Fall / 2006

Think Thermally®

Practical news for practicing thermographers

In This Issue:

Thermal Solutions®

A Conference for Professional Thermographers

Thermal Solutions, the largest independent infrared conference for professional thermographers, returns to Sarasota, Florida, January 22-25, 2007 at the Hyatt on Sarasota Bay.

Thermal Solutions welcomes all camera manufacturers and features two complete tracks of paper presentations, eight educational short courses, the largest exhibit hall of any infrared-specific conference, ***Ask the Expert*** consultation sessions, group panel discussions and countless networking opportunities.

The two main paper tracks, ***Condition Monitoring*** and ***Building Applications,*** provide attendees with a diverse choice of presentations from which they can learn and discover "best practices" of thermography in a particular field. Participants may attend either track or, if they choose, alternate between each focus area to experience a variety of topics and applications.

Thermal Solutions is also home to the largest exhibit hall of any infrared-specific conference. "For anyone looking at getting into the industry or purchasing new equipment, Thermal Solutions is the best place to see all the manufacturers in one location," says John Snell, President of Snell Infrared. "At the same time, it's an environment that is conducive to learning without the heavy focus on sales."

The Hyatt Sarasota, a beautiful resort, marina and conference center located on the water in the heart of Florida's west coast, provides the perfect setting for this upcoming event. Many onsite amenities are available including fishing, boating, biking and golf.

For more information on Thermal Solutions 2007, including paper presentations, short courses and exhibitors, please visit the conference web site at www.thermalsolutions.org or contact Snell Infrared directly at 1-800-636-9820.

Thermal Reflections

John Snell, ASNT NDT Level III
President – Snell Infrared

Like many other states, Vermont set a record peak for electric usage this past August. Shockingly, we also became a summer peaking state for the first time in history!

As you read this newsletter we have moved on into autumn with its cooler nights and thoughts of the long winter heating season. Regardless of the season or where you live or even your political point of view, it becomes more and more difficult to ignore the probable impact humans are having on the Planet.

I have always seen thermography, in large part, as vital to the conservation of the Earth's resources – whether energy, equipment, product, or people. When you consider it this way, the impact thermographers have had over the years has been significant. It is, however, perhaps time to ask ourselves "What more can I do?"

I recently replaced my 25-year old refrigerator. It still operated perfectly but I knew that more efficient models were available and I felt replacing it was something I should do. I was pleasantly surprised to notice a $20 reduction in my next month's power bill. At that rate I will pay for the new appliance in about two years – not a bad return on my investment! (Of course, had I simply moved the old refrigerator to my garage for a "spare" all my efforts would have been negated!)

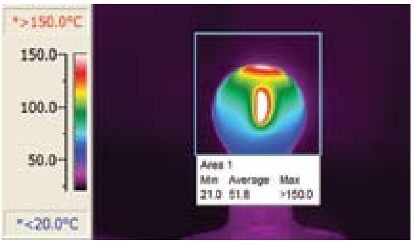
John Snell

On a more global scale we can talk about how such actions reduce our "carbon footprint" providing a greater return for the whole Planet. In fact, studies suggest that replacing all old refrigerators and freezers in the United States with energy efficient ones would immediately replace the output of power plants producing 40 gigawatts of electricity, half of which currently comes from carbon-intensive coal-fired facilities.

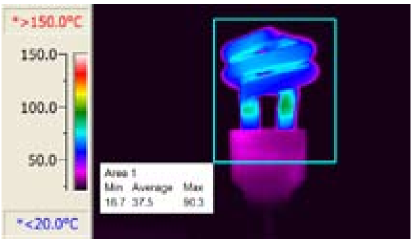
Well over a million new homes will be constructed in the United States in the next year. Thermography is playing a significant role in helping to ensure they are energy efficient with effective insulation and reduce air leakage rates.

More than half the electrical energy in the world is consumed in buildings. A large portion of that is for lighting. The infrared images below show the thermal difference between two light bulbs. Both provide exactly the same amount of light but the incandescent bulb uses four to five times as much energy, much of it wasted as heat, compared to the compact fluorescent light (CFL). Investments in reducing energy usage not only impact energy use and carbon output but also help to control the need to build more peak generation capacity.

These are just a couple examples of things each of us can do to make a difference that will affect the world our children and our grandchildren will live in. As thermographers I'm sure you can find other ways to impact the thermal future for the better.



Incandescent Bulb



Compact Fluorescent Light

Think Thermally® is a publication of Snell Infrared, providers of training, certification and support services for thermographers.

