The New Buyer's Guide to

Thermal Imaging

Fire Service Edition

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How to use this Buyer's Guide

Much has changed in the world of thermal imaging for the fire service since its introduction in 1998. This guide serves as a tool to help anyone in the fire service understand today's options, considerations, and advancements. In addition, it is designed to offer innovative ideas to firefighters who use thermal imagers, purchase thermal imagers, or are interested in learning more about thermal imaging.

This Buyer's Guide will:

- Explain advanced and technical concepts in easy to understand language and images
- Offer templates for TI evaluations
- Compare features and warranties
- Provide information on batteries and maintenance

What to look for:

- Quick tips
- Checklists
- Glossaries

The Changing Landscape of Thermal Imaging for the Fire Service

Are you up-to-date?

Thermal imaging for the fire service has changed dramatically in the past several years. Thermal imaging technology has become more accessible for more departments. The technology in these cameras has become more sophisticated and the cost of thermal imagers has decreased significantly. For these reasons, the key elements and features that fire departments look for and value have evolved as well.

The shifts in thermal imaging are exceedingly obvious when you look at a few key changes:

- **Small form factors**

  Some imagers are lighter than two pounds and designed to easily clip to turnout gear with a retractable strap.

- **Improved image clarity**

  The latest technology in image processing keeps the heat of a raging fire from "blowing out" the details around it. Previously, detail was lost as the entire scene was processed in a single high-heat or low-heat mode. Now, some imagers can process different portions of a scene differently, to display details even in areas with extreme temperature variances.

- **Greater affordability options**

  Access to thermal imaging technology has changed as imagers now can be purchased for as low as $5,000 and can carry low total costs of ownership, in some instances. This is a far cry from the days when even the least expensive thermal imager could run more than $20,000.

What this means for firefighters

1. A Thermal Imager (TI) can be simple, light, and easier to use.
2. Images can be extraordinarily clear.
3. Upgrade options, promotions, and decreased total cost of ownership can make it possible to deploy more units in more places.

What this means for TI purchases

1. Hands on demos are more important than ever.
2. Image clarity has trumped camera resolution as the most important factor in displaying scene details.
3. Understanding the true total cost of ownership over the life of the imager is critical when making purchasing decisions.

Looking ahead

As thermal imaging technology continues to advance, it will be increasingly vital that the users, purchasers, and trainers of thermal imagers be educated on the latest information. Luckily, there are many resources that keep the fire service up-to-date on training, tactics, and options. Check out the sidebar for some of these valuable resources.

Purchasing a new thermal imager?

Check out these helpful articles:

Evaluation checklist, page 12

Innovative T&E ideas, pages 13-14

Image Clarity: What to look for...

We all know that seeing the details is critical in a fire scene. For years, when it comes to image quality in thermal imagers, much of the discussion has centered around image resolution. While image resolution is important in thermal imaging, new technology has made it possible to process images in an advanced manner that brings greater resolution detail.

It's all about image processing.

These days, image processing is where all the magic happens in thermal imaging. Image processing is actually a very technical activity. During image processing, the engine core of the camera (the "brains") takes the signal it receives from the camera sensor and converts it into an image. See "How a TI Works" on the next page for more detail about how the image is created.

High gain or low gain? And what does that really mean?

Images can be processed in lower gain modes or higher gain modes. The "gain" is essentially the level of sensitivity. Just as with a radio, an infrared detector must adjust its gain level to filter out background noise. Some thermal imagers process the entire scene in either a high gain mode or low gain mode. This works fine except in instances where a firefighter needs to see the detail of lower temperature items (like people or egress points) in the same field of vision as a raging fire.

The environment in a fire makes image processing difficult.

That's why the best processing must be pretty complex.

In the same way that a bright sun can obscure the details in a photographic camera, the gain mode required to process the thermal image of a hot fire reduces the detail of other items within the same scene.

