Think Thermally®

December 2004

Practical news for practicing thermographers

See inside:

Need An Answer?

Ask an Expert at Thermal Solutions® 2005

Thermal Solutions participants have asked us over the past few years to increase the number of educational opportunities available at the conference. As part of that effort, Snell Infrared is pleased to announce the addition of a new session called *Ask the Expert* which will debut at Thermal Solutions® 2005.

Ask the Expert gives conference attendees the opportunity to participate in open discussions (either individually or in small groups) with a remarkable collection of Expert thermographers in their area of expertise. The Experts will staff table-top exhibits where they will use a collection of images, props and demonstrations to illustrate "best practices" about their topic or application.

The Experts will also respond to a series of questions with samples of those responses (including images) to be placed in the upcoming Thermal Solutions® *Proceedings*.

The following is an overview of the presenters and topics planned for this year's *Ask The Expert* session at Thermal Solutions®:

Jeff Backer
Snell Thermal Inspections
Heat Exchanger Inspections

Everyday Jeff Backer deals with various types of heat exchangers in his capacity as a thermographer for Snell Inspections. Jeff is knowledgeable and very willing to share what he has learned about using thermography to diagnose performance issues in this piece of critical equipment.

Fred Bartel
Snell Thermal Inspections
Inspecting Low-Slope Roofs

They say "you can't teach an old dog new tricks". Fred Bartel is someone who proves that saying wrong. This "old dog" will share with participants his extensive experience inspecting roofs of all sizes. With a strong construction background and the determination of a Marine, Fred has worked hard over the years to develop a professional understanding of what is needed to conduct a roof inspection.

Budd Beatty
JELD-WEN
Inspecting Exterior Insulation & Finish Systems (EIFS)

EIFS style buildings have developed significant problems in many parts of the country due to the high moisture-related failure rates as well as poor detailing and maintenance. Through his work with JELD-WEN, a major manufacturer of windows, Budd has become an expert on diagnosing problems in EIFS buildings.

continued on page 2

Need an Answer? *continued from page 1*

David Brown
InspectorTools
Moisture and Mold in Buildings

For those who are interested in learning more about the rapidly growing application for thermography in the "restoration" industry. David Brown will discuss his knowledge of applying infrared to this unique application as well as talk about the supplementary moisture tools which are used by inspectors today.

Norm Garver
HSB Inspections
Inspecting Pulp and Paper Mills

Papermills have a great deal of unique, as well as critical, mechanical equipment that can be readily inspected with thermography. In addition to the infrastructure of the pulp and paper making processes, there are considerable opportunities to monitor the product itself.

Geoff Generalovic
Dofasco, Inc.
Using IR in a Steel Mill

Even if you never plan to tour a steel mill, don't miss this exciting opportunity to speak with Geoff Generalovic. Participants will leave this discussion with a new appreciation for how work is done systematically and intelligently to achieve remarkable results in this type of process.

Jon Grossman
Hi-Tech Inspections, Protec USA
Thermography and Pest Control

Jon Grossman has been involved for a number of years with the rapidly growing application of thermography to locate pests in buildings. While insects are often associated with moisture intrusion, this type of work is not as simple as it seems. Even though this application is not for everyone, speaking with this Expert is a great place to start.

Roy Huff
Snell Thermal Inspections
Inspecting Motor Control Centers (MCCs)

Roy Huff is a gifted electrical engineer, an ASNT Level III certificate holder, head of Snell Thermal Inspections and an occasional Snell Infrared instructor. Participants will learn about the typical components found in a Motor Control Center and what they should look like thermally.

Charlie Jones
Snell Thermal Inspections
Inspecting Electrical Bus and Distribution Systems

Charlie Jones' persistence in developing inspection techniques for electrical bus systems has helped literally dozens of other thermographers improve their work. Participants will leave this Expert session ready to get results inspecting their own bus work as well as related portions of the power distribution network.

Greg McIntosh
Snell Infrared - Canada
What's Going On Inside Your Camera?

Thermographers often take for granted what goes on inside their IR camera. Greg McIntosh is someone who throughout his career has seen the insides of countless systems. In addition, he has also designed cameras as well as helped manufacturers in the development process. Come learn more about terms like non-uniformity correction, calibration, detector response and measurement repeatability.

Jim McLeod
Mississippi Power
Pad-Mount Transformer Inspections

Jim McLeod will show participants the various thermal signatures one can expect to see with Pad-Mount Transformers as well as explain how to distinguish among them. Jim will also discuss why problems occur and what you can do to help prevent them.