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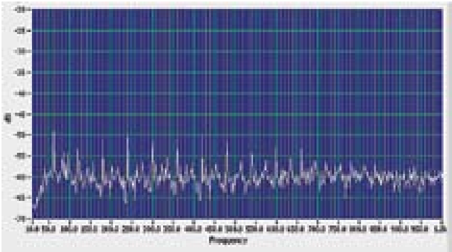
Successfully Correlating Two Types of Technologies

Correlation of technologies can be critical in optimizing the results of PdM inspections. At Snell Inspections we correlate the results of different technologies when appropriate. Mechanical anomalies can be verified with vibration analysis or contact ultrasound. Steam trap routes can be improved by identifying suspect trap operation and confirming the condition with contact ultrasound. High resistance connections identified during motor circuit analysis can be located with infrared. The list goes on.

When making recommendations on findings identified by a PdM technology, the proper fault description, repair recommendation and severity can be greatly improved by reviewing the results of a second or third technology that has been applied to the asset.

Snell Inspections routinely uses ultrasound on electrical enclosures before allowing their escorts to open panels or doors. This is done primarily as a safety precaution for the thermographer and the escort. During a recent infrared inspection a member of the Snell Inspections team, Bill Mountford, identified what he suspected to be corona discharge during this pre-inspection with ultrasonics.

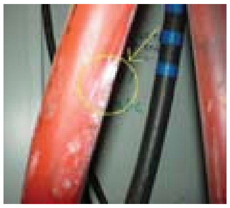
While "listening" around the enclosure of a 23KV Feeder Main Disconnect, Bill heard the familiar sounds of corona discharge. When using either a scanning module or a long range module, it should always be tuned at 40 kHz to get the greatest sensitivity to detect the corona in the air. There are no ultrasonic frequencies that are characteristic of corona. This equipment did have infrared windows but corona does not typically create abnormal heating and during the infrared portion of the inspection no anomalies were identified through the windows. Bill recorded the sound file for further analysis in his software. Here is the representative waveform:



It is important to note that corona has the following characteristics:

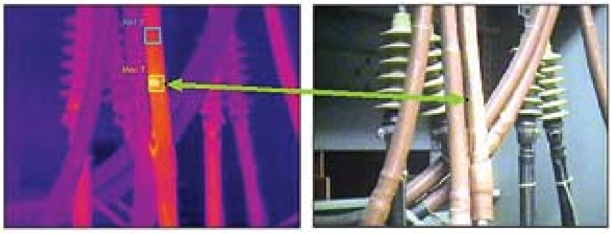
- In the Spectrum mode, it has rich harmonics of 60 Hz with frequency content between the peaks. You should look at the spectrum below 1 kHz.
- In the Time Domain mode, you will see many peaks come out of the noise floor.

With these results plant management was contacted to gain approval for access to the high voltage equipment. Additionally the electrical escort and thermographer dressed in Personal Protective Equipment (PPE) to conduct further testing on an open cabinet.



The back cover of the electrical enclosure was opened and the results of the original ultrasonic scan were confirmed. There was a visual indication of corona (presence of white residue or powder) and a thermal hot spot was detected thanks to thermography.

The thermographic image below is B phase approximately 16" below the termination end and about 18" below the IR window (out of the Field of View provided by the infrared window). The adjacent visual image shows the build up of nitric acid, (HNO_3). It was noted that several of the leads were very close to each other and in two places the leads were touching.



Label	Value
Max T. : max	85.7°F
Ref T : max	77.3°F
Delta T	8.40°F

IR information	Value
Date of creation	6/14/2006
Time of creation	6:14:22 AM
File name	G0614-01.img

The following recommendations were made:

- Clean the terminal ends.
- Install another layer of shrink tube insulation over the areas of concern.
- Install fiberglass unistrut bracing to separate the leads.
- Consider adding additional infrared windows to the enclosure.

After these repairs were made and power restored, a re-qualification survey was completed using ultrasound and infrared. No abnormal heating was observed and a reading of 0dB was recorded indicating a successful repair. Without utilizing multiple technologies this opportunity may have been missed.

Snell Infrared Conducts Training for Shuttle Mission

Thermal Imaging Utilized for Non-Destructive Testing of Orbiter

In case you've been away from earth the past couple of months (maybe visiting the former planet Pluto) you probably heard that NASA's Space Shuttle mission from earlier in the summer was a resounding success. If you followed the mission closely you know that a hand-held infrared camera was on board and that several experiments were conducted using the "IR spacecam." What you probably did not know is that Snell Infrared, along with Thermal Wave Imaging (TWI) of Ferndale, Michigan, provided the infrared training for that portion of the mission.