To overcome that, new processing techniques available in some thermal imagers apply something called Adaptive Rescaling. Here's what that means:

> *Behind the scenes, the image is instantly broken down into three spatial frequencies that independently process in high, mid, and low gain modes, depending on the needs of that part of the image.*

This allows the camera to immediately process the image of very hot items and cooler items within the same scene, without losing the image details. Adaptive Rescaling allows firefighters to see details that have previously been obscured.

Focusing on the details.

In addition to the gain mode in which the image is processed, there are other ways to help firefighters see the details in a fire scene. The camera's engine core can bring out the edges of objects, as compared to the background of the image. This is basically sharpening the image.

Another processing technique that can be applied is Dynamic Contrast Thresholding. This process definitely is as complex as the name sounds. Ultimately, the engine core isolates the most significant image content in the scene and applies special image processing to that portion of the scene to instantly boost the image contrast in that area.

You don't necessarily have to understand the science. You'll know it when you see it.

The elements that make an image clear are complex and varied. It's not as clear-cut as comparing the specs on resolution. However, the difference in image quality is evident when cameras are compared side by side in a fire scene. The best thermal imagers are designed with an eye to balancing each of the image processing elements mentioned above with good resolution and high quality displays.

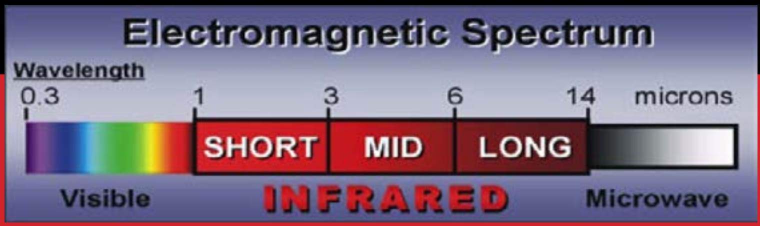
Where does resolution come into play?

Resolution is the number of pixels per unit of area. In theory, with more pixels available per area comes the capacity to show greater detail. However, that clarity is limited to the amount of detail the image processing can translate into pixels. That's why greater thermal imaging resolution can only create a clearer image when partnered with advanced image processing.

What to look for? Balance.

When evaluating thermal imagers for image clarity, you'll want to look for a design that has balanced the image processing, resolution, and brightness of display to create an image clarity that reveals the details your fellow firefighters will need to see to make critical decisions during a fire. It's definitely a balance you'll recognize when you evaluate an imager design that gets image clarity right.

How a Thermal Imager Works



All objects have a certain temperature and emit waves of energy called infrared radiation. Hot objects emit more energy than cold objects. A thermal imager translates these energy waves into a viewable image, which shows a "heat picture" of a scene. On the screen of a thermal imager set to white-hot, hotter objects show as white, cooler objects show as black, and objects in between these temperatures are displayed in shades of gray.

In some respects, the detector in the thermal imager is similar to the human eye. The thermal imager's detector (called a "focal plane array", or FPA) and the eye are both receivers. They receive electromagnetic energy and convert it into an image for our brains to interpret. The eye receives wavelengths of energy called "visible light," while the FPA receives wavelengths of heat energy called "infrared."

The human eye and the TI do not "see" through most materials. Drywall, plaster, concrete, steel, wood, paneling, down comforters, doors, sofas and the like are not transparent to visible light or infrared. They "see" only what is on the surface: colors for the eye, temperature differences for the TI. However, due to the unique characteristics of IR, you can see through thick smoke.

Comparing Warranties

Top questions to ask

1. What does this warranty cover?

Some cover all parts and labor. This is the ideal option, since there are so many parts of an imager that could potentially fail. Some of these critical parts can be expensive to replace if not covered by warranty, including various electronic boards, engine core, and sensor.

2. What are my options with battery warranties?

Batteries have a shorter lifespan than thermal imagers. They also require a regular charging and maintenance schedule. Make sure you understand your options when it comes to maintaining your batteries over the course of your camera's lifespan.

3. What is required to access the warranty?

With some warranties, you can purchase an extension. Other warranties may require some type of registration for it to be activated.

