

Buying a Thermal Imager for Building Applications

What Equipment Specifications Should You Consider

Some features such as thermal sensitivity and detector size are useful in evaluating performance, but a data sheet is not going to tell you how the camera functions and feels while you are out performing an inspection.



Over the past few years there have been considerable breakthroughs in the market for thermal imagers. Prices have dropped considerably and image quality has improved significantly. Infrared cameras are also finally being designed with the end user and building applications in mind. Advances in technology and materials get a lot of credit for this, but an expanding use of cameras in home inspections, energy audits and building science moisture investigations have made camera manufacturers more competitive and responsive to customer requirements. The reality is that today's imagers have never been lighter, smaller and easier to use at a lower cost.

New to the market in the past few years are “personal” thermal imagers. These are available both as a stand-alone camera and as an accessory (or even built-in) to a smartphone. Initially designed for the hobbyist and priced between \$200 and \$1000, the upper end of these cameras now overlaps the capabilities of entry-level professional cameras. This has caused even greater marketplace confusion, particularly when the high end personal camera seemingly has better performance than the lower end professional camera. Like the visual camera market however, there are differences between amateur and professional infrared cameras.

Ten years ago, you really could not find a new, fully-featured, imager appropriate for building inspections much less than \$10,000 USD. Today, depending on the nature of your investigative needs, there are many choices out there building applications with a wide range of features in prices ranging from under \$1,000 to \$10,000 USD.

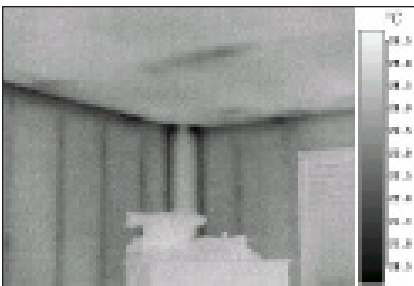
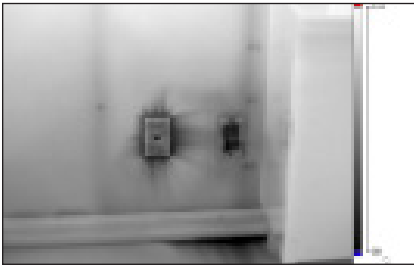
Even better, the ideal thermal imager often does not necessarily need to be “top-of-the-line” or “most expensive”. For most small building interior inspections there are many fine choices in the lower half of the price range that can often meet your needs. If you are a home inspector, energy auditor, restoration specialist, or building science investigator, the information contained in this document will help decipher the complex world of infrared and choices for infrared thermal imaging cameras.

What IR Camera Features are Important?

As complex as some systems may seem, infrared cameras are comprised of some basic components: lens, detector, processing electronics, display, controls and power supply. One would not think that, however, if you were to take a quick glance at a typical technical data sheet for a camera. Some features such as thermal sensitivity and detector size are useful in evaluating performance, but a data sheet is not going to tell you how the camera functions and feels while you are out performing an inspection. If you are considering purchasing any infrared camera be sure to try it before you buy and compare it to others of similar performance but perhaps different style.



Infrared cameras come in all shapes and sizes, so be sure to test them out in the field and get a feel for their weight and balance.



Air leakage investigations (top) often have large temperature variations which require “de-tuning” the camera sensitivity by widening the span, while moisture investigations (bottom) often require “tuning up” the camera sensitivity to its maximum by narrowing the span to detect the subtle patterns of moisture (in this case in the ceiling area).

There are a number of factors to consider in addition to cost and after-sales service. Please keep in mind as you read this that The Snell Group is vendor-neutral. We do not sell equipment nor are we a subsidiary of any infrared camera manufacturer. As such, this paper is not going to recommend a specific brand or model of thermal imager. What it will do, instead, is summarize which equipment specifications are important for you to consider and which ones maybe are not. Ultimately this document should help you determine which cameras could be right for the job.

Temperature Range: The most important specification before all others is that the camera must have the temperature range to meet your application temperatures. This is determined by the coldest surface temperature to be inspected and the warmest surface temperature to be inspected. Make sure the camera you select exceeds these limits. For most residential building inspections a range of -20 to $+100^{\circ}\text{C}$ (approx. 0 to 212°F) is adequate. If you plan to use the camera for exterior inspections in extreme northern climates you may want to ensure your camera is sensitive to, and can perform at, even lower temperatures. If you plan on using your camera for commercial building inspections, which may include mechanical applications such as boilers and steam systems you may want a camera with an upper temperature as high as 500°C (900°F). Also important is whether you require measurement within the entire range of detectable temperatures. *At the temperature extremes, particularly cold, some cameras are not as sensitive, calibrated, nor accurate to the entire specified range of detectable temperatures.*

Thermal Sensitivity: After Temperature Range, for building investigations, this is probably the most important specification to evaluate. Be certain that your thermal imager is able to detect temperature differences of better than 0.08°C . Existing standards for building inspections call for a camera and operator capable detecting better than 0.1C on surfaces as cold as 0°C so the industry accepted norm to achieve that is a the camera capable of detecting 0.08°C or better on a 30°C object.. (e.g. sensing 30.00 from 30.08) This is often stated on a specification sheet as 80mK or milliKelvin (see the Glossary at the end of this document for this and more definitions). The smaller the number the better (i.e. more sensitive) the camera. For moisture detection, strong consideration should be given to cameras with even lower thermal sensitivities such as 40 to 50mK (0.04 to $.05^{\circ}\text{C}$), particularly if there is little cost increase over an 80mK camera.

