Summer / 2008

Think Thermally®

Practical news for practicing thermographers

In This Issue:

Thermal Solutions® & Motor Solutions™

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The Snell Group is pleased to offer educational and networking conferences for professional thermographers, motor circuit analysis technicians and reliability leaders that showcases the knowledge of infrared and motor circuit analysis. Gain professional development and industry insight from paper presentations, case studies, product demos and expert forums while attending the co-located Thermal Solutions & Motor Solutions conferences in 2009.

At either location attendees can learn, discover and explore the best practices of their peers while having the choice to participate in two conferences; Thermal Solutions and Motor Solutions.

Thermal Solutions, featuring Infrared Thermography (IR), addresses everything from electrical systems to mechanical equipment as well as building and roof

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The Westin Columbus
310 S. High Street

Thermal Solutions & Motor Solutions
Memphis, Tennessee
October 7-9, 2009
Fogelman Executive Conference Center, University of Memphis

www.LearnNewSolutions.com

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The Snell Group
Our Knowledge. Your Advantage.

The Snell Group is the world's leading expert on using Infrared Thermography (IR) and Motor Circuit Analysis (MCA) to reduce risk, increase uptime, save money, conserve energy and improve safety.

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John Snell, Principal
The Snell Group

Infrared "Greenwash"

I recently saw a thermal image of two houses in a national "green" magazine, purportedly "proving" that one was better insulated than the other because the exterior was cooler. It was obvious to me, and would have been to any critical thinker with a basic understanding of heat transfer, that nothing of the sort had been proven. The difference was caused by the sun shining on the two homes, one of which was painted a light color, the other dark. I can demonstrate a similar phenomenon with the image of a building corner (Image 1) both sides of which are identical, except one is being heated by the sun 45°C (113°F) while the other is in the shade 18°C (65°F). I expect we will see a lot more of this in the near future, especially where a quick buck can be made.

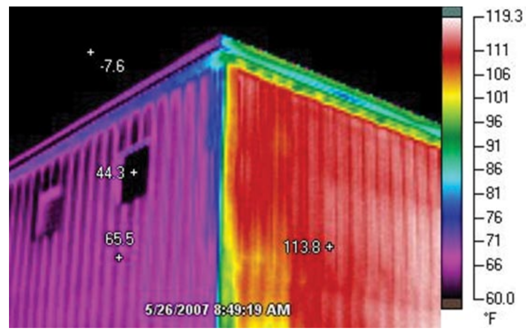


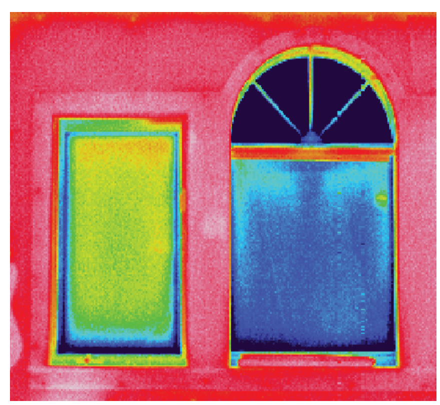
Image 1

"How hot do you want that to be?" I've long joked when demonstrating how to change the level and span settings on a camera during class, knowing we in fact have tremendous power to use our imagers to persuade—or deceive. With the market being flooded with easy to use, low cost cameras I expect we will see more of the same going forward. The latest camera, priced at just $3,000 is being marketed as "so easy to use no training is needed" yet it includes emissivity and background corrections, a very low measurement resolution and fixed focus.

You cannot whitewash or "greenwash" physics and heat transfer! Global warming, on the one hand, is a very complex set of interrelated issues. On the other hand, it is rather simple: when we burn fossil fuels, we add CO_2 to the atmosphere. That in turn reduces the rate at which heat can radiate to space. It is a balance; with the same amount of energy shining down on the Earth, but less leaving some observations are showing that the planet appears to be warming up.

