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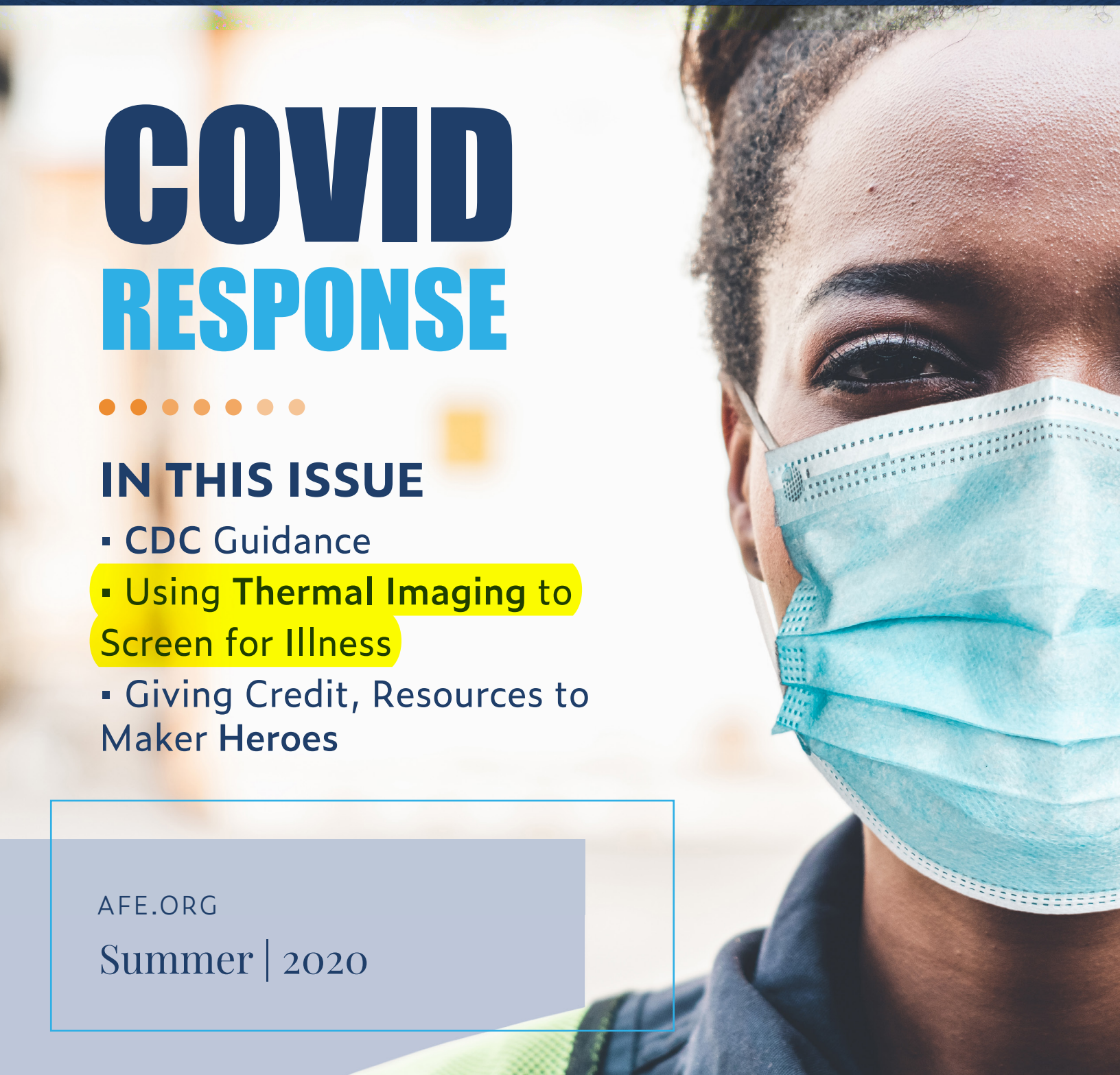

COVID RESPONSE

IN THIS ISSUE

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WHAT IS FEVER SCREENING AND WHAT DOES IT HAVE TO DO WITH THERMAL INFRARED (IR) IMAGING?

