IRISH MANUFACTURING RESEARCH

Introduction to Temperature Screening Principles

Irish Manufacturing Research

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Context

COVID-19 is the infectious disease caused by the most recently discovered coronavirus. This new virus and disease were unknown before the outbreak began in Wuhan, China, in December 2019. COVID-19 is now a pandemic affecting many countries globally.

The most common symptoms of COVID-19 are fever, dry cough, and tiredness. These symptoms are usually mild and begin gradually. It is therefore of crucial importance to be able to monitor symptoms, such as fever (high temperature - 38 degrees Celsius or above).[1].

Figure 1 - HSE COVID-19 Symptoms

Businesses that remain operational during the COVID-19 pandemic are faced with the challenge of determining what they can do to minimize the risk of spreading the virus while still being able to provide critical products and services to our communities. Many of these essential employers are envisaging or have started screening employees' temperatures in an effort to ensure that employees with symptoms of the illness do not infect their co-workers[2].

The Irish Government has published on the 8th of May 2020 a **Return to Work Safely Protocol**[3] designed to support employers and workers to put measures in place that will prevent the spread of COVID-19 in the workplace when the economy begins to slowly open up. This protocol is sets out in very clear terms for employers and workers the steps that they must take before a workplace reopens, and while it continues to operate. One of the key steps outlines in the protocol is the implementation of temperature testing "in line with Public Health advice"[3].

This IMR introduction to Temperature Screening principle is an effort to help Irish industry begin their Temperature Screening Technologies. The paper compares various temperature screening technologies and addresses some of the best practices in deploying a temperature screening solution to help manufacturers get back in production safely. This paper is not a comprehensive guide and should not be read as such.

Disclaimer

While most of the best practices presented in this document are aligned with the current Public Health Authorities guidelines, the content contained here is intended as a resource to help manufacturers during these extraordinary times and is solely based on the current understanding of the advice issued on the measures to reduce the spread of COVID-19 in the workplaces. As the advice issued by the National Public Health Emergency Team (NPHET) continues to evolve, the measures employers and workers need to address may also change. Therefore, it should be noted that the attached details are indicative only and subject to change. Readers are encouraged to seek updates on the latest protocols issued by the local public authorities.

Temperature measurement paradigms

Contact thermometers

Digital thermometers

Regular digital thermometers use electronic heat sensors to record body temperature. These thermometers can be used in the rectum, providing the best readings for children up to age 3, mouth, usually accurate — as long as the mouth is closed while the thermometer is in place, or armpit, usually the least accurate[4].

PROS: Available on the market. Appropriate for newborns, infants, children and adults.

CONS: Can cause discomfort. Requires a 15 minute wait after eating or drinking to take an oral temperature. Must be cleaned with a new alcohol wipe after each use or have a plastic tip that detaches and can be discarded after taking each individual's temperature.

Digital ear thermometer

Digital ear thermometers, also called tympanic thermometers, use an infrared ray to measure the temperature inside the ear canal. Clinical research has shown that the ear is an ideal site for taking body temperature as the eardrum shares blood vessels with the hypothalamus, the part of the brain that controls body temperature[5].

PROS: Fast, accurate results. Unaffected by factors such as talking, drinking, and smoking.

CONS: A new and undamaged probe cover must be attached before each use. Earwax or a small, curved ear canal can interfere with the accuracy of a temperature taken with a digital ear thermometer.

Contact forehead thermometer

Contact forehead thermometers, also known as temporal artery thermometers, read the heat waves coming off the temporal artery, a blood vessel running across the forehead just below the skin. To read the temperature, the sensor's head is placed at the center of the forehead and slowly moved across the forehead toward the top of the ear while keeping contact with the skin.

The thermometer process determines temperature by accurately measuring the balance between the tissues warming from arterial blood and tissues cooling (warming) caused by heat loss (gain) to the environment.

PROS: Available, cheaper, less invasive than typical digital thermometers.

CONS: Must be cleaned with a new alcohol wipe after each use. Relatively slow process.

Non-contact thermometers

Medical non-contact infrared thermometer (NCIT)

Infrared thermometers work based on a phenomenon called black body radiation. The hotter a body is, the faster the molecules inside it move around and the more infrared radiation they emit. Infrared thermometers detect and measure this radiation[6].

