FLIR

The Complete Guidebook on

THERMAL SCREENING FOR ELEVATED SKIN TEMPERATURE

FLIR EST™

Thermal Screening Solutions

Minimizing the spread of infections

Infrared thermography can detect elevated skin temperatures, which may indicate the presence of a fever. When followed by a screening with a medical device designed specifically for measuring body temperature, such as a thermometer, the use of an infrared camera as an adjunctive diagnostic tool may help contain or limit the spread of viral diseases such as bird flu, swine flu, or COVID-19.

Since the outbreak of serious flu strains such as H1N1, public health authorities have been looking for a reliable method to detect elevated body temperature as part of this disease prevention policy. The focus is specifically on elevated body temperature—or fever—because it is often a reliable indicator of many serious infections. Infrared thermography provides a fast, easy, contactless (non-invasive) method to initially screen individuals for signs of elevated skin temperature. Only those who appear to have an elevated skin temperature would then be screened with a medical device to confirm the presence of fever. When used properly, infrared cameras can therefore be a vital tool in screening travelers, hospital patients and visitors, warehouse workers, customers, and more.

TYPICAL SCREENING LOCATIONS

Infrastructure, Manufacturing And Industrial Spaces

- High-traffic areas with large throughput
- Multiple entrances requiring screening stations
- Need for self-service or minimally-assisted stations

Examples:

– Hospitals
– Universities
–Transportation hubs
– Fulfillment centers
– Stadiums
– Manufacturing facilities
– Commercial buildings

Government Facilities

- Medium to high-traffic areas
- Security entrances that require the addition of screening stations
- Need for assisted screening that could be permanent, temporary, or portable

Examples:

– Military bases
– Border checkpoints
– Federal buildings
– National parks
– Federal prisons
– Federal transportation screening

Small Business And Retail

- Low-traffic areas with minimal throughput
- Fewer entrances requiring screening stations
- Need for easily-deployed self-service stations

Examples:

– Banks
– Gyms
– Urgent care centers
– Assisted living facilities
– Hotels
– Stores
– Small offices

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SCREENING PROGRAM CONSIDERATIONS

Launching an elevated skin temperature screening program with an infrared—or thermal—camera may feel like a daunting task, especially if you are unfamiliar with thermography. It can be extremely useful to understand the physics behind thermal imaging and measurement; the relationship between skin surface temperature and internal temperature; the effect of environment on measurement; and screening standards from agencies like ISO, IEC, and the U.S. FDA. These are just a few of the many factors to consider when building an efficient and effective screening program.

At FLIR, we have been developing and deploying thermal imaging technologies for more than 50 years in thousands of applications including elevated skin temperature measurement. Drawing upon our extensive experience, we created this document to help you make sense of all the decisions that go into developing the right screening program for your organization. Our goal is to get you started down the right path by thinking about the core program needs.

Of course, we are always available to answer your emails, speak directly over the phone, or even come to you and conduct an onsite demonstration. Just let us know how we can help.

ABOUT FLIR

FLIR saves lives and livelihoods by helping professionals detect system failures, troubleshoot repairs, see through smoke, and much more. With more than 50 years infrared innovation and systems in use worldwide, FLIR is the global leader in thermal imaging technology.

Key Program Considerations

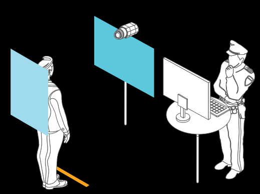
What is your screening throughput?

A key factor to consider when designing your program is your anticipated screening throughput. Knowing how many people you may need to screen per hour or per day will determine the size of your scanning set up, the need for operators, the technology performance, and the need for network integration. Low throughput rates (e.g. fewer than 100 scans per hour) can be satisfied with simple one-to-one type configurations where you have one operator monitoring one subject at a time. Medium throughput rates (100 to 1000 scans per hour) require more sophisticated technology to shorten scan duration as well as the use of multiple lanes or require advanced automation to minimize line size and wait times. High throughput rates (more than 1000 scans per hour) will require multiple scanning stations, several operators, system integration, and/or some form of automation.