A camera with a smaller sensitivity value is capable of discerning smaller surface temperature variations. This can be an advantage in marginal inspection conditions (such as when the inside to outside wall surface temperature difference is low or the thermodynamics, of say moisture phase change, is occurring beneath a surface). Bear in mind, however, that a more sensitive camera will identify more thermal detail, and the knowledge of being able to interpret real anomalies from normal thermal variances increases. Every thermal anomaly that you identify will require some sort of validation so while using a high sensitivity camera is desired, training and experience is absolutely necessary in order to know when and how to “detune” the camera sensitivity for the particular inspection situation. Air leakage investigations with a blower door are an example where one likely needs to “detune” the sensitivity of a 50mK camera while moisture investigations likely require the camera staying tuned up to nearly the highest sensitivity.

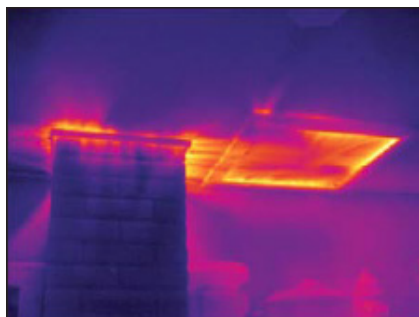
Effectively Level and Span adjustment allows the user to “tune up the image” to the thermal sensitivity required, or “detune” the image for a wider range of temperatures in the image.

Related to thermal sensitivity are the functions that allow the operator to set the temperature scale of the palette. Often called Level and Span adjustment this allows the user to take control and match the sensitivity of the camera to the span of temperatures distributed over the building surfaces to be inspected. Effectively Level and Span adjustment allows the user to “tune up the image” to the thermal sensitivity required, or “detune” the image for a wider range of temperatures in the image. Ease of Level and Span adjustment allows for more efficient scan times and detecting small but important thermal details. *Having Level and Span adjustment, or at least a “Span Lock” capability, is an essential function for a building camera. Many entry level and “personal” IR cameras do not have Level and Span adjustment, or if they do the adjustment can be difficult or time consuming.*

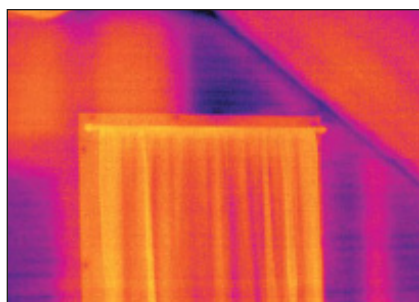
Detector Array Size: This relates to the number of pixels or sensors on your camera’s detector. While IR imagers available for the civilian market are a long way from the 5-8 megapixel visual arrays we are used to seeing on most smartphone cameras today, many out there are more than adequate for most building diagnostic work. More pixels generally means greater spatial detail. Excellent infrared systems for home inspections are now being made with 120 x 120 (14,400 detectors), 160 x 120 (19,200) and 320 x 240 (76,800) focal plane arrays (FPAs). FPAs smaller than 120 x 120, while financially attractive, do not provide sufficient spatial resolution for building diagnostics and are not recommended. FPAs larger than 320 x 240, such as 640 x 480 (307,200), do produce an impressive image but cost more and are bigger than what is needed for most residential work. If, however, you will be inspecting larger buildings (multi-family units, high rise apartments/offices, or industrial facilities) the bigger array size (as well as interchangeable lenses) is worth considering. See the following section on resolution.

Resolution: When buying an infrared camera, you need to carefully consider what your needs are for resolution. What is your typical target size? What are the average and extreme distances will you be working at? Do you have the ability to easily and safely move closer or further away? Are optional lenses available and at what cost? Will you need to measure temperatures? These are all important considerations. A thermographer performing exterior high-rise inspections is going to require a camera with a higher spatial resolution. A residential home inspector who is only looking for larger defects on a wall or ceiling from 1-2 meters (3-6 feet) away does not require a high resolution camera. The two major camera features which determine resolution are the detector array size, and lens Field of View. *When it comes to resolution there are two types: resolution required for detection, and resolution required for measurement.*