After the Columbia accident over three years ago it was suspected that foam from the external fuel tank had come loose and impacted and damaged the leading edge of the orbiter wing. This surface is composed of a composite material called reinforced carbon-carbon (RCC). NASA needed a way to inspect the RCC in space so that if a problem was found a repair could be made in space before re-entry.

In order to bring NASA and the United Space Alliance technicians up to speed on the theory and application of thermal inspection of the RCC, Rob Spring of Snell Infrared and Steve Shepard of TWI conducted a series of LI and LII training classes at Kennedy Space Center during 2004. This methodology is now the standard inspection for RCC panels before every flight of the Space Shuttle.

> **"If you followed the mission closely you know that a hand-held infrared camera was on board and that several experiments were conducted using the 'IR Spacecam.'"**

NASA engineers had two problems to solve; how to inspect the RCC on earth to verify there were no subsurface flaws resulting from the previous flight and how to verify there was no damage caused during launch that would prevent a safe return to earth. For the pre-flight inspection they chose pulse active thermography using a system designed and manufactured by TWI.

In pulse active thermography, high intensity light is used to induce a thermal transient into the composite panels. High speed digital thermal images are captured and analyzed using sophisticated image processing software. The theory behind this method is that subsurface structural anomalies will disrupt the even flow of heat into the panels and a surface temperature change will present itself.

The purpose of having a camera on the Discovery flight was to conduct EVA (extra vehicular activities) experiments on several composite samples to determine if subsurface flaws could be detected. Also a variety of radiometric measurements were scheduled to be made on interior components of the orbiter. Prior to Discovery's flight, Rob Spring conducted another training session at the Johnson Space Center. The purpose of this course was to train the mission imaging specialists who worked with the astronauts to develop procedures used during the flight.

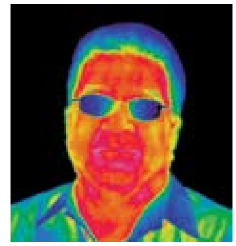
Because a pulse active system was not practical for EVA applications, another system had to be found to inspect the RCC panels in space. During the Discovery's summer flight several methodologies were employed after launch, including high definition visual and laser inspection directed from the robotic arm.

Infrared analysis was only to be evaluated for its functionality on this flight. Instead of using a high intensity lamp to induce a thermal transient into the panel, the Astronauts relied on the sun to heat the part and then quickly shaded it. According to reports this method worked well and Snell Infrared is proud to have participated in this groundbreaking mission.

Liftoff of the Space Shuttle Discovery (STS-121) on July 4, 2006. Image courtesy of NASA.

So You've Gone to Training... NOW WHAT!?

Dan Thurmond
Instructor, Snell Infrared



You, your tradesman or technician just came back from Level I and are ready to take on the world. While these mountaintop experiences are invigorating, reality quickly sets in and you realize you're the only one "pumped up." So, now what do you do? How do you keep this surge of interest and expectation from being lost in the pressures of the normal workplace routine?

I would like to share some practices that might help you take these initial steps in getting a new or stalled program off the ground. The decisions you make at this early stage will often determine whether you will have an active or continuously struggling infrared program six to twelve months after your return.

The old adage, "use it or lose it," strongly applies to the materials covered in an infrared training course as there is much packed into this short period of time. The most counter productive path to take is to place the camera on a shelf for a week or more while you or others plan the direction of your program. Instead, on the first day back, get your camera out of the case and start scanning equipment (starting with those that are most critical or pieces with a history of failure) and start saving images.

This will begin to clarify and reinforce the concepts that were introduced in the classroom such as camera operation, emissivity, reflection and resolution. It also helps maintain your new level of interest and enthusiasm.

I find one of the best ways to strengthen my own understanding of a subject is to share that knowledge and excitement with others. Don't be afraid to load the camera's software and start making reports. One of the fastest ways to gain experience is to either perform your own repairs or ask for detailed feedback from those who complete the work order. Complete the circle by taking follow-up images to show how the repair was accomplished. Finally don't be shy or too humble. Make sure others are aware of your success.