The infrared thermometers essentially consist of a lens that focuses the infrared thermal radiation on to a detector, which then converts the radiant power to an electrical signal that can be displayed in units of temperature after being

compensated for ambient temperature. This permits temperature measurement from a distance without contact with the object to be measured[7].

PROS: Reduces the need for physical contact, fast, suitable for high throughput.

CONS: More expensive, depends on the distance, supply shortage. Sometimes, especially near ambient temperatures, readings may be subject to error due to the reflection of radiation from a hotter body rather than radiated by the object being measured, and to an incorrect assumed emissivity.

General purpose non-contact infrared thermometer (NCIT)

Considering the worldwide shortage medical infrared thermometers, general purpose infrared thermometers usually intended for food service, food processing, industrial, scientific and general home use can be considered for detecting elevated body temperatures with proper technique and cautions taken into account.

Medical forehead thermometers, contrary to their general-purpose equivalent, make a mathematical adjustment to display an equivalent oral temperature of the forehead temperature, which is several degrees lower than core body temperature (37 C). Moreover, emissivity settings in medical thermometers are calibrated for human skin, which is not the case for general purpose thermometers, which have either an "adjustable emissivity feature" or a factory setting for emissivity of 0.95. Additional calibration and offset might have to be put in place for an acceptable temperature measurement.

Such scans are usually regarded as an unreliable absolute measurement of core body temperature, and only a scanning or screening indication[8].

PROS: Reduces the need for physical contact, available, cheaper than medical equivalent.

CONS: Lack of calibration, may display lower temperature than actual, forehead skin temperature can vary several degrees depending on your environment (indoors or out), exercise, perspiration, direct heat or air conditioning, etc.

Thermal imaging

A thermal imaging camera produces infrared images or heat pictures that display small temperature differences. This allows thermal cameras to create and continually update a visual heat map of skin temperatures. In addition, most of the thermal imaging cameras are sensitive devices capable of measuring small temperature differences.

Many thermal cameras that are appropriate for measuring skin temperatures also offer built-in functions like visual and sound alarms that can be set to go off when a certain temperature threshold is exceeded. The operator can then instantly decide whether the subject needs to be referred for further screening with additional temperature measurement tools[9].

PROS: Near real-time process, useful for rapidly screening large numbers of people.

CONS: Expensive. Many factors can affect the accuracy, such as focus, distance, the emissivity of the target, the ambient environment, and the speed at which the temperatures are acquired.

Overall comparison

An overall comparison of the different temperature sensing technologies is shown in the table below.

	Availability	Process speed	Accuracy	Ease of use & reuse
Digital thermometer	Wide	Reading obtained after 10 seconds. Not suitable for high throughput.	± 0.1°C, within the range of 36.6°C and 38.9°C. Highly dependent on the thermometer's position.	Can cause discomfort. Must be cleaned with a new alcohol wipe after each use.
Digital ear thermometer	Wide	Reading obtained after 2 seconds. Not suitable for high throughput.	Display temperatures of between 1.02°C below and 0.91°C above those detected by other recording devices[10]. Earwax, small, curved ear canal, or inconsistent positioning of the probe can interfere with the measurement accuracy.	A new and undamaged probe cover must be attached before each use.
Contact forehead thermometer	Wide	Has to be slowly moved across the forehead. No suitable for high throughout.	Temporal thermometers have been found to have a low sensitivity (true positive rate) of around 60–70%, but a very high specificity (true negative rate) of 97–100% for detecting fever and hypothermia[11]. Sensitive to ambient temperature and to any covering.	Less invasive than typical digital thermometers. Must be cleaned with a new alcohol wipe after each use.
Medical NCIT	Constrained	Response time of 1 second	±0.2°C within 35 to 42°C otherwise ±0.3°C[12] . Readings sometimes be subject to error due to the reflection of radiation from a hotter body rather than radiated by the object being measured, and to an incorrect assumed emissivity.	No contact necessary. Suitable for high throughput.
General purpose NCIT	Wide	Response time of 1 second	Usually regarded as an unreliable absolute measurement of core body temperature and should be only a scanning or screening indication.	Calibration required. No contact necessary. Suitable for high throughput.
Thermal imaging	Limited	Response time of 1 second	Standard thermal cameras have an accuracy of ±2°C at 30°C, some achieving ±0.5°C at 37°C. Many factors can affect the accuracy, such as focus, distance, emissivity of the target, the ambient environment, and the speed at which the temperatures are acquired[13].	Calibration may be required. No contact necessary. Suitable for very high throughput.