Normal basal temperature (core body temperature) in the human body varies as shown below, but the average is 37°C or 98.6°F. Infections usually cause the body's temperature to rise. A fever is considered any core temperature above 38°C or 100.4°F. Fever Screening is the act of checking the internal temperature of a human being by placing an analog or digital thermometer in the mouth, armpit, ear or rectum. At entry points into buildings, a checkpoint can be set up and people can be screened for fevers using this method before entry is granted. However, at airports, factories and other buildings where there is even a moderate flow of people per hour, this process is extremely slow and inefficient. This is where thermal IR Imaging comes into play.

Since there is a relationship between the internal and external body temperatures of humans, **to reduce screening times, and to reduce the risk of cross-infection** between the incoming person and the screener, thermal infrared imaging does offer an acceptable level of accuracy and repeatability to be used confidently as a primary screening method of fever screening. In the **primary fever screening** process, when people with a skin surface temperature higher than that of a given set point are found by using thermal IR imaging, this apparent elevated temperature warrants that persons should be directed to secondary fever screening, using thermometers to determine if they actually do have a fever. See Figure B, a high-flow IR system set-up.

If you spent any time on the internet over the past 60 days looking for anything about fever screening, you have probably seen it described in several different ways. So, to end the mystery; International and US protocols recognize **thermal infrared imaging** as a valid method of detecting **Elevated Body Temperature** in humans by using **Skin Temperature Measurement** which significantly speeds the process of employees and visitors safely entering buildings. This is **Human Febrile Temperature Screening**, or fever screening

Figure B – 3-D Rendering of High Flow IR Fever Screening

THE INCORRECT USE OF 'TEMPERATURE GUNS'
[Spot Radiometers, Actually]

Almost all of what is being shown in the public now are perfect examples of completely ineffective fever screening techniques and inappropriate equipment –which makes professional temperature measurers cringe. The most prolific of these is the use of 'temperature guns' held to the forehead in an inappropriate setting (see Figure C). The forehead is not even the correct target area on the face (see further down the article). This is almost all of what the public is now seeing regarding fever screening, and it is completely wrong. Below, two sets of reasons why companies should not get spot radiometers and give them to the guard at the gate to use for fever screening:

1 | Technical reasons not to use spot radiometers:

- Spot radiometers are notoriously inaccurate.
- Unless the screener is dressed in full PPE, the screener and the person entering the building violate the 6-foot stand-off distance guidance, risking cross-infection.
- Since spot radiometers must be closer than 6 feet to read correctly (target size to spot distance ratio), this means the target is too small to read accurately from six feet away.

Note: the laser which is installed on many spot radiometers can potentially damage a person's eye, is only a guide and does not represent the size of the spot where the temperature is being taken.

- The environment where temperatures are taken must be at steady state, meaning that the people and the room where the screening takes place cannot be outside at the gate or in any unconditioned space.
- Using spot radiometers is a labor-intensive, slow and inaccurate process, especially in a facility where more than 30 people per hour who need to pass at any one time. In contrast, IR imaging systems can handle traffic flows of 400-500+ people/hour and document all the results.

2 | Business reasons not to use spot radiometers:

- Using spot radiometers is a totally unprofessional method which shows that the company using them is not serious about reducing the risk of infection in their buildings.

Note: as of the writing of this article, there have been about 10 articles about this issue and there will be many more to follow. Very soon, companies using spot radiometers are going to suffer an image problem if they continue this practice.

- There is ZERO legal documentation of the temperature of every person screened every day with a spot radiometer. When an employee (or his family) sues the company because the employee was infected with the COVID-19 virus at work, a diligent company will have image records and complete image and temperature documentation showing that each person passed the fever test -and the time when they did not pass it and were denied entry into the building. This can only be done with a thermal infrared imaging system, connected to a computer.

Figure C – Image from New York Times Article: 'Thermometer Guns' on Coronavirus Front Lines Are 'Notoriously Not Accurate'

FEVER SCREENING HAS ISSUES...

