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Basic Thermography for the Occasional User

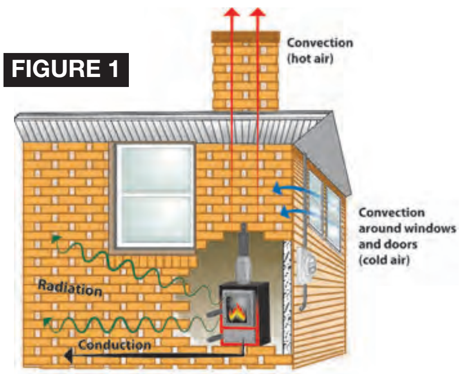
Basic Thermography for the Occasional User

By John Olobri

This article is on basic concepts and use of infrared thermography. I will address it from my perspective as a fairly new user (within the last year) of the technology. I am sure that those more knowledgeable and more trained than I may have a somewhat different or a better perspective on some of the points addressed in this article. My intent is to provide some basic understanding of the technology and some good practices that will assist the reader in providing good quality measurements with the right instrument selection for the application.

Thermal imaging cameras are an effective tool to quickly locate electrical hot spots in wiring, circuit breakers, motors and more. Electrical maintenance contractors and technicians find them to be a useful and safe tool as they are a non-contact device that can be used in detecting problems on live circuitry.

FIGURE 1



Prior to spending the time to understand how infrared cameras function and taking a certification class on the subject I had a very basic and simple, sometimes incorrect, understanding of the technology. My philosophy was "how complicated could it be? Just point and click and you have your results". This was far from a correct concept.

I will attempt here to discuss some of the things that I now have a better understanding of as well as some operational characteristics along with features and functions that make successful operation of a thermal imaging camera more effective for electrical maintenance work.

First of all let's address some basic understanding of how a thermal camera works.