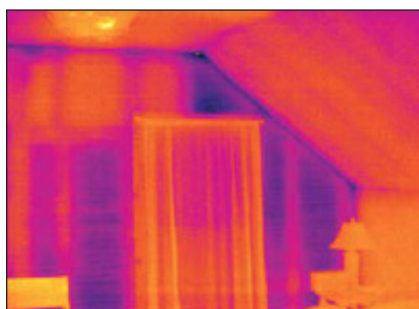
Spatial resolution, often called Instantaneous Field of View (IFOV), can be thought of as the Field of View of one detector. IFOV is the smallest object size that an infrared camera can detect at a given distance with a given lens and detector array. It is usually written on the specification sheet as a unit of milliradians or mrad, which is simply an angle of measurement. The smaller the mrad value, the smaller angle which translates into a better ability to detect smaller objects at greater distances. Just a few of the IFOV specs that you might see listed are 0.65, 1.4, and 3.6 mrad. An infrared camera with a 1.4 mrad IFOV resolution, for example, is theoretically* capable of detecting a 1.4” object or larger at a distance of 1,000” while a 3.6 mrad can only discern a 3.6” object or bigger at that same distance. In the metric system, the mrad number can be translated



Air leakage is a qualitative (i.e. without temperature measurement) investigation. Here we observe the effects of warm air infiltration while depressurizing with a blower door under warm-weather conditions.



The image above was taken with a standard lens while the one below was captured with a wide-angle lens



directly to the detection size in mm at a 1m distance. (In this example a 1.4 mm object size at a 1 meter distance) ***For residential building inspections you should have a camera with better than 3mrad to meet some standards. For larger building inspections you should ensure the resolution of the camera can resolve better than 0.5"x0.5" size *(13mm x 13mm) of building surface area at the intended inspection distance.***

Measurement Resolution, often called measurement spot size or IFOV_{measure}, it is the smallest object size that an infrared camera can accurately measure the temperature of at a given distance. This is usually not listed on a camera's specification sheet, but a good rule of thumb is that the measurement resolution is typically at least 3x worse than the spatial resolution (e.g. for a camera of 1 mrad spatial resolution the measurement resolution will be typically greater than 3 mrad). If you require accurate measurement resolution on small objects you should check with the manufacturer before purchasing that their camera can indeed measure accurately for your requirements. ***Many building applications, particularly for moisture and air leakage are qualitative inspections, which must be validated by other test methods, so measurement resolution may not be important unless you are also performing electrical and mechanical inspections.***

Field of View: The lens Field of View (FOV) is the measure of the angular view of what a camera detects. Usually measured in degrees, it determines the thermal imager's overall viewing area and is defined by horizontal and vertical angles. The bigger the angle value the larger the field of view. Standard general purpose lens FOV is considered to be between angles of about 20 to 30 degrees. Wide angle lenses are considered to have an angle greater than 40 degrees. Telephoto lenses are considered to be less than 15 degrees (The magnification from a standard lens is determined by dividing the standard lens angle by the tele lens angle. A 2x magnification would be realized when a 12 degree lens is installed instead of a 24 degree lens. ***For interior residential work many standards call for imaging up to 3 stud cavities of width (48" or 1.2m) in one image. With a 24 degree standard lens this would require being 10 feet (3m) away. A wide angle lens in this case would be useful as it would allow an inspection distance of only 5ft (1.5m).***

It is the lens field of view and detector array size that are the primary factors in determining the resolution of an infrared camera. Optical lens quality can also be a factor, particularly on cameras with low cost fixed lenses. ***Many low cost entry level low pixel count cameras (e.g. 80x60 arrays) also use low cost wide angle lenses. (e.g 45 degree or greater lens) This can result in inadequate spatial and measurement resolution which does not meet the minimum required by standards.***

Interchangeable Lenses: Optional interchangeable lenses are useful when future inspection requirements are not predictable or could change. If inspections are always going to be conducted from the interior then optional lenses are generally not required. If, however a residential inspector decides to branch out to commercial high rise inspections then having the option of buying a telephoto lens could preclude the need for buying a higher resolution camera just for that application. And, again while not required it certainly is advantageous have a wide angle lens in tight space interior inspections such as bathrooms, closets and stairwells.

Many thermographers seem to enjoy the control one has over image clarity with a manual focus where the operator is able to “dial it in”.

