Buying a Thermal Imager for Condition Monitoring

What Equipment Specifications Should You Consider

Depending on your inspection requirements there are many fine choices in the lower half of the price range that can often meet your needs whether you are an in-plant thermographer or outside service contractor.

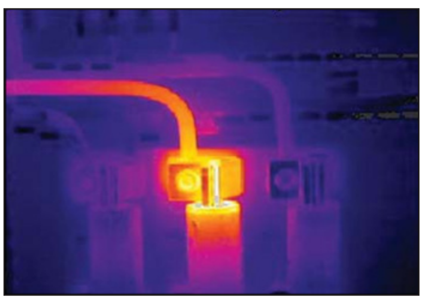

Figure 1

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 specific applications in mind. Advances in technology and materials get a lot of credit for this, but an expanding market in both applications and number of users 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 for much less than $20,000 USD. Today, there are many fantastic choices out there for condition monitoring applications with a wide range of features in prices ranging from $1,000 to $20,000 USD.

Even better, the ideal thermal imager for industrial maintenance today does not necessarily need to be "top-of-the-line" or "most expensive". Depending on your inspection requirements there are many fine choices in the lower half of the price range that can often meet your needs whether you are an in-plant thermographer or outside service contractor. If you are a plant manager or maintenance supervisor 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 on a route in the plant. If you are considering purchasing any type of infrared camera be sure to try it before you buy and compare it to others of similar performance but perhaps different style.

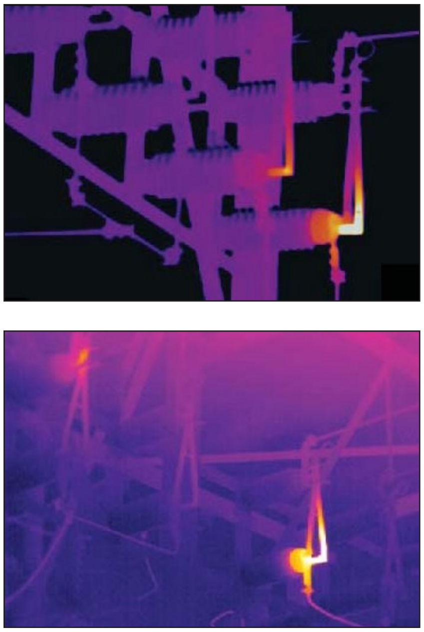

Figure 2

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 electrical applications, a range of -20 to +250°C (approx. 0 to 500°F) is adequate. For some mechanical applications, such as furnaces, or monitoring processes and process vessels, the upper temperature could be as high as 1000°C (1832°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.***

Detector Array Size: This relates to the number of pixels or sensors on your camera's detector. While new infrared imagers that are used for industrial maintenance have far less pixels than the 5+ megapixel visual arrays we find on most smartphone cameras today, they are typically more than adequate for use in reliability maintenance cameras. More pixels generally means greater detail at any given distance. Excellent infrared systems are available with 120x120 (14,400 detectors), 160x120 (19,200 detectors) and 320x240 (76,800 detectors) focal plane arrays (FPAs, see glossary). While cameras with less than 10,000 pixels (e.g. 80 x 60 (4,800 pixels) can work for inspecting at close distances such as low voltage components they may have safety/distance issues when inspecting equipment which has an ARC flash rating and limits of approach. FPAs larger than 320 x 240, such as 640 x 480 (307,200 detectors), produce an impressive image and are worth considering if you will be inspecting small components at long distances (e.g.: outdoor substations and electrical utility transmission and distribution systems).