4. What type of service can I expect?

You can find this out by asking about the turnaround time and shipping costs. You can also get a feel for the type of warranty service you'll receive by talking with other departments about their various warranty experiences. A good sales representative should be able to give references of departments who have experience with the manufacturer's service department.

Sample Warranty Comparison Chart

	Bullard	Comparison 1	Comparison 2
Standard Length	5 years		
Coverage	All parts and labor for five years, plus lifetime housing warranty		
Shipping Costs	Free inbound and outbound shipping		
Turnaround Time	48 hours from receipt of camera		
Any Requirements to Activate Warranty?	None		
Are Batteries Covered?	Optional 5-year CareFree warranty covers all battery costs and replacements		
Other Benefits	Includes new housing, preventative maintenance, and new factory seals for all serviced cameras.		

Side-by-Side: Compare Thermal Imager Features

	Form Factor	Resolution Option	Image Clarity	Warranty	Performance	Colorization Features	Heat Source Features	DVR Feature
Eclipse® LDX	Small; less than 2 lbs.	320x240 or 240x180	Excellent; Uses ICE™ image processing	Full service 5-year parts and labor included	Bright LCD display; Bullard Tough durability	Super Red Hot offers predictable colorization	Optional Electronic Thermal Throttle® pinpoints source of heat	Optional SceneCatcher DVR integrated into body of imager.
Comparison 1								
Comparison 2								

Deploying Today's Thermal Imagers

As thermal imagers have become more affordable for the fire service, the deployment of imagers has evolved. While the technology was often limited to one thermal imager per station or department, it's now realistic for departments to have one TI for each apparatus or even multiple TIs per apparatus.

Popular Deployment Strategies

There are four common deployment strategies for thermal imagers:

- One TI for the entire department
- One TI for each station
- TIs for special units (Search and Rescue, etc.)
- One TI for each apparatus
- Multiple TIs on an apparatus

Many departments will either use one or more of the strategies listed above, depending on budget and department needs.

Five Questions to Ask

There are five important items to consider when implementing a deployment strategy.

1. **Should our department's TIs be standardized?**

   Some departments standardize their thermal imagers by brand or by model. The benefits of standardization can include easier maintenance and quicker training.

2. **Is camera and battery maintenance handled centrally or per station?**

   Much of this decision is influenced by the size and capability of the department. Camera maintenance can include software updates and upgrades, replacement of some field-replaceable items such as displays or glare shields, cleaning, and equipment inspection.

3. **Should I continue to use my current thermal imagers or look for upgrade options?**

   The best thermal imagers will be durable and offer a long service life. However, there may be instances where it's beneficial for a department to take advantage of a trade-in or upgrade promotion, even when the unit is still in service. One important note: because performance and quality can vary from manufacturer to manufacturer, it's still vital to make sure promotional opportunities don't keep your department from selecting the right thermal imager for your needs.