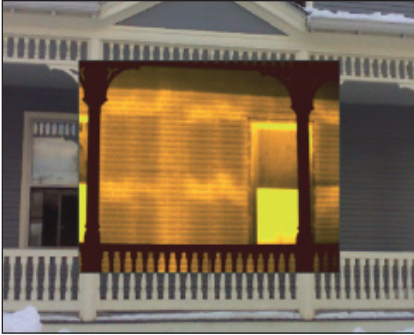
Because pixel count is two-dimensional (area based) specification and resolution is one dimensional specification (e.g. horizontal IFOV) then a 2x lens on a smaller resolution camera may be a lower cost than a camera with 4X the number of pixels. *A 320x240 (76,800 pixel) camera with a 12 degree lens has the same resolution as a 640 x480 (307,600) camera with a 24 degree lens (both = 0.65 mrad).*

Focus: Camera lenses come in several varieties including motorized/auto focus, manual focus and fixed focus. Fixed focus imagers, while convenient, can have trouble with clarity when looking at objects either very near or far. Motorized/auto focus cameras are nice for their simple function which allows for quick, “one- hand”, operation on some models. One drawback is that you might find it difficult to fine tune the image. Many thermographers seem to enjoy the control one has over image clarity with a manual focus where the operator is able to “dial it in”. This is something you need to test for yourself and is often a personal preference. *There is really no wrong type of focus method as long as you get the right focus.*

Radiometric Measurements: Today, most infrared cameras have at least one fixed temperature spot in the center of the screen. Some models go a bit further and allow you to add area boxes, circles or line profiles that can provide apparent maximum, minimum and average temperature readings across a component. As mentioned previously for many type of building inspections radiometric measurements are not required. If temperature measurement is required it is for energy quantification or legal purposes, a contact thermometer can/should be utilized to validate the temperature since unlike electrical inspections, the surface can be safely touched. That being said some building inspectors do include inspections of the electrical panel and some mechanical components (HVAC vents) in which case a center spot or area min/max temperature feature is both necessary and useful (refer to the section on Accuracy).

The emissivity table many cameras now have pre-installed as part of the menu system can be very misleading (and dangerous) if you intend to take temperature measurements. With a few exceptions, these should be completely avoided. The other problem with temperature measurements is that some thermographers often pay far too much attention to the actual value (especially when prioritizing an anomaly) and not enough to what the pattern in the image is really telling them. *Changing emissivity value alters the temperatures but not the image and is not important for many building qualitative applications. That does not preclude the inspector from having emissivity “awareness” which only comes from proper training and experience.*

Accuracy: All cameras capable of radiometric measurement will have a theoretical accuracy specification. Many people assume that the accuracy is simply equal to the thermal sensitivity but this is NOT the case. This accuracy will be very much greater (worse), and typically be specified as a greater of value, typically +/- 2°C or +/-2% of reading whichever is greater. In this case it means that for measurements up to 100C the accuracy will be +/-2°C and for say a measurement of 150°C it will be +/- 3°C (2% of reading). *The accuracy of most IR building cameras is typically not suitable for performance evaluations and should be avoided. Instead, where performance measurements are required the camera should be used to locate the minimum/maximum/average locations that an accurate contact measurement can be made.*



The visual border of a picture-in-picture feature helps thermographers identify what the infrared camera is pointing at as they pan around a scene

Visual Image Capture/Viewer: A useful and common feature of many imagers is a built-in visual camera that captures a visual picture and links it to the saved infrared image - a must for complete reports. Some visual cameras are better than others at this task but most will provide decent, visual documentation, of where the infrared image was taken. Although not necessary for the infrared image capture, a camera that has a visual camera should have some type of flash or illuminator to light up a scene for visual image capture of dark spaces like attics and crawl spaces.

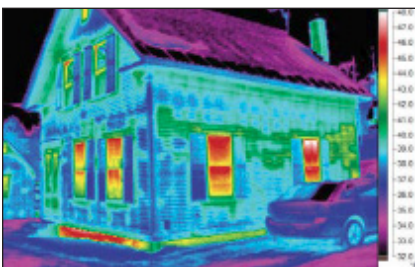
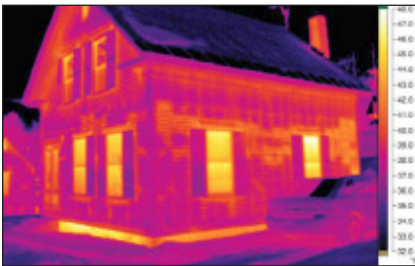
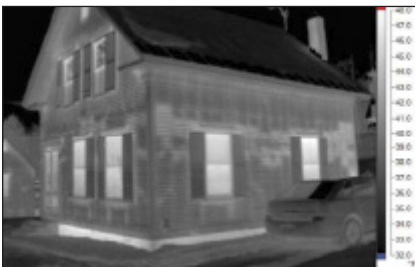
On some models the visual camera allows for a picture-in-picture feature or a “fused” mode that combines the infrared and visual features of a camera.