Table 1 - Overall comparison of different temperature sensing technologies

Considering the throughput required by businesses to be able to deploy an efficient temperature screening solution, the next section is focusing on non-contact thermal screening options, mainly Medical NCIT and thermal cameras.

Non-contact Temperature Screening

Considerations for non-contact temperature screening technologies[14]

A number of specifications listed for infrared thermometers and thermal cameras have to be taken into account to ensure you're considering the right camera for your application:

Compliance with IEC 80601-2-59:2017

IEC 80601-2-59:2017[15] applies to the basic safety and essential performance of screening thermographs intended to be used for the individual non-invasive febrile temperature screening of a human under controlled environmental conditions.

A technical report, ISO/TR 13154:2017[16], was developed to provide guidance on the implementation of IEC 80601-2-59 to minimize the spread of infectious diseases. The ISO/TR 13154:2017 technical report provides general guidelines for the deployment, implementation and operation of a screening thermograph intended to be used for non-invasive febrile temperature screening of individuals under indoor environmental conditions to prevent the spread of infection.

Measurement location

According to the ISO/TR 13154:2017, the best location to measure body temperature for the purpose of fever detection is the lacrimal caruncle area of the eye (tear ducts area) or the ear hole. Temperatures can also be measured and averaged over large areas of the face but the actual temperature might vary from person-to-person based on blood pressure and variations in the heat distribution in the face[17].

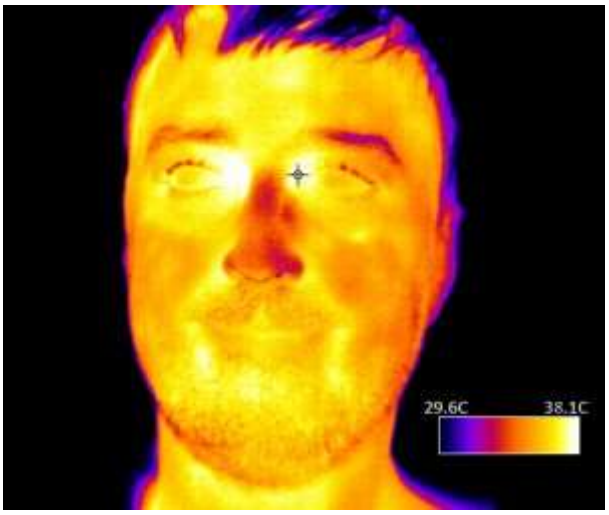

Figure 2 - Lacrimal caruncle area. Picture credit: Teledyne Dasla

Absolute vs relative temperature

Comparing relative temperature increases is much more reliable and precise for cameras than to estimate the absolute temperature of a body. It is recommended to include in the temperature screening systems a known temperature reference (e.g. black body radiator)[17].

Range

Range is the span of temperatures the device is calibrated to and capable of measuring. For detecting individuals with an elevated skin temperature, the range should encompass temperatures between 35°C to 42°C, which most of them do.

Field of View (FOV) – Thermal Cameras

Field of View is determined by the camera lens and is the extent of a scene that the camera will see at any given moment. For work being done close-up, you need a lens with a wide angle FOV (> 45°). For long distance work, you need a telephoto lens (12° or 6°).

Distance to Spot ratio – IR Thermometers

The distance-to-spot ratio (D:S) is the ratio of the distance to the measurement surface and the diameter of the temperature measurement area. A thermometer with a higher ratio of D to S is able to sense a more-specific, narrower

surface at a greater distance than one with a lower ratio. The ideal target area should be at least twice the size of the spot at that distance[18],with smaller areas relative to distance resulting in less accurate measurement. An infrared thermometer cannot be placed too close to its target, or this proximity causes heat to build up in the thermometer's housing and damages the sensor. Measurement error generally only decreases with too much distance because of the effects of reflectivity and the inclusion of other heat sources within the sensor's field of view.

IR Resolution

The resolution of the camera is how many pixels the camera has on the scene. Higher resolution means that each image contains more information: more pixels, more detail, and a greater likelihood of getting an accurate measurement, but at a higher cost.

Thermal Sensitivity (NETD)

Thermal sensitivity or Noise Equivalent Temperature Difference (NETD) describes the smallest temperature difference you can see with the camera. The lower the number, the better the thermal sensitivity of the infrared system.