Having said that, one of the images in Figure 2 was captured using a 640 x 480 infrared system while the other was taken with a 320 x 240. Can you tell the difference between these two images? If anything, what these examples really show is that ***you should most certainly test a camera in the field before you buy as the array size spec does not tell you everything about how well a thermal imager might perform.***

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 working for an electric utility is going to require a camera with a higher spatial resolution value than say an in-plant technician who is only looking at panel boards from 1-2 meters (3-6 feet) away. The two major camera features which determine resolution are the

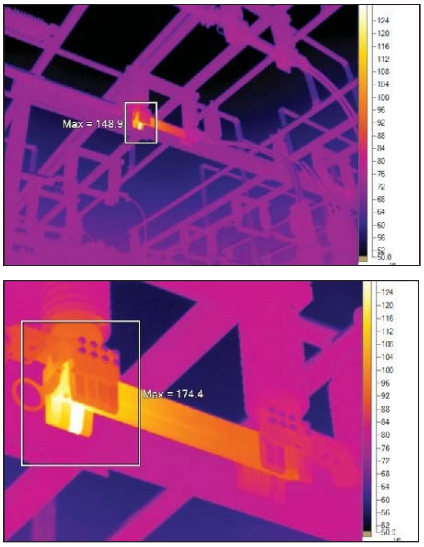

Figure 3

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 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). ***Note: while the mrad number is useful for comparing camera performance it is theoretical, and users may or may not be able to achieve that small a resolution in the field.***

Measurement Resolution, often called measurement spot size or IFOVmeasure , 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. ***You may find that to meet your application measurement requirement you need to purchase a camera with higher resolution or purchase a tele lense.***

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.

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 use low cost wide angle lenses. This can result in very poor spatial and measurement resolution.***

Optional Lenses: The least expensive way to improve resolution, if its practical and safe, is to simply move closer. If that is not possible, then using an optional telephoto lens, if the camera has that capability, is the next best way to improve resolution. Op-

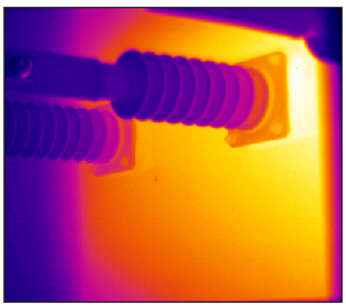

Figure 4

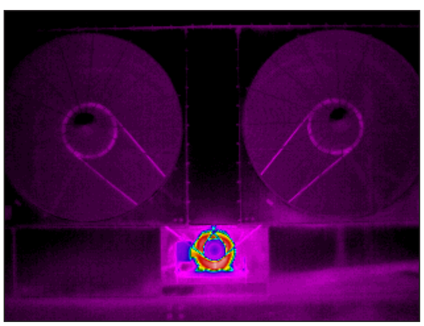

Figure 5

tional lenses do cost more and may carry with them a separate calibration expense, but having a telephoto lens is certainly helpful for situations where a component, say a hot connection on a disconnect in an outdoor substation, is too far away to analyze (i.e. measure) properly at a particular distance. When small resolutions are required it is also useful to compare the price of a higher pixel camera with a single lens to a lower pixel count camera with an optional telephoto lens. 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 lense has the same resolution as a 640 x480 (307,600) camera with a 24 degree lens (both = 0.65 mrad).***

We can see in Figure 3 (previous page) showing two perspectives of the same disconnect, how both lens type and distance affects not only our ability to detect a hot spot, but our capability of measuring its temperature too. Both images were taken from the same position in the yard. While we may be able to still detect the anomaly at this distance (i.e. the spatial resolution is fine) with the wider field of view, it does not provide sufficient measurement resolution of the hot connection. Notice how the area max temperature of the box in the top image is only reading approximately 149°F (65°C) while the one from the telephoto lens (bottom) measures 174°F (79°C). The optional telephoto lens image, not only provides us with greater detail, but also a better evaluation of the severity of the find as indicated by the apparent temperature change which results from the improved resolution of the image.

In tight spaces where your perspective may not be wide enough, such as when inspecting the back of switchgear that does not have a lot of clearance behind it, a wide-angle lens is something to consider. Certain ultra-wide angle lenses, (e.g. 65 degrees plus) like those used in conjunction with a view port opening (Figure 4) or an infrared trans-missive window, allow thermographers to capture a wide-angle field of view of connections inside an electrical cabinet without having to open the door to inspect; an important safety consideration for many programs.