FIGURE 2

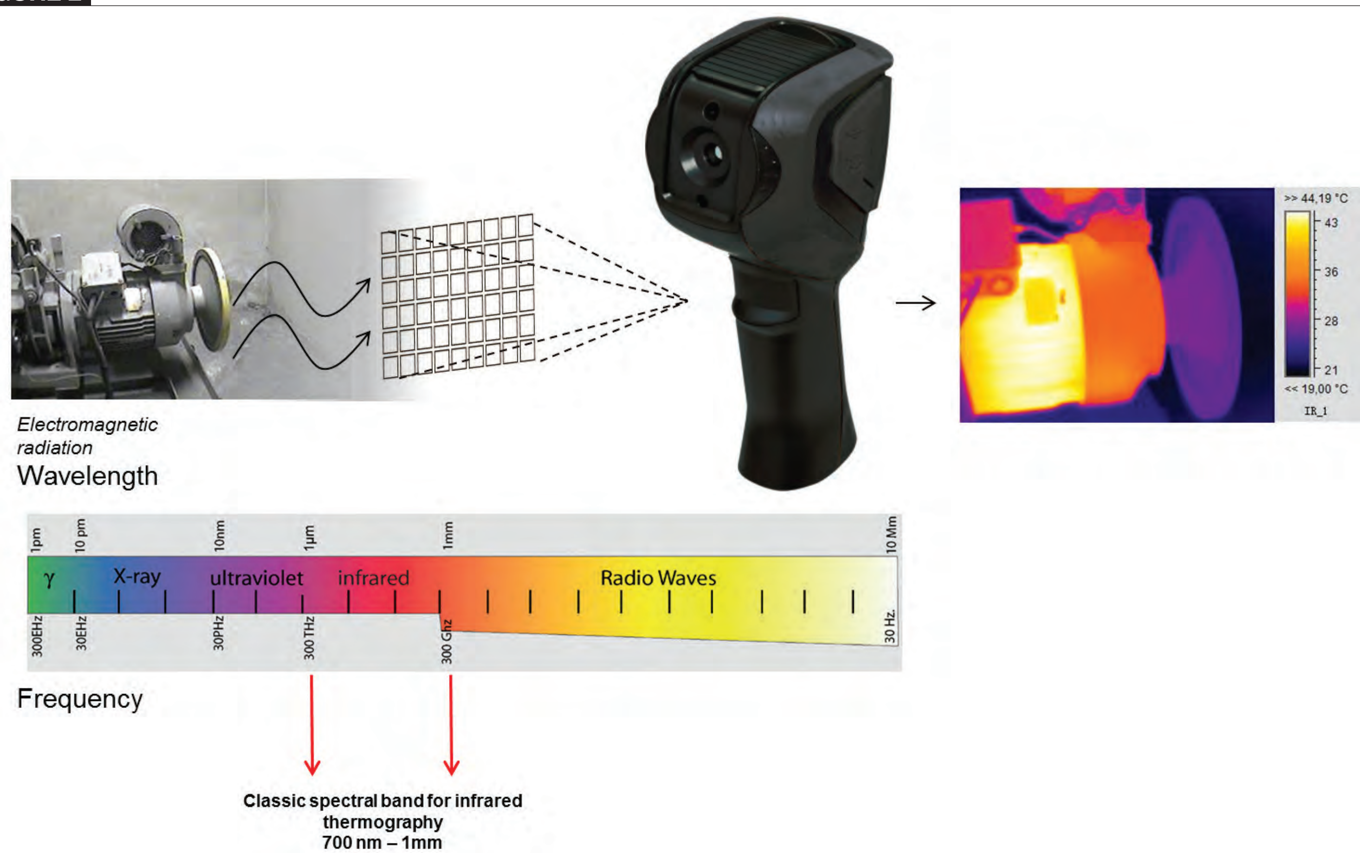


FIGURE 3

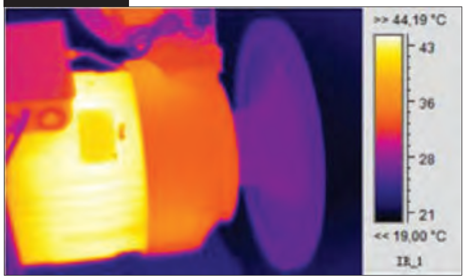


FIGURE 4

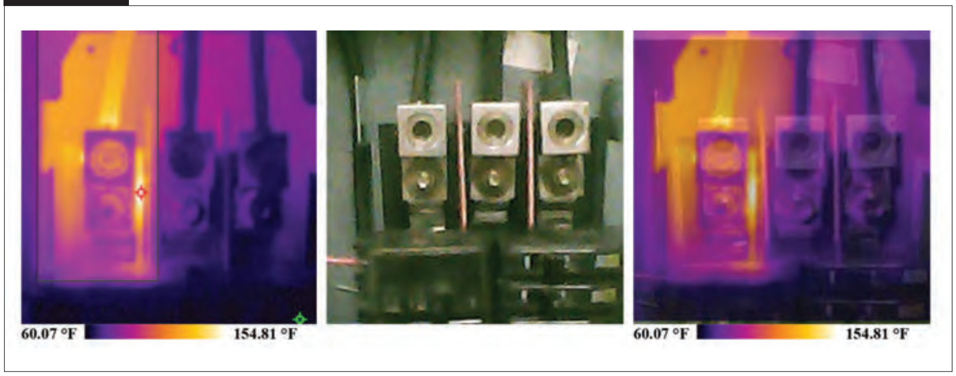
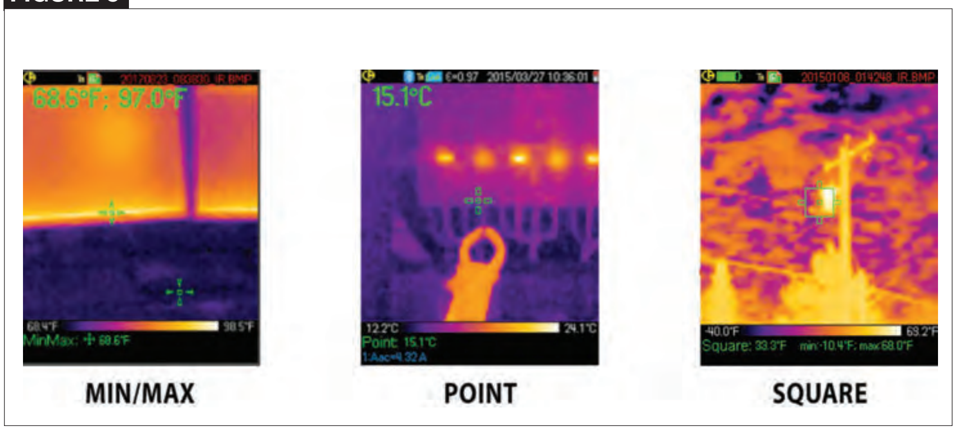


FIGURE 5



There is a common misconception that thermal imaging devices emit a signal or some sort of radar in order to detect temperatures and thus also have the ability to penetrate solid objects to see what is on the other side. This is a fallacy. Thermal imaging cameras detect and measure thermal radiation received on its surface, much like your eye does with visible light, not the other way around.