Strategies many are exploring to reduce global warming include "reducing our carbon footprint" or "offsetting carbon." We can reduce our footprint by using less fossil-based energy or by consuming it more efficiently. Countless measures can be effectively implemented to make a difference, such as using high efficiency windows or testing the effectiveness of insulation systems.

Offsetting carbon is more challenging. When we burn fossil energy we add a given amount of CO_2 to the atmosphere.



Infrared image taken from the inside, looking at the outside wall, of a building during the heating season showing three different types of windows and their thermal performance relative to each other.

Continued on page 9

Jeremy Kays
On-site IR & MCA Technician
The Snell Group

A Better Understanding of a Non-VFD Rated Motor and the Thermal Effects When Used with a VFD

The motor in question for this case study was on a Variable Frequency Drive (VFD) but was not VFD rated. While on my infrared mechanical route I found this particular motor running hot. The surface of the motor appeared to be approximately 58°C (136°F) while the surrounding motors were showing 10°C (50°F). The temperature outside was 4°C (25°F) with 2 to 3 mph winds.

When this particular plant reaches full capacity there is a need to slow down the rate of product until operations can catch back up. The device in question is an old Siemens motor that is not VFD rated and does not have the torque curve by design so that when the operator slows down the process the motor starts to stall, which in turn causes the VFD to increase output and forces the motor to surge up and down in speed.

This surging can increase mechanical stresses on the motor while forcing the system out of alignment. At the same time the fan on the motor is unable to push enough air through the unit to keep it cool at slower speeds. This also creates a problem in the overloads such that the motor draws enough current to trip it, which in turn will interrupt production and cause down time.

Figure 1, shown right, contains the thermal and visual images of the motor when I encountered it during my route.

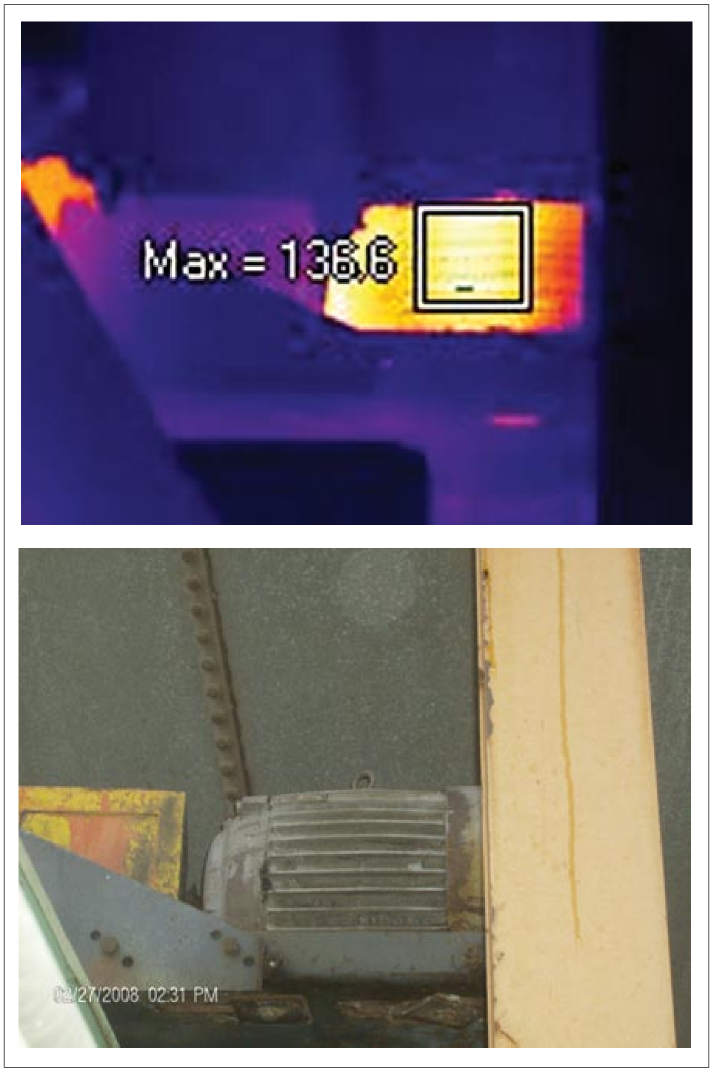


Figure 1

Problem resolution:

