Think Thermally®

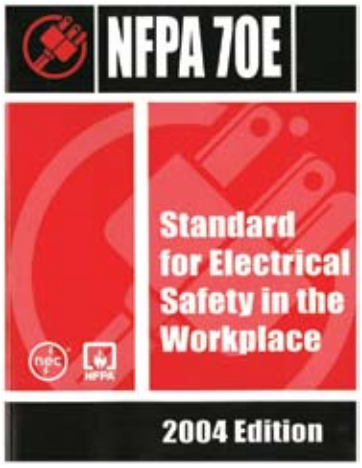
Summer / 2006

Practical news for practicing thermographers

In This Issue:

New Edition of NFPA 70E Planned

In the past five years no document has had more of an impact on thermographers than the National Fire Protection Association's (NFPA) 70E, Standard for Electrical Safety Requirements for Employee Workplaces. While the current edition (7th) of the standard does not specifically mention the task of thermography, it is clear to most that our work is included. As a result thermographers have developed protocols for inspecting energized electrical equipment including wearing Personal Protective Equipment (PPE).



All NFPA standards are periodically reviewed and updated by committees in a consensus-based process with input from the general public. The entire process is detailed on NFPA's website (www.nfpa.org) under the "Codes & Standards" tab, "Code Development Process." Copies of the current standard are also available through the website.

The committee governing the review process is a diverse group of industry experts, each of whom would welcome honest, informed input from the infrared inspection community. It is probable they will not be receptive to hearing comments such as "I hate PPE," but, in all likelihood, would consider a request to specifically define thermography as a task and address the special needs of those conducting inspections.

Thermographers who would like to comment on the standard should review the current edition and complete a comment form found in the back of the standard (Please remember, it is vital to use the format provided). Comments can also be submitted online at http://forums.nfpa.org:8081/pcsubmit/pctop.html and are due no later than August 31, 2007.

If all goes as planned, the committee will review all input and publish the new edition of 70E by October 1, 2008.

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

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Finding the Right Imager for You

Wow! Never in my dreams would I have believed the infrared camera market would change so quickly. Today there are an amazing range of choices from among some of the best systems I have seen in the twenty-five years in this business. If that isn't enough, the prices of all cameras have dropped significantly. Whether you are buying your first camera, replacing an old one or adding more to the fleet, there has never been a better time to buy a thermal imager!

Along with this good news is some not so good news. With choice comes confusion. I see some of our customers looking like the proverbial "kid in the candy store." Even worse, I think I've seen a few "evil witches" trying to lure them in!

As has always been the case, Snell Infrared doesn't sell infrared cameras. We are, of course, strong proponents of the technology and do our best to represent all products fairly and honestly. When a person who is in the market for a system calls, an almost daily occurrence, I'm thankful that I can just be honest and try to help them make some sense of the market without any hidden agenda.

John Snell

Cost is almost always at the top of everyone's list. I remind people to consider the total cost including analysis software, lenses, batteries, etc, however, cost alone should not drive a purchase. Rather I try to get people to think of this as an investment that should, if all goes well, provide handsome returns. The main point here is to optimize the return rather than spend as little as possible.

Many people get fixated on the specifications of the system. While the specs can be useful, it is crazy to buy a camera based on that information alone. Array size, for instance, has become important with the introduction of 160x120 and 120x120 focal plane array systems. Of course 320x240 arrays are preferred (or essential) for some work where need for detail is great such as with utility substations, large building diagnostics and medical applications. In other situations, the remarkable image quality of the smaller array systems challenges us to even see a difference! (figure 1, page 5)

Ergonomics is probably more important than it has ever been, especially with the need for some of us to wear Personal Protective Equipment (PPE) while conducting inspections. Fortunately there are many remarkably good camera designs available, although some are still shockingly poor. I always suggest a prospective buyer try a camera for at least an hour or two before purchase.

Do consider carefully if the display screen will be effective in your real work conditions. Challenge yourself as to whether your really need a camera that is fully radiometric in the field or can one with a single spot do the job. While thermal sensitivities are amazing, if you are doing buildings work you may want to spend an extra couple thousand dollars for more sensitivity.

