To Err is Human – Is to IR Divine?

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As far as IAQ tools are concerned, few are sexier than the infrared (IR) camera. IR cameras exude a certain 007, Star Trek, Mr. Wizard quality. They elicit a powerful WOW factor with both clients and passersby. Take for example the classic "thermal handprint maneuver" where you touch a wall, remove your hand and show everyone the remnant heat signature (Insert oohs! and aahs! here.). Sparks always fly when a wife sees the droplets around the toilet area, indicating husband needs to take one step closer to the target.

In addition to being fun, IR cameras are invaluable diagnostic and investigative instruments. These specialized cameras are used by a variety of professionals such as firefighters, military personnel, refinery operators and more. IR cameras are now among the common tools you'll find in the kits of indoor environmental quality (IEQ) professionals including energy auditors, restoration firms, industrial hygienists, HVAC technicians and building inspectors.

Disclosures, Limitations, & Other Excuses

I (and CSC) don't manufacture or sell IR cameras or any associated support products, such as software, carrying cases or custom paint jobs. We don't service or repair IR equipment. We are end users in a very specific industry … the IEQ industry. We stand to gain or lose nothing, whether you frame a copy of this article for your wall or use it to line your birdcage.

IR technology visually represents temperature relationships of materials for all to see. Notably, this article contains zero photos and zero IR images or (thermographs), but I'll do my best to fill your mental canvas with vivid images using only words.

I'm not the industry expert on all things infrared. I can't build one with a roll of duct tape, a gum wrapper and a paperclip. I cannot explain the physics or electronics in great detail. I cannot opine to nuances of every industry employing IR technology (i.e. law enforcement, utility companies, veterinarians, physicians, etc.). So don't expect this article to break new ground or to solve the Palestinian-Israeli conflict.

As a leading provider of building science and IEQ consulting services, I do have extensive expertise (about 10 years) utilizing infrared cameras inside buildings. We utilize thermography as another tool to save our client's time and money by quickly quantifying the extent of water intrusion into structures, identifying sagging insulation, verifying framing nailing schedules, locating leaking HVAC supply ducts, tracing hot water lines, etc.

IR cameras are tools. As such, there's a time and a place to use them. Used appropriately by skilled hands, they can make jobs easier and faster for many IAQ professionals. Used inappropriately, they can lead to costly and embarrassing errors.

IR 101

While staring at the sun (kids, do not try this at home) astronomer Sir William Herschel discovered infrared radiation around 1800. He noticed that even with filters in place to block out visible light, he sometimes felt warmth on his eye. Infrared describes heat energy relating to the range of invisible radiation wavelengths from about 750 nanometers (just longer than the visible light red spectrum) to about 1 millimeter (bordering the microwave region).

Infrared detection has come a long way in the 200 plus years since the time of hot-eyed Herschel. We now have IR cameras and thermography. Infrared cameras produce images from detected invisible infrared or "heat" radiation emitted or reflected from a surface. Thermography is the science or practice of collecting and interpreting infrared images. Radiometry is infrared imaging coupled with quantitative temperature measurements.

The U.S. military developed infrared

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imaging in the 1950s. Over the next 25-30 years IR cameras were essentially fixed position or vehicle portable and required cumbersome cooling using liquid gasses. Portable IR cameras are relatively new. In the 1980s Honeywell developed the first uncooled IR camera. And, over the next 30 years IR cameras continued to shrink, electronic components got smaller, information storage became greater, software improved, battery life was extended, screen resolutions became clearer and prices trended downward.

25 IR Myths

1. All manufacturers' claims are true.

In the immortal words of Fred Sanford, "No, you big dummy!" Manufacturers of products, including IR cameras, want you to buy, buy, buy. So, they employ marketing speak, which emphasizes the highlights and downplays the lowlights. You, the consumer, should do your homework to get the facts beyond the trifold brochure. This will ensure you get precisely what you need, nothing more and nothing less.

2. My images will always look like the examples on the manufacturer's website.

No they won't. Images in sales brochures and websites are cherry picked. They represent the quintessential IR image. You cannot blame them. After all, who would use a blurry, homogenized or indistinguishable image on any sales material? Most of your field images will be far less discernable.

3. IR cameras are too expensive.

The term expensive is relative. To many, a new car is expensive, but to others even a bus fare is expensive. Regardless of your price point, the cost of IR technology continues to drop like plates at a Greek wedding (Opa!).

Christopher Weedon, Director of Products and Shipping at EMLAB P&K, stated "Eight years ago a common camera used by IAQ professionals was around $12,000, and today that same model camera sells for around $4,000 with a lot more bells and whistles."