Be wary however of any real-time “fusion” “outlining” or “blending” techniques where the visual image characteristics overwhelm or produce enhanced visual detail while obscuring and reducing contrast of the infrared image. These techniques are often used on low resolution cameras to give the impression of an “apparent” higher resolution but will create confusion, particularly when observing visually reflective or high contrast surfaces (such as glass and multicolored objects). *Thermographers are trained to interpret thermal patterns so any function, like visual blending or outlining, can distract from this ability and while often useful in reporting is often a detriment in the field.*

Voice or Text Annotation: While stand-alone digital voice recorders can be helpful for note taking in the field, the integrated voice recorder in the camera allows thermographers to work more efficiently. Keep in mind that loud environments may make using this feature difficult, however, it can greatly facilitate and expedite report writing. Since the voice file is tied to the captured thermal and visual images, all that one has to do is just open the file in the report software, play back their notes, and type those into the report. No pens, clipboards or separate voice recorders that can be cumbersome to carry around. Voice recording is particularly useful when working in tight spaces or outside in the cold with gloves where traditional note-taking or using a separate voice recorder is difficult. There is already enough to carry so having an integrated digital voice recorder can certainly simplify your life.

Current text annotation capabilities do not offer nearly the same ease of use as voice recording, but can be helpful for basic note taking, especially if pre-set text values are set-up in the camera’s software prior to the inspection. You can create categories and tag these labels to the images with the pre-set information as you save them. Having said that, until cameras have better more user friendly on-screen keyboards, *voice annotation is an easier, more efficient method of field note-taking.*

Batteries: There are three choices for batteries listed in order of preference: removable, built-in, or powered by another device’s battery such as a smart phone (not recommended). Battery life will vary with the model, the user’s inspection habits and the camera’s settings such as display screen brightness. It is recommended to have a camera that last 3-4 hours on a single battery. To achieve a full day of inspection multiple removable batteries are typically required. A built in-battery requires the camera to be plugged in to re-charge the battery, and recharge times are typically at least 1-2 hours. Batteries and chargers are typically unique to the camera manufacturer so plan on buying these up-front with camera rather than after the fact.



These are examples of three different types of color palettes; grayscale, monochromatic (ironbow) and high contrast (rainbow). It is important to note that some systems work better in one palette versus another, so be sure to check what kinds of color palettes are offered on the camera you are considering.

Image Display: A high-quality LCD display screen is essential to diagnosing an image. The size of these vary considerably from model to model so be sure to try at least a couple of different brands/units. Larger displays are helpful if more than one person is viewing an image (the homeowner, crew member or auditor) and you are trying to communicate the problem or facilitate on-the-job training. One downside to an LCD display screen is that they can be challenging to use outdoors whether on a sunny or cloudy day. Some manufacturers provide sun shields or visors that can easily be slipped over the camera's display to help reduce issues with glare. You will also still find some models that offer both an LCD display and a viewfinder. Although expensive, perhaps something to consider if you will be working outside more often than not.

Image Palettes: A camera should have at least three temperature scale palettes: Grayscale; Monochromatic, and High Contrast (shown respectively below). Many thermographers prefer either using a grayscale or monochromatic (shades of a few colors) type palette as they are easier to focus than a high contrast palette. A grayscale palette is essential for those who are color blind, and monochromatic color is often preferred for those who have a color imbalance. A high contrast palette is useful for some wide range mechanical applications (e.g. furnaces and HVAC equipment). The palettes on an image stored by the camera can be changed in the report software provided by the camera manufacturer.

Ergonomics/Ease of Use: Often overlooked, but important, the camera must be simple and easy to use. Image adjustment, focusing, and basic operation must be intuitive. Complicated menu systems or cameras that make the most important, and often used, adjustments such as focus, level/span and image capture cumbersome to execute should be avoided. Will the instrument be comfortable to hold for an hour or two or even all day? Is it balanced properly or does it cause strain on arm, wrist or back? Will some controls induce repetitive stress? Can the camera be used by one hand and if so either hand or is it left or right handed preferential. When observing wide or tall areas are you able to turn the camera sideways and the annotations on the image automatically rotate on the screen. Can the camera be used easily outside in the cold with outer-ware and gloves. Will you be inspecting attics and crawl spaces where observing the a pistol grip camera screen will be much more difficult than an articulating screen. If so an articulating camera may be preferential to a pistol grip camera (see photos, next page).

Frame Rate: Many detectors are dual use for both US military and commercial use. Military use systems require a high frame rate such as 30 or 60 frames per second (Hz). Many of these higher frame rate cameras however are restricted for sale within the USA and Canada due to what is called an ITAR restriction. To avoid this restriction, many camera manufacturers produce either a 60 Hz model for sale within the USA and Canada, and/or a 9 Hz model for sale to other countries. Some manufacturers choose to produce only a 9 Hz model. Some use techniques such as frame averaging to reduce the detector output from 60 Hz to 9 Hz while other simply choose to have an output of 9 Hz. The difference can be dramatic however, as in the former case a moving object (or unsteady camera) the image will be blurred while with the latter a moving object will appear to jump across the screen (the shutter speed is still 1/60 second) because a new image is updated 9 times per second. Frame rate is typically not an issue for static object examination such as inspecting a wall or roof when the camera can be held still.



An articulating camera (left) may sometimes be preferential to a pistol (right) grip camera.



Camera with a laser pointer.