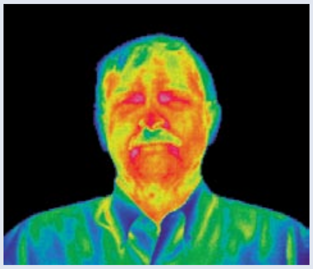
The customer installed a VFD rated motor to help handle the function that this motor is intended to perform. The next thermogram (Image 1) is from a follow-up inspection after installation of a VFD rated motor and was taken during similar environmental conditions to the first inspection. It shows a maximum surface temperature of 17°C (62.3°F).

Image 1

What was learned:

Make sure that the person who orders your motors understands the application parameters and the limitations imposed.

So, You Want to Start a Motor Testing Program



Don Donofrio
Instructor and Consultant
The Snell Group

This is the first in a series of articles that will begin at the initial implementation of a motor testing program and continue through full implementation of "Off-Line," "On-Line," and Power Quality Testing. We will cover the majority of motor tests and the various methods that motor tester manufacturers use to accomplish these tests.

In 1986, the Electric Power Research Institute (EPRI) funded General Electric to conduct a study for the causes of motor failures. Of the motor failures monitored, 36% of the failures were Stator related and an additional 10% were attributed to Rotor failures. The majority of other failures were mechanically related. Looking at the basic statistics, 47% of the failures were electrically related. However, no study was performed to determine if any of the mechanical failures were electrically induced.

This study prompted the development of various motor testing technologies that are now making significant contributions to reliability programs.

Establishing a Testing Program

When you first start a motor testing program at you facility there will be a learning curve related to manufacturer software and data analysis. Implementation of a successful program also requires the establishment of credibility. Production supervisors and personnel are always reluctant to support shutdowns that require major maintenance, especially when the determination for that shutdown is a new technology. A good method for establishing both proficiency and credibility is to start with testing warehouse spares. The time spent conducting that testing allows you to become familiar with the test instrument while affording you the opportunity to identify faults in the warehouse spares. In most cases it is normal to find faults in approximately 20% of spares.

The next step in program establishment is determining what to test. It is necessary to determine the criticality of your facility's motors and prioritize the motors that should be tested. Some basic guidelines for establishing priorities are:

- Medium / High Voltage motors with frequent starts
- Medium / High Voltage motors
- Low Voltage high horsepower motors with frequent starts
- Low Voltage high horsepower motors
- Critical motors that run off of VFD's
- Critical motors regardless of horsepower that will affect production

This prioritization covers the "high dollar" motors first. The medium and high voltage motors are expensive to purchase, repair and replace. Motors that are utilized in applications that require frequent starts are also prioritized as they receive the most operational stress. Another major factor that should be considered in establishing priorities is the effect on production and the time for replacement. In many cases small and even fractional horsepower motors can interrupt processes and may take a considerable amount of time to access and replace. In these cases the cost of lost production time should be seriously factored into establishing testing criticality. As with any unscheduled shutdown the expense that is of the greatest concern is not the repair costs, but that of lost production.

Other considerations for prioritization of testing depend upon the manufacturing process. Safety and health related issues and accessibility should also be considered. This process can

" When you first start a motor testing program at you facility there will be a learning curve related to manufacturer software and data analysis."

also be contracted out. Many companies now perform plant assessments which involve a thorough review of the plant's assets and processes. Using the assessment, all assets are prioritized based on the equipment's criticality and a testing process is then recommended. This provides you with a means of gradually implementing a program and allowing it to grow as personnel become trained and the funding for necessary equipment is allotted.