STAND ALONE

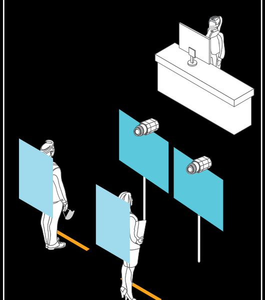
Fully operator-controlled

All gate passages are controlled by trained EST-operators.



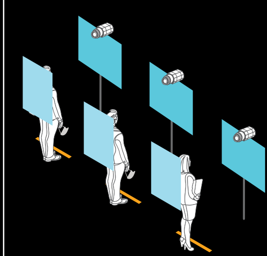
Assisted self-service

Reactive operator available for guidance & alarms.



Self-service

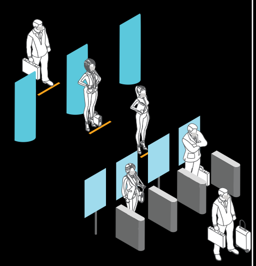
No operator support available on-site.



INTEGRATED

Partly integrated with access control

Passage system is connected to the screening result.



Fully integrated with on-site passage system

The screening is fully integrated in the passage system.

Automated and remotely monitored

Passive security monitoring.

Where will you conduct the screening?

Carefully consider the location for screening stations, as environmental factors can influence thermal measurement accuracy.

- Intermittent air flow from a heating/cooling vent will create convective heat transfer conditions. This could artificially raise or lower the skin surface temperature of the screening subject.
- Hot objects in the background could inflate measurements if the thermal camera detects them.
- Outdoor locations are generally discouraged as solar loading or solar reflection could falsely trigger a measurement alarm. Selecting a proper indoor location will prevent or lessen thermal interferences and contribute to screening speed and accuracy.

Will your program be permanent or temporary?

Thermal cameras come in all shapes and sizes for use in a wide variety of applications and installations. Screening programs that are only needed temporarily or intermittently could be satisfied with a handheld, battery-operated thermal camera on a tripod. Certain handheld cameras come with touch screen displays and on-camera screening capabilities for simple set-up, operation, and take down.

Permanent screening stations could incorporate computer systems or servers to run higher performance software that perform automated tracking and measurement. For these situations, a fixed mount thermal camera can be hardwired in for power, command, and display.

Will your screening system be part of a larger ecosystem?

If your organization would benefit most from a stand-alone screening system, then camera connectivity and communication protocols may not be something you need to explore. However, if there is a need for future scaling or if the immediate plan involves large system integration, then camera robustness, remote control, connectivity, and communication capabilities will be critical considerations.

For example: some thermal cameras have on-board screening capabilities with ONVIF compliance making them compatible with most video managment systems (VMS). These cameras can be easily integrated into existing or new security systems for on-edge screening. Some thermal cameras also offer integrated digital I/O for easy installation into access control systems.

What screening methodology is best?

Crowd scanning, black body references, outdoor versus indoor, secondary screening, relative versus absolute temperature measurement, thermal camera stability: these are just a few considerations that can lead to decision paralysis when developing a screening program. Sorting through all the program recommendations can end up delaying implementation and compromising confidence that you're screening in the right way.

There are several non-biased sources for screening standards and tips on best practices, such as the U.S. FDA's thermal imaging system guidelines. However, partnering with technology providers, consultants, and integrators who understand the standards and know the best practices will ensure your program meets the application requirements and aligns with expert recommendations.

What support options are available?

Application and factory support are key in getting the most out of your thermal camera investment. Support needs can range from the simple, like questions about delivery times, to advice on how to integrate thermal cameras into existing security access control. As you research technology providers and integrators, here are some considerations that ensure optimal performance:

- Does the camera manufacturer provide loaner systems during service or repair?
- Are experts available to answer complex questions about thermal imaging?
- Does the manufacturer or supplier have established relationships with reputable integrators for advanced installations?
- Are there training programs to ensure correct use?

We'll discuss some other considerations that could affect your buying decision in Chapters 4 and 5.

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THERMAL CAMERA SELECTION

Not all IR cameras are created equal

Ask the average person, "What is thermal imaging?" and you'll likely hear about the night-vision cameras movie heroes use to hunt bad guys in the dark. Many people are surprised to learn that thermal imaging cameras can also measure the surface temperature of an object.