Phil McMullan
Thermo-Scan
Concrete Masonry Unit Building Inspections

Phil McMullan is active on many professional fronts, including helping develop standards for the inspection of concrete masonry unit buildings. Phil will share his extensive knowledge and experience with attendees about how to locate structure reinforcing as well as insulation in this widely-used type of construction.

Mark Nichols
ConocoPhillips
Refractory Inspections

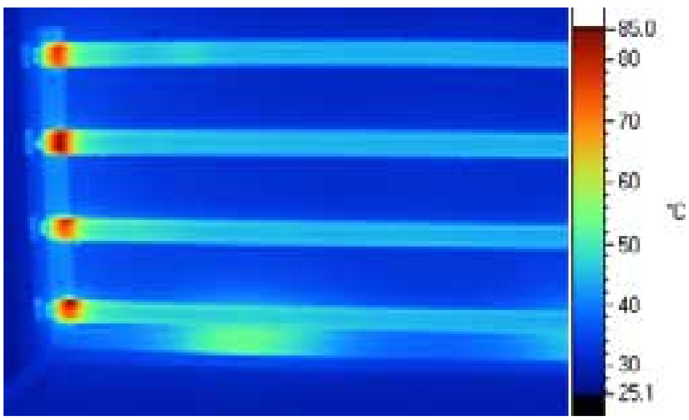
Production in a petrochemical plant or refinery is driven by thermal processes that

continued on page 3

Hot Bulbs – Cool Tubes

We are often asked during our Level I classes why fluorescent light bulbs are so much cooler than incandescent light bulbs. This question usually arises after we have shown Planck's curves for the spectral distribution of radiation emitted by a black body surface as its temperature changes. The curves show a blackbody surface not only emits heat but that it is also emitting visible red light when its surface temperature approaches 1300˚F (704˚C). Light bulbs glow because the filament is hotter than this temperature. But how do Planck's curves relate to fluorescent bulbs which have no filament?

While the visible spectrum is generally defined as electromagnetic wavelengths from .4–.7 microns (400–700 nanometers), it actually extends out to wavelengths as large as .75 microns. At what point humans can actually see electromagnetic radiation can vary slightly from person to person. Experiments with four people in a darkened room showed they could visibly detect the dull red glow of a heating stove burner element when it reached a temperature of between 940˚F–960˚ (504˚–515˚C).



As objects increase in temperature, they give off additional wavelengths of electromagnetic radiation, including heat and light. (Of course, the majority of the energy is emitted as heat). As a surface reaches approximately 10,340˚ (5,727˚C), the light is a very bright, light yellow, similar to sunlight. Sunlight contains all wavelengths of visible light, from violet to red, combined into what we call "white light."

Incandescent light bulbs radiate similar blends of visible wavelengths but because the filament is cooler than the sun there are

continued on page 7

Need an Answer? *continued from page 2*

are contained within a high-temperature refractory. When the refractory fails, the process—and sometimes personnel safety — can be jeopardized. Mark will share his valuable experiences of using an infrared camera with this application.

Richard Strmiska
Sumter Electric Cooperative
Inspecting Outdoor Substations

Participants will not be disappointed with this presentation because of Richard's years of experience in this industry. He has seen just about everything there is in substations and is looking forward to speaking. Bring your questions and concerns and leave with input from a true Expert.

Harold Van De Ven
Snell Infrared
Motor Coupling Inspections

Over the years, Harold Van De Ven has looked at literally thousands of motor couplings of all different types throughout a variety of industries. You won't find a more enthusiastic, knowledgeable Expert on this topic anywhere.

Larry Welch
Ford Motor Company
Inspecting Robot Welding Machines

Since they rely heavily on water-cooled power lines, robot welding machines can be very susceptible to heat related failures when flow is restricted. The result? Poor quality welds, damage to the welder components (mainly hoses, cables and welding tips), as well as safety hazards to those working around them.