Set-up

Infrared thermometers and thermal cameras come in various settings: handheld, tripod-mounted, wall-mounted, or ceiling-mounted. The placement of the screening device should take into account the field of view of the cameras – or the distance to-spot-ratio for infrared thermometers, size and location of the temperature checking-line, employees' throughput, and presence of nearby heat sources.

Hand-held devices have important disadvantages including the following[19]:

- Holding the camera continuously leads to operator fatigue.
- Camera movement (even slight movement) leads to image blur, resulting in inaccurate measurements.
- Inconsistent screening distance between the camera and subject leads to inconsistent screening results.
- Cameras can be easily dropped and damaged.

Be mindful of these considerations and specifications when determining which thermal imaging camera or infrared camera is best suited for your requirements. Ensure compliance with the relevance standards.

Comparison of thermal cameras suitable for mass screening

The tables below provide an indicative comparison of some thermal cameras available on the market. Note that this list is not comprehensive. Readers are advised to seek further information and specifications – especially around standard compliance before any purchase.

					
Model	Optotherm Thermoscreen[20]	GUIDE IR236 IR Fever Warning System[21]	T120H Fever Screening Thermal Camera[22]	C400M IR Fever Warning System[23]	SATIR CK350-F[24]
Installation methods	Fixed-Mounted on mobile platform	Fixed-Mount	Handheld, Tripod	Handheld, Tripod	Ceiling-Mount
Temperature measurement range	0°C to 80 °C	-10°C to 50°C	20°C to 50 °C	20°C to 60 °C	0°C to 60 °C
Thermal sensitivity	<50mK @ 25°C	<40mK	60mK	40mK	40mK @ 26.85°C
Thermal Accuracy	±0.3 ℃ between 30°C to 40 °C	≤ 0.3 ℃ (ambient temperature 16 to 32°C)	≤ 0.5 ℃(Ambient temperature 25 ℃, target distance 1m, target temperature 32 ~ 42℃	≤±0.4℃ (target temperature 32℃~38℃)	≤ 0.3 ℃ (Emission rate, distance, ambient temperature, etc..)
IR resolution	-	400x300	120x90	384x288	384x288
Minimum focus distance	0.10m	-	-	0.4m	-
Recommended distance	2m	2 to 8m	0.6 to 1.2m	3 to 5m	2 to 2.3m from the ground
Field of view / Focal Length	48° × 38° (12 mm lens)	38° × 28° (9.7 mm lens)	50° × 38° (2.28 mm lens)	21.7° × 16.4° (25 mm lens)	46°x 35.3° (8mm lens)
Features	Automated screening, audible alarms, no external calibration source required	External blackbody, automatic calibration after selecting mode, warnings	Over-temperature alarm	Automatic warning, automatic temp calibration,, wireless remote control	Motion detection, Disk alarm, I/O alarm, Temperature alarm
Size	355x180x125 mm	173x184x212mm (camera head)	194x61.5x76 mm	206x145x135 mm	212×182×136 mm
Net Weight	5 kg	45kg (total weight)	0.35kg	1.35kg	2 kg

Table 2 - Comparison of thermal cameras suitable for mass screening (1/3)

				
Model	Omnisense Sentry MK4[25]	FLIR A400/A700 Smart Sensor[26]	FLIR Exx-Series[27]	FLIR A320 Temp-screen[28]
Installation methods	Fixed mount / Tripod	Fixed-Mount	Handheld / Tripod	Fixed-Mount
Temperature measurement range	30°C to 45 °C	-20°C to 120°C	–20°C to 120°C	–20°C to 120°C
Thermal sensitivity	≤50mK nominal	Lens dependent	<40mK @ 30°C	<40mK @ 30°C
Thermal Accuracy	±0.1°C	±2°C or ±2% of reading, for ambient temperature 15°C–35°C.	±2°C or ±2% of reading for ambient temperature 15°C to 35°C, Screening: 0.5°C accuracy @ 37°C with reference	±2°C or ±2% of reading
IR resolution	384x288	320 × 240	320 x 240 (FLIR E75) 464 × 348 (FLIR E95) 384 × 288 (FLIR E85)	320 × 240
Minimum focus distance	-	0.15 m	0.15 m	0.4m
Recommended distance	-	-	-	-
Field of view / Focal Length	24.6° Horizontal	24° × 18° (17 mm lens), 42° × 32° (10 mm lens), 14° × 10° (29 mm lens)	24° × 18° (17 mm lens), 42° × 32° (10 mm lens), 14° × 10° (29 mm lens)	25° × 18.8° (18 mm lens)
Features	Intelligent febrile tracking, User defined temperature trigger threshold, zoning, masking	Alarm Functions on any selected measurement function	Moisture alarm, insulation alarm, measurement alarms	6 automatic alarms on any selected measurement function,
Size	135x90x80mm (Camera)	123x77x77 mm	278x116x113 mm	170x70x70 mm
Net Weight	No data	0.82 kg	1 kg	0.7 kg

