ways of using the technology are being developed everyday.

Thermography can be applied in any situation where a problem or condition can reveal itself by means of a thermal difference. For many situations, this is quite easy to apply; a thermal condition can be seen because the process involves release of thermal energy. An example of this is inspecting the condition of electrical distribution equipment. When electrical current passes through a resistive element, heat is generated. If the target emissivity is high enough, we can see that heat with an infrared camera. Sliding and bolted connections can become resistive through loosening, corrosion, etc. This increase in electrical resistance usually results in increase in heat generation and the camera can quickly pick it up. Sounds simple, and often it is. Frequently, it is not simple due to the nature of heat transfer. Good training is the key to successful application of infrared technology.

Another example is the inspection of concrete bridges. As many of us know, concrete can develop delaminations, which can lead to potholes. When a pothole develops, it is quite easy to detect; usually your tire and wheel "find" the hole and you end up with an unpleasant repair bill. Wouldn't it be great if we could find these before they cause problems? By cleverly using the sun's energy as a heating medium, and viewing with an infrared camera; we find that subsurface delaminations have a different heating effect than the sound parts of the deck structure, so the camera can see it. This example shows that even though the bridge deck doesn't generate heat it can still be analyzed with thermography given the proper conditions.

Here is another example of an application where we can use passive heating or cooling. Recently developed composite aircraft materials are extremely sturdy and lightweight. These materials are vital to aircraft performance and airworthiness. However, the honeycomb structure of this material presents a potentially dangerous problem: water ingress.

It has been discovered that certain control surfaces tend to absorb water in the honeycomb structure, for reasons that are not fully understood. The problem is aggravated by the effects of lightning and hail, which cause barely visible impact damage. The water enters the honeycomb and freezes when the aircraft is at high altitude. As the ice expands it breaks down the cells in the structure. This condition grows like a cancer and eventually jeopardizes the entire structural integrity of the component.

Until recently, the only effective method of diagnosing the problem was through radiography. While this is still the most accurate way, it has several disadvantages: it is expensive in time, equipment, and manpower, and can expose maintenance personnel to hazardous ionizing radiation.

Thermography can be an indispensable tool for inspecting planes for this problem. After the plane has landed, the ice remains at 0^{o}C while it is melting. The rest of the plane has warmed to ambient temperatures on the approach. This provides an ideal opportunity to search for the ice pockets with a thermal imaging system while the plane is being serviced.

Graph 3.0 Thermogram showing water ingress (dark areas) on illustrated section of aircraft. An entire aircraft can be surveyed in 20 minutes with no downtime. Images are recorded digitally for later analysis at an image processing workstation.

3.1 Benefits of Infrared Thermography

- Significantly reduce unscheduled power outages
- Detect problems quickly, without interrupting service
- Assess priorities for corrective action
- Minimize preventive maintenance and troubleshooting time
- Comply with insurance company requirements
- Check for defective equipment while still under manufacturer warranty

There are many more instances when thermography can be utilized. Here are a few:

3.2 Electrical Systems

- Power generation inspections including exciters, 4,160 connections, motor control centers and isophase bus ducts.
- Substation Electrical inspections including switchgear, breakers, transformers and capacitor banks.
- Overhead urban and rural distribution electrical inspections.
- Electrical motor inspections

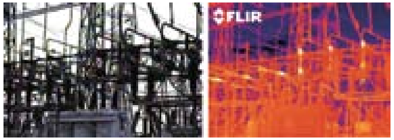
Electrical *- Infrared testing is used as a means to detect potential circuit overload or areas of unusually high electrical resistance, allowing electricians to replace the circuit before failure, eliminating costly downtime or further damage to the electrical system.*

Fuse *- Hot fuse connection.*

3.3 Utility

In the utilities industry, failure is not an option. That's why infrared thermal imaging has become a key tool for predictive maintenance programs for utility firms everywhere. FLIR provides utilities with the most advanced thermal imaging solutions to support a 24/7 monitoring programs that keep the vital electrical power grid up and running.