Register for Thermal Solutions®
January 24–27, 2005 Clearwater Beach, Florida
http://www.thermalsolutions.org

Inspecting Building Systems with Thermography

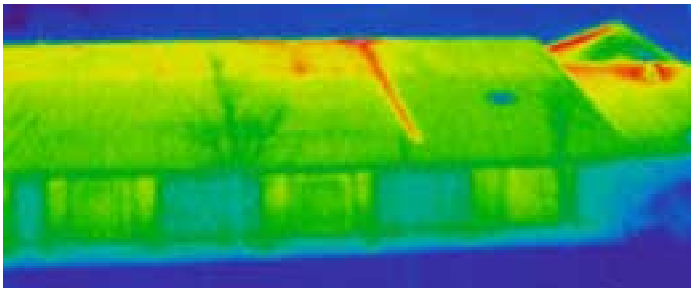
Buildings of all sorts, from homes to high rises, can be troubled by problems that are often difficult to diagnose and resolve. These include, among other items, excessive energy use due to performance issues in insulation; too much air-leakage; moisture damage due to leaks; condensation or ice dams; ice and sun damage to roofs; poor HVAC distribution or performance; verification of construction details or buildings performance and sick building syndrome.

All too frequently the problems, as well as their causes and consequences, simply cannot be seen until after costly damage has been done. Infrared thermography is an invaluable tool that allows us to see the otherwise invisible thermal signatures of a building. When properly used, thermography enables building owners, architects, contractors and inspectors to locate problems, verify building performance and validate solutions. The result? Significant savings, improved comfort and safer buildings!

How Can Infrared Help Solve Building Problems?

Under the right conditions, most building components or problems exhibit unique thermal patterns that can be diagnosed by a qualified person. While the infrared systems themselves are quite easy to operate, the tasks of interpreting the image, understanding the problem and finding a solution are more difficult. Because of this, thermographers often work closely on a team with building specialists, architects or contractors. There are two keys to successfully using thermography. First is understanding what thermal patterns are associated with the problems being studied, and second, knowing when those patterns will become visible in the infrared image.

This home clearly has missing insulation in the front wall and, on either side, a poor definition of the thermal boundary. Over the life of the building, these problems will cost thousands of dollars and result in a drafty, uncomfortable house, perhaps with serious moisture problems.



Excessive heat loss and poor ventilation resulted in costly ice damage to this commercial roof.

What Are the Primary Applications for Thermography?

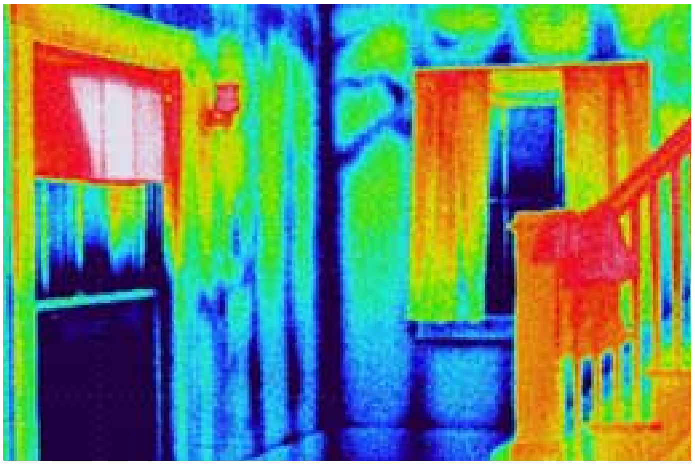
In the thirty years thermography has been used to solve building problems, a number of major applications have been developed. These include:

Insulation checks

Missing, damaged or non-performing insulation will stand out clearly in a thermal image when there is at least a 18°F (10˚C) temperature difference between the conditioned space and the outside air. The inspection is done from both inside and outside, with the best results usually gained from inside where the thermal patterns are more distinct. When work is done in the daytime or early evening, the impact of solar loading must be considered. The effects of the sun can remain on a wall six to eight hours after sunset. Wind must also be reckoned with as it can quickly eliminate the thermal difference on an exposed surface. Keep in mind that wind can also enhance thermal patterns, especially those associated with poor performance of insulation.

It is essential to know the type of insulation in the building as well as construction details, including how the insulation was

continued on following page



When conditions are right, it is possible to locate missing or damaged insulation, such as this poorly installed injected foam in a residential building.