While there are several brands of thermal imagers on the market with many models at a range of price points, not all are designed to meet the demands of accurate elevated skin temperature measurement. Key camera specifications and features necessary for a successful screening program include sensitivity, accuracy, stability, and resolution.

COMPLIANCE STANDARDS

It's important to know compliance standards for accuracy, ambient drift, black body use, and more. For information and specific compliance notes, see the back cover.

*IEC 80601-2-59:2017 Annex AA, AA.1 General guidance. "Facial thermography of surface areas other than the region medically adjacent to the inner canthi is unreliable, and may be complicated by perspiration, facial skin flushed from exertion, etc."

Sensitivity

Most infrared camera companies have settled on a specification called Noise Equivalent Temperature Difference (NETD) to grade the sensitivity of an infrared camera. Also referred to a Noise Equivalent Delta-T, NEdT, or NEΔT, this specification is not the same as the accuracy or minimum resolvable temperature as some sources suggest.

In practical terms, the NETD value specifies the minimum resolvable temperature difference, or the smallest temperature difference the camera can clearly distinguish out of the noise.

The NETD for an infrared camera is measured in millikelvins (mK). The scale of sensitivity goes up as the numbers go down, meaning that 38 mK is nearly 3 times as sensitive as a 100 mK. Therefore, the lower the NETD, the more detailed images it can produce. Highly sensitive thermal imaging cameras will show more color and temperature differences; this high sensitivity also has a direct correlation with measurement accuracy.

Accuracy

The accuracy of an infrared camera system tells you the absolute measurement error of a known temperature target like a black body source, which is a programmable emitting device of electromagnetic radiation. For most infrared cameras, accuracy can be expressed in degrees, as a percentage temperature range, or both. For example, an industrial camera's specifications may list the accuracy as ±2°C (±3.6°F) or ±2%.

Usually manufacturers note that the accuracy is based upon the greater of the two values, like this: ±2°C (±3.6°F) or ±2% of reading, whichever is greater. What this particular accuracy specification means in application is described as follows:

An electrical fuse at 50°C (122°F) could have a ±2% error measurement of ± 1.0°C (±2.4°F). Because the percent error (±1.0°C/2.4°F) is less than the stated degree error of ±2°C (±3.6°F), the relevant accuracy value for the fuse is the greater specification of ±2°C (±3.6°F).

FLIR thermal cameras that are engineered for elevated skin temperature screening can achieve accuracies of ±0.3°C (0.5°F) over a temperature measurement range of 15°C to 45°C (59°F to 113°F). This aligns with the U.S. FDA Guidance for Industry and Food and Drug Administration Staff as well as with ISO/TR 13154 specification. High accuracy is ensured by using the camera in a stable ambient environment, by limiting targets to humans, and by frequently updating temperature reference samples according to the population being screened.

Thermal Screening Solutions

FLIR offers a wide selection of products designed specifically for skin temperature screening, including cameras, software, and accessory kits. Visit FLIR.com/ehs for more information.

Drift/Stability

Closely related to thermal camera accuracy is the ability of the camera to make accurate measurements during changing camera environmental conditions. This includes changing conditions outside and inside the camera, like camera electronics heating up or cooling down. A thermal camera's ability to produce consistent accurate measurement while experiencing these changes is referred to as drift or stability.

Thermal cameras create an image by responding to total thermal energy falling on the detector. If the camera is designed well, most of this energy will be from the scene instead of the camera itself. That said, it's impossible to eliminate thermal energy contributed by materials surrounding the camera detector and from the optical path. Without compensation, changes in the temperature of the camera body or lenses will affect the camera's temperature readings. FLIR cameras designed for measurement are unique in that they have internal sensors that measure the temperature within the camera and include a correction in the measurement reading. This ensures FLIR cameras will remain accurate throughout the entire environmental operating range of the camera (typically -15°C to 50°C/5°F to 122°F).