According to Steve Oberstein of FLIR Systems Inc. "In 1999 the least expensive camera we carried was $49,000, and in 2011 the least expensive cameras we manufacture are around $1,500." Steve went on to say "Today, the cameras used by the building envelop industries (restoration, energy audits, IAQ consulting, etc.) run from $1,500 to $15,000 on average. And, today's $15,000 unit has additional capabilities over 1999's $49,000 model."

4. I need all the bells and whistles.

Doug Goodwin of Testo says "Camera selection begins with your application. Like anything else, quality costs money, but you need to really consider if the camera you are considering has the features and specifications necessary to perform your targeted application."

Christopher Weedon of EMLAB P&K says, "You need to establish what you will use the camera for. Before you make a decision on a camera or options, you should consider four things: temperature range, accuracy, detector pixel count and thermal sensitivity. These are the big drivers of IR camera price."

5. All cameras can perform all applications.

Testo's Goodwin says, "If one camera setup could satisfy the needs of every industry and application, do you really think manufacturers would offer so many models and options? If I could invent one camera that did it all, I'd be retired in Bora Bora right now."

6. The more expensive the camera, the less likely I will need training.

Bob Bove of Testo likens getting your Level I thermographer training to passing your driver's license exam without ever having driven on the road. "You may possess the license, but you wouldn't call yourself a good driver or a good thermographer. Experience behind the wheel or behind the camera is critical to the education of the operator. Just as with driving, thermography is both part science and part art."

Here's a case study for you. An IR image of a bathroom wall depicts a cool anomaly. And, both non-penetrating (nonintrusive) and penetrating (destructive) moisture meters alarm when applied to the wall. So, the wall is wet, right? Not so fast hot rod. Thanks to training and experience, the wall is actually determined to be dry. The penetrating and non-penetrating moisture meters falsely alarmed due to the foil-infused wallpaper. And, the IR anomaly was a spot on the wall cooled by a nearby air conditioning register. Reduce your likelihood of being duped, and get some training.

According to Jody Thomason, Director of Product Development of EMSL "You cannot buy your way into expertise. I'd rather see someone purchase a $1,500 camera and get some training, rather than purchase a $15,000 camera and get no training. I'm always surprised when people balk at the price of training when making such a large capital investment."

7. I took a class, so now I'm an uber-thermographer.

Slow down! You may know how to turn on the camera, change palates and download the images, but as Master Yoda says "An IR master, you are not."

You become proficient at capturing quality IR images and accurately interpreting them the same way you get to Carnegie Hall: practice, practice, practice. According to EMSL's Thomason "There's no substitute for real world experience."

8. I must have a quantitative analysis at all times.

No. Radiometry is infrared imaging coupled with actual quantitative temperature measurements of pixels. It can be useful in some instances. For example, radiometrics coupled with psychrometics can help identify surfaces approaching the dew point (100% relative humidity). Rarely do restorers or IAQ investigators use this feature. Testo's Goodwin says his customers "don't really use radiometrics most of the time."

9. IR Cameras define problems.

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Neither the thermal image nor the camera define problems. You do. As the trained, experienced investigator, you define the existence of a deficiency. According to Rod Hoff, of Restoration Consultants Inc. "When you look through an IR camera and you see an anomaly you have merely identified an area for investigation, no more, no less."

10. Anything cold appears blue.

Nope. The terms "hot" and "cold" are relative terms. Just ask any married couple that sleeps in the same bed. There are various palates (i.e. Rainbow, Greyscale, Iron Bow, etc.), and each palate can be programmed to represent a range of temperatures. According to FLIR's Oberstein, "Color palate is 100% artificial." Depending on your chosen range, blue can be whatever you like 1°C or 1001°C.

11. IR images tell you what is wet.

Nyet, nein and no. IR cameras simply translate differences in surface temperature into a visual image.

Color differences represent temperature differences, but not wetness or dryness. Keep in mind dry surfaces can be colder and wet materials can be hotter than their surroundings. Also consider wet surfaces can be the same temperature (homogenized) as the surrounding surfaces, whereby no anomaly will appear in the IR image.

Because they tend to be cooler or warmer than surrounding dry building materials, wet materials are often distinguishable via IR. Thermography is useful in quickly identifying suspect wet materials, which are not conducive to a moisture meter survey, such as vast areas or hard to reach areas like drapery, ceilings or high walls.