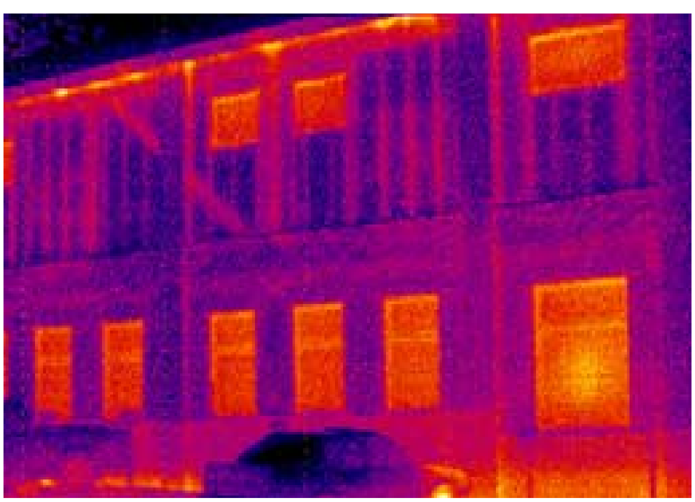
installed. It is not unusual to find insulation in place but not performing up to specifications. The costs of poor insulation performance are numerous. In addition to excessive energy consumption, there may be costly freeze-ups of water pipes or sprinkler systems; health issues associated with mold growth in cold spots and damage to roofs and interiors caused by ice dams and water intrusion.

More and more insulation contractors are using thermography to better understand the construction of existing buildings before they begin work or, in some cases, before they bid the job. The thermal image provides them with a high-quality "map" of both the structural elements and any insulation that may already be in place. With this tool their work is more accurate and cost-effective. Contractors who inject foam insulation are finding thermography allows them to see "fill levels" during installation, expediting their work and assuring it is of the highest quality.

Air leakage location

Air leakage can account for up to half of the energy consumed to condition buildings. Of course, adequate air exchange is essential for health and safety, but most buildings have a far higher rate than is necessary. The root cause is poor design and/or construction, which allows air to move through the thermal perimeter. This can be as straightforward as a failed door weather seal or as complex as an air pathway through a plumbing chase in an interior wall or ceiling plenum. The leakage pathway is often complex and—without infrared—difficult to visualize.

Air leakage can be seen under natural building conditions, but the results can be confusing and incomplete. Inspections are best conducted when air flow is directed and controlled. This can be easily accomplished with exhaust fans, a blower fan door, or—in larger buildings—by temporarily altering the HVAC system to create a negative pressure inside. During the heating season, sites of air infiltration appear cooler as cool outside air results in a cooling of the interior surfaces.



All the framing and insulation is clearly visible in this commercial building. Normal pressure differences on the top floor result in air leaking past the envelope through various pathways.

Moisture Intrusion

As building designs and techniques produce tighter thermal envelopes, moisture (from leaks or condensation) has created more and more problems. Locating moisture with thermography can be simple because it has both a high thermal conductivity and a high heat capacitance. The growing popularity of buildings using Exterior Insulation and Finish Systems (EIFS) has been accompanied by numerous cases of moisture-related structural damage and health problems.

Although often attributed to the performance of windows, water typically intrudes where sealing or flashing systems were inadequate or have begun to fail. Sometimes this can occur around the windows, but there are many other possibilities. Once water intrudes, moisture is trapped under the relatively impervious foam. In warm climates, decay of structural wood elements can be shockingly rapid. Thermography is an invaluable tool to locate moisture in EIFS systems. Inspections are best conducted in the early evening from the outside after a sunny day with little or no wind. It may also be possible to locate moisture from inside during cooling or heating conditions.

In metal buildings and mobile homes, moist air can bypass an ineffective moisture-retarder and condense in cooler wall and ceiling cavities. The water is typically mistaken for leakage. Damage includes structural deterioration, mold growth and reduced insulation values. In commercial high-rise buildings, similar problems can lead to brick spalling and fastener corrosion.

One of the fastest-growing new uses of the technology is in the "restoration" business. When buildings are damaged by floods, broken water lines or other sources, insurance companies are often involved in a settlement. Before the claim can be settled, all parties must be assured the building has been restored to a dry condition to prevent further damage from residual moisture, mold and decay. Thermography, often in conjunction with contact moisture probes, is being widely used to provide this documentation.

HVAC performance

HVAC systems can be plagued by design and installation problems resulting in excessive energy use and/or uncomfortable (or even dangerous) buildings. Thermography helps building specialists visualize the otherwise invisible impact of this poor performance as indicated by excessively hot or cold areas. Once these have been located, the root cause can be determined; these may include reversed or misdirected airflow or supply air short circuiting into return ducts.