The links section on our website at www.snellinfrared.com (http://www.snellinfrared.com/resources/links.asp) is an excellent portal to all the major suppliers. If you can narrow down the list of possible cameras to those that

Continued on page 5

Roy Huff, ASNT NDT Level III
Sales & Business Development Manager – Snell Inspections

The Importance of Inspecting ALL Panels

Snell Inspections has been helping clients operate their industrial and commercial facilities more safely and reliably for over eight years. This is accomplished by offering infrared inspections, as well as motor circuit analysis testing and electrical ultrasound services. Over the years we have seen many different types of reliability programs. We all know that developing successful programs for customers is a process.

This method includes; educating clients, creating asset lists, establishing asset criticality, assigning the proper technologies, setting inspection frequencies and establishing reporting criteria. And still, with all that work, we see some clients struggle for success. A common mistake made by many is skipping infrared inspections of power and lighting panels, or failing to properly access the equipment by removing the panel and the dead front.

Power and lighting panels now support critical equipment such as personal computers, PLCs, networks, communications and safety systems. Yet many clients believe the panels are non-essential equipment and do not need to be inspected. During a recent inspection, one of Snell Inspections' Regional Reliability Technicians, John McDowell, convinced the client that these panels should be checked.

As is Snell Inspection procedure, he conducted a pre-inspection safety scan of the 225 amp service asset prior to the escort removing the covers. The technician observed what appeared to be several heavily loaded breakers with the covers still in place, but nothing of a critical nature. The apparent temperature was approximately 130°F, which is just slightly warmer than a normally functioning 20 amp breaker.

> **"A common mistake made by many is skipping infrared inspections of power and lighting panels, or failing to properly access the equipment by removing the panel and the dead front."**

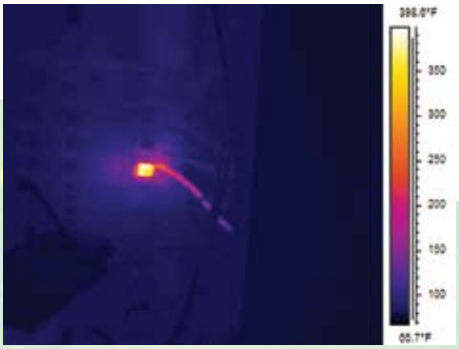


Figure 1

Figure 2

As can be seen in Figure 1, with the covers removed, the thermographer saw a high resistance connection measuring nearly 400°F on the load side! The failure of this component would probably have tripped the main and thus all power to the panel's 42 circuits. It never ceases to amaze people when they see large thermal gradients like this.

What else can be hidden by those panels? Mains, neutrals, load balances, broken wires, burnt or discolored components, and of course the bus and load connections. If you look at Figure 2 closely, you'll see the discoloration that had occurred on the faulty connection due to overheating. Good thermographers will not only know how to Think Thermally®, but must always remember to "Think Visually" as well.

Snell Inspections also finds that repair procedures are a critical part of a successful reliability program. Industry studies indicate over 50% of repairs made as a result of an infrared inspection are unsuccessful. In the case of this anomaly, merely tightening the connection is not enough. The breaker should also be replaced, and the conductor will need to be cut back or replaced and properly torqued. Finally, reassessment of the repair and re-qualification of the asset will validate the success and ultimately lead to a more safe and reliable environment.

So if you would like to have a better infrared reliability program, don't forget to inspect (and open!) all panels to ensure success.

Thinking Thermally in South Africa

Dr. Roderick Thomas, CEng. FIET Level III Thermographer
UK General Manager – Snell Companies International

Thermal imaging continues to grow in popularity and applications in South Africa, especially with the development of new power stations being planned, including new power lines and municipal upgrades. It is inevitable that profitability and reliability of operations will pivot on a successful maintenance strategy, probably one that utilizes objective measurement information in which to develop Predictive Maintenance.

Since 2005, Snell Infrared/Snell Companies International has been conducting infrared training at ABB'S prestigious School of Maintenance (ABBSoM) located at Sunninghill in Johannesburg. Snell Companies International has established a complete training portfolio including Levels I, II & III, plus customized onsite courses and two-day specialty classes that focus on electrical applications, mechanical equipment and building systems.

One of the many advantages that come with training at this location is the inclusion of an industrial plant visit to an ABB factory to view electric motor manufacturing. This gives attendees the opportunity to consider how infrared is applied to predictive maintenance on these machines.

The ABB School of Maintenance recently launched a new website with additional information on training programs offered. Go to http://www.abb.co.za/ and select the Service Guide from the left-hand navigation for a complete listing of course details, a brochure and registration information.