As stated earlier, fever screening is far from a perfect solution, and this needs discussion in every company. There are three categories of issues which merit discussion regarding fever screening:

A	B	C
ETHICAL & LEGAL ISSUES	ECONOMIC ISSUES	TECHNICAL ISSUES

A. ETHICAL AND LEGAL ISSUES

- This is an opportunity for company's worried workers to feel better about going back to work but opening the doors also means putting them at risk, as workers are going to become infected by asymptomatic people in the building, and they will bring lawsuits against the company.
- Fever screening during a declared Pandemic is legal and many agencies have weighed in on this. To mitigate liability, most companies will choose to use forms of artificial intelligence to save photo imagery/ temperature data of each employee every day. Where this is a smart move for companies, many people think it has a negative impact on human rights, including the right to privacy.
- Employees may get a false sense of security from seeing everyone "passing" the checkpoints, could get sloppy about physical distancing, sterilization and other measures and in turn, get infected.
- Just because a company has a COVID-19 policy, that does necessarily mean that the policy has been well thought out or will be well-executed.
- Even if the policy is well thought out and well executed, that does not mean that the various individual programs and methods to institute the policy will be effective, or efficient.

B. ECONOMIC ISSUES

- Primary screening (infrared thermal imaging) and secondary fever screening (thermometers) will both cost some time and money to implement and will open the company up to liability. No matter how bad a company's financial situation at the moment, all will have to figure out what to do about fever screening; a few will do nothing, some will deploy very good policies, systems, and procedures, and many will do something in the middle, but all will spend money on it in one way or another.
- Doing nothing or vacillating over the inevitable sensible decision to institute all mitigating measures such as fever screening will cost companies more time and money than just doing it.
- Other than the possibility of becoming infected, employees are also going to pay for mitigation in the form of time, money and irritation. Doesn't everyone enjoy standing in line and then having their picture taken before they punch the timeclock?

C. TECHNICAL ISSUES

- Just because a person has a fever and is stopped at the checkpoint, that does not mean they are infected with Covid-19.
- Just because someone does not have a fever and gets past the checkpoint, that does not mean that they are not infected with Covid-19. (This is the scary one, folks!)
- Just because someone gets past the checkpoint, that does not mean that they do not have a fever. Both Primary and Secondary procedures must be sound and adhered to properly. Systems and procedures can and will be flawed and even if the system is sound and the procedure is followed properly, people with fevers will still get past the checkpoints.
- Some people will commit fraud to get into the building.
- Nobody knows what the rates of false-positives and false-negatives are going to be because the industry does not yet have enough data, given the new systems and procedures offered now.
- Nobody knows what the rate of positive Covid-19 findings will be.

Even with all the issues discussed above, fever screening is a still a good and prudent procedure to implement for the safety of everyone, and every company in the USA needs to accomplish these screenings with all the other measures. The idea is that we do the best we can with what we have.

TYPES OF IR IMAGING SYSTEMS FOR FEVER SCREENING

IR Imaging Systems for Fever Screening currently available can be categorized in four groups:

1 | SINGLE-ENTRY POINT SECURITY SYSTEMS

This type of system is an IR imager mounted on a wall or table just before a door entrance, which is tied to the building's security system. The best use for these are for small offices, especially high security buildings that already have checkpoints established at the entryways. The concept is that a fever screening IR imager can be integrated into the system as an additional biometric, just like fingerprint, iris, or face recognition, but technical integration and proprietary software issues must be addressed.

2 | SCREENING KIOSKS

This category covers kiosks using two completely different grades, based on imager resolution: high-resolution and low-resolution. Kiosks are unmanned booths or boxes where the user walks up to an area in front of the box and performs a self-test. The idea seems intriguing, and these can be set up anywhere that there is electricity. Most kiosks have IR imagers with detector resolution that are not much better than that of a spot radiometer, so the people must get very close to the kiosk, exposing the device surfaces to contamination. Are cleaners supposed to sanitze the kiosk surfaces after each employee or visitor leaves the machine? Now, there are kiosks available that utilize IR cameras with detector spatial resolution and thermal sensitivity sufficient to keep the six-foot rule, but our research on fever screening kiosks has found that these are extremely high-priced given that it is really just an camera, a monitor and a computer in a box.

3 | STAND-ALONE IR CAMERAS

Many companies already have IR cameras used to check for worn out bearings, overheating switchgear, moisture-entrained commercial roofs, and all the other numerous uses for infrared thermography in facilities. These cameras could be a good choice for fever screening, and facilities engineers could deploy these assets, so use them if you have them. Now, these are likely industrial IR imagers with varied specs which not purpose-built systems for fever screening, so it may take a hardware and/or software upgrade to work well. Further down this article, there will be more detailed discussion about specific methodology and additional equipment allowing for these cameras to be used successfully.