Another application where a wide angle lens can be very helpful is when you are trying to image the entire drive train of a mechanical system. (Figure 5) To capture the entire system in one shot is helpful when either trying to get the "big picture" or trending specific multiple component temperatures not only can be a time saver but allows for a much better problem finding and analysis.

Digital Zoom: Some cameras have a "digital zoom" function, but this is only an electronic enlargement of the existing FOV and not a true optical zoom capability. The general rule for the usefulness of a digital zoom is when the resolution in pixels of the display is less than the resolution pixel count of the detector. Most 320 x 240 (80,000 nominal pixels) utilize a 640 x 480 (300,000 nominal) pixel count display so a digital zoom is not useful. If a camera with a 1024 x 768 detector (800,000 nominal pixels) has a 640x480 display a digital zoom may be useful, particularly for focusing. This can be the case with many high resolution cameras which have a viewfinder rather than LCD for outdoor use.

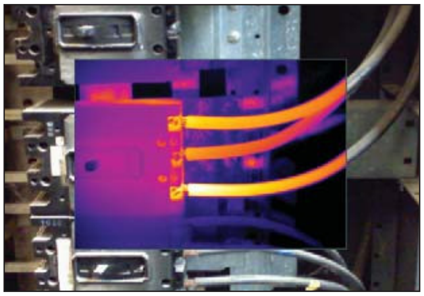

Figure 6

Thermal Sensitivity: This is specification, also called NETD (Noise Equivalent Temperature Difference) on a specification sheet, defines the smallest temperature difference that a camera can detect. It is typically stated in milliKelvin (mK). A 100 mK camera, for example can theoretically detect a temperature difference of 0.1°C (0.18°F). The smaller the number the more sensitive the infrared camera. Current camera sensitivities range anywhere from 20-50mK (0.02-0.05°C) on high-end thermal imagers up to 200 mK (0.2°C, or 0.36°F) on lower-cost cameras.

Typically for condition monitoring applications you do not necessarily need the best (lowest) thermal sensitivity. Low sensitivity can often be important for cameras used for building, aircraft NDT, and bio-medical investigations.

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 surface of the object of interest. 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. ***Many entry level cameras do not have Level and Span adjustment, or if they do the adjustment can difficult or time consuming.***

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. Having at least one spot to use in the field can be helpful, however, a thermographer MUST be qualified if they are going to be measuring temperatures with an infrared camera. Temperature values will be wrought with error if the thermographer does not properly understand (and correctly adjust the emissivity and background/reflected temperature values in their imager. If you are going to attempt temperature measurements through an IR window or similar, then having the ability to adjust transmissivity is important too.

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 qualitative applications.

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 object being measured must be greater than the IFOV measure, and is only valid for high emissivity surfaces.***

Figure 7

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 electrical cabinets or dark spaces.. Not every electrical panel or motor resides in a well-lit area of a plant and you want to be sure that you have sufficient contrast for examining detail in the recorded visual image.

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. Picture in picture, shown in Figure 6, can be useful for pinpointing which phase is running warm while still having a visual reference in the frame. Color "alarm" or "thresholding where the infrared image only is shown when a threshold has been surpassed and then the remaining image is overlaid on the visual image is also very useful when inspecting for a singular over-temperature event such as a warm bearing (shown in Figure 7).

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 plant 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. Those having to use PPE such as hard hat and face shield when conducting an electrical scan will appreciate this. 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.***

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. Larger displays are helpful and easier to see, especially if