At the 2006 Thermal Solutions Conference in Sarasota, Florida the Manager of ABBSoM, Ms. Lisa-Anne Fairley, presented a paper 'A School of Maintenance: A Portfolio of Skills Based Learning and Experiences in South Africa, on the role and objectives of these training programs. ***A follow-up paper which will note new developments and future plans of the maintenance school is being drafted and will be presented at the next Thermal Solution Conference, January 22-25, 2007 in Sarasota, Florida.***

Debriefing outside of ABB Factory at Alrode, Johannesburg, March 2006

"Since 2005, Snell Infrared/Snell Companies International has been conducting infrared training at ABB's prestigious School of Maintenance (ABBSoM) located in Johannesburg."

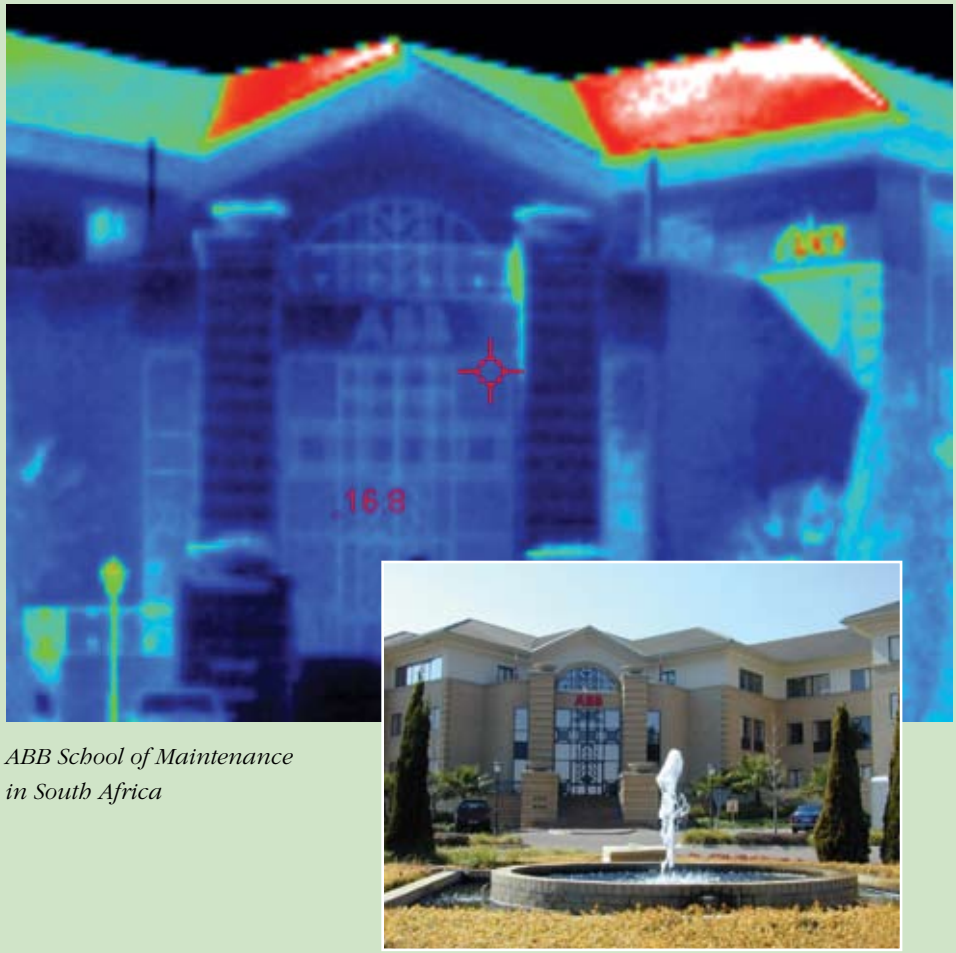
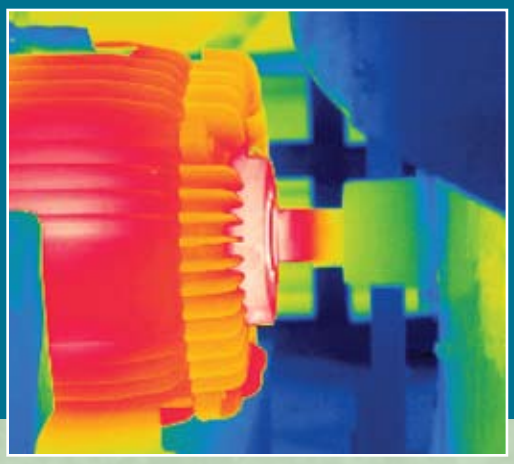