4 | PURPOSE-BUILT HIGH FLOW IR SYSTEMS

Industrial-grade cameras systems are often used in fever screening thermal IR systems, but have specialized software and hardware installed to make them purpose-built for this particular application. High-flow IR systems have many advantages over the other types, such as...

a. The ability to screen 400-500+ people/hour.
b. Cost is about the same as any industrial system.
c. They seek out the warmest spot on the face automatically, which is usually the canthus of the eye (as shown on Figure D).
d. They record the photo and or thermal image of all who pass through the checkpoint for archiving purposes.

No matter which type of imaging system used, the correct procedures must be followed in order for any thermal IR imagery to determine whether the person being screened should be sent to secondary screening with a thermometer.

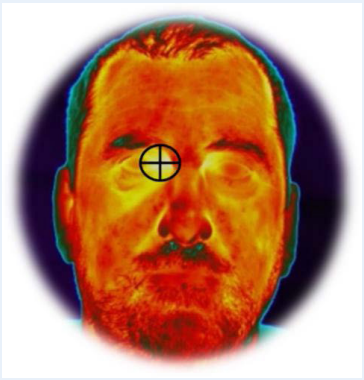


Figure D – IR Image of a face showing the medial canthus with a crosshair.

ABOUT REGULATIONS, ISO STANDARDS AND THE US FDA

When thermal imaging is used to screen people for fevers, it is then considered to be a medical device. US Food and Drug Administration (a division of the US Department of Health and Human Services -HHS) regulates medical devices in the United States according to risk. To market a medical device in the United States, the FDA requires that the company file a 510(k) premarket approval application before marketing the product, so that it can be evaluated and possibly "cleared". FDA does not "clear" companies. Telethermographic systems are identified under product code LHQ and are Class I devices subject to premarket notification requirements under section 510(k) of the FD&C Act (21 U.S.C. 360(k)) and 21 CFR 807.81. The document for IR imaging systems used as adjunctive medical device is: Applications for Medical Device Product Code "LHQ"(System, Telethermographic (Adjunctive Use)). FDA regulations for telethermographic systems cite two main international standards as it refers to human febrile fever screening:

- **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'.

In the past, many companies have obtained FDA 510k clearance for adjunctive use for detecting elevated body temperature (EBT), skin temperature measuring, etc., but only two have obtained FDA clearance for human febrile temperature screening, and the clearances are for a limited number of their imaging systems:

- **Infrared Cameras, Inc. (ICI)**
- **FLIR Systems, Inc. (FSI)**

Importantly, according to ISO/TR 13154:2017, to accomplish the screening procedure correctly, one needs an IR imaging system with a reliable camera, an integrated software, integrated blackbody in the image, and a correct procedure that works repeatably. Only Infrared Cameras, Inc. has such models (Series P & Series S) with cleared complete integrated systems.

So, does a company have to buy an IR imager or imaging system that has FDA Clearance?
No, not likely for a long time. The reason is that on April 16, 2020, the day that "Opening up America Again" came out, the FDA Center for Devices and Radiological Health, Office of Product Evaluation and Quality released a document entitled: 'Enforcement Policy for Telethermographic Systems During the Coronavirus Disease 2019 (COVID-19) Public Health Emergency'. This document relaxes FDA regulations on the marketing of Telethermographic Systems for medical use until HHS declares the 'Emergency' is over: "This policy is intended to remain in effect only for the duration of the public health emergency related to COVID-19 declared by HHS, including any renewals made by the HHS Secretary in accordance with section 319(a)(2) of the Public Health Service (PHS) Act (42 U.S.C. 247d(a)(2))." In this document, the FDA uses words like "recommends" and "should" throughout, and importantly, not "shall", therefore, until the FDA withdraws this guidance, all manner of equipment and procedures are available to the public –a sort of Carte Blanche for anyone to sell all manner of "heat thingies", so be careful what you read on the internet. Why did FDA do this? Well, from this document: "FDA believes the policy set forth in this guidance may help address urgent public health concerns raised by shortages of temperature measurement products by helping to clarify the regulatory landscape and expand the availability of telethermographic systems used for initial body temperature measurements for triage use during this public health emergency."