Coming up in the next issue:

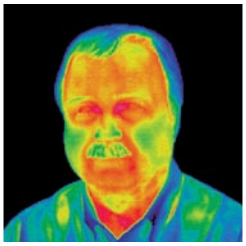
Motor Acceptance – The Last Line of Defense

MOTOR TESTING TIP

Never run an offline motor test while the motor is turning. This will yield faulty data and your analysis of this information will most likely be incorrect. How could a motor be turning, you ask, if it is locked out and tagged out for offline testing?

Fans....If the wind is blowing.
Pumps....may have fluid moving in them causing them to turn.

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



Understanding Specularity Makes for Brilliant Thermography

Have you ever noticed your reflection in a painted MCC panel or piece of glass and then wondered "wait a minute how can this be?" I thought that paint typically has an emissivity between 0.9 and 0.95 and glass has an emissivity in the 0.8 range (in the long-wave spectrum). How can a good emitter also be a good reflector? That seems contrary to what we learn in Level I training.

In fact, these emissivity values are in the correct ballpark and in Level I we do cover the RAT rule (R + A + T = 1) and Kirchoff's Law (A = E) and put them together for an opaque surface (T = 0) into that all important radiometric relationship of R = 1-E (i.e. a good reflector is a poor emitter and conversely, a poor reflector is a good emitter).

But this occasionally leads us to an incorrect assumption that when we see a clear reflection the surface must be a poor emitter or when we do not see a reflection it must be a good emitter. How is it possible that these assumptions can sometimes be incorrect? There are a few reasons for this, the most obvious being that a very high temperature source in the background can often be observed as a reflection even on a high emissivity surface. But less obvious is the issue of specularity.

The word specular is an adjective defined as 'of, relating to, or having the qualities of a mirror"[1], hence a specular surface is a mirror-like surface. You can think of the game of pool as being a 'specular' game because a ball 'reflects' predictably off the cushion at an angle equal and opposite to the angle that it strikes the cushion. An intense infrared reflection where you can clearly make out background thermal detail is a specular reflection.

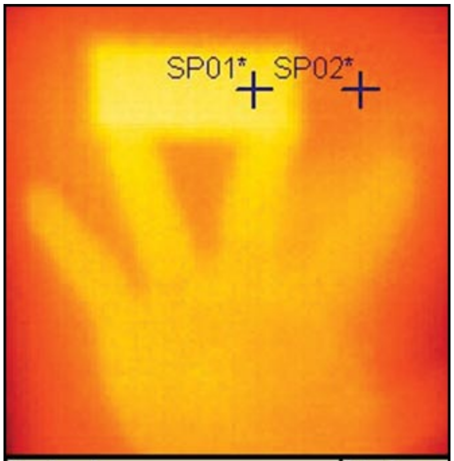
The opposite of a specular surface is a perfectly diffuse (or Lambertian) surface. In this case, parallel infrared rays from a background strike a surface and bounce off at all different angles. Imagine playing pool on a homemade pool table with plywood as a cushion – the angle of reflection would be totally unpredictable – and the ball would bounce off in any direction it felt like (My brother-in law's pool table must have this type of cushion as this perfectly describes my game).

Whether a surface is specular or diffuse (or realistically a little of both) originates with the smoothness (or roughness) of a surface and not its emissivity. We can have high emissivity surfaces which appear to be reflective (e.g., glass) and lower emissivity surfaces which do not appear to be highly reflective (e.g., brushed aluminum). If we were to look at a piece of glass we can clearly see our reflection, yet we simultaneously can obtain a reasonable thermal emission from the glass.

This emissivity test (Figure 1) on heated glass performed with a piece of electrical tape reveals an emissivity of 0.82, yet you can clearly see a reflection of my hand below the electrical tape. When inspecting glass surfaces we must have a uniform background in order to make any sense out of the patterns. Building inspections can be particularly problematic as we can have the clear sky and clouds and even the building across the street clearly defined in the windows as specular reflections. Yet, if we are careful in controlling our inspection technique we can indeed find problems related to failed insulated glass units.