You only require a camera with a higher frame rate than 9Hz if you intend to be looking at moving objects, or working from a moving platform (car or aircraft). *If you plan on taking your camera outside the USA your life may be much easier (i.e.: avoiding government paperwork and or delays at the border) if you buy a 9Hz camera or non-ITAR classified camera.*

Laser Pointer: This optional feature is not required, but can sometimes help provide a visual guide to where the camera is pointing. Due to parallax or fixed offset the laser does not often line up exactly with the center-spot temperature displayed on the screen, it can be close. While the laser does not necessarily line up with the spot temperature displayed on the screen, it can be useful for both beginner thermographers or building owners who like to see where they are pointing to on a wall or ceiling.

Insulation/Dew Point Indicators: Some cameras designed specifically for building inspections have some features such as Insulation Efficiency and Dew Point Indicators that seem at first glance to enhance an inspection. These features are simply a mathematical derivation from radiometric measurements and are subject to both the inaccuracy of the radiometric measurements and require accurate data input from the user of measurements such as outside air temperature, indoor air temperature and relative humidity. Inaccuracy in the values of any of these numbers can result in significant inaccuracy of predicting either dew-point or insulation performance. Also any of these conditions (emissivity, background temperature, indoor air temperature, relative humidity, or localized air temperature outside) can change throughout the inspection, making these screen indicators either too sensitive or not sensitive enough. This can lead to either false positives or even worse false negatives (you miss the problem).

These marketing features are overly simplistic and attempt to take critical thinking out of the inspection process. They are a poor substitute for proper training, knowledge and experience, and can actually place a thermographer at high liability if they are relied upon with inaccurate or incorrect data input and a problem is missed. This is why a thermographer needs to be trained and qualified to think critically during an inspection instead of having a computer with limited or inaccurate information make the decision of what is or is not a problem. *Computerized analysis whether on-screen or in a computer, particularly when based upon poor inspection technique, conditions or inaccurate data, is no substitute for “thermal common sense” of a trained professional.*

Image Storage: Images are saved electronically either on a small removable standard digital card (shown next page) or on internal storage media. Both can work but make sure you can download it to your computer. When considering a camera, think realistically about how many images you need to store before downloading. Most SD cards now are 2 gigabytes at a minimum; more than enough space for your typical inspection day. Recording video, particularly 14 bit, may be limited in amount of recording time by internal memory size and require very large (32Gbyte+) cards.

Recorded images, whether still image or video, can be one of two types: A low bit (typically 8 bit) standard format (e.g. .jpg, .bmp, .mpg) duplicate of the screen, or a high bit (typically 14 bit) proprietary image containing raw data of the entire camera range and thermal sensitivity. Entry level cameras typically record low bit images or



Images are often saved electronically on a small removable standard digital card.

video, which mean they cannot be manipulated later in the manufactures software. High bit proprietary still image or video format can only be read by the manufacturers software, but allows changing important radiometric and image parameters such as emissivity, reflected temperature, level, span, palette, and measurement tools. Whether you choose a camera with low or high bit recording really depends on three questions:

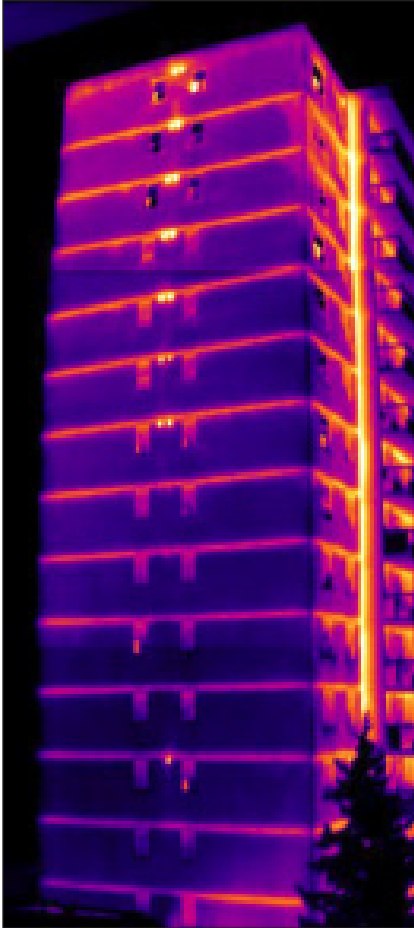
- 1) Are you willing to spend the time getting the all image settings set correctly in the field?
- 2) Are you using third party building inspection or energy auditing reporting software and want the efficiency of bringing your IR images into that software directly without the intermediate step of using the camera manufacturers' software?
- 3) Do you want the ability to manipulate or analyze your thermal images now or in the future and then either use the manufacturer's software for reporting or import them into third party software?