Table 3 - Comparison of thermal cameras suitable for mass screening (2/3)

					
Model	Hikvikson Turret cameras DS-2TD2636B/37B[29]	Hikvikson Bullet cameras DS-2TD1217B[30]	Infisense FS256[30]	InfiRay ITS II 300[31]	Auto-Temp
Installation methods	Turret	Bullet	Fixed-Mount	Tripod	Free standing
Temperature measurement range	30°C to 45°C		30°C to 45 °C	0°C to 60 °C	-20 °C to 100 °C / 0 °C to 250 °C
Thermal sensitivity	<40mK @ 25°C		<50mK @ 25°C	<40mK @ 25°C	40mK
Thermal Accuracy	±0.3°C with Blackbody calibrator, ±0.5°C without		±0.5°C with Blackbody calibrator	±0.3°C @ target temp of 33-42°C with Blackbody calibrator (≤ 0.5°C without)	±0.5°C with Blackbody calibrator, ±2°C or ±2% (whichever is greater) without
IR resolution	160x120 / 384x288	160x120	256x192	384x288	382x288
Minimum focus distance	0.2m (3.1mm lens) 0.6m (6.2mm lens) 1.2m (9.7mm lens) 2m (13mm lens) 2.5 (15mm lens)	0.2mm (3.1mm lens) 0.6mm (6.2mm lens)	0.15 m	-	0.3mm
Recommended distance	Up to 40/50m	Up to 15m	0.15 to 2m	5 to 10m	0.8 to 1m
Field of view / Focal Length	50° × 37.2° (3mm.lens) 25° × 18.7° (6.2mm lens) 37.5° × 28.5° (9.7mm lens) 28.8° × 21.6° (13mm lens) 24.2°× 18.4° (15mm lens)	50° × 37.2° (3.1mm lens) 25.0° × 18.7° (6.2mm lens)	56° × 42° (3.2 mm lens)	47° × 35.6° (7.8 mm lens)	29°x22° (12.7 mm lens)
Features	iVMS-4200 software features AI detection to reduce false alarms caused by other heat sources.		Identity recognition, auto audio alarm	Human face recognition, alarm, body temperature correction	IEC 80601-2-59 compliant. Alarms, motion sensors, clock-in system, reception sign-in.
Size	358.3x113.5x115.2 mm / 376.1x119.1x118.1mm	138.3x138.3 x123.1 mm	80×80×14.2 mm	-	650x386x145mm
Net Weight	1.76kg / 1.82kg	0.94kg	-	-	7.2kg

Table 4 - Comparison of thermal cameras suitable for mass screening (3/3)

Organisational considerations

More than a technological challenge, temperature screening at the workplace is also an organisational challenge. This section aims to provide some best practices in the deployment of temperature screening solutions in line with the Public Health advice.

How to ensure maximum buy-in on the workplace?

Strong communication and a shared collaborative approach between employers and workers is essential to achieve success and maximum buy-in. Employers and workers are to have regular engagement about COVID-19 and preventative measures in the workplace. Information and guidance should be provided by employers to workers as well as a COVID-19 induction training.

Each workplace is to appoint at least one lead worker representative charged with ensuring that COVID-19 measures are strictly adhered to in their place of work. The person(s) undertaking the role should be clearly identifiable in the workplace and must receive the necessary training and have a structured framework to follow within the organisation to be effective in preventing the spread of the virus[19].

Who Should Take the Temperature?

For workplaces with a medical professional onsite, the trained personnel should be taking temperatures and/or training non-medical personnel to do so[2].