Verification of Construction Detail

No area of application is more important these days, particularly in commercial buildings, than the verification of construction details and performance. Thermography is being used with great success to verify bond beams and placement of reinforcement in concrete masonry unit (CMU) walls as well as structural

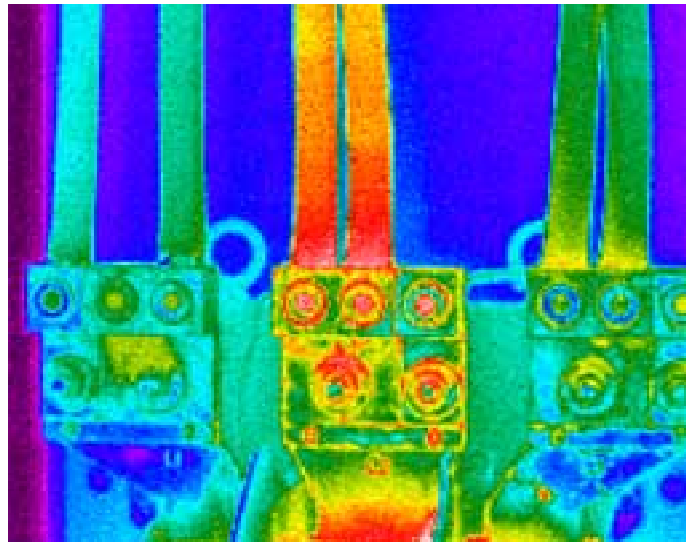
continued on page 7

Beware Of Thermal Gradients

Many thermographers struggle with some of the basic tenants of radiometric measurements before they become accomplished and experienced thermographers. In many cases, there can be a considerable difference between the surface temperature of the object you are inspecting and the internal temperature which is associated with the anomaly. In situations where surface heating is indirect, this difference is commonly referred to as a "thermal gradient."

Good examples of extreme thermal gradients are enclosed bus or oil-filled devices. The reason is that the thermographer is examining an area that is not "thermally connected" to the close proximity where the heat is being generated. By way of example, the voltage regulator *(image at left)* was only about 10°F (6˚C) warmer than the voltage regulators for the other phases. Yet inside the warmer regulator the contacts had melted *(see image below)*. This means the internal temperatures were in excess of 1800°F (982°C). Even when we have a direct view of a component, such as the bolted connections *(image at upper right)*, a thermal gradient of hundreds of degrees may exist between what we record with the thermal imager and the small area where high resistance heating is actually occurring.

The size of a thermal gradient depends on the complex relationships among the conductive and convective characteristics of the component, its capacitance and diffusivity, the emittance of the surface and the surrounding ambient environmental influences. Due to these interdependent complex relationships, it is not easy to even estimate the actual size of the thermal gradient in most fieldwork situations.



Simple everyday examples of this phenomenon abound. Think about thermal gradient the next time you put a foam insulating jacket around a cold drink *(image below)*, grab the handle on a hot cup of coffee or use a pot holder on the handle of a hot pan. What we feel on the outside surface of these items is what the camera would image and measure, and it can be vastly different from what is happening inside.

Thermal gradients, among many other subjects, are discussed extensively in all of our courses. Thermal gradient is one reason we see many thermographers make mistakes when prioritizing their finds by using temperature as the sole criteria. While it is not an easy task becoming a skilled thermographer, proper training and experience can provide a solid base for professional development.

Hot Bulbs — Cool Tubes, *continued from page 3*

fewer violet wavelengths and more red ones. This explains the warm glow of these incandescent bulbs.

Fluorescent light tubes give off light quite differently than incandescent bulbs. A high voltage arc is pulsed down the tube, which is filled with an inert gas and, typically, a small amount of liquid mercury. The arc vaporizes the mercury, which then emits radiation, predominantly in the ultraviolet part of the spectrum. A phosphor coating on the inside surface of the tube absorbs this UV radiation and re-emits it as visible light. The color of a fluorescent tube depends mostly on what type phosphors are used rather than being related to the tube temperature. This process is much more efficient than incandescent bulbs because the tube gives off light without having to be hot.

One other issue that confuses some people is that fluorescent tubes are given a color temperature index in Kelvin. Kelvin, as all trained thermographers know, is a unit of temperature based on the absolute scale. The tube rating is based on what color light an incandescent surface would emit at the rating temperature. It is merely a convenient way of categorizing the color of the light given off by the fluorescent tube and does not have anything to do with how hot the tubes actually are.

Many new thermographers think that turning off the lights, whether incandescent or fluorescent, will improve the thermal image by reducing reflections. Such is not the case! The camera will still see infrared radiation, whether from a warm bulb, a cooler tube, or a cold light of either kind.