ABB School of Maintenance in South Africa

Remaining 2006 Snell Companies International Training Schedule

► LEVEL I	DATE
Bridgend, United Kingdom	October 16-20
Johannesburg, South Africa	November 6-10
► LEVEL II	DATE
Johannesburg, South Africa	August 14-18
Milton Keynes, United Kingdom	October 23-27
Johannesburg, South Africa	November 13-17
► LEVEL III BEST PRACTICES	DATE
Johannesburg, South Africa	November 22-24
► ELECTRICAL APPLICATIONS	DATE
Milton Keynes, United Kingdom	December 4-5
► MECHANICAL EQUIPMENT	DATE
Johannesburg, South Africa	November 20-21
Milton Keynes, United Kingdom	December 6-7

Snell Companies International, Inc.™



Finding the Right Imager for You

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may meet your needs, then invite sales representatives to your site for demonstrations. Expect that things may be confusing at this point as each salesperson jockeys for position with their competition! I strongly suggest you let each make their "pitch." Also make certain they let you actually use the camera yourself, preferably under conditions that simulate the real work you will be doing. Take lots of notes and ask questions.

Don't try to make a final decision at this stage of the process. As I said, it is very natural to favor some systems. Wait until you have fairly and objectively evaluated all contenders before making any decisions. You may even want to rent a camera for a week to try it. Suppliers are often willing to apply that fee to the purchase price in the hopes you'll be convinced by trying their product.

If you feel confused at any point in the process, pick up the phone and give us a call! We want you to get a camera that meets your needs as completely as possible. Another key, of course, is getting the right training. Any of the camera suppliers can package our training with a camera making it easy to get started on the road to success. With training, experience and just about any camera in today's market, you really cannot go wrong! So roll up your sleeves and jump into the process.

The choice of cameras in today's market is amazing! The image quality of nearly all systems is remarkable. Detector array size, while important, is not the only determining factor as these two images, one taken with a 320x240 camera (top) and the other with a 160x120 camera (bottom), clearly show.

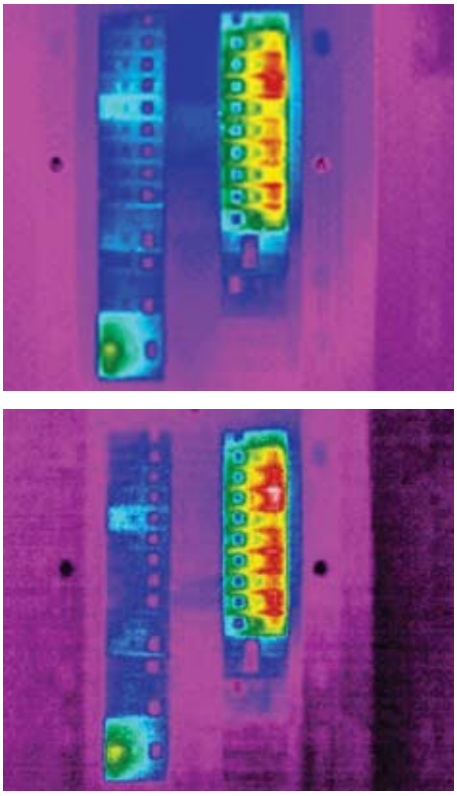

Figure 1

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

Myths and Truths About Wind and Load Correction Factors

There are a number of formulas and computer programs for 'correcting' or predicting what will happen to the temperature (or temperature rise) of an electrical fault when the load or wind changes. While these formulas are somewhat useful to indicate that significant changes in temperature may take place when the load or wind changes, they are subject to much abuse and misuse and may be downright misleading when it comes to prioritizing repairs.

We like to ask thermographers who regularly use these formulas why they use them. Invariably their answers include: to better predict the priority; to 'normalize' one fault against another; to correct a trend in a graph when monitoring a fault condition; or to predict when failure may occur.

Indeed our Level I, II and Electrical Specialty classes are witness to excellent experiments which illustrate the effects of convection and/or load in order to understand why and how the fault temperatures should generally change with increasing load and wind. But when it comes to predicting, normalizing, or correcting a temperature, or temperature difference, there is a significant danger of severely under-estimating or over-estimating the 'true' fault temperature and the consequent severity and priority.