Regular IR Scans Keep the Lights On *- Electric companies must have reliable power lines to provide their customers with the service they expect and deserve. Unfortunately, when lightning arresters fail, the whole system hangs in the balance. Regular inspections can help prevent power outages by detecting bad lightning arresters in substations and faults in distribution lines.*

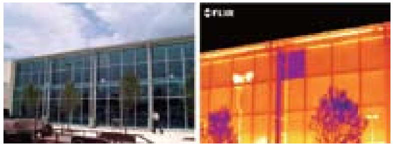


Substation *- A wide view of a substation can quickly show areas where unwanted high resistance connections exist. Electrical current passing through a resistive connection produces heat; electrical systems get hot when connections loosen or corrode and power is not properly transmitted — no other predictive maintenance technology is as effective for electrical inspections as IR thermography.*

Transformer Radiators - *This infrared image shows a cold radiator (lower left) possibly due to a bad pump. This could be a serious problem as the capacity of the transformer is reduced.*

3.4 Building Envelopes and Structures

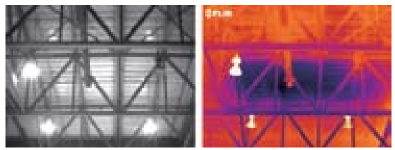
- Thermal heat loss inspections for buildings, plants, facilities, refineries.
- Moisture contamination evaluations in buildings, condos, plants facilities
- Concrete integrity inspections
- Concrete water heated floor inspections for leaks and temperature distribution
- Locate missing or damaged insulation
- Identify air leakage energy losses
- Evaluate the thermal performance of retrofits
- Locate radiant heating wires or pipes
- Detect delaminations in concrete bridge deck
- Locate and identify mold growth areas in building structures



Building diagnostics - *Infrared testing is used to detect heating & cooling loss or moisture problems due to insulation deficiencies or construction issues.*

3.5 Roofing Systems

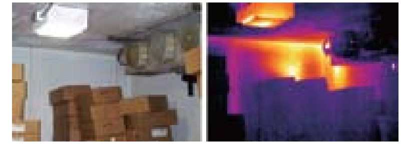
- Flat roof leak detection for buildings, plants, facilities
- Identify water damaged portions of a roof quickly and accurately
- Eliminate unnecessary replacement of good roofing
- Plan accurate budgets based on facts
- Document problems before the warranty/bond expires



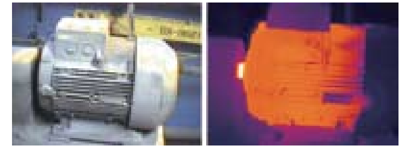
Roofing - *Infrared testing is used to detect water damage & leaks beneath the surface of the roof allowing the opportunity repair the section before it continues to spread.*

3.6 Mechanical Systems

- Boilers
  - Inspect burners for flame impingement and burner management
  - Look at combustion patterns of fuel
  - Detect thermal patterns on boiler tubes and measure tube skin temperature during normal operation or when boiler is on standby
  - Scan and record temperatures in areas of boiler not monitored
  - Scan the exterior of boiler for refectory damage or locate warmer areas where potential refectory damage may occur
- Detect coke buildup in crude oil furnaces
- Power Plant boiler flue gas leak detection
- Mechanical bearing inspections
- Heat ventilation air conditioning equipment evaluation
- Cold Storage cooling losses.
- Detect insulation leaks in refrigeration equipment



Freezer – *Poor insulation in a walk-in cooler*

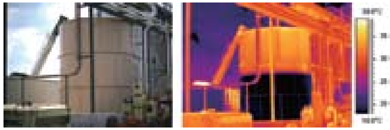


Preventative Maintenance - *Plant maintenance technicians use infrared testing as a form of preventive maintenance by monitoring a variety of machine parts. By evaluating a machine's temperature signatures when in normal operating conditions, one can perform periodic infrared inspections to detect overheating joints, bearings, etc. in order to avoid costly downtime. This kind of preventative or predictive maintenance is critical to increasing & maintaining plant efficiencies.*