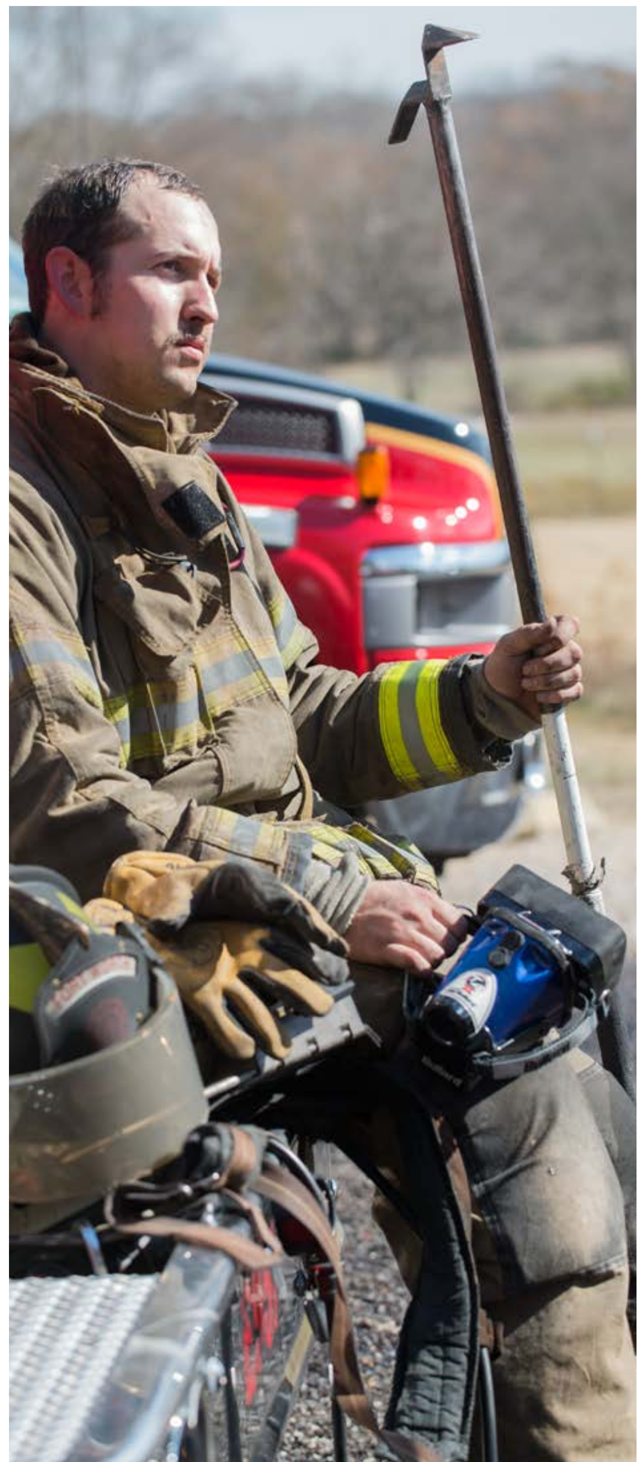
Five Questions to Ask (continued)

4. What features do I need for each deployment location and use?

The features and benefits of thermal imaging can vary drastically from model to model. Some models are designed to be small, lightweight, and simple to use when in the middle of a fire scene. Other models are more sophisticated and offer various diagnostic features, such as temperature colorization and hot spot pinpointing. Features used for recording and size-up may be better suited for cameras to be deployed in a different manner than smaller, more basic models designed to be clipped to turnout gear and worn by several firefighters inside a scene.

5. How frequently should we reevaluate our deployment strategy?

Like any technology product, thermal imagers are advancing and evolving on a regular basis. That's why regular evaluation of a departments' thermal imaging needs, as well as reevaluation of available technology and products is essential. The frequency of reevaluation may vary per department. However, a good practice is to designate a few individuals within the department to stay abreast of the changing technology, updating key personnel as the technology advances. This responsibility may lie in the training department or another key area. A more formal reevaluation of the deployment strategy may happen every few years or as the department grows or changes.



Understanding TI Batteries

When discussing care and maintenance of thermal imagers, the topic of batteries is a hot one. While the best thermal imagers will last for many years with very little maintenance, batteries by their nature require regular maintenance and rotation.

They're designed to be protected from high heat.

Some thermal imager batteries, like those from Bullard, are surrounded by a high-heat thermoplastic outer housing. Bullard Thermal Imager batteries are specially procured nickel metal hydride (NiMH) rechargeable battery cells that are encased in a high-heat Ultem® thermoplastic housing.

Batteries lose their charge even if not in use.

Any regular NiMH battery will normally lose its charge over a period of days and weeks (up to 1%-2% per day). If a battery is allowed to enter and remain in a state of discharge for an extended period of time (several weeks to months), it will need to be "exercised" in order to restore it to optimal performance.

Batteries need exercise, too.