Heat is transmitted by conduction, convection and radiation. See Figure 1. Thermal imaging cameras work by measuring radiation.

Let's take a look at a basic functional diagram of a thermal camera. In the diagram shown in Figure 2 we see a thermal camera pointed at a motor. The motor gives off (radiates) thermal information that is actually based on several characteristics. These are the radiated, emitted and reflective properties which we will discuss the importance of later. These values are detected by the measuring elements on the cameras' thermal lens which is called a microbolometer.

A microbolometer is a specific type of detector used in a thermal imaging device which is made up of many detectors (pixels) known as a Focal Plane Array.

On the lower end we find infrared cameras with 80 by 80 or 160 by 120 pixels. Higher end cameras have 640 by 480 and higher pixel arrays. The higher the pixel resolution the clearer the thermal image will be. As you can imagine as you go up in pixel count you also go up in price. For this article I will be addressing the lower end cameras that are adequate for electrical maintenance and are also cost effective for that work. One nice characteristic of microbolometers used in thermal imaging is that they do not need to cool down between measurements. As you point the camera to different areas of interest the measurements appear essentially in real time.

Infrared radiation occurs in a spectrum just below visible light. These wavelengths between 700-1000 nanometers strike the detector material, heating it which changes its electrical resistance. This resistance change is measured and processed into temperatures which can then be used to create a thermal image. The conversion process also takes into account other influencing quantities such as emissivity, environmental temperature and relative humidity. Once this information is processed by the camera's electronics, a thermal image is presented on the color graphic screen for the user's view and analysis. This thermal image is called a Thermogram, See Figure 2.

Thermography makes it possible to see the measurement environment with or without visible light. The amount of radiation emitted by an object increases with temperature; therefore, thermography allows you to see variations in temperature. When viewed through a thermal imaging camera, warm objects stand out well against cooler backgrounds and hot spots in electrical equipment become easily visible against the environment, day or night.

Cameras with auto focus or focus free capability makes the task of capturing good thermal images a lot easier and faster.

A typical thermogram will show a color coded temperature scale as well as the thermal image. This scale will usually be on the left or bottom of the image and is a necessity in determining the temperature at different points on the object. Figure 3 is a typical thermogram.

Most Thermal cameras will also capture the real image, using a separate lens, and provide the ability to overlay the thermal image on the real image which delivers a better analysis tool for troubleshooting and reporting.

Figure 4 shows the thermogram, real image, and overlayed images.

Once the Thermal image is captured it is now time to analyze and make decisions about the measurement and the quality and accuracy of what was captured.

First, let's talk about the quality of the data. To accurately produce the thermogram you need to know the emissivity of the object you are pointing at and adjust the camera accordingly. Secondly, it is important to be sure the captured data does not contain a lot of reflective thermal data which can alter the thermogram. Finally, ambient conditions need to be taken into account. Most cameras will allow you to make emissivity corrections after capturing it either on the camera or from the accompanying software once the data is transferred from the camera. Many infrared cameras incorporate built-in emissivity tables which can be quickly used for this purpose.