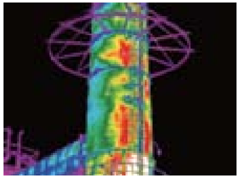
Transformer - *Excess heat on this distribution transformer was attributed to internal damage plus low oil level.*

3.7 Petrochemical Applications

- Refinery process line insulation loss or leak detection
- Refinery process evaluation
- Heat exchanger Quality and efficiency evaluation
- Furnace refractory (insulation) inspections
- Furnace internal flame evaluation and tube inspections
- Flame propagation explosion analysis.



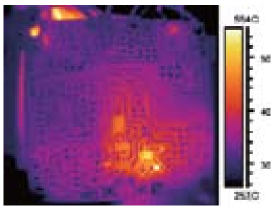
Liquid storage tank - *An IR camera can show when there are multiple levels in a tank, allowing workers to determine whether or not the product is contaminated or the tank itself needs to be serviced. This allows them to optimize the product. And when weather conditions are optimal, leaks from PRV's, steam, hot gases and propane can be illuminated.*



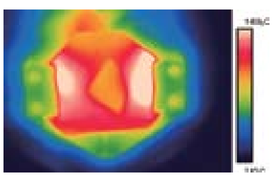
Refractory lined equipment - *Furnace refractory breakdown a crude heater stack is clearly shown in this thermal image. If it is unchecked, the condition would accelerate and cause metal degradation and catastrophic failure.*

3.8 Electronic Equipment

- Printed circuit board evaluation and troubleshooting
- Thermal mapping of semiconductor device services
- Circuit board component evaluation
- Production-type inspection of bonded structures
- Inspection of hybrid microcircuits
- Inspection of solder joints



Wafer Board *- This is an annealing process for wafers. Thermography can quickly identify thermal irregularities on critical parts.*



PC Board *- PC board with overheating component.*

3.9 Environmental Applications

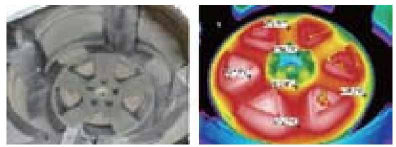
- Locate old waste disposal sites
- Locate old buried tanks on industrial sites
- Locate and monitor oil spills

3.10 Research and development applications

- Design proto typing evaluation

3.11 Automotive Application

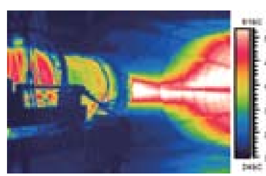
- Motor racing suspension and tire contact diagnostics
- Brake and engine systems evaluation for performance and cooling efficiencies



Mold temperature *- Mold temperature in an automotive seat.*

3.12 Aerospace Applications

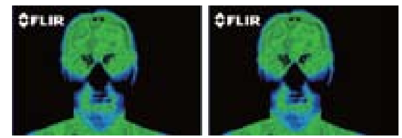
- Water ingress in airplane control surfaces and radomes
- Tire and brake system diagnosis
- Windshield and wing surface deicing system diagnosis
- Stress crack and corrosion identification and location
- Jet and rocket engine analysis
- Composite materials delamination and disbanding location
- Target signature analysis



Jet Engine *- Jet engine testing*

3.13 Medical / Veterinary Applications

- Medical injury examinations for whiplash, back injuries, Carpal Tunnel syndrome
- Disease evaluation - breast cancer, arthritis and many more
- Dentistry, tempomandibular jaw dysfunction and more
- Sports injuries evaluation, and therapy progress
- Equine (horse) injury examination, stress fractures, lameness
- Laser dosimetry determination