If you answered "Yes" to the first two questions and "NO" to question 3 then you do not require 14 bit recording and can stay with a camera with only 8 bit recording. If you answered NO to either of the first two questions or YES to the third question then you need to consider a camera which has 14 bit recording. If you answered "Sometimes" to any of the three questions you may want to consider a camera which has the ability to store both proprietary 14 bit images and standard 8 bit images. ***If you intend to use your camera for commercial building, mechanical, or industrial inspections then you should consider a camera 14 bit recording capability.***

Image Analysis and Reporting Software: Whether you need image analysis and reporting software really depends on how you answered the questions in the Image Storage section. If you like many energy auditors and building inspectors want or have to use third party reporting software, want to bring your images directly into that software and are willing to "get your image right" in the camera before storing it then you should be more concerned about the efficiency of doing so with standard format 8 bit thermal images (ie: .bmp or jpg) rather than have the burden of bringing the images into the manufacturers software and then exporting.

Almost all cameras that have 14 bit recording also come with a free, basic software package provided by the manufacturer. With these you can typically perform simple image adjustments, add analysis and comments, export individual shots with adjusted temperature scales, change color palettes and generate basic reports of multiple images at a time. You may find that some manufacturers offer more robust software program at an additional cost, but typically these packages offer far more features than what is really needed to generate basic, yet effective, reports. Many require Word or Adobe installed on your computer as the final report file is typically exported to either one of these formats.

If you intend to use your camera for any commercial building inspections, mechanical or industrial inspections then you should consider 14 bit recording capability and the manufacturers' software for manipulating the images. Many exterior commercial building exterior inspections require thermal "mapping" which are high resolution mosaics comprised of multiple images. This creates an image of the entire building façade. Manipulation of the images into a uniform standard (level, span, palette, emissivity etc.)



These 3 images were manipulated in software to the same Level and Span before being assembled into a single high resolution mosaic. Mapping an entire façade allows complete image analysis, in this case air leakage due to stack effect and the identification of potential moisture in the masonry in the upper three floors.

is often required in the manufacturer's software prior to assembly of the mosaic. These mosaics can be done in standard PC software (e.g.: Microsoft Word or PowerPoint) third party software, or in some of the camera manufacturers more advanced software.

Similarly some building retrofit inspections require before and after imagery when the environmental conditions may have been different. In this case and the manufacturers' software will often be required to manipulate the images for proper before and after comparison.

Infrared Standards for Building Inspections

There are a handful of standards for conducting infrared building inspections that thermographers should know. In addition to proper training, all thermographers should be familiar with these:

ISO 6781: Thermal Insulation, Qualitative Detection of Thermal Irregularities in Building Envelopes, Infrared Method www.iso.org

ISO/NP 6781-2 Performance of buildings -- Detection of heat, air and moisture irregularities in buildings by infrared methods -- Part 2: Equipment Requirements. (Draft) www.iso.org

ISO 6781-3:2015 Performance of buildings -- Detection of heat, air and moisture irregularities in buildings by infrared methods -- Part 3: Qualifications of equipment operators, data analysts and report writers. www.iso.org

ASTM C-1060: Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings www.astm.org

ASTM E-1186: Air Leakage Site Detection in Building Envelopes and Air Barrier Systems www.astm.org

ASTM E-1153: Standard Practice for Location of Wet Insulation in Roofing Systems Using Infrared Imaging. www.astm.org

ASTM C1046-95(2013) Standard Practice for In-Situ Measurement of Heat Flux and Temperature on Building Envelope Components. www.astm.org

RESNET: Interim IR Guideline for Thermographic Inspections of Buildings www.resnet.us

Canadian GSB 149-GP-2MP: Manual for Thermographic Analysis www.pwgsc.gc.ca

Canadian National Master Specifications NMS Section 02 27 13: Thermographic Assessment – Building Envelope www.pwgsc.gc.ca

Canadian National Master Construction Specification NMS 022716 Thermographic Assessment – Roof www.pwgsc.gc.ca



Proper Training and Qualification

Infrared cameras today are certainly easy to use and affordable, however, operators still need to be qualified to use them properly. That includes having the right training and experience. One should not be concerned with whether or not someone is “certified” as a building thermographer but rather that they are a qualified to conduct a particular type of building inspection. Those that are do better work, get better results, and work more efficiently.

Unfortunately, as imagers have now broken below the \$2,000 barrier and continue to drop, some are calling into question whether similarly priced infrared training is still necessary. Well, anyone can buy a framing hammer. They too are easy to use and inexpensive, but it takes a skilled carpenter to know how to frame a wall correctly. The same is true with an infrared camera. Just like the hammer, one can do quite a bit of damage if it is used improperly. Being successful with this technology requires not just great camera skills, but also an in-depth understanding of heat transfer, radiation physics, inspection conditions and building science.