FDA was right about supplies. Chinese electronic parts are used in many IR cameras and there was a disruption in the supply chain from China at the beginning of the year. By the time that was sorted out, the pandemic had reached the US and some factories were shut. But most importantly, IR camera manufacturers have just been completely overwhelmed with orders for fever screening imagers, so supplies are extremely short. Since a company may be purchasing thermal infrared imaging systems for fever screening far into the future, should the company buy only FDA-cleared equipment? If possible, yes, but none of the systems are expensive, so if you cannot get the imaging system that you want delivered for 3-4 months, just get one that you can live with for as long as needed. Nobody knows what is going to happen in the future, when there will be a cure, or a vaccine.

DO THERMAL CAMERA SYSTEMS NEED TO BE HIGH RESOLUTION, CALIBRATED, WITH BLACKBODIES, AND UTILIZING COMPLICATED METHODOLOGY TO BE USEFUL?

Emphatically...YES! We are dealing with exact temperature measurements in this application where only one- or two-degrees F is the difference between fever and no fever (go/no go). Accuracy of temperature measurement is accomplished by using proper equipment and sound methodology.

THERMOMETRY

If we divide thermometry into two groups, these would be contact and non-contact:

- **Contact thermometry** includes devices such as thermistors, thermocouples, RTDs, LCTs, heat-sensitive tapes, paints, inks and crayons, irreversible element, and thermometers, such as liquid-in-glass, bimetallic and contact radiometers. All of these are more accurate for temperature measurement than non-contact devices because they touch the surface. The reasons not to use contact thermometry are of convenience, like speed, saving time and money. The only case where non-contact is preferred are where the surface is so sensitive to conductance from the device itself contacting the surface, that the temperature must be calculated using a non-contact device.
- **Non-Contact thermometry** relies on radiated energy causing a change in a detector within an infrared device. These are spot radiometers, line scanners and imaging radiometers –the latter being what the World refers to as infrared imagers or infrared cameras.

There are many devices better at obtaining accurate temperature measurements of objects than thermal imagers, but they can be useful and accurate 'enough' as long as the infrared thermographer pays close attention to important issues of detector spatial resolution and thermal sensitivity, the properties of the target and the atmosphere, the spot size to target distance ratio, calibration of the imager and blackbody reference temperatures, and then makes adjustments required to maintain the highest accuracy possible. This is what infrared thermography is all about, and fever screening is no different from any other IR imaging endeavors in that respect.

ACCURACY OF THERMAL IMAGERS IN GENERAL

All IR camera systems have inherent inaccuracies, and usually this uncertainty is stated by the manufacturer on the specification sheet. Of course, one must either trust the manufacturer or test the device themselves to be sure. Today, most commercially available industrial thermal cameras use longwave (~8 - 14µm) microbolometer detectors. Radiation strikes the detector material and heats it, changing its electrical resistance. This resistance is measured, and the processor creates the 'radiometric' image. Typically, microbolometer detectors have acceptable inaccuracies of ~2% at a given temperature. Where +/- 2°C (or 3.6°F) is not perfect, it is not a big factor when performing most qualitative industrial scanning. But when one is fever screening, since the threshold temperature for a fever is a core body temperature of 100.4F, that means that in the worst case, it could theoretically read between 96.8F and 104.0F and still be within the manufacturer's spec accuracy.

METHODOLOGY

Yes, the worst case of +/- 3.6°F is a huge spread for fever screening, and all the IR systems have some inherent inaccuracies, but that does not mean that we cannot have a fever screening process that works. Sound methodology is critical to the success of any program. **We must eliminate as many uncertainties as possible with good equipment and good techniques and then deal with uncertainties that we cannot fix as effectively as possible after that.** Here are some ways to do that:

Add a blackbody device to the system...

By installing an integrated blackbody into the image, accuracy and repeatability are markedly increased. A blackbody device is a device that has a very high emissivity surface and a very constant temperature. When using IR thermography to measure absolute temperatures, the blackbody device appears in the image and sends temperature data back to the computer. If you have delved into thermal imaging for fever screening deeply, you may have noticed some confusion about whether an integrated blackbody is needed to preform fever screening.
This confusion comes from people who want to sell IR cameras without a blackbody device integrated into the system. But no harm comes from using an integrated blackbody device, the cost is negligible and the accuracy of temperature measurement of human skin temperature is improved to ~ +/- .3°C.