As oxide forms on the surface of materials such as copper or aluminum two things happen: the emissivity of the surface increases, but also it gets rougher. So a switchyard component may not appear shiny or reflective, but its emissivity may still be quite low. In effect, on a diffuse surface the angle of incidence still equals the angle of reflection, but because the surface is rough the parallel incoming rays bounce off in different directions.

There are two ways to make a surface smooth. You can polish it (remove the rough high spots) or you can coat it (fill in the dips). Most of the time we do both: remove the oxide layer through polishing and then add a protective finish to prevent the oxide from forming and keeping the surface smooth and specular. Unlike the visible band of electromagnetic radiation where both



Label	Value
SP01*	40.4°
SP01*: emissivity	0.95
SP02*	40.5°
SP02*: emissivity	0.82

Figure 1

polishing and coating often create a highly reflective surface, in the infrared portion of the spectrum the two processes can produce differing results. On metal surfaces polishing removes the oxide layer and smoothes the surface, simultaneously dropping the emissivity and making the surface specular. Coating a surface with paint can raise the emissivity but add some specularity – we see this on factory painted electrical panels on switchgear and MCC panels – an emissivity test tells us that, just like the glass shown in Figure 1: the painted metal has a high emissivity, but yet we can often see a reflection of ourselves in the panel.

Specular reflections will happen on many smooth materials when there are well-defined hot or cold sources in the background and we are observing the surface at an equal and opposite angle to them. When both the background source and observer are at low angles the specular reflection can become quite intense. Some thermographers have used this concept to “see around” line of sight obstacles such as Plexiglas® panels that don’t extend right to the edge of an electrical enclosure.

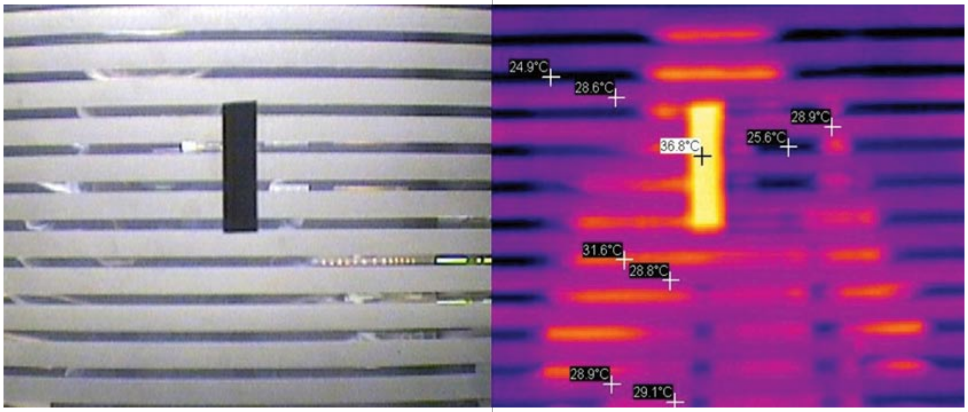
A heated aluminum test panel in our Infrared Learning Laboratory™ is shown in Figure 2. This piece of aluminum has alternating brushed and polished aluminum strips. You can clearly see the reflection of me in the polished strips but not in the brushed strips. Our Level II students often make the assumption that the polished aluminum is low emissivity and the brushed aluminum is higher emissivity (since they do not see their reflection in the brushed aluminum). But, placing a piece of high emissivity electrical tape across the strips clearly demonstrates that both strips have a low emissivity. In this particular case we have typical background like we would find in a substation. The background walls are varying from approximately 25°C to 26.5°C (77°F to 79.7°F) and my surface temperature is varying between 31°C and 34°C (88°F and 93°F). The shiny metal strips are clearly showing all of these background variances including my thermal outline against the walls behind me. But the diffuse strips are averaging everything in the background together, creating what appears to be a remarkably uniform surface temperature of 28.7°C (83.6°F) +/- 0.02°C. An emissivity test on the diffuse strip revealed a very consistent e of 0.28.