Medical – *If used correctly, medical thermograms provide visual images of diseases like breast cancer, carpal tunnel and arthritis.*

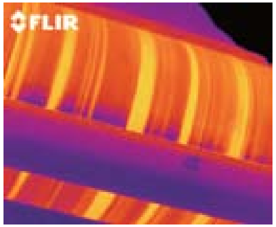
Horse *- Images reveals significant inflammation in the area of the proximal suspensory and proximal aspect of the medial splint bone.*

3.14 Airborne applications

- Pipeline inspection, leak detection, stress corrosion cracking areas
- Environmental inspections, pollution dumping, thermal dumping of waste water
- Fire Mapping, hold over fires, fire line and mop-up inspections
- High Voltage Aerial Electrical inspections for transmission lines
- Search and rescue
- Covert surveillance

3.15 Pulp and Paper

- Detect uneven heat distribution in Fourdrinier steam boxes
- Identify wet streaks, non-uniformity, that can have adverse effects on paper quality
- Identify basis weight variations
- Monitor size press performance
- Analyze dryer temperatures to look for non-uniformity in dryers
- Monitor coating to see that it is being applied uniformly to surface of the paper
- Analyze reel to find anomalies that may be induced by pieces of process equipment connected to the paper machine
- Inspect chip piles for hot spots



Paper Web Process *- Thermal image of a paper web process. Moisture shows up clearly in the image.*

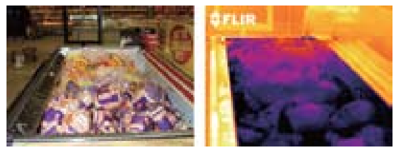
3.16 Steam Turbine and Hydroelectric Generators

- Locate inter-laminar faults in stator cores
- Monitor the effectiveness of repairs to the damaged areas
- Help maintain quality control during a stator core repair
- Obtain a thermal image of the stator core that serves as a permanent record of the condition of the stator core following repairs

Boat - *An IR camera can detect alterations made to vessel structure. Image shows a plate welded to the hull.*

3.17 Miscellaneous Applications

- Detect RF heating in antennas, wave guides, guy wires and frame structures
- Locate low-intensity sleeper fires on forest lands
- Locate lost people
- Remote sensing applications
- Firefighting – Locate people in burning buildings and navigate through smoke
- Locate non uniform densities in hot mix asphalt paving
- Locate moisture and delaminations in marine construction
- Food processing



Frozen Chicken – *This thermograph shows frozen chickens in a grocer's freezer. By scanning frozen goods in the freezer unit, problems such as improper temperature can be avoided or quickly remedied and food spoilage or foodborne illness can be avoided.*

Cooling asphalt mat - *With only a 3 Fahrenheit degree differential, the longitudinal section shown in the thermograph indicates that this cooling asphalt mat exhibits exceptional thermal uniformity. The mean density of this asphalt mat is 2,205 kilograms per cubic meter, with a maximum of 2,247 kg/m3 and a minimum of 2,179 kg/m3.The visual photo of the road taken a year later shows no evidence of wear or degradation.*

4.0 Features for Maximum Accuracy and Comfort

This section will introduce some features in an Infrared camera which will maximize the measuring accuracy and user comfort.

There are wide ranges of IR cameras available at FLIR Systems with a mixed of different features we explained herein.

Please visit www.flir.com.hk for product catalogue or contact your local dealer if further assistance is needed (please refer to p.23).