Check the calibration of the IR imager often...

Even though most of the types of IR cameras that are used for this application will not be capable of user adjustments of the firmware, checking the calibration of the IR imager can be done quickly and easily using a reference source with a known temperature, so use the blackbody device to see if the camera readings are off – and if so, by how much. Then depending on the software, adjust the camera to compensate for the differences. Do not use an IR camera that is unreliable, faulty or outside the calibration specification. Keep the certificate of calibration specific to that camera in a safe place.

Allow for proper start-up time...

A fever screening IR imager may take 10-15 minutes to equilibrate to the room temperature and for the microbolometer to settle down, so allow plenty of time for that.

Run direct comparisons of imaging systems...

If a company has more than one system, do side-by-side comparisons whenever possible to check the different system(s) and see how close they are.

Share data and techniques...

By cooperating with other fever screeners and by sharing data, statistics and successful techniques, the operation will improve.

Create set points and alarms by averaging skin temperature data...

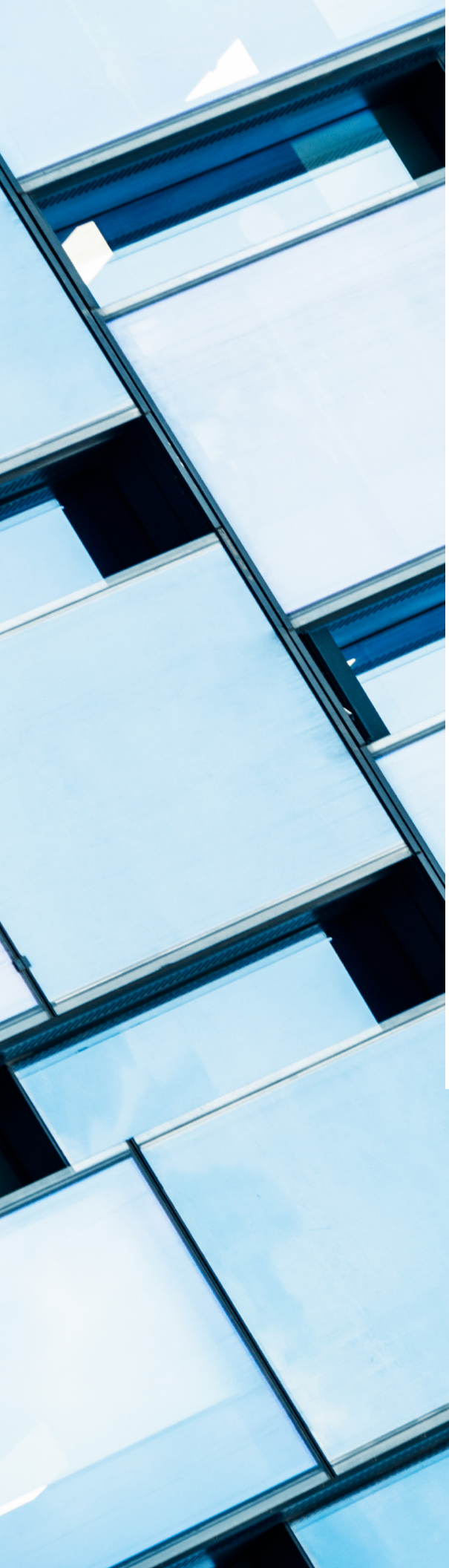
Humans have different and varying normal core temperatures and therefore different corresponding skin temperatures. From Wikipedia: "Human body temperature varies. It depends on sex, age, time of day, exertion level, health status (such as illness and menstruation), what part of the body the measurement is taken at, state of consciousness (waking, sleeping, sedated), and emotions." As data from millions of temperature readings of humans become published over the next year, we will have better statistical standard deviations to work with and will learn all the ways that false-positives and false-negatives can be reduced. In the meantime, one way to address this uncertainty factor is to average the temperatures of people coming through the screening line. But this should be used in conjunction with an integrated blackbody system – not instead of it. Of course, if your company has no blackbody, this is the best alternative.

Other Miscellaneous Considerations...