Surface specularity is one of the reasons that we encourage students in Level I to move around when they think they see a hot spot. A specular reflection will move with you. A diffuse reflection, however, may not appear to move as much and may require significantly changing the background. It is for this reason that we also encourage you, whenever possible, to have a uniform thermal background, and when you don’t have one, to try to create one with say a welding screen or large piece of cardboard.

Now let’s finish off with some Level III geek stuff. A Lambertian surface comes from Lambert’s cosine law which says that radiation emitted from a diffuse surface will fall off as the cosine of the angle from the perpendicular. So why do we say in class that you can change your angle up to about 45° when viewing a diffuse surface? The reason is that as an observer to the surface our viewing area gets larger as we change our angle closer to the surface. More area = more radiance which counteracts the angular falloff. So a Lambertian surface will appear to be a uniform reflector, or emitter, up to a reasonable angle (In other words it will appear to have equal ‘brightness’ as we change our viewing angle). Now what about that maximum angle? For a spot radiometer (with a narrow field of view) experience has shown that for many real surfaces it should be a maximum of about 60°. Since our imagers have a much wider field of view we must take that into consideration and reduce the 60° guideline by approximately 50% of our lens field of view. Since most of us use a 20° to 30° standard lens we have to reduce the 60° by 10° to 15° – or the center of our viewing area should be no more than about 45° to 50° from the perpendicular. If we were using a 60° wide angle lens we should decrease our maximum viewing angle to about 30° from a perpendicular.

" The word specular is an adjective, defined as ‘of, relating to, or having the qualities of a mirror”[1], hence a specular surface is a mirror-like surface."

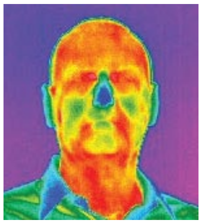
Figure 2



Specular reflections: A ‘bright’ concept that’s worth some thought as we perform our field inspections.

[1] “Specular”, Merriam-Webster Online Dictionary, 2008.

Jump Start Your Infrared Condition Monitoring Program



Colin Thielmann
National Sales Manager
The Snell Group

Is your company currently doing infrared (IR) inspections as part of their condition monitoring program? Is your reliability/maintenance team using IR for electrical inspections but not for mechanical inspections of electric motors, gearboxes, or other rotating assets? Do you not have an in-house IR inspection program and need to figure out how to justify it and get started? Regardless of what stage your company is at utilizing infrared as a reliability tool, consider the benefits of an audit of your current program or an assessment for developing a new program, all of which allow your team to reduce risk, increase uptime, save money, conserve energy and improve safety.

If you are currently using IR in your predictive maintenance (PdM) program an independent audit can be a great way for finding potential improvements. By bringing someone in from the outside you can get an unbiased view of your program and how it compares to industry best practices. While internal audits are a critical part of any continuous improvement process, there is great value in a periodic audit being performed by an external industry expert whose knowledge may help bring a new perspective.

If you do not have an IR-based asset management program and you recognize the value in getting one started, an assessment by an expert outside of your company can be a great way to develop a roadmap for your program development efforts. Once you have laid the foundation and mapped out the course, it is much easier to achieve the goals you set for your program. In fact, setting performance goals and metrics should be a critical part of any assessment.