Wind Correction

The misuse of wind correction mainly comes into play when thermographers use infrared under conditions of high convection to 'permit them to continue' and estimate the temperature when the wind will be lower. There are

> "There are so many variables unknown to the thermographer that predicting thermal run-away simply becomes guesswork."

however many other variables, other than wind speed, which affect the convective heat transfer co-efficient including wind direction (orientation), shape of the object, surface roughness and whether the flow is laminar, turbulent, or has separated from the surface.

The change in the convective heat transfer co-efficient can increase significantly when wind increases from 0 to 15 mph and may, for a horizontal downward heated surface increase more than five times (1.08 to 6 BTU/hr-ft2-F), yet for an upward facing surface increases only 3.7 times (1.63 to 6 BTU/hr-ft2-F)

The *ASHRAE Handbook of Fundamentals* shows that at 15mph the convective heat transfer co-efficient changes by 50% by moving from a smooth surface to very rough surface. (6 to 9 BTU/hr-ft^2-ºF)

Either of these two factors could easily represent more than a 50% error in temperature calculation if an incorrect assumption about orientation or roughness is made in the correction factor.

While we could argue this complexity and even try to correct for it using a more sophisticated model, the fact remains that we can be a significant distance from the energized surface. How do we know the windspeed we are measuring on the ground is the same as the wind speed at the object, which can be many feet in the air, and away from any surface effect? Add to this that the wind is constantly changing in velocity and direction and we find ourselves in a very uncertain place.

Load Correction

Fault heat generation varies with the square of the current. There is no doubt that if load increases the component temperature will rise. But by how much? Load increase algorithms over-simplify the real-world. The question you should always ask is whether the surface temperature being observed is the actual fault temperature or simply an indicator of the fault temperature.

In all likelihood the surface temperature we measure will not be the fault temperature. If the fault is beneath, or behind the surface being detected with infrared, the 2nd Law of Thermodynamics states that the heat will flow from the point of highest temperature (the fault) to the area of lowest temperature (likely the surrounding air).

Heat, like electricity, however takes the path of least (thermal) resistance to achieve this flow. The surface temperature we are observing may or may not be along this path of least resistance.

In reality, whether it is a cabinet attached to a wall, a conduit leading away from a box, or the bus bar/conductors leading out of the vicinity of the fault, unknown parallel paths of heat flow will exist. The pathway creating the resistance between the

fault and the surface we are observing results in a thermal gradient which may or may not have a very large value – i.e.: the surface temperature may be quite different than the fault temperature and any load correction formula made to the 'surface temperature' may not produce a correction factor even close to reality!

Thermal Run-Away

Another very important part of prioritization involves the issue of thermal run-away. Many types of failures occur when a change to the system happens (load increases, motor starts, wind decreases, ambient temperature increases) and the thermal output of the fault increases.

At this point many variables come into play to dissipate the additional heat generation including specific heat, mass, surface area and paths of thermal conductivity. If this additional heat generation at the fault cannot be dissipated as fast as it is generated, the temperature of the fault increases accordingly.

The electrical resistance of many types of faults increases with temperature, which in turn generates more heat and a rapid failure cycle starts. This is called thermal run-away. There are so many variables unknown to the thermographer that predicting thermal run-away simply becomes guesswork.

If predicting failure is guesswork then prioritization based on such assumptions can only be described as irresponsible. One thing we do know is thermal run-away most often occurs at the worst possible time: at startup; during switching; at peak loads; or at extreme ambient conditions.

Alternative Strategies

One thing that is true about correction formulas is that they are dangerously convenient. Everyone's job would be far easier if we could just plug in a number and find a solution. Unfortunately, the only real answer to prioritization is to say 'We have a identified a potential problem" and the more we do not know or understand about it, the clearer we have to be that we simply do not know how bad it is or could get. So what is an alternative?

1) Ask yourself whether you really need to quantify the problem at all. Based upon all factors such as criticality, safety, spare parts, quality, reliability, etc., if you do find a problem (no matter what the temperature or temperature rise is) the best course of action in most cases is simply get it fixed!

2) Identify whether there are other methodologies better suited to diagnose this particular type of problem. Motor circuit testing, impedance testing, megaohm testing and oil testing are sometimes viable fault validation tools.