Enjoy the rest of your winter. Look for the next issue of Think Thermally® this March!

Inspecting Building Systems, *continued from page 5*

elements of pre-cast, tip-up walls. How? The solid portions of these walls change temperature more slowly than the rest. The inspection can be conducted anytime the wall is in thermal transition—typically in the early evening as it cools down. The inspection is conducted during construction—rather than after completion—allowing deficiencies to be corrected prior to occupation, often with minor inconvenience and cost.

Sick-building Syndrome

When buildings are too tight or too moist, health-related problems quickly come to the forefront. Grouped together as “sick building syndrome,” these can stem from inadequate HVAC performance, moisture trapped in walls, mold growth on cold, damp surfaces and inadequate air change rates. Many of these present signatures that can be visualized and diagnosed, at least in part, with the aid of thermography.

What’s Next?

Thermography, perhaps now more than ever, continues to prove itself to be an invaluable tool for builders and building owners. Good work can not only save energy costs, but, in many cases, also the building itself! While building inspections may look simple, they are, in fact, among the most complex tasks a thermographer may ever face. It is essential that you understand building dynamics and construction as well as the basics of heat transfer and radiometrics. And, given the wide range of performance that infrared cameras can deliver today, thermographers must also learn to work within the inherent limitations of their systems. The good news is that there is every reason to expect that the use of thermography for building diagnostics will only continue to grow.

You can reach *Think Thermally®* at:

Snell Infrared
P.O. Box 6
Montpelier, VT 05601-0006

Phone: 800-636-9820
Fax: 802-223-0460

E-mail: thinkthermally@snellinfrared.com
Web Site: http://www.snellinfrared.com

Snell Infrared

2005 North American Training Schedule

Level I — $1,495

Montpelier, Vermont	January 10–14
Phoenix, Arizona	February 7–11
Tampa, Florida	March 7–11
Memphis, Tennessee	April 4–8
Toronto, Ontario	April 18–22
Indianapolis, Indiana	May 9–13
Minneapolis, Minnesota	June 6–10
Montpelier, Vermont	July 25–29
San Diego, California	August 22–26
Charlotte, North Carolina	September 12–16
Indianapolis, Indiana	October 3–7
Toronto, Ontario	October 17–21
San Antonio, Texas	November 7–11
Montpelier, Vermont	December 5–9

Intro to Thermography — $750

Toronto, Ontario	March 22–23
Toronto, Ontario	June 1–2
Toronto, Ontario	September 7–8
Toronto, Ontario	December 13–14

Research & Development** — $750

Toronto, Ontario	September 27–28

Level II — $1,495

Phoenix, Arizona	February 14–18
Tampa, Florida	March 7–11
Toronto, Ontario	April 4–8
Indianapolis, Indiana	May 9–13
Minneapolis, Minnesota	June 6–10
Cincinnati, Ohio	September 19–23
Toronto, Ontario	October 24–28
San Antonio, Texas	November 7–11

Level III Best Practices — $1,495

Toronto, Ontario	April 11–14
Cincinnati, Ohio	September 19–22

Flir Software — $750

Toronto, Ontario	January 18–19
Toronto, Ontario	June 23–24
Toronto, Ontario	September 29–30
Toronto, Ontario	December 8–9

*Level I or extensive thermographic experience is a recommended pre-requisite for these two-day Specialty Courses.

**Level I training required.

Electrical Applications* — $750

Toronto, Ontario	February 22–23
Tampa, Florida	March 14–15
Indianapolis, Indiana	May 17–18
Detroit, Michigan	September 13–14
Dallas, Texas	November 14–15
Toronto, Ontario	November 29–30

Mechanical Equipment* — $750

Toronto, Ontario	February 24–25
Tampa, Florida	March 16–17
Indianapolis, Indiana	May 19–20
Detroit, Michigan	September 15–16
Dallas, Texas	November 16–17
Toronto, Ontario	December 1–2

Building Systems* — $750

Phoenix, Arizona	February 16–17
Indianapolis, Indiana	June 7–8
Minneapolis, Minnesota	October 5–6
Toronto, Ontario	December 6–7

Products & Processes* — $750

Toronto, Ontario	June 21–22

Thermal Solutions® — January 24–27, 2005 — www.thermalsolutions.org

Snell Infrared
Training, Certification and Support for Thermographers

P.O. BOX 6
MONTPELIER,
VERMONT
05601-0006

1.800.636.9820
FAX 802.223.0460

New Training Courses and Dates Now Available for 2005