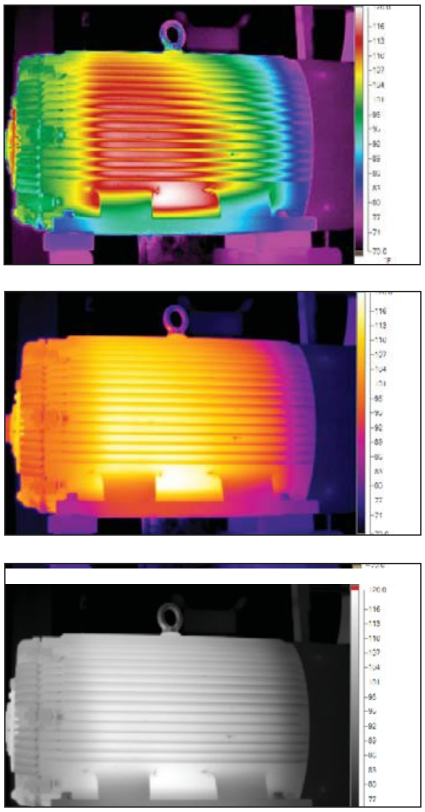

Figure 8

more than one person is trying to view the problem. One downside to an LCD display screen is that they can be challenging to use outdoors whether on a sunny or cloudy day. Many manufacturers are providing sun shields/visors that can be easily slipped over the camera's display to help reduce issues with glare, but if you are going to be mostly working outdoors, a viewfinder may be the better option.

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.

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.

Image Palettes: A camera should have at least three temperature scale palettes: High Contrast; Monochromatic, and Grayscale (shown respectively in Figure 8). 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. boilers and furnaces) or situations requiring a thermal delineation (liquid and sludge levels in tanks, or line blockages). The palettes on an image stored by the camera can be changed in the report software provided by the camera manufacturer.

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. This is typically not an issue for static object

Figure 9

examination (e.g. scanning an electrical cabinet) when the camera can be held still, but can be an issue when examining moving or rotating objects. A 30 or 60 Hz camera frame rate is preferred for CM work provided you are not going to take the camera outside of the USA or Canada. 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. This can be useful for both beginner thermographers and those who are working in highly complex industrial environments such as a power plant or petrochemical facility where you often encounter a cluttered web of piping, valves, and steam traps when trying to pinpoint your target.

Image Storage: 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 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 mage parameters such as emissivity, reflected temperature, level, span, palette, and measurement tools. ***High bit recording is essential for almost all condition monitoring applications.***

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

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. One hand operation can be important in tight spaces or have a poor viewing angle? Can the camera be used easily with PPE including button control with gloves and when using a face shield? Will you be inspecting items near the floor or above your head? If so an articulating camera (Figure 9 left) may be preferential to a pistol grip camera (right).

Image Analysis and Reporting Software: Most infrared cameras today work with a free, basic software package provided by the manufacturer. With these you can typi-

Figure 10

cally 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 might at the very least require Word or Adobe installed on your computer as the final report file is typically exported to either one of these formats.

Some reliability programs that are using multiple inspection technologies including vibration and ultrasound testing might have a need for a comprehensive condition management software that compiles information from all of these data points into one database for analysis. In some instances, once a problem is suspected a data-trending software or histogram analysis feature is required. If so, basic IR software will likely not meet your needs.

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. Those of us at The Snell Group are not concerned with whether or not someone is “certified” as a thermographer. We are far more interested in that they are qualified. 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, crescent wrenches are inexpensive and easy to use too, but it takes a qualified maintenance professional to know how to properly fix a machine. The same is true with an infrared camera. Being successful with this technology not only requires great camera skills, but also an in-depth understanding of heat transfer, radiation physics, inspection conditions and machine operation.

Industrial systems can be complex. Variable loads, large thermal gradients and emissivity issues can mask infrared signatures and lead one to misdiagnose an anomaly. The thermographer must understand what they are seeing—and not seeing—in the thermal image. Without a solid foundation in 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 the needs of 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 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 cameras is astounding. Now is the time to analyze your current needs and see if investing in a thermal imager makes sense. Do your homework, 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 lense.

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." In a visual image

Measurement Resolution: See IFOVmeas 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 ratio = 1000/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 milli-Celsius 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 cameras 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 and infrared training, visit www.thesnellgroup.com or contact The Snell Group at 1-800-636-9820.