4.1 User Interface

Large display

Left selection button (Access to the menu or OK)

Navigation pad

Right selection button (Esc or Close)

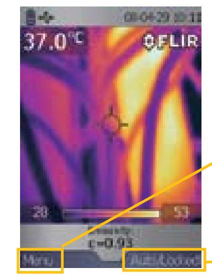
Recall saved images

On / Off

Save trigger

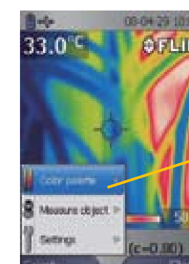
4.2 Menu Operations

- Push the left selection button to open the Main Menu
- Simply use the +/- button to select Sub Menu
- Validate by pushing the left selection button



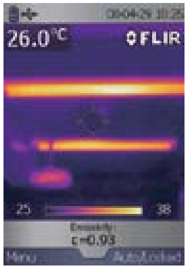
Use **left selection** button to access the menu

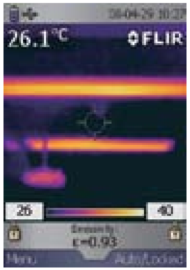
Use **right selection** button to toggle between "Auto" and "Locked" mode



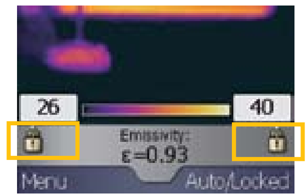
Selectable options are highlighted in **blue**

4.3 Auto mode and Lock mode



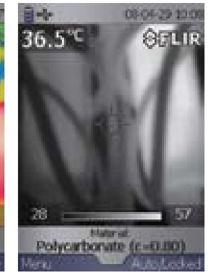


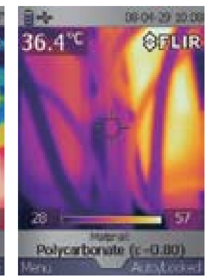
- In “Auto” mode, the temperature scale adapts to the best min-to-max interval of temperatures of the IR image.
- However, sometimes this automatic adjustment might be inappropriate for your needs.
- The example shows that a slight increase of the max value of the temperature scale results in a much better IR image which emphasising on the actual target instead on the surroundings.
- The “Locked” mode makes it also easier to compare different but similar objects when using the same temperature scale for all of them.



- Switch between “Auto” and “Locked” using the right selection button.
- Select “Auto” mode and point on any thermal scene with the min and max temperatures you would like to use.
- Push the right selection button to lock the scale.
- Two small locks are now shown below the temperature scale.
- Now, point the camera to the target which you want to look at with that specific temperature scale.

4.4 Colour palettes





1. Push the left selection button to open the Main Menu.

2. Select **Colour palette** and validate.

3. Use the +/- button to select desired palette.

4. Validate by pushing the left selection button.

4.5 Get Temperature Right

An infrared camera measures and images the emitted infrared radiation from an object. The fact that radiation is a function of object surface temperature makes it possible for the camera to calculate and display this temperature.

However the radiation measured by the camera does not only depend on the temperature of the object but is also a function of the emissivity. Radiation also originates from the surroundings and is reflected in the object. The radiation from the object and the reflected radiation will also be influenced by the absorption of the atmosphere.

To measure temperature accurately, it is therefore necessary to compensate for effects of a number of different radiation sources. The following object parameters must, however, be supplied for the camera:

- The emissivity of the object
- The reflected apparent temperature

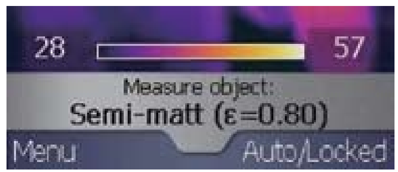
4.5.1 Set emissivity

The most important object parameter to set correctly is the emissivity which, in short is a measure of how much radiation emitted from the object, compared to that from a perfect blackbody of the same temperature.

Normally, object materials and surface treatments exhibit emissivity ranging from approximately 0.1 to 0.95. A high polished (mirror) surface falls below 0.1, while an oxidized or painted surface has a high emissivity. Oil-based paint, regardless of color in the visible spectrum, has an emissivity over 0.9 in the infrared. Human skin exhibits an emissivity 0.97 to 0.98.