12. If I have an IR camera, I can throw away my moisture meters.

"This is a very common myth among restoration contractors" says Rod Hoff of Restoration Consultants Inc. According to EMSL's Thomason, "People still need to understand; despite what they spend on a camera, they still need their inexpensive moisture meter to verify the anomaly is actually wet."

Infrared images of visually accessible (unobstructed) building materials can help you visually determine areas with a likelihood of elevated moisture. But, substantiating that anomalies are indeed wet will require verification with a moisture meter.

13. Anything wet will appear blue.

According to Scott Warga, of American Construction Specialists and Investigations LLC. (ACSI), "I recently observed an interesting phenomenon when working on a window leak test on a hot Arizona day" Warga further stated "As water leaked into the building the water temperature changed within a few feet. So much so, that to the IR it appeared red hot as it penetrated the building materials, it became invisible as it equilibrated with the cooler interior surfaces and it turned cold blue as the water further cooled through the process of evaporation."

14. If it was once wet the IR will pick it up.

Historically wetted, but currently dry, materials have no unique IR signatures. If a roof leaks rainwater like a sieve, but it hasn't rained in months, then IR is of no use in tracking moisture, because there's none.

15. If it is hotter, it cannot be wet.

Not true. Generally the process of evaporating water cools wet materials, but if there is an impermeable barrier over wet materials (i.e. vinyl wall paper, vinyl-backed carpet, membrane roofing, etc.) then no evaporation can occur. In this case you may need to rely on thermal inertia (capacitance).

Water has a higher thermal inertia than air. If you live near a body of water you understand the effect the water has on local temperatures. Wet materials under a roof membrane will maintain their temperature (usually hotter from solar heat gain) longer than dry materials. Perform the inspection just after sundown and wet areas will appear warmer. P.S. You'll be focused on the camera and your night vision will be shot from the bright screen. So, always bring a spotter so you don't walk right off the roof.

16. If it is wet with the moisture meter, it has to show up on the IR image.

Objects with the same temperature (homogenized) all appear the same color. Generally wet surfaces will be cooler or hotter than surrounding materials, but not always. Wet surfaces can be the same temperature as surrounding dry materials and therefore no anomaly will be discernable. You can walk right by saturated building materials if you are not careful. This is particularly noticeable on day one of a flood restoration project when wet objects practically jump out of the screen and bite you. But, on day two, the temperature differences between wet and dry materials may not exist, and therefore no anomaly may be notable. Sadly at that point you'll have to get old school and crawl around on the floor with your moisture meter.

Testo's Goodwin opines, "It is all about thermal capacitance of the materials, but without a difference in temperature, you will see a homogenized image that is all one color."

17. IR cameras can detect mold.

No: too bad, so sad. FLIR's Oberstein says

"In a laboratory environment where you can control all variables you might see the heat given off by biological processes. However, in the field you don't have variable control so identifying mold is impractical if not impossible. What you are far more likely to see is the temperature effects of moisture that might be supporting mold growth."

In rare circumstances you might "see" exposed mold growth in an IR image. If a dark colored mold heavily populates a wall surface, then the mold may slightly obscure the walls reflective, emissive and/or absorptive properties. But, exposed mold colonies are readily visible to the naked eye, so there's no IR advantage. And, IR cannot help determine the presence of mold in obstructed areas (within wall cavities, behind furniture, etc.).

18. IR cameras can see asbestos or lead-based paint.

No way, man. Asbestos fibers were historically and ARE CURRENTLY added to a large variety of building materials. They're resilient, abundant and natural. They're impervious to heat, cold, acids, bases, UV light, microbes and bugs. Asbestos fibers have a stronger tensile strength than steel fibers. Asbestos fibers are not, however, distinguishable using an infrared camera. Lead-based paint cannot be distinguished from other painted surfaces using an infrared camera.

19. If I see hot anomalies on the floor, there must be a hot water leak.

Not so. Reflected heat can throw you a curve ball. The best way to see the reflective phenomenon is to stand in front of a window or stainless steel fridge; the humanoid image you see is your reflection. Shiny surfaces reflect infrared radiation well. Waxed floors reflect hot overhead lights, fooling some into thinking the floor has dozens of hot evenly spaced rectangles. Metal pipes under a sink reflect your body heat, making you think one side of the pipe is hotter than the rest. Move around a little, and you'll see the hot side is always the side facing you. Hopefully this clues you in.

20. It works just like on TV.

Productions such as Predator, *Behind Enemy Lines* and *Mission Impossible* use "Hollywood-ized" versions of IR to make you believe you can see through walls, hide your IR signature from aliens and other magical stuff. I wish IR worked that way, especially when I'm trying to evade aliens, but it doesn't.