Cameras with this ambient drift compensation do not require a black body reference in the field of view to meet the recommended drift/stability specification of less than 0.2°C(0.36°F) within a specified time frame. Cameras that cannot meet this specification on their own must include a black body reference in the filed of view. More on black body measurement in the next chapter.

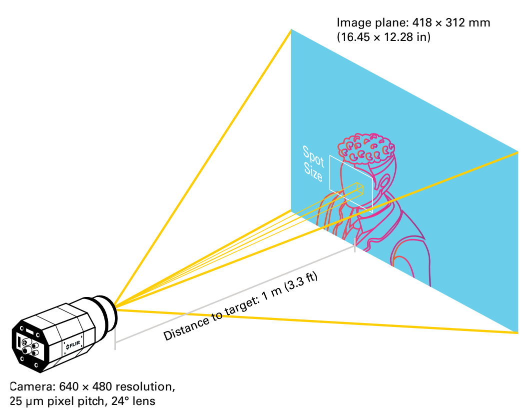
Spatial Resolution

Thermal camera images are generated by several thousand individual detector element measurements referred to as pixels. The combination of all pixels in a detector is referred to as a focal plane array (FPA), typically represented with values like 320 × 240 or 640 × 480. The spatial resolution of a thermal camera is the smallest area that one pixel can measure at a specific distance - also called spot size. The spot size for a camera will depend on the detector pixel size, lens, and distance to target.

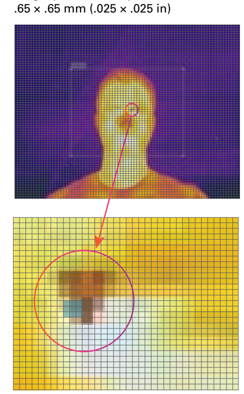
A general guideline for accurate measurement is to project a 3 x 3 pixel area on the subject that is smaller than the measurement area of interest. As the objective for elevated skin temperature screening is to measure the area near the inner canthi* (corner of the eye), it's important to choose the right camera, lens, and setup to project a 3 x 3 pixel area smaller than the area of the canthi (~ 5mm^2).

For example, an infrared camera with a 640 × 480 resolution, pixel pitch of 25 µm, and 24° lens positioned at 1 meter from the screening subject would project a 3 × 3 pixel area of 3.8 mm^2. Because our 3 × 3 sample area is less than 5mm^2, this camera configuration and setup meets the spatial resolution requirements for accurate elevated skin temperature measurement.

Contact your local FLIR representative if you need assistance selecting the right system for your screening set-up.



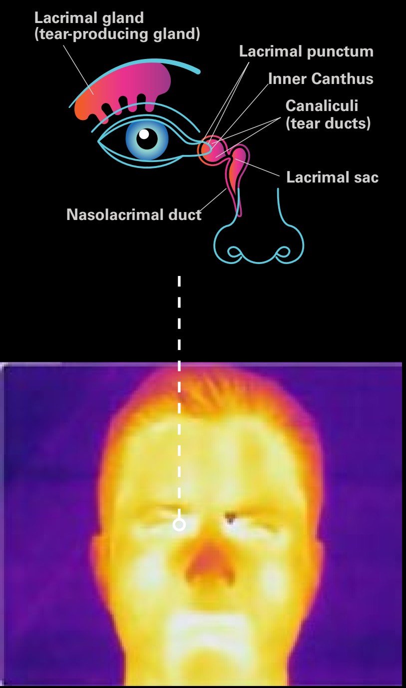
Single pixel sees a spot size of .65 × .65 mm (.025 × .025 in)



If you set up a 640 × 480 resolution infrared camera about 1 meter from a subject, the resulting image plane would be 418 × 312 mm (16.45 × 12.28 in). Therefore, a single pixel would have a spot size of .65 × .65 mm (.025 × .025 in).

3

ENSURING PROGRAM SUCCESS



Where to Measure for Accurate Screening

Human body temperature is a complex phenomenon. Humans are homeothermic, radiating heat through layers of skin to control internal temperature. As a dynamic organ, skin constantly adjusts the optimum balance between the physiologic demands of the body and external environmental conditions.