With a few exceptions, most of you are going to need help and support to launch a sustainable infrared program. Managers and supervisors need the cooperation, support and commitment of the trades as much as the technicians need support from management. Make sure you select the right personnel for your team. Just one person not willing to commit will be an anchor and cause contention between everyone. Gather everyone and have an open and honest discussion about their role, commitment, support, vision and goals for the program. If you do not explore and unify these expectations now it will be much more difficult later.

Infrared really provides an opportunity for everyone to win; less equipment failure and downtime as well as the excitement of adding a new and challenging technology to your job. So for now, first and foremost get behind camera and go to work. Then find the right players and start building a committed infrared team.

Snell Infrared Introduces New Webinar Service

Snell Infrared is pleased to announce a new webinar service for thermographers who would like to supplement their standard infrared training. These brief online educational seminars range from 1-2 hours in length and allow maintenance professionals to expand their infrared knowledge base without having to travel hundreds of miles or miss valuable time at their plant or office.

This new service will offer live, regularly scheduled, webinars hosted by a Snell Infrared instructor. Each seminar will feature real-time instruction as well as an interactive question and answer session. Pre-recorded webinars are also planned and will be available for purchase 24 hours a day.

Starting in 2007, Snell Infrared will offer a regular series of webinars with topics that range from introductory lessons to more advanced applications of thermography. Look for additional subjects to debut online in the coming months.

Anyone with a computer, internet access and telephone connection can participate (minimum 56k modem required for internet access). For more information, including a list of upcoming webinars, please visit http://snellinfrared.webex.com or contact Snell Infrared directly at webinars@snellinfrared.com.

Greg McIntosh, P.Eng.,
Managing Director, Snell Infrared Canada

Instantaneous Field of View (IFOV)

Understanding Instantaneous Field of View (IFOV) is a core component of a Snell Infrared Level II course. This article is an overview of this critical infrared camera specification.

Instantaneous Field of View, as defined by most camera manufacturers, is the theoretical spatial resolution of one detector cell determined by the formula: (17.453 x lens angle) / number of detectors. (17.453 is the number of milliradians per degree of angle. A radian is the radius of a circle laid on the circumference so 2 pi radians = 360 degrees or 1 radian = 57.3 degrees = 1000 milliradians. 1000/57.3=17.453)

Take, for example, a 320 x 240 camera with a 24 x 18 degree lens (horizontal x vertical degrees). The theoretical Horizontal IFOV should be approx (17.453 x 24)/320 = 1.3 milliradians. Notice that the vertical resolution is exactly the same: (17.453 x 18)/240 = 1.3 milliradians.

IFOV is a theoretical value however. The practical spatial performance that can be achieved by a camera is determined by a test called 50% Slit Response Function (SRF). The test is conducted by observing a blackbody through a vertical slit of adjustable width. The slit is initially set wide enough such that the reading on the blackbody is at the maximum signal. The slit is then narrowed until the signal drops by 50%. The width of the slit is measured and divided by the distance (and multiplied by 1000) to obtain the SRF value in milliradians. IFOV = (object size/distance) x 1000.

50% SRF test results, however, are seldom specified by any manufacturer as it may be significantly worse than the theoretical IFOV value for detection. There are many variables in why SRF values may vary between cameras with the same IFOV, such as lense quality, detector design, and low frame rate (actually or through frame averaging) when the camera is not held steady.

> **"Just because you can detect an object does not mean that you can measure it correctly."**

Image averaging improves the signal to noise ratio (image quality) and may, depending on the type of noise, improve the sensitivity of the system. But unless it is tripod mounted, any slight movement by hand-holding will effectively blur the image. Since IFOV is the field of view of one pixel, then any type of averaging (mathematical or movement within the time of one frame) effectively averages the size of object associated with one IFOV with that of the surroundings.

Just because you can detect an object does not mean that you can measure it correctly. A specification for measurement performance is IFOV measure value, which is typically much greater (worse) than IFOV or 50% SRF. The test for IFOVmeasure is a 95% or 98% response. This is done exactly in the same fashion as the 50% SRF test except the drop in signal is typically 98% or 95% which represents a 2% or 5% drop in signal. (Note that a particular drop in signal does not necessarily mean that same % drop in temperature.) A 2% drop in signal often results in a nominal (but measurable) drop in temperature.

Very few manufacturers will publish actual tested IFOVmeasure values but if you attend a Snell Infrared LII class we have students test their cameras for IFOV measure. In a recent LII class we found two different makes of cameras to have IFOVmeasure values about 3x larger than the IFOV values. In one class, one imager tested (consistently) more than 6x larger than the IFOV value.