If you're not actively using your NiMH batteries for more than 30 minutes at least one or two times per week, you'll want to completely cycle (or "exercise") each battery by doing the following:

1. Place battery in imager, and turn imager on.
2. Allow imager to remain on until battery is discharged and the imager shuts off.
3. Fully charge battery again.

If a battery has been in a state of discharge for several weeks or more, repeat the cycle above three to four times.

Weekly and monthly battery maintenance is important.

On a weekly basis, perform the following:

1. Verify that the batteries do not show physical signs of damage.
2. Rotate the batteries in your imagers and charger units.
3. Fully charge all your batteries.

On a monthly basis, exercise your batteries by following the steps listed in the section on exercise. An ideal way to maintain your batteries is with a battery conditioning and analysis system. This type of system is offered by some TI manufacturers. Look for features that make the battery conditioning convenient and easy to use. For example, the Bullard PowerUp battery conditioning and analysis system offers battery inventory control and user friendly indicators to identify the condition of batteries. It begins a conditioning cycle to increase battery run time for batteries that are not performing optimally.

Bullard batteries don’t have a “memory.”

Bullard Thermal Imager batteries may be charged any time during the discharge cycle (for example, after 30 minutes of use or multiple hours of use.) Bullard batteries are not affected by “battery memory” caused by repeated incomplete discharge cycles.

Batteries will need to be replaced.

The potential lifespan of batteries like Bullard Thermal Imager batteries will depend on proper maintenance and the amount of use in the field. Batteries will typically need to be replaced every one to two years.

You don’t necessarily have to worry about batteries.

There are some options, such as the optimal Bullard CareFree 5-Year Battery Warranty, that give you free batteries for five years. With this program the replacement, shipping costs, and evaluation of batteries are completely free for the entire five years of the warranty.

Innovative Ideas in Test & Evaluation

The testing and evaluation process for any fire equipment is always quite thorough. However, when it comes to a tool as complex as a thermal imager, the Test & Evaluation (T&E) plan should be exceptionally well planned. Departments or committees typically develop a written testing plan that includes evaluations focused on the following:

- Image quality
- Durability in heat, cold, and water
- Ease of use
- Performance in live burn
- Ergonomics

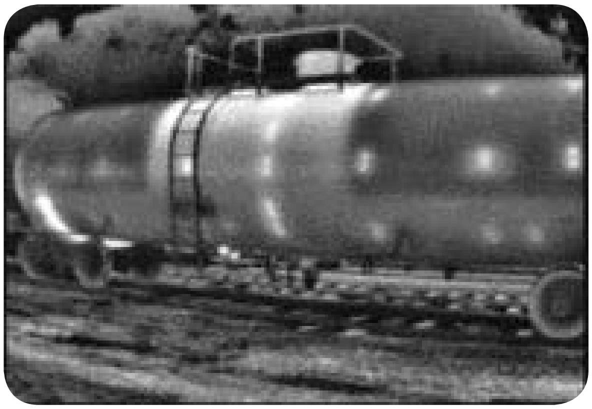
In addition to these testing areas, some departments are bringing innovative ideas to their T&E practices for thermal imagers. Check out some of the ideas below.

Online Feedback

Great for Station Evaluations. Using online tools (even pre-existing ones, such as Survey Monkey), many individuals across multiple shifts can quickly and easily provide feedback after runs with the imager. This online feedback makes data collection, recording, and analysis quick and easy. Surveys can be set up to give options for rating or ranking various qualities, providing multiple choice answers, and typing in custom feedback or comments.

Hazmat Tests

Great Test for Alternate TI Uses. Thermal imagers are frequently tested in live burns. However, they can also be used in hazmat operations. One way to test thermal imagers for hazmat operations is to evaluate the detection of vapors being released from a pressurized container, such as a propane cylinder. In addition, these cameras can be tested as they detect the level of liquid within certain containers (for example, identifying the level of liquid within a drum barrel.) These tests can be performed from various distances.