- All fever primary and secondary screenings should be conducted safely and respectfully, with measures in place to maintain confidentiality, and should follow all application laws
- and regulations.
- Secondary screening procedures should be agreed upon using the same six-foot rules as utilized with primary screenings and when someone is found to have a verified fever, a procedure should be in place to respectfully and caringly exit them from the building without passing by the incoming employees and visitors and as part of that procedure, that person should visit a doctor's office before returning to work.
- Many facilities have instituted an employee screening questionnaire as part of their intake forms. Of course, this is not meant to represent a dispositive indication of an employee's exposure risk and usually only asks a few questions like, do you have a cough, diarrhea or shortness of breath, or are otherwise concerned you have COVID-19 and is anyone in your family have COVID-19, etc.
- Do all the personnel involved in primary and secondary fever screenings at the entryways need to have a thorough understanding of all aspects of thermal imaging technology? It would not hurt, but it is probably not necessary when an automated high flow system with audible alarms is set up and running. The above said, someone at the company should be designated to be the administrator of the fever screening system that person should receive a course on IR fever screening.

CHECKLIST FOR SUCCESS...

- ☐ Work with top management to define the overall goals of the program.
- ☐ Based on goals, decide which, how many, and the type of IR imaging system that will be needed to accomplish the goals considering; budget, number and type of entry points, traffic flows, shift schedules and other logistical considerations –and specific to each location.
- ☐ Lay out the checkpoints on a drawing, based on the area available.
- ☐ Work with the company management to get the checkpoints set up.
- ☐ Set up IR imaging systems in the buildings.
- ☐ Train the staff who will operate the system.
- ☐ Make sure everything is working properly and turn over the system.
- ☐ Maintain and support the program with on-line and in-house technical support.



WHAT'S A COMPANY TO DO?

Do nothing...

- Look like mean-spirited businesspeople who do not care about the health and well-being of their employees or visitors.
- Deal with bad company image and lawsuits.

Check the box...

- Buy $39 spot radiometers at Home Depot, give them to the guards and look like box-checkers.
- Buy a low-resolution KIOSK, put it in the lobby on a desk or stand-alone and hope nobody sneezes on it.

Add a thermal camera to the existing security system...

- Integrate a thermal system into the existing security systems using biometrics. This will work for small offices and high-security operations. This will probably take some number of months to integrate the system if going with this option.

Do it right and do it now!

- Secure the equipment needed and learn how to use it effectively and efficiently.
- Spend the money to buy a high-resolution Kiosk, put it in the entryways and monitor it well.
- Hire a safety company, security company or infrared thermography company to subcontract the entire fever screening operation. This will be the highest cost method, but it would work until you get the system needed.

Hiring a professional thermography consulting company to guide a company through the fever screening process might be the best option, given that the company will not have to learn everything about fever screening to get the best equipment and methods for a given building based on factors known and unknown. One would need to supply a layout of each company building, showing ingress and egress in the form of drawings and supply the consultant with other information, like expected traffic flows. The consultant can also help a great deal with the supply problem, having a handle on system specs and availability of systems.

CONCLUSIONS

Facilities engineers need to research, evaluate, and recommend a policy to corporate management which will include programs, methods and procedures that will mitigate the negative impacts of the COVID-19 at their facilities. Protecting the safety of the company's employees and visitor's health is going to be paramount to a company getting back to an acceptable level of production until a vaccine is developed, tested and successfully distributed.

Fever screening has a great ROI but has its issues —the scariest of which is that asymptomatic COVID-19 infected people are going to pass through the check points undetected. Nobody can fix that. In order to protect itself, every company will have to install fever screening and do all those other mitigating measures. So, get going on this now, because vacillating about something that is going to done eventually anyway is already costing companies millions of dollars. In the case of SARS-CoV-2, the novel coronavirus that causes coronavirus disease 2019 (COVID-19), good things do not come to those who wait.

GREGORY R. STOCKTON, M. CIT

Gregory Stockton is a principal in three infrared (IR) companies. He has thirty-one years' experience in infrared thermography related to infrastructure maintenance and facilities operations. Mr. Stockton has published thirty technical papers about infrared thermography and written numerous articles about applications for IR thermography in trade publications since 1989. Greg is a member of SPIE (Society of Photo-Optical Instrumentation Engineers), a member of the Program Committee and Chairman of the Buildings & Infrastructures Session of the annual ThermoSense Conference at the Defense and Security Symposium.