SRF testing (and good measurement practice in general) should also be conducted in the center region of the image. Lenses, depending on their quality, may distort the image near the edge and wide angle lenses in particular will have a larger effective IFOV near the edges.

Image IFOV, sensitivity, frame rate, and lense quality are all interrelated and tested through different functions depending on what you want to achieve from your camera (spatial resolution, measurement resolution, sensitivity, accuracy, uniformity).

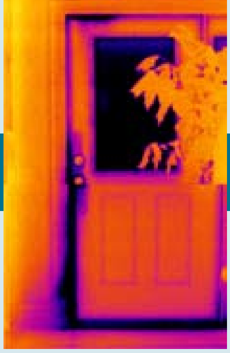
The shape of the object may affect the IFOV performance, however, many of our measurements are on objects that have long aspect ratios (such as wires, fuse clips etc.) making a slit response test a fair evaluation method. If however you are detecting or measuring small circular objects, you probably should conduct a circular (aperture) test rather than a slit test.

Also the 98% SRF test for IFOV measure is very demanding so you do not see as much difference in the affect of object shape than the less demanding IFOV test which is typically a 50% SRF test. Here there can be big differences in signal falloff depending of the shape and orientation of the object.

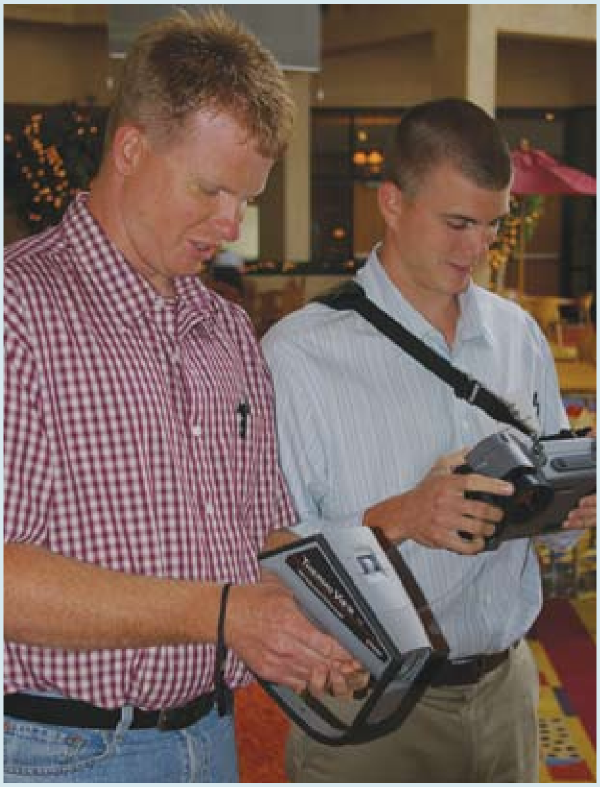
To detect an object which is 2.5mm (0.1") at 50cm (approximately 20") requires a 5mrad IFOV. Almost all

Continued on back page

2007 North American Training Schedule



LEVEL I	DATE	$1,595
Norfolk, Virginia	January 8-12	
Toronto, Ontario	January 29—February 2	
Phoenix, Arizona	February 5-9	
Tampa, Flaorida	March 12-16	
Toronto, Ontario	March 12-16	
Dallas, Texas	April 9-13	
Cincinnati, Ohio	April 16-20	
Toronto, Ontario	April 30—May 4	
Kansas City, Missouri	May 14-18	
Minneapolis, Minnesota	June 4-8	
Montreal, Quebec (French)	June 4-8	
Toronto, Ontario	June 18-22	
Montpelier, Vermont	July 16-20	
Toronto, Ontario	August 13-17	
San Diego, California	August 13-17	
Charlotte, North Carolina	September 10-14	
Manchester, New Hampshire	September 17-21	
Toronto, Ontario	September 24-28	
Indianapolis, Indiana	October 15-19	
Toronto, Ontario	November 5-9	
San Antonio, Texas	November 5-9	
Montpelier, Vermont	December 3-7	
Toronto, Ontario	December 10-14	



LEVEL II*	DATE	$1,595
Phoenix, Arizona	February 5-9	
Tampa, Florida	March 12-16	
Indianapolis, Indiana	April 23-27	
Toronto, Ontario	May 7-11	
Charleston, South Carolina	June 4-8	
Montpelier, Vermont	July 16-20	
Montreal, Quebec (French)	September 10-14	
Cincinnati, Ohio	September 10-14	
San Antonio, Texas	November 5-9	
Toronto, Ontario	November 12-16	