FIGURE 6

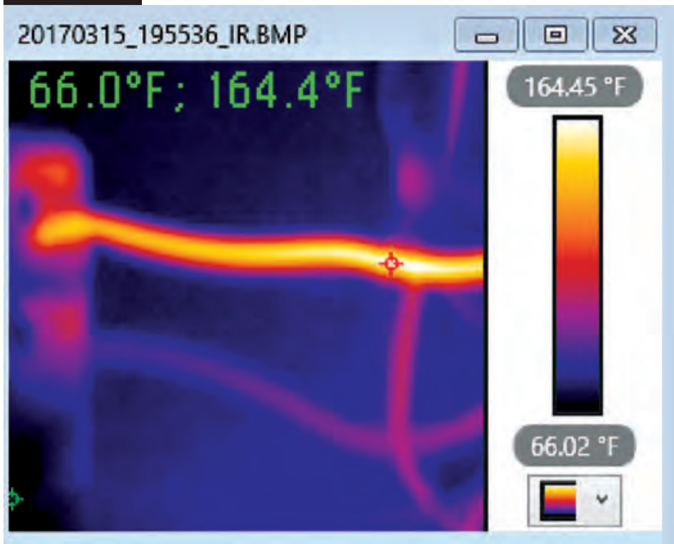
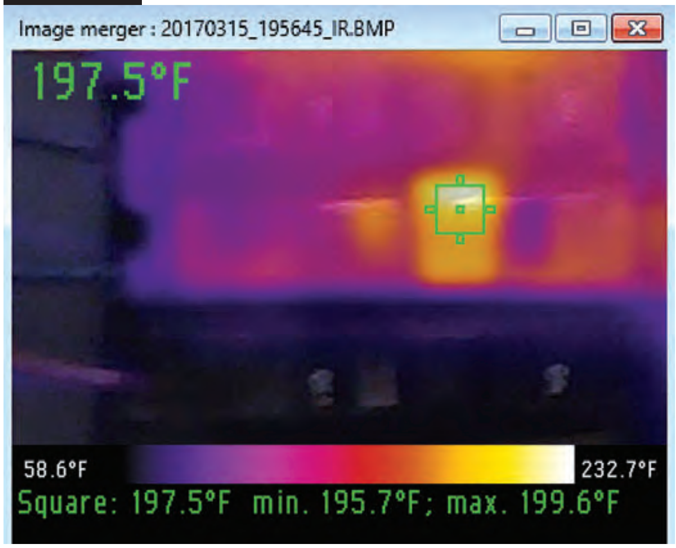


FIGURE 7



Alternatively, a sample specimen of known emissivity can be placed on or next to the device under test to facilitate actual comparison. This provides the ability to manually adjust the emissivity to ensure that the device under test and the sample specimen provide the same temperature on the thermogram.

Regarding reflective temperatures, it is important to understand and visually survey the objects around what you are testing including yourself. All of these will reflect temperature changes to what you are measuring. Shiny objects will include more reflective temperatures than matte or flat finished objects and often include the body temperature of the technician holding the camera. Here we can see an object on the wall being measured that also includes a reflective image of the technician doing the measurement. In this case the reflected temperature is higher than the specimen that the technician is trying to measure.

Most cameras also provide the ability to adjust for ambient temperature and humidity in the camera itself. If this is not possible, the application software provided with the camera usually will give you this capability as well.

There are many tools provided in the camera and accompanying software that help you analyze the captured data. One that I find very useful is selectable cursor types that provide visual location and digital readout of the temperature at the cursor point.

The particular camera that I use offers six different cursor types that can be employed with the thermogram. The three that I find most helpful are called Point, Square and Min/Max as shown in Figure 5.

Point, as you would expect, is a single cross hair that moves around the thermal image on the camera using the cameras navigation keys to obtain the temperature at a particular point.

Min/Max on the other hand affixes the cursor at the lowest and highest temperature point in the thermogram and displays the corresponding temperatures.

Square allows you to construct a square around an area of the thermogram which in turn will display the min/max and average temperatures within the square.

These tools make life easier in analyzing and tracking thermal radiation in electrical maintenance applications.

There are other very useful features and functions that are available in infrared cameras and their accompanying software that will provide quality data capture, analysis and reporting.

As a quick recap, IR cameras come in a variety of screen sizes, resolutions and costs.

The screen sizes vary from 2 inches or less to 4 inches in a typical hand held pistol type camera.

The resolution typically referred to as pixels can be 80 x 60 on the low end to 640 x 480 or more on the high end. Often this specification is stated as the total number of pixels. For example, a camera with 160 x 120 resolution is referred to as a resolution of 19,200 where as a camera with a 320 x 240 resolution produces 76,800 pixels.

Thermal cameras detect radiated light in the infrared spectrum in the same way your eye detects visual light. They do not look through solid objects such as walls, windows or clothing therefore, they cannot detect temperature from items on the other side. This infrared capture is converted to a visual light presentation and displayed on the camera's screen where the human eye can see and is called a thermogram.

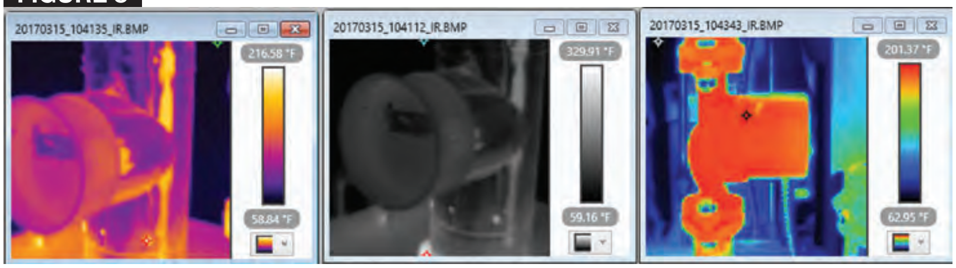
Different material will absorb, reflect and transmit energy at different intensities. They will radiate hot or cold energy at different rates which can be detected by infrared cameras and presented as thermograms.