Outside the Box Involvement

Great for Comprehensive Evaluations. It's obvious that your evaluation will include the evaluation committee members and other firefighters. However, other key decision makers can benefit from seeing the thermal imagers' performance and differences first hand. These key decision makers can include the purchasing department, trainers, and equipment maintenance manager. They can provide insight and understanding from a unique angle that can positively affect your department's decision making.

Multiple Types of Burn Tests

Great for Understanding Imager Performance. It's typical to take a test imager to a live burn or on a few real life runs. However, departments get a better understanding of how an imager may switch gain modes (sensitivity modes), show human figures, or display colorization when exposed to various environments. Top departments are not only evaluating thermal imagers during basic evolutions in a one-day burn. They are also testing them in their academy with live fire, comparing performance with a flashover simulator, and performing basic laboratory testing (drop tests, oven tests, freeze tests, and submersion tests). In addition to these burn tests, evaluations for ergonomics, simplicity, and ease of use, especially when in use with gloves and full turnout gear, can provide a complete picture of how the imager will perform for your department.

When Live Burns Aren't an Option

In some instances, conducting a live burn for TI evaluation isn't feasible. With local and federal restrictions, these types of burns are becoming more and more difficult for many departments. However, it's still important to see how each thermal imager performs in the presence of a heat source. Innovative ideas for testing this include using other heat sources, like a hot stove, barrel fires, or even asking the manufacturers for videos of actual burns.

Template Evaluation Checklist

Unit Specs	Manufacturer: Bullard Unit: LDX Distributor:	Manufacturer: Bullard Unit: T3X Distributor:	Manufacturer: Unit: Distributor:	Manufacturer: Unit: Distributor:
Unit Design				
Shell Material	Ultem® Thermoplastic	Ultem Thermoplastic		
Strap Material	No Straps	Nomex®/Kevlar®		
Strap Locations	None	Left and Right Side		
Video Display	3.5"	3.5"		
Weight				
TI + Standard Battery	1.9 lbs.	2.5 lbs.		
TI without Battery	1.65 lbs.	1.9 lbs.		
Detector				
Detector Technology	Vanadium Oxide	Vanadium Oxide		
Detector Size	240x180 / 320x240	240x180 / 320x240		
Update Rate	60 Hz.	60 Hz.		
Power Supply				
#/type of battery included	2 NiMH Batteries	2 NiMH Batteries		
Are batteries rechargeable	Y	Y		
Optional alkaline battery pack available? Cost?	N	Y		
How are batteries recharged?	Charged in unit and in charger	Charged in unit and in charger		
Is a vehicle mounted charging system available?	Yes	Yes		
Evaluations				
Performance in Conference Room Evaluation				
Performance in Live Burn				
Performance in Drop Test				
Performance in Submersion Test				
Performance in Freeze Test				

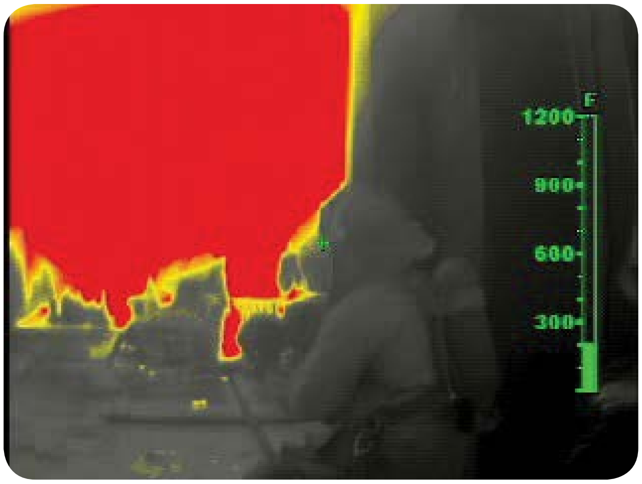
Thermal Imaging Glossary: Getting Past the Technical Jargon

Pixels: These are the independent squares on the infrared detector that sense and react to the infrared energy. Pixel size, as well as the number of pixels on the detector, helps determine the resolution and quality of the thermal image. However, the processing hardware and software play a far greater role in determining picture quality. The detectors in the fire service range from 80x60 to 384x288.