There are ten areas that should be covered in any comprehensive audit or assessment, which include:

- **Applications:** You must detemine what types of assets you are going to inspect. Are they electrical, mechanical, or both? Developing a list of critical equipment should be a part of this process.
- **Equipment:** If you have a condition monitoring program you should evaluate the thermal imaging equipment you are currently using and determine if it still meets your inspection needs. If you are developing a program then you must first determine what types of inspections you are going to do and then determine which camera has the capabilities you need to perform those inspections.
- **Safety Practices:** Personnel safety should be a primary concern of any reliability-centered maintenance (RCM) program. When following industry best practices you should use NFPA 70E as one of your guidelines.
- **Routes and Scheduling:** Knowing what you want to inspect and developing efficient routes and schedules for conducting the inspections in a realistic time frame given available personnel resources will be critical to your success.
- **Inspection Procedures:** Once you have your list of equipment inspection list, routes, and scheduling done you must then develop inspection procedures for the different types of equipment to be inspected.
- **Reporting:** An important part of any condition monitoring program is reporting. Reports must be detailed enough so that maintenance technicians can identify what repairs need to be made to each asset.
- **Training and Certification:** If your program follows or will follow American Society for Non Destructive Testing (ASNT) guidelines, then training and certification is very important. Under these guidelines the goal of any program should be to get IR technicians to Level II standards in an efficient manner through quality training programs and plenty of fieldwork and hands-on camera time.
- **Performance and Metrics:** No program is complete unless measures of success are clearly defined. Some of these include maintenance costs and downtime reduction targets, increased productivity targets, and a reduction in catastrophic failures or planned maintenance.
- **Program Management:** How will you manage and sustain your condition monitoring program over time? Will a software-based solution be used? Will it have to be integrated into your CMMS? Don't forget that after the newness has worn off a certain amount of self promotion will be necessary to keep the results and benefits well known within your organization.
- **Continuous Improvement:** Finally, continuous improvement should always be a goal of any effective condition monitoring program. Processes and procedures for executing continuous improvement initiatives must be put in place.

Once you and the decision makers within your organization recognize the benefits that can be achieved by committing resources to developing and/or optimizing an in-house condition monitoring program, you only need to determine how to tap the knowledge of reliability experts specializing in consulting, inspections, mentoring and training.

Thermal Solutions & Motor Solutions: Twice the Knowledge, Many Advantages!

Continued from Page 1

applications, while Motor Solutions, showcasing Motor Circuit Analysis (MCA), explores the application of both offline and online motor testing. Additionally, knowledge on program development and procedures plus case studies from specific industries will be presented by professionals who are active in the industry.

A shared Exhibit Hall showcasing new products from both IR and MCA equipment manufacturers, as well as related technology and knowledge vendors, is another highlight of the conference. "For anyone considering new equipment or looking to upgrade, Thermal Solutions & Motor Solutions is the best place to see the latest technologies from the industry," says John Snell of The Snell Group. "At the same time we remain a vendor-neutral conference in that all equipment manufacturers are welcome to exhibit. This enables us to offer the greatest diversity of product demonstrations while providing the best value for those in attendance."

In addition to paper presentations and the conference exhibit hall look for the popular Ask the Expert and Case Study forums to return along with a number of opportunities to network with other attendees. Thermal Solutions & Motor Solutions is the perfect setting to meet professionals from a variety of industries and backgrounds. Planned receptions and breaks throughout the three-day event allow participants to make new contacts, explore business opportunities and share experiences with other attendees.

Ongoing conference announcements will be posted on our website, www.LearnNewSolutions.com. You can also stay updated on the latest developments with the 2009 events through the "Snell Group Conferences" e-newsletter sent monthly via e-mail. Those interested and not already registered can sign up online at www.thesnellgroup.com/ebriefs.