Otherwise, the COVID-19 response management team should designate at least one worker representative who should receive the relevant and necessary training. The tester(s) should review the user instructions of the temperature screening equipment to ensure proper use.

What PPE should the testing staff use?

Testing staff should be provided with appropriate PPE and no testing shall take place where PPE is not available. The employer should be responsible to have adequate and suitable PPE available at points of use, which should include Face masks, gloves, long-sleeve gowns, and eye protections[32].

How to ensure social distancing during temperature screening?

Social distancing requirements have to be taken into account for the employees awaiting to have their temperatures checked [2].

- Consider whether additional shifts can be established to reduce the number of employees in the worksite at one time;
- Stagger shift start- and end-times greater than normal when possible, to eliminate employees from congregating during the shift change-over, and from over-crowding at entrances and exits;
- Create corridors where employees can enter the facility through a temperature-checking line;
- Have multiple lines and entrances if possible to reduce crowding;
- Consider placing markings on the ground for safety distance demarcation.

An employee tested positive, what do we do?[2]

If a temperature reading is equal or superior to 38°C (indicative value for standard fever detection – refer to public health guidelines for advised temperature threshold), consider a re-testing protocol to ensure that the high temperature did not result from other factors, such as high heart rate, excess sweating, makeup, or head movement. A re-testing could take the form of additional measurement(s) and/or the use a secondary testing system.

If the high temperature is confirmed following the re- testing, the COVID-19 manager/response team should:

- isolate the worker and have a procedure in place to accompany the individual to the designated isolation area via the isolation route, maintaining a distance of at least 2 meters between the symptomatic person and the others at all times.
- provide a mask for the person presenting with symptoms if one is available.
- assess whether the unwell individual can immediately be directed to go home and call their doctor and continue self-isolation at home.
- facilitate the person presenting with symptoms remaining in isolation if they cannot immediately go home and facilitate them calling their doctor.
- arrange transport home or to hospital for medical assessment. Public transport of any kind should not be used.

Additional advice on dealing with a suspected case is available from the NSAI[33].

Should I Keep a Record of the Temperature Checks? [2]

While employers are permitted to take temperatures during this pandemic, if the temperature of employees are "recorded," that information must be maintained confidentially and only provided to those who should have knowledge of the information. The information that is recorded should be treated as a confidential medical document and not placed in any employee's personnel file.

Is temperature screening an effective way to prevent to spread of COVID 19?

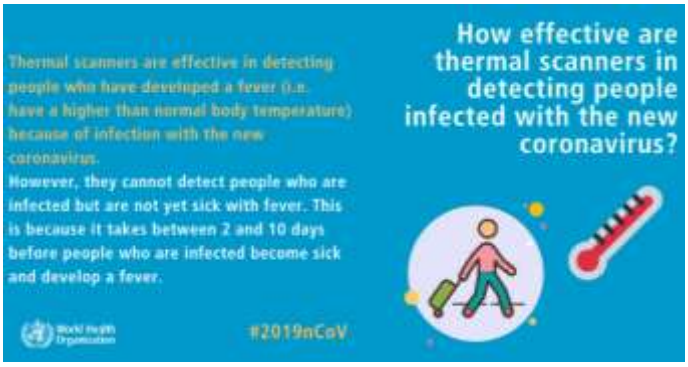

Figure 3 - Thermal Scanning Effectiveness (Credit: WHO)

According to the World Health Organisation, temperature screening is not an effective way to stop the international spread of the virus. This is because infected individuals could be in the incubation period of the disease, or may be asymptomatic early in the illness, or indeed may have used medication to lower their temperature – all factors which render temperature measurement an ineffective screening tool for the viral infection.[34].

For this reason, taking temperatures does not eliminate the need to practice to maintain other steps to avoid the spread of the virus: maintaining social distancing best practices, including promoting remote work as much as possible; maintaining adequate distances between employees who are in the workplace; frequent hand washing and disinfecting; and, frequent cleaning and disinfecting of common areas and touch-points throughout the workplace.

For further guidance on how to implement, maintain and improve an organisation's ability to protect against, prepare for, respond to and recover from COVID-19 related disruptions when they arise, consult the NSAI's COVID-19 Workplace Protection and Improvement Guide and the Return to Work Safely Protocol.

Recommended readings

This IMR paper only acts as an introduction to Temperature screening technologies and does not act as a comprehensive guide. Further information and guidance onto that space, readings recommendations are provided here below.