LEVEL III BEST PRACTICES	DATE	$1,595
Montpelier, Vermont	June 5-8	
Toronto, Ontario	October 22-25	

BUILDING SYSTEMS*	DATE	$1,095
Charlotte, North Carolina	February 27-28	
Toronto, Ontario	April 18-19	
Chicago, Illinois	June 12-13	
Cincinnati, Ohio	September 20-21	
Montreal, Quebec (French)	November 21-22	
Toronto, Ontario	December 6-7	

ELECTRICAL APPLICATIONS*	DATE	$1,095
Toronto, Ontario	February 19-20	
Charlotte, North Carolina	March 1-2	
Indianapolis, Indiana	April 10-11	
Montreal, Quebec (French)	June 14-15	
Cincinnati, Ohio	September 18-19	
Toronto, Ontario	November 29-30	

MECHANICAL EQUIPMENT*	DATE	$1,095
Toronto, Ontario	February 21-22	
Indianapolis, Indiana	April 12-13	
Cincinnati, Ohio	September 20-21	

NON-DESTRUCTIVE EVALUATION OF MATERIALS

Available. Please Call.

* Level I or Introduction to Infrared training required.

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The latest issue of ThinkThermally

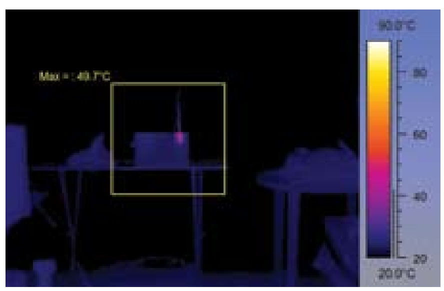
Lessons From the Lab

Continued from page 6

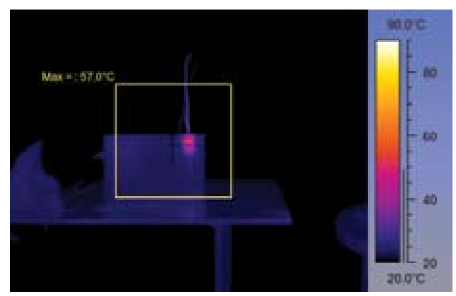
instruments out there can achieve this. If you want to measure 2.5mm at 50cm it will require a 5mrad IFOVmeasure. This is very typical of the performance of most 320 x 240 systems with their standard lens or many 160x120"s with a 2x lens.

The bottom line is evaluate your camera for your application (object size and distance) and know both the IFOV and IFOVmeasure that you can actually achieve with your camera. If you don't work within your practical IFOV limits, you run the risk of missing a problem. If you don't work within your practical IFOVmeasure capabilities, you run the risk of measuring the target incorrectly.

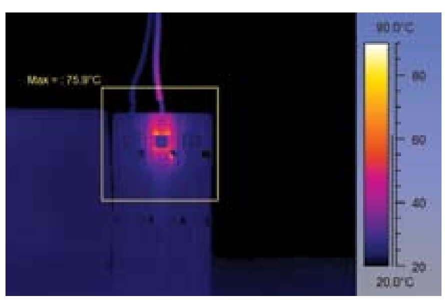
For further information on these topics which includes such things as noise equivalent temperature difference (NETD), modulation transfer function (MTF), minimum resolvable temperature difference testing (MRTD), and slit response function (SRF) consider attending at least a LII and preferably a LIII or R&D class.



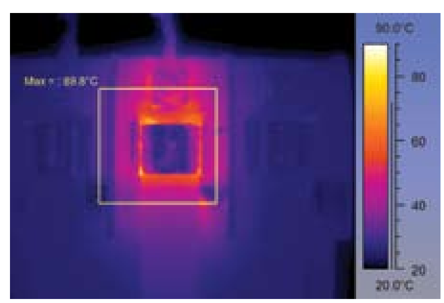
6m (@ 20 ft.) Tmax = 49.7˚C



3m (@ 10 ft.) Tmax = 57˚C



1m (@ 3 ft.) Tmax = 75.9˚C



.3m (@ 1 ft.) Tmax = 89.8˚C

This IFOV measurement demonstration shows how the maximum temperature of the area box increases as the distance to the target decreases from 6m (20 ft) to .3m (1 ft). Please note: Images taken in a laboratory under controlled conditions. Always respect safe approach distances while out in the field.