Emissivity of the material is also an important point to consider for accurate measurement. It is the amount of radiation emitted from an object compared to a reference; assuming both are at the same temperature. Adjusting the emissivity is important when comparing the temperatures of different entities. Many cameras include built in emissivity tables allowing you to make a quick adjustment.

Okay, now let's take a look at the therom-gram itself. For this exercise I have captured the thermal image of two different circuit breaker panels with similar but different problems. Figures 6 and 7 shows the thermograms resulting from each measurement.

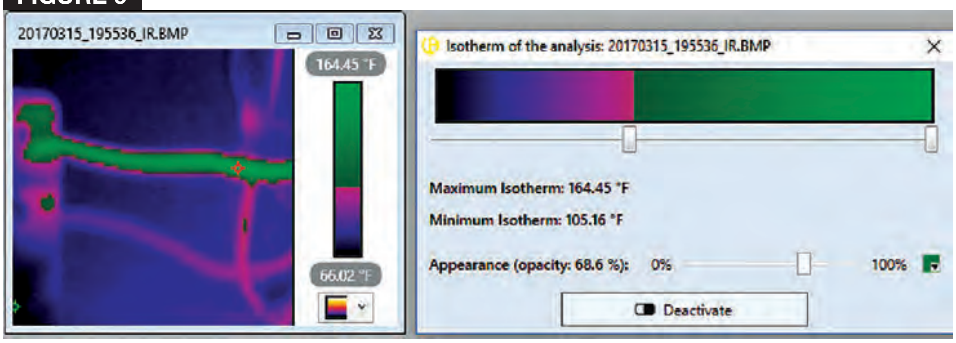
Analysis of each gives the overall span of the temperatures radiated from the section of the panel measured along with a color bar graph to identify the temperature gradient. In this case, black represents the coolest temperature and white the hottest with varying colors in between. Without the use of cursers it is difficult to pinpoint the exact temperature of a given point or section of the captured thermal image. As discussed earlier, I like to use two of the features available in the camera that I use. These are Min/Max and Square. The Min/Max places two crosshairs on the image at the exact location of the coldest and

FIGURE 8



STEEL GRAYSCALE RAINBOW

FIGURE 9



hottest temperatures and presents a digital display of these values right on the thermogram as shown in Figure 6. The other is the Square cursor. This type of cursor lets me define an area of the thermogram by moving and resizing the square to the section of interest. Then the min, max and average temperatures within the square are displayed on the thermogram as shown in Figure 7. There is another observation that is important to point out when analyzing these thermograms and that is the location of the hot spots with respect to operation of the device in question. You will notice that in Figure 6 the hottest area is the wire connected to the circuit breaker. In Figure 7 the hottest area is the circuit breaker itself. The conclusion to be drawn from this is that in one case the cause of the problem is coming from the load in the case of the hot wire and in the other it is coming from the source where the circuit breaker is the hottest point and is most likely defective. Paying attention to these subtle differences will save you considerable time and effort in isolating and correcting the problem.

There are two other tools, among many that are available from the various IR camera manufacturers, that I would like to briefly mention before we discuss some features and functions that you should look for in an infrared camera. These are color palettes and Isotherms.

Most cameras on the market offer a selection of color palettes that can be employed in thermogram. On the particular camera I am using these palettes are called Steel, Rainbow and Grayscale. The thermograms in Figures 6 and 7 were captured used the Steel color palette and that is generally the best choice for printed reports. I like the Grayscale palette when capturing thermal images from objects that do not have a wide variation in temperature. I find that I get a better image definition of the object. The Rainbow selection provides a crisp definition of the hot area of the image. Figure 8 will give you a good example of these three choices.

The Isotherm is a great tool to use to quickly visually identify areas of the thermogram that are in the same temperature range. With some models you can set the temperature range of interest and the color to be used for the isotherm from the cameras' menu or in the application software supplied with the camera. Figure 9 shows a typical isotherm. Here I selected a temperature range of 105°F to 164°F and the color green to represent that range.