I've provided environmental consulting services on a variety of Hollywood creations (JAG, Seventh Heaven, and Charmed to name a few). I've learned what you see on the big screen is designed to captivate and entertain you, but is in no way designed to represent reality. Realism does not sell, so filmmakers embellish to improve the movie going experience.

Andy Perry of Thermal Dynamic Resources says, "Intent has to match integrity." "Inexperienced field personnel and inexperienced editors incorrectly interpret the images they produce. I'm not sure if it's abuse, misuse or both, but Hollywood often does not accurately portray infrared because their intent is based on creating a larger viewing audience."

21. Seeing is believing.

It turns out the image you view on the screen is not always what you get during the download. ACSI's Warga said "It is obviously critical to get good focus on your images on your LCD display, but keep in mind the image quality on the small LCD may not reflect the presumed focus clarity or the resolution on the IR image you download to your computer."

This is a strong case for taking visible spectrum images (fancy term for photographs) and/or for using the picture-in-picture (also known as Fusion™ technology). At a minimum, taking a photo corresponding with the IR image is a great way to orient yourself and others as to the anomaly's location. Trust me, back at your office your 100 thermal images will all tend to blend together. Newer cameras offer the visible camera and the IR in one package. This is a convenient feature you might consider. Regardless of how you photo document, in a day or a year from now, you want to be able to tell the client or the jury exactly where your "cherry picked" image was collected.

22. IR Cameras see through walls or through clothes.

No, they don't. Often you can see what appears to be the outline of structural members and nails in the IR image of the wall, so IR cameras can see through walls right? No. It is the temperature of the surface (i.e. the paint) the camera is detecting and translating into an image. What you see in the image isn't the stud or nail head. What you're seeing is the temperature of the paint affected by a combination of the temperatures of the room and the adjoining materials. Outdoor heat or cold is transferred most efficiently through the metal fasteners, second by the wooden structural members and least efficiently by the insulation in the wall cavities. The rates of energy transfer affecting the wall surfaces are different at each location, giving an IR image the illusion of x-ray vision.

According to EMLAB P&K's Weedon

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"This is by far the most common myth. Three of five people inquiring about IR cameras ask me if they see through walls. And, of course the answer is no." EMSL's Thomason agrees "Seeing through walls is hands down the number one myth I have to dispel with customers."

As for clothing, thin or tight cloths can produce illusions of translucency, and may tell more than some folks appreciate. Here's a word of caution to keep you from getting slapped and sued. Keep the modesty of others in mind. Use professional discretion when aiming IRs around people who may not understand the technology, or who may question your moral foundation.

23. Infrared can see through glass.

The IR cameras used in the IAQ industry measure IR radiation at wavelengths that do not penetrate glass. What IAQ folks see when looking at glass is the IR radiation originating from and reflected to the side where you are standing. Often, you are just seeing your own reflection.

According to Lew Harriman of Mason-Grant Consulting, "It's true that IR wavelengths between 7 and 14 microns do not go through glass, and it is true 7-14 microns is the range of sensitivity most IR cameras are designed to detect. But it's also true that many of the IR wavelengths below about 4.0 microns do indeed go through glass quite easily." "There are some specialty IR cameras that view the IR wavelengths that penetrate glass," says Restoration Consultants' Hoff.

24. I can't perform IR surveys in the summer.

Yes you can. Unless the temperature of your target is exactly the same temperature as the environment, you will see the temperature differences. Hot and cold are relative terms. When it's -30°C outside, a house made of ice cubes (igloo) is warm.

The hot and cold rolls may be reversed based on the season, but the temperature differences will be distinguishable. Thermal Dynamic Resources' Perry says, "What's red in January can just as easily be blue in June."

25. IR cameras send out infrared radiation waves that endanger people.

No, they don't. IR cameras simply detect infrared radiation or heat that is already present. Says Restoration Consultants' Hoff, "People hear the word 'radiation' in infrared radiation and think the camera somehow generates harmful radiation. They get scared for no reason."

Just like all electronic devices, IR cameras emit some electromagnetic energy. Considering the multitude and magnitude of electromagnetic fields people expose themselves to daily (i.e. cell phones, clock radios, blenders, etc.), the addition of an IR camera is like adding a drop of water to the sea.

Instruments such as IR cameras can make your job easier, faster and more complete, but no tool can replace the experienced trained professional. A monkey can be taught to point an IR camera. You, the expert, must be curious, vigilant, and knowledgeable. You must question results when they challenge your hypothesi as well as when they support your hypothesis. You must know how to distinguish myth from reality.

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