While the forehead is easier to quickly screen, it is more susceptible to environmental interferences and more likely to generate measurement errors. Research has shown that the corner of the eye—the region medially adjacent to the inner canthus—provides a more accurate estimate of core body temperature than other areas of skin. This is because skin at the canthi is thin (decreasing insulating effects), is less exposed to environmental factors, and is directly over major arteries which increase blood flow and heat transfer.

How to Measure – Relative vs. Absolute Temperature

Research has shown that skin temperature can vary by as much as several degrees throughout the day depending on environmental and other factors. For example, an increase of 10°C (18°F) in ambient temperature can lead to a skin temperature increase of up to 3°C (5.5°F). As such, the same person could likely have a different skin temperature in the cool early morning, compared to an afternoon on a sunny day.

Skin temperature fluctuations make screening for elevated temperatures using absolute methods very challenging. This is because the temperatures of people with and without a fever are on a continuum and inevitably overlap, even when the measurements are all made indoors at "ambient" room temperatures (about 15°C to 25°C/59°F to 77°F). Defining an absolute threshold alarm temperature can result in two unwanted effects:

- False alarms: Setting the threshold too low may result in the camera detecting elevated temperatures in people who don't have a fever.
- Missed fevers: Setting the threshold too high risks missing people who have a fever but remain below the threshold temperature.

One way to avoid the errors seen with absolute skin temperature screening is to perform relative temperature screening with a delta (difference) threshold. This method involves comparing an individual's skin temperature measurement to an average sampled population of known, non-fever measurements. The screening alarm is set to the delta threshold from the population instead of to an absolute threshold. In general, setting a relative threshold alarm to a difference — or delta — of 1.8°C/°F will overcome the unwanted effects of absolute temperature screening.

For example, the skin temperatures of individuals entering a building from a cold environment would all be impacted by exposure to cold, including the skin temperature of someone with fever. If conducting an absolute screening, the cold exposure could reduce the skin temperature of someone with fever low enough to fall under an absolute threshold alarm (say 38.6°C/101.4°F). However, if the skin temperatures of all individuals entering the building are compared to each other, someone with fever would still screen warmer than everyone else and trigger a delta threshold alarm (say delta threshold of 1.8°C/°F).

With this in mind, let's look at relative temperature measurement using a thermal camera. FLIR has several options available for performing relative skin temperature measurements, including the on-camera Screen-EST Mode and on-computer Screen-EST Software. All options compare individual screening measurements against a sampled temperature average that's updated periodically. When a screening result falls outside the user defined delta threshold, on-screen pass/fail graphics are presented and optional audible alarm is sounded. Body temperature measurement can then be conducted with an approved medical device to confirm the presence of fever.

How to Measure – Black Body Use

In theory, a black body is a physical object that is characterized by having an emissivity of 1.0, which means that it perfectly absorbs and radiates 100% incident thermal radiation. Black body radiation sources, or generators, are devices with an emissivity ranging from 0.90 to 0.99 and can be programmed to constantly emit radiation at a constant temperature. As such, they are routinely deployed as references sources as part of the thermal camera calibration process.

EMISSIVITY

A target's emissivity is its ability to emit thermal radiation. For example, ceramic mugs, clothing, and even human skin have high emissivity, while polished metals have low emissivity.

Because black body sources maintain a constant temperature with minimal drift, they can be deployed with less stable thermal cameras to reduce measurement uncertainty. For a black body to reduce drift or detection errors during measurement, it must be mounted in the same plane as the person being screened. This ensures the black body remains in focus and functions as an accurate reference source.

Recommendations for screening with a black body are set forth in ISO/TR 13154:2017 and include:

- Position the camera horizontally and vertically perpendicular to the individual's face.
- Position the individual being screened and the black body at the optimal focal distance from the camera.

Certain FLIR cameras are engineered and calibrated with automatic ambient drift compensation that eliminate the need for a black body reference. Reasons for this include:

- Camera calibration is part of the production process and is based on multiple high-end black bodies sources.
- The cameras integrate internal temperature sensors that compensate for a possible calibration shift.
- A shutter between the camera detector and the lens is used as a reference to perform non-uniformity corrections when the camera environment changes.