Infrared "Greenwash"

Continued from Page 2

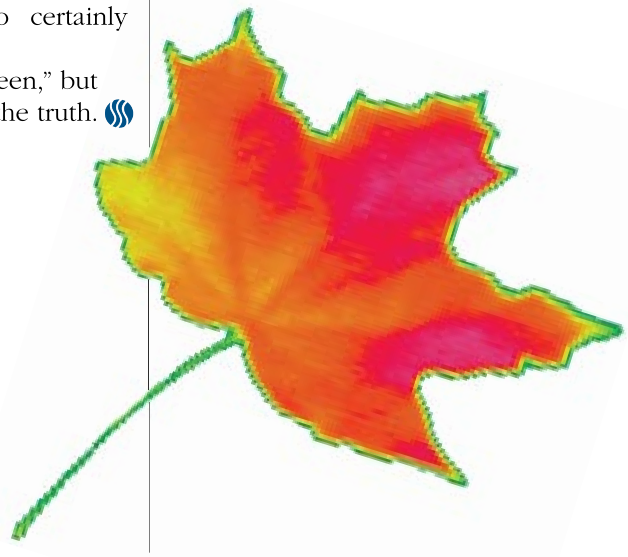
If we then somehow "trap" an equal amount of CO_2, say by growing trees or plants that use it, we have made up for the expenditure by creating a savings account. Another simple balancing act: carbon added plus carbon stored results in a "net zero" situation. While controversial, offsets will probably be part of a long-term strategy to slow global warming.

In the short run, however, carbon offsetting is fraught with problems. Will the tree actually grow and thrive? Have we destroyed a local vegetative ecology that was more efficient at storing carbon in order to plant the tree? Were the insulation and new windows properly installed so that they really are reducing consumption and, thus, our carbon footprint? I don't pretend that these are all simple issues that can be easily resolved, nor do I pretend to have all the answers.

I am suggesting that we need to make certain that the cornerstone of our exploration for answers comes from good science. There can be no room for "greenwash" and the level of misinformation that is so unfortunately common of late. Thermal imaging will certainly play a role in the process – from helping improve the energy efficiency of buildings to reducing catastrophic damage to machinery to providing information that will allow us to improve many of the fundamental processes upon which we rely. But the technology will also certainly be misused.

Let's keep infrared "green," but not use it to "greenwash" the truth.

" You cannot whitewash or "greenwash" physics and heat transfer. "



Webinars from The **Snell** Group

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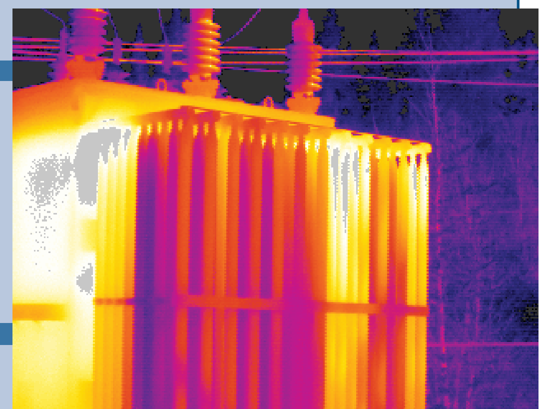
Infrared Thermography



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- Determining Your Camera's Measurement Resolution
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Global Course Schedule

(July thru December 2008)

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Level I-Thermographic Applications	**Date**	**$1,695 USD/person**
Montpelier, Vermont	July 14-18	
San Diego, California	August 11-15	
Indianapolis, Indiana	September 8-12	
Philadelphia, Pennsylvania	September 15-19	
Charlotte, North Carolina	October 6-10	
San Antonio, Texas	October 20-24	
Tampa, Florida	November 10-14	
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Level II-Adv. Thermographic Applications*		**$1,695 USD/person**
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Level II - Ferndale, Michigan	October 20-23	
Motor Circuit Analysis		**$1,895 USD/person**
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CANADA

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Toronto, Ontario	29 September-3 October	
Calgary, Alberta	6-10 October	
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Toronto, Ontario	15-19 December	
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	Date	
Level I	**Date**	**£1,165 GBP/person**
Bridgend, Wales	15-19 September	
Level II*		**£1,165 GBP/person**
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* **Pre-requisite:** Level I Infrared Training

** **Pre-requisite:** Level I & II Infrared Training

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