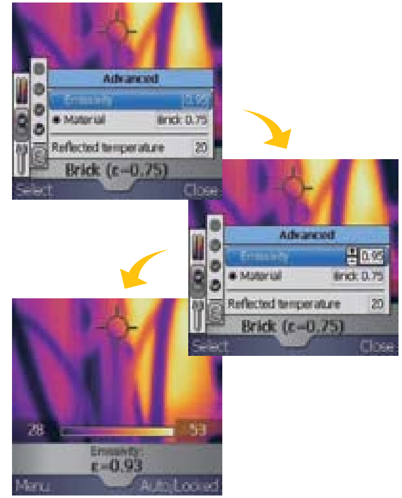
Non-oxidized metals represent an extreme case of perfect opacity and high reflexivity, which does not vary greatly with wavelength. Consequently, the emissivity of metals is low – only increasing with temperature. For non-metals, emissivity tends to be high, and decreases with temperature.

FLIR camera includes an emissivity table for customer to select the correct emissivity factor according to the surface reflectivity of the measure object i.e. Matt, Semi-matt, Semi-glossy or Glossy. By doing this, user can compensate measuring error due to the incorrect input of emissivity or even fixed emissivity.



1. Push the left selection button to open the Main Menu.
2. Select **Measure object** and validate.
3. Use the +/- button to select appropriate target surface characteristics.
4. Validate by pushing the left selection button.
5. Surface characteristics are displayed below the temperature scale.

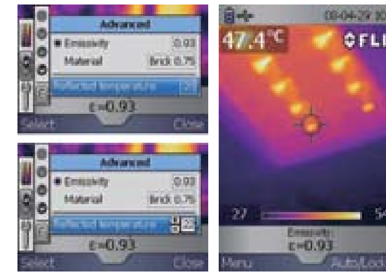
Or, if the user knows exactly the emissivity factor of the measure object (please refer to the emissivity table on the product manual) , the FLIR camera allows user to put the factor direct to the camera:



1. Push the left selection button to open the Main Menu
2. In the Main Menu, select and validate **Measure object**
3. Scroll to **Advanced**. Validate
4. Scroll to **Emissivity** and push the left selection button
5. Use the +/- button to select the desired numerical value. Validate
6. The selected emissivity is displayed below the temperature scale

4.5.2 Set Reflected Temperature

This parameter is used to compensate for the radiation reflected in the object. If the emissivity is low and the object temperature relatively far from that of the reflected it will be important to set and compensate for the reflected apparent temperature correctly.



1. Push the left selection button to open the Main Menu
2. Select **Measure object** and validate
3. Scroll to **Advanced**. Validate
4. Scroll to **Reflected Temperature** and push the left selection button
5. Use the +/- button to select the appropriate value. Validate

The spot meter is fixed in the centre of the IR image.

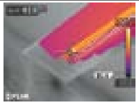
Remember that the spot meter has to cover completely the object you look at.

Otherwise, you will read the wrong temperature, i.e. a mixture of the target and it's closest surroundings.

4.6 Images Fusion

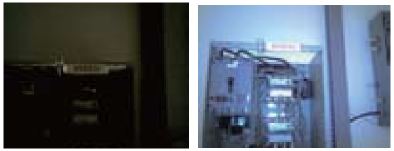
What is Fusion?
Fusion was created in 1970s by FLIR Systems AB, it is a function that lets you display a part of digital photo as an infrared image. For example, you can set the camera to display all areas of the image that has a certain temperature in infrared, while all other areas will be displayed as a digital photo. You can also set the camera to display an infrared image frame on top of the digital photo. You can then move around the infrared image frame, or change the size of the image frame. Images Fusion helps thermographers isolate problems, better identify and report suspect components and enable the repair to be done right the first time.

Table 4.6 This table explains the four different types of fusion

Fusion Type	Images
Above All areas in the digital photo with a temperature Above the specified temperature level are displayed in infrared.	
Below All areas in the digital photo with a temperature Below the specified temperature level are displayed in infrared.	
Interval All areas in the digital photo with a temperature Between two specified temperature levels are displayed in infrared.	
Picture in Picture An infrared image frame is displayed on top of digital photo, and depending on model selected, user can *Move, Resize, Reshape* the infrared image.	