3) Always take into consideration the possibility of thermal run-away and the factors which may cause it. If you are not sure run-away could happen, or when it might happen, say so. An underestimated fault which fails has cost the credibility of more than a few thermographers' programs.

4) Go back and re-shoot the component under different, more favorable conditions (lower wind, higher load).

5) Start trending the problem – the less you understand about the nature of the problem (and the severity) the greater the initial inspection frequency should be for this particular component.

6) Gather other information that will allow you to prioritize without using temperature as the only determining factor. Consider all relevant factors contributing to the thermal situation such as present load, future load, duty cycling, ambient temperature, wind, and past history of the component to estimate the probability of failure. Combine this estimate with the criticality of the component with respect to safety, environmental consequences, effect on operations and the cost of failure and you have a very good method for prioritizing each fault.

Finally, always remember that while correction formulas for wind and load may provide thermographers with convenient thermal performance indicators, unfortunately, they are not very reliable for prioritizing repairs. It is our recommendation that you give strong consideration to these alternative strategies when conducting inspections.

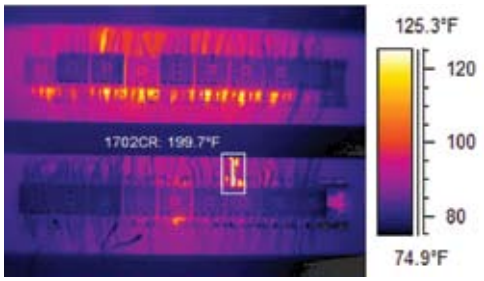

Image 1 – 12:44 p.m.

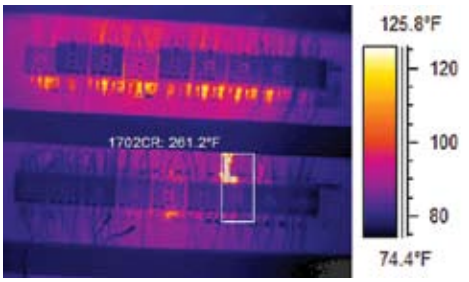

Image 2 – 1:25 p.m.

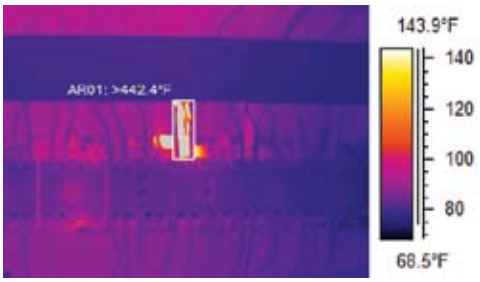

Image 3 – 1:29 p.m.

Example of Thermal Run-Away. Images taken over a 45 minute period during an inspection on May 22, 2003. The strands were arcing in image 3 at 1:29 p.m. Images courtesy of Doug Gerbold.

Upcoming Training Opportunities – Snell Infrared

► LEVEL I	DATE	$1,495
Portland, Oregon	August 14-18	
Toronto, Ontario	August 28-September 1	
Indianapolis, Indiana	September 18-22	
Charlotte, North Carolina	October 16-20	
Toronto, Ontario	October 23-27	
San Antonio, Texas	November 6-10	
Montpelier, Vermont	December 4-8	
Toronto, Ontario	December 11-15	

Thermal Solutions…

…where professional thermographers go to Think Thermally®!

January 22-25, 2007

Sarasota, Florida –
Hyatt on Sarasota Bay

ThermalSolutions.org

► LEVEL II*	DATE	$1,495
Indianapolis, Indiana	September 18-22	
Toronto, Ontario	October 30-November 3	
Charlotte, North Carolina	November 6-10	
► LEVEL III BEST PRACTICES	DATE	$1,495
Toronto, Ontario	November 6-9	
► BUILDING SYSTEMS*	DATE	$995
Charlotte, North Carolina	October 25-26	
Toronto, Ontario	December 6-7	
► ELECTRICAL APPLICATIONS*	DATE	$995
Toronto, Ontario	September 25-26	
Charlotte, North Carolina	October 24-25	
Toronto, Ontario	November 29-30	
► MECHANICAL EQUIPMENT*	DATE	$995
Toronto, Ontario	September 27-28	
Charlotte, North Carolina	October 26-27	
► RESEARCH & DEVELOPMENT*	DATE	$995
Available by Request	Please Call	

* Level I or Introduction to Infrared training required.

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