This proprietary mix of technologies ensures the thermal camera measurements remain stable and constant meeting the standard set forth in IEC 80601-2-59:2017, which states thermal cameras "may use SELF-CORRECTIONS to maintain the drift within acceptable limits… to allow for substitution of the CALIBRATION SOURCE".

Screening Location

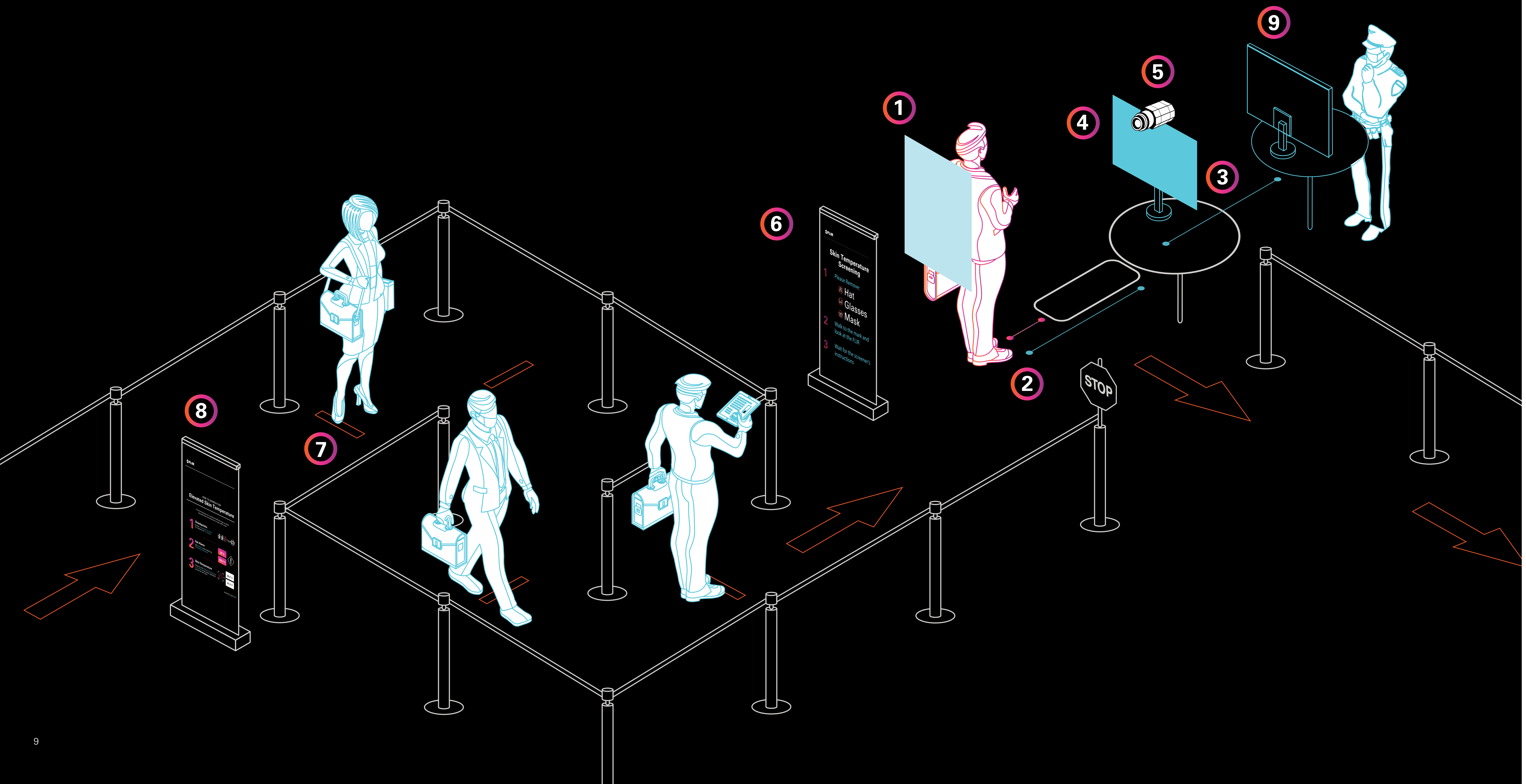
The screening location can significantly impact the efficacy of screening process. Care should be taken to ensure the following:

- Indoor screening is best with room temperatures maintained at 20°C to 24°C (68°F to 76°F) and relative humidity between 10 and 50 percent.
- Screening should be carried out in an area with no air movement, out of direct sunlight, and away from heat sources.
- Avoid locations with reflective backgrounds (e.g. windows or metallic surfaces).
- Allow for appropriate distancing between people in the screening queue, between the individual being screened and the camera, and between the camera and the screening operator.
- If screening must take place outdoors, steps should be taken to minimize the ambient environmental impacts on the persons being screened (i.e. – use of tents or shielding structures).

Screening Workflow

As per the guidance of governing and regulatory agencies, a screening workflow should involve:

- Screening people one at a time.
- Allowance for people to stabilize their temperature if it was raised by exercise or strenuous physical activity.
- Instructions to have individuals remove any face obstructions before measurement.
- Positioning of the individual at a fixed distance from the thermal imaging system.
- Positioning of the individual so they directly face the camera and have their entire face in the image area.
- Secondary screening on individuals who display an elevated skin temperature using a medical device designed specifically for measuring body temperature.



EXAMPLE WORKFLOW

1. **Screening Back Drop**
2. **Placement Floor Sticker**
3. **Table for Camera Setup**
4. **Monitor Facing User**
5. **IR Camera**
6. **Screening Instructions**
7. **Queue Indicator**
8. **Screening Information**
9. **Operator's Monitor**

4

EDUCATION AND SUPPORT

A vital question to consider when buying a thermal camera system is: What kind of support and educational opportunities will the camera manufacturer or supplier provide? As with any sophisticated instrument, ongoing training and technical support—from repairs to upgrades—are crucial to getting the most out of your camera system investment.

FLIR is always there when things don't go as planned, when repairs are required, and when training sessions are needed. We have unmatched experience in skin temperature screening, including:

- Specialized ITC - Infrared Training Center® certificate program for Elevated Skin Temperature Screening.
- More than 17 years of FLIR products deployed in elevated skin temperature screening operations.
- Global manufacturing and local support network with product distribution spanning more than 170 countries.

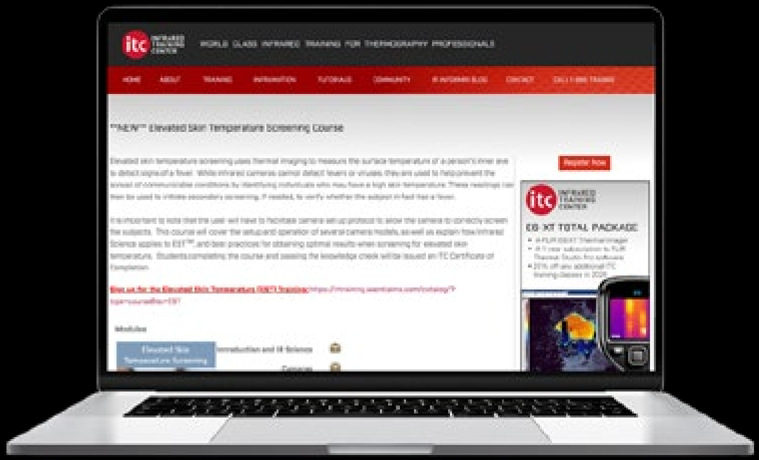
The ITC is the world leader in infrared thermography training, offering comprehensive hands-on labs and workshops in training facilities around the world. Our ITC staff provides training in more than 15 languages and can schedule training sessions at your facility if needed.

Customers who purchase directly from FLIR benefit from:

- Access to service and support professionals who are thermography experts.
- Direct flow of information including upgrades, new releases, and education.
- Dedication and focus to providing the best infrared products on the market.

If you're just getting started with elevated skin temperature screening, FLIR offers several short video tutorials for on-camera Screen-EST™ Mode to help get you started. The FLIR Customer Support Center portal offers access to our support team, software and documentation, service contacts, and more.