Buildings are complex. In fact, it could be argued that an infrared building inspection is one of the most, challenging applications of infrared thermography. In many instances, inspections have to be conducting with conditions that are often less than ideal, in buildings that are in a transient, and confusing state of thermal transfer (early morning vs. sunny afternoon), built with different materials (wood vs. concrete) and that have highly varied surface emissivity (windows vs. glass, shiny metal, paint walls, etc.). A qualified thermographer understands how that affects what they are seeing and not seeing in the thermal image. Without a solid foundation training and experience, expect to make mistakes. Some may be costly

Good training options are available, but make sure the one you choose specifically covers the camera you have and your applications. For groups, specialized onsite training that allows your team to avoid travel, lodging and meal costs probably makes the most sense.

Be wary too of training organizations that purport to “certify” those who attend just their training class or perhaps purchase one of their products. Those types of certifications are more of a marketing and sales product than a service that actually qualifies thermographers.

The Future is Bright for Infrared

The number of choices today for fully-featured, inexpensive, infrared systems are astounding. Now is the time to analyze your current needs and see if investing in a thermal imager makes sense. Do your homework, look at—and try!—several systems. If you are considering buying an infrared camera give us a call or drop us an e-mail as we are more than willing to help you through the decision making process. We are not going to tell you which brand or model of infrared camera to buy, but we will work with you to ensure that the camera you do end up getting meets both your needs, and more importantly, your budget.

Infrared Equipment Glossary

Background: The source of radiation that reflects off of the target the IR instrument is viewing.

FOV: Field of View, a measurement of the angle seen by the camera; the specification is typically given in degrees horizontal and vertical, such as 24° x 18°.

FPA: Focal Plane Array infrared system that has a Detector Array placed at the focal distance of the lens.

Detector Array: A detector array is a composed a number of individual detectors arranged in columns and rows, typically 320 x 240 or 160 x 120 in size. Multiplying the two numbers together yields the total number of detectors. E.g. 320x240=76,800.

Emissivity: A property of a material's surface that describes its ability to radiate energy by comparing it to a theoretical perfect radiator (blackbody) at the same temperature. Emissivity values range from zero to one.

IFOV: Instantaneous Field of View; the smallest sized area that can be detected by an infrared camera at any one instant in time. Also known as Spatial Resolution. Units are milliradian.

IFOVmeas: Instantaneous Field of View-Measurement; the smallest sized area that can be measured by an infrared camera at any one instant in time. Units are milliradian (mr) See also Measurement Spot Size.

Isotherm: A software function that outlines or highlights areas of apparent similar temperature or radiosity in the image.

Level: The position of the thermal span within the particular thermal range to which the camera is set. Similar to "brightness."

Measurement Resolution: See IFOV-meas and Measurement Spot Size

Measurement Spot Size: The size of an area that can be measured at a given distance by a radiometric system. Can be specified in milliradians: object size at 1000 units of distance or alternatively Distance to Spot (D/S) ratio where the spot size is always unity (1). $D/S \text{ ratio} = 1000/\text{mrad value}$. E.g. a 4mrad IFOVmeasure = 250:1 D/S ratio

MilliKelvin (mK): One thousandth of a Kelvin unit of Temperature. Equal to temperature difference of 1 milliCelsius degree (0.001°C or 0.018°F).

NETD: Noise Equivalent Temperature Difference. A test method typically used to determine a camera's Thermal Sensitivity. See Thermal Sensitivity

Palette: The colors associated with the color scale assigned to the image by the operator. Often called false color (does not correspond to natural color scale).

Qualitative Thermography: Thermal imaging without radiometric temperature measurement.

Quantitative Thermography: Thermal imaging with radiometric temperature measurement.

Radiometric: The response of the detector to IR radiation is calibrated so that temperatures can be inferred from the amount of radiation detected. If a camera is fully radiometric, temperatures can be read anywhere in the image. Others have only a center spot that is calibrated for measurement.

Range: The preset range of temperatures set by the factory that can be viewed and/or measured. Many cam-

eras for condition monitoring have several ranges for higher temperatures while cameras marketed for building or medical applications have just one "low" range.

Spatial Resolution: See IFOV

Span: The difference between the high and low temperature extremes displayed on the color scale of the thermal image. Similar to "contrast" in a visual image.

Spot Radiometer: Also known as point radiometer. A non-imaging radiometric device that outputs a temperature or other radiometric measurement. Also called an infrared thermometer. While useful if used properly, these inexpensive (\$100-1000) devices can have severe limitations with regard to spatial resolution and emissivity correction. The measurement resolution of a spot radiometer is often expressed as a D/S ratio.

Thermal Sensitivity: Often determined by an NETD test, thermal sensitivity is the minimum temperature difference (in milliKelvin mK) that can be theoretically detected by a camera on a surface at a given temperature. Typically this surface is 30°C (86°F). Thermal Sensitivity values of a camera will often increase (ie: get worse) at lower or higher temperatures than the surface temperature at which it was tested.

For additional information about thermography, building inspections, and infrared training, visit www.thesnellgroup.com or contact The Snell Group at 1-800-636-9820. 