4.7 Visual Target Illuminator/Lamp

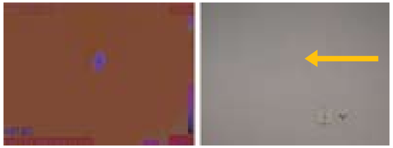
Visual target illuminator/Lamp ensure good reference visual images can be documented regardless of the lighting conditions.



Graphs 4.7 Below visual images taken in a poor lighting environment (i.e. electrical cabinet) however the second image was taken by a camera with visual target illuminator/ lamp.

4.8 Laser LocatIR™/ Laser pointer

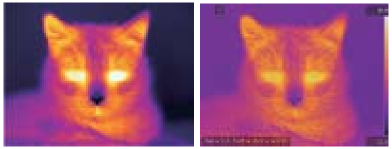
The Laser LocatIR™ boosts productivity. Simply push a button and the laser position you see on an objects is automatically aligned and displayed in the Infrared image. User can identify the measuring target without guess work.



Graphs 4.8 (right) see the red dot beams on the wall whilst (left) the hot temperature spot displayed in the Infrared image.

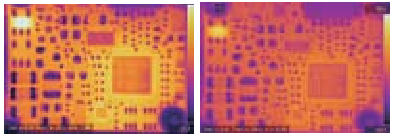
4.9 Dynamic Details Enhancement (DDE)

FLIR's exclusive DDE capability brings out detail in Infrared images.



Without DDE *With DDE*

Graphs 4.9a Object with lot of details

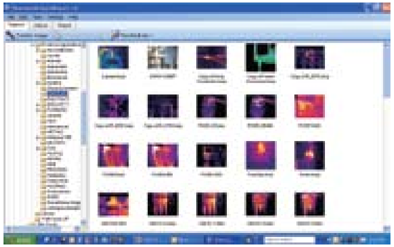


Without DDE *With DDE*

Graphs 4.9b Electronic circuit board captured with 50 micron close-up lens

4.10 Image format

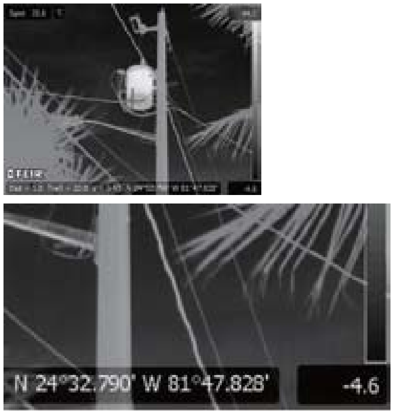
FLIR cameras store images under standard JPEG format, unlike either proprietary or dead bmp images, it makes easier to create compelling reports by drag and drop.



Graph 4.10 Plug and Play – easy download images in Standard JPEG format.

4.11 GPS

Forget typing addresses or trying to recall where images were taken? The GPS technology helps to record location information.



Graphs 4.11a Camera automatically adds position data to each IR-image

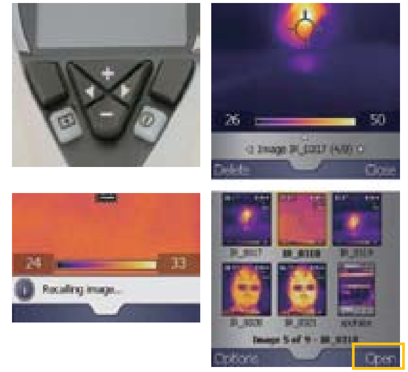
Graphs 4.11b Signals from satellites received by camera

4.12 Save an image

1. Check the image for correct focus and image composition

2. Press the “Save” trigger

4.13 Recall an image



1. Press the “Archive” button

2. Use the navigation pad left/right to select previous/next image

3. Push the “+” button to go to thumbnail view

4. Navigate up/down and left/right with the navigation pad

5. Press the right selection button marked “Open”

4.14 Thumbnail Gallery

FLIR cameras are designed with maximum user comfort. When the memory card can stores up to thousands images, FLIR camera allows user to preview images in camera on site immediately to check images are correctly captured or if they need to trace image(s).