Once all images associated with the project are captured, reviewed and downloaded, the report generation software becomes a valuable tool to analyze the thermograms and create reports with recommendations for correction where necessary. This could be a topic for a future article.

Let's take a look at some basic features, functions and specifications to consider if you are in the market for an infrared camera.

Resolution – IR cameras come in all shapes and sizes. Detector resolution is a key element to consider. Picture clarity increases as the resolution increases and so does the cost of the camera. For general electrical maintenance applications, the lower resolution cameras are adequate and fit most budgets.

Sensitivity a.k.a. NETD (Noise Equivalent Temperature Difference) – represents the smallest temperature change the camera can detect. For example, a camera with 0.1° NETD can distinguish between two surfaces with only a 0.1 degree temperature variation.

Temperature Range is another important factor to consider. The range defines what the minimum and maximum temperatures are that the camera can measure (-4°F to 482°F) is common for cameras adequate for electrical maintenance work.

Focus – like the camera you use to take visual photographs, thermal cameras also need to be focused to provide image clarity. Many cameras on the market today are focus free or auto focusing saving you time and effort in getting good quality results.

Field of View expressed in degrees and Spatial Resolution (also referred to as IFOV) expressed in milli-radians provides an indication of how large an area you can capture in a thermogram and the ratio between distance from the object to the size of the area captured.

Image Capture – the ability to capture both real and thermal images with the capability to overlay them when creating reports is very useful especially if the report is sent to someone not involved with the actual test data.

Environmental Adjustments – Many cameras offer the ability to compensate for things like ambient temperature, humidity, reflectivity and emissivity. These are beneficial in providing the most accurate results for your efforts.

There are many more characteristics of thermal imaging we could discuss if space allowed.

The intent here is to present some basic points of understanding and practices to use.

If you are involved or plan to be involved with infrared thermography for your work on a regular basis, there are formal certification courses available that I would strongly advise that you consider. It will be well worth the time and expense in giving you the understanding and tools to conduct thermal analysis correctly and accurately and it will save you countless hours from trying to figure it all out on your own through trial and error. ❑

Model 1950: Focus Free simultaneous capture

Versatile tool for performing infrared thermography. This technology is an indispensable means for ensuring safety in industrial production.

Thermal Imaging IR Camera Model 1950 is a simple-to-use “focus free” instrument that features a 20° x 20° field of view. The camera can be used as a real-time viewer for detecting hot spots and other thermal anomalies. Thermal images (also known as thermograms) can be recorded and stored on the instrument. You can also add audio comments and measurement data (provided by a compatible clamp-on meter or multimeter) to the stored image files.

The instrument features *Bluetooth* technology for connecting to electrical measurement instruments and a headphone for recording narration. You can download stored thermograms to a computer running CAmReport software (provided with the instrument) for image processing, analysis, and report generation.

Key features & functions

Provides a wide 20° x 20° field of view with an IFOV spatial resolution of 4.4mrad.

This allows you to quickly inspect a large area in real-time, and capture a high level of thermal information in a single thermogram. Focus on a 0.086" (2.2mm) object from 9.8' (3m) away. Capture desired measurements from a distance with the camera's 75:1 ratio.

Focus free quality.

Provides crisp, clear thermal and digital images without the need for adjustments.

Accurate temperature measurement over the full range.

From -4 to 482°F (-20 to 250°C) with a stability of 80mk at 86°F (30°C).

Audio narration can be recorded with thermograms.

You can describe the circumstances of each image, providing additional text and description to be stored with each image.

Automatic non-uniformity temperature correction.

Compensates for any internal drift to improve accuracy.

Measurement data can also be stored with each thermogram.

The Model 1950 can wirelessly connect via *Bluetooth* to a compatible AEMC® clamp-on meter or multimeter, enabling you to combine electrical measurements to the imaging data.

Offers broad range of operational capabilities.

Locating the cold and hot spots in the image, measuring the temperature of a selected point in the image, displaying the temperature profile of a line in the image, displaying points at the same temperature in the image, and freezing the colors representing the temperatures.

CAmReport software.

Included for downloading stored files from the instrument to a computer for further processing, analysis, and report generation.

This camera is built to last.

Its rugged design survives accidentally dropping on any of its surfaces from as high as 6'.

Exceptionally long 13 hour battery life.

Ensures no loss of test time during a typical work day.

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