White Out: This term is a holdover from the early days of fire service TIs. The first handheld TIs introduced to the fire service could be easily overloaded by an intense heat source, such as a fire. These systems would either fail as a result of the thermal overload, or they would shut down as a means of "self-preservation." The end result in both situations was that the TI would have an all-white display. This "white out" could only be eliminated by removing the TI from the environment and giving it time to recover, or by replacing the damaged sensor.

All of the technologies available today are immune to "white out." The sensors can be overloaded by a fire, but they do not suffer irreparable damage in the process. In short, white out is no longer a concern for departments buying a modern thermal imager.

Saturation: This term reflects the fact that every TI sensor has a maximum amount of energy that it can receive and process. If the sensor is exposed to more heat (thermal energy) than it can measure, then it is said to be "saturated." Therefore, if a sensor can receive up to 1000°F in energy, then it will not be able to display a difference between a 1000°F item and a 1500°F item... the most it can sense is 1000°F. If a large number of pixels become saturated, then an image may be mostly white or clouded by white. This is not "white out." The detector, and thus the TI, is performing properly. It has been exposed to a significant heat source and is generating a mostly white image as a result.



If the TI has a colorization system, then the saturation will be indicated by the "hottest" color (normally red).

Dynamic Range: This has two meanings. The technological definition of dynamic range relates to how many temperatures can be displayed in any given scene. Each TI has a maximum range of temperatures between black (cold) and white (hot). The larger this range, the more gray scales are available to the system and the greater the range of temperatures that can be shown in a given image. In a very dynamic scene, this larger range generally results in a higher quality image. The second meaning of "dynamic range" is probably more common in the fire service. It refers to the maximum temperature the detector can receive before it is saturated. This usage of the term is synonymous with "saturation point."

Microbolometer: This is a type of infrared detector. The term refers to the way the individual pixels on the detector receive thermal energy and translate them into an electrical current for the software to analyze. Most new thermal imagers are microbolometers, based on detectors made of vanadium oxide or of amorphous silicon. The primary advantage of a microbolometer is that it can be designed to calculate surface temperatures based on the readings its pixels receive. All microbolometers have a shutter, which will "fire" at different intervals to refresh the image. When this happens, the image on the display appears to freeze. The picture freeze is normal on all fire service microbolometers.

The other type of sensor is a ferroelectric detector. These are commonly referred to as BST detectors, since the material on the sensor is barium strontium titanate. Ferroelectric detectors are not inherently better or worse than microbolometers; they merely operate on a different electrical principle. Ferroelectric detectors do not have a shutter, so there is no image freeze. However, these detectors cannot calculate surface temperatures from their pixels.

Remember that any surface temperature measurement is subject to inaccuracy based on a number of factors outside the user's control.

Normal Gain

Gain Mode: Just as with a radio, an infrared detector must adjust its gain level to filter out background noise. Current fire service TIs have automatic gain adjustment systems, thus the firefighter does not have to concern himself with adjustments. The gain adjusts based on the amount of thermal energy in any scene. Microbolometers commonly have two gain levels, "normal" or high gain and "EI mode" or low gain. When these TIs switch modes, the shutter will fire, and there will be a momentary freeze of the image. Some TIs display a symbol to indicate that the TI has switched from high gain to low gain mode. Two examples of symbols that indicate low-gain mode are "EI" and "L".

Low Gain

Operational Range: Many TI specification sheets will indicate an operational temperature range. This refers to the temperature of the detector, not the scene being scanned or the environmental temperature. If the detector itself has a temperature outside of the range, it loses electrical conductivity and will not produce a proper image. The newest TIs have operational ranges of 0°F to 185°F. Insulation and heat management devices inside the TI help keep the detector in this range during normal operations. Depending on the TI, it could take an hour or more of exposure at an extreme temperature to actually make the detector temperature move outside its operational range.

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