Although no thermal camera can detect coronavirus or diagnose COVID-19, FLIR cameras can be used to detect elevated skin temperature through quick individual screening. Detecting individuals with elevated skin temperature, who should then be further screened with medically approved devices such as thermometers, can help identify elevated body temperature and reduce the spread of infection.



RESOURCES

ITC: infraredtraining.com

FLIR customer service: flir.custhelp.com

Elevated skin temperature screening – how-to videos: flir.com/ehs


Qualitative analysis: patterns

5 WORKING WITH A REPUTABLE PARTNER

The final point to consider when choosing a thermal imaging system is the reliability and reputation of the camera provider. Do they have depth of experience in both elevated skin temperature screening and infrared technology, in general? Will the company have the longevity to provide service, technical support, and warranty coverage for years to come?

FLIR has been in the commercial infrared business from its inception, bringing the first commercial IR camera to market in the 1960s. Today we are the only global company totally dedicated to finding and fixing thermal problems through IR imaging systems. Our company's mission is to provide the most advanced systems available, with the highest possible quality, and show thermography practitioners how to get the most out of them.

FLIR does this through a full range of thermal imaging cameras, temperature measurement tools, and thermal analysis software that are both innovative and compatible with systems and networks that are considered industry standards.

FLIR offers dozens of U.S. FDA 510(k) registered cameras for elevated skin temperature screening, most of which offer FLIR Screen-EST Mode. Finally, many of these cameras are dual use, meaning they can also be applied to security, people counting, electrical inspections, and other industrial applications.

This experience with IR technology, the diversity of our temperature monitoring products, and the dedication of our more than 350 engineers, all provide assurances that FLIR will be around to provide customer support and service for years to come.


FLIR

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FLIR | The World's Sixth Sense®

Note: ISO 201.101.4 Measurement drift

The permissible drift of a SCREENING THERMOGRAPH shall be less than or equal to 0.2°C over an interval of 14 days or the CALIBRATION interval specified in the technical description, whichever interval is longer. A SCREENING THERMOGRAPH may use SELF-CORRECTIONS to maintain the drift within acceptable limits.

Note: Thermal Imaging Systems (Infrared Thermographic Systems / Thermal Imaging Cameras) | FDA

Some systems require the use of a calibrated black body (a tool for checking the calibration of an infrared temperature sensor) during evaluation to make sure measurements are accurate. Check the manufacturer's instructions to determine if a black body Some devices do not require one.

Note: IEC 80601-2-59:2017: 201.101.9 which states "The horizontal and vertical special resolution of an IMAGE PIXEL when imaging the TARGET in NORMAL USE ≤1 value shall be disclosed in the technical description."

Note: ISO 201.12.2.103 348 WORKABLE TARGET PLANE

The size or coordinates of the WORKABLE TARGET PLANE shall be greater than or equal to 240 pixels by 180 pixels. In NORMAL USE, the FACIAL IMAGE shall fill at least 75 % of the WORKABLE TARGET PLANE. If the SCREENING THERMOGRAPH requires that the OPERATOR frame the FACIAL IMAGE in the WORKABLE TARGET PLANE, a guide or mask shall be provided in the image of the WORKABLE TARGET PLANE on the display. [37] The WORKABLE TARGET PLANE should be perpendicular to the FACIAL IMAGE to improve ACCURACY. [37]

NOTE: IEC 80601-2-59:2017 for "screening thermographs for human febrile temperature screening" calls for inner canthus measurements saying others are unreliable: Facial thermography of surface areas other than the region medially adjacent to the inner canthi is unreliable, and may be complicated by perspiration, facial skin flushed from exertion, etc. The current evidence indicates that the region medially adjacent to the inner canthi is the preferred site for fever screening due to the stability of that measurement site. This is because this region is directly over the internal carotid artery.

Sources for screening standards and tips on best practices:

- ISO/TR 13154:2017 'Medical electrical equipment — Deployment, implementation and operational guidelines for identifying febrile humans using a screening thermograph'.
- IEC 80601-2-59:2017 'Medical electrical equipment — Part 2-59: Particular requirements for the basic safety and essential performance of screening thermographs for human febrile temperature screening'.