4.15 Delete an Image

1. To delete a single image in standard view, press the left selection button marked “Delete”

2. In thumbnail view, press the left selection button marked “Options”

3. Select “Delete image” or “Delete all images”

4. Validate by pushing the right selection button marked “Delete”

4.16 Download Images

1. Remove the Mini SDTM Memory Card

2. Insert it into a card reader

3. Insert the card reader into your computer

4. If necessary, follow the Found New Hardware Wizard to install needed software

5. Alternatively, use the USB-Mini-B cable to connect the camera to your computer (Camera must be switched on)

6. In Windows Explorer, move the images from the card or camera using a drag-and-drop operation

Contact Addresses Asia Pacific

Headquarters Asia Pacific
Infrared Training Courses (ITC) subsidiary
Hong Kong

FLIR Systems Co Ltd.
Room 1613 – 15, Tower 2,
Grand Central Plaza,
138 Shatin Rural Committee Road,
N.T, Hong Kong
Tel : +852 2792 8955 Fax : +852 2792 8952
Email : flir@flir.com.hk Web : www.flir.com.hk

China Head Office
Shanghai

FLIR Systems AB Shanghai Representative Office
Unit 22C-D, Hua Du Mansion,
828 Zhang Yang Road, Pudong,
Shanghai 200122, P.R.China
Tel : +86 21 5169 7628 Fax : +86 21 5466 0289
Email : shanghai@flir.com.cn Web : www.flir.com.cn

Beijing Representative Office
Room 509,Building C,Vantone Center
No.A-6 Chaoyangmenwai Ave
Chaoyang District, Beijing 100020, P.R.China
Tel : +86 10 5979 7755 Fax : +86 10 5907 3180
Email : beijing@flir.com.cn Web : www.flir.com.cn

Guangzhou Representative Office
Unit 1806,Tower A, Victory Plaza,
No.103 Ti Yu Xi Road, Tian He,
Guangzhou 510600, P.R.China
Tel : +86 20 8600 0559 Fax : +86 20 8550 0405
Email : guangzhou@flir.com.cn Web : www.flir.com.cn

Japan Head Office
Tokyo

FLIR Systems Japan KK
Nishi – Gotanda Access Bldg, 8/F
3-6-20, Nishi – Gotanda,
Shinagawa-Ku, Tokyo,
141-0031, Japan
Tel : +81 3 6277 5681 Fax : +81 3 6277 5682
Email : info@flir.jp
Web : www.flirthermography.com/japan

Australia Head Office
Melbourne

FLIR Systems Australia Pty Ltd
10 Business Park Drive Notting Hill, VIC,
3168 Australia
Tel : +61 3 9550 2800 Fax : +61 3 9558 9853
Email : info@flir.com.au Web : www.flir.com.au

New South Wales Office
Norwest Central
Suite 610
12 Century Circuit
Baulkham Hills NSW 2153
Tel : +61 2 8853 7870 Fax : +61 2 8853 7877
Email : info@flir.com.au Web : www.flir.com.au

Western Australia office
Suite 39, 44 Kings Park Road
West Perth, WA, 6005 Australia
Tel : +61 8 6263 4438 Fax : +61 8 9226 4409
Email : info@flir.com.au Web : www.flir.com.au

Queensland Office
Suite 3, Level 3, Commonwealth Centre
18 Banfield Street, Chermside, QLD,
4032 Australia
Tel : +61 7 3861 4862 Fax : +61 7 3350 0808
Email : info@flir.com.au Web : www.flir.com.au