- Elevated Body Temperature (EBT) fundamentals, Industrial Monitoring & Control: https://www.imcontrol.com.au/white-papers/ebt-fundamentals/
- Best Practices for EBT, Industrial Monitoring & Control: https://www.imcontrol.com.au/white-papers/best-practices-for-ebt
- Enforcement Policy for Telethermographic Systems during the Coronavirus Disease 2019 (COVID-19) Public Health Emergency Guidance for Industry and Food and Drug Administration Staff, April 2020: https://www.fda.gov/media/137079/download
- 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 https://www.iso.org/standard/69346.html
- ISO/TR 13154:2017 Medical electrical equipment — Deployment, implementation and operational guidelines for identifying febrile humans using a screening thermograph https://www.iso.org/standard/69347.html
- ISO 80601-2-56:2017 Medical electrical equipment — Part 2-56: Particular requirements for basic safety and essential performance of clinical thermometers for body temperature measurement https://www.iso.org/standard/67348.html

Follow-up

If you wish to know more about this topic or the COVID-19 response activities from IMR, visit imr.ie. IMR is here to support your manufacturing business during these unprecedent times.

For any further advice on coronavirus prevention measures in the workplace, contact the NSAI (National Standards Authority of Ireland) at COVID-19-support@nsai.ie.

References

[1] WHO website, Q&A on coronaviruses (COVID-19), 17April 2020. https://www.who.int/news-room/q-a-detail/q-a-coronaviruses#:~:text=symptoms

[2] Foley, Best Practices When Implementing a Program for Taking Employee Temperatures During the COVID-19 Pandemic, 21 April 2020. , https://www.foley.com/en/insights/publications/2020/04/best-practices-employee-temperatures-covid19

[3] Government of Ireland. Return to Work Safely Protocol - COVID-19 Specific National Protocol for Employers and Workers https://dbei.gov.ie/en/Publications/Publication-files/Return-to-Work-Safely-Protocol.pdf

[4] Mayo Clinic, Thermometers: Understand the options, 15 September 2018. https://www.mayoclinic.org/diseases-conditions/fever/in-depth/thermometers/art-20046737

[5] Pharmacare Distribution Ltd. http://pharmacare.ie/product/omron-gentle-temp-520-digital-ear-thermometer/

[6] Sciencing, How to Use a Temperature Laser Gun, 24 April 2017. https://sciencing.com/use-temperature-laser-gun-5720527.html

[7] Wikipedia, Infrared Thermometer. https://en.wikipedia.org/wiki/Infrared_thermometer

[8] Thermoworks, COVID-19 Temperature Screening. https://www.thermoworks.com/covid-19-screening?tw=twblog

[9] FLIR, Efficient, Effective High-Traffic Area Screening, 10 April 2020, https://www.flir.com/discover/public-safety/efficient-high-traffic-area-screening/

[10] Nursing Times, Reviewing the effectiveness of tympanic thermometers, 10 August 2004, https://www.nursing-times.net/archive/reviewing-the-effectiveness-of-tympanic-thermometers-10-08-2004/

[11] Journal of Clinical Nursing, Agreement of infrared temporal artery thermometry with other thermometry methods in adults: systematic review, 27 January 2016. https://onlinelibrary.wiley.com/doi/abs/10.1111/jocn.13117

[12] Thermoworks, WAND specification sheet. https://www.thermoworks.com/wand

[13] FLIR, Frequently Asked Questions: Thermal Imaging for Elevated Skin Temperature Screening. https://www.flir.com/discover/public-safety/faq-about-thermal-imaging-for-elevated-body-temperature-screening/)

[14] FLIR, Thermal Camera Specs You Should Know Before Buying, 18 December 2019. https://www.flir.com/discover/professional-tools/thermal-camera-specs-you-should-know-before-buying/

[15] 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 https://www.iso.org/standard/69346.html

[16] ISO/TR 13154:2017 Medical electrical equipment — Deployment, implementation and operational guidelines for identifying febrile humans using a screening thermograph https://www.iso.org/standard/69347.html

[17] Industrial Thermal Cameras for Pandemic Fever Detection, Jean Brunelle, 20 April 2020 https://www.novuslight.com/industrial-thermal-cameras-for-pandemic-fever-detection_N10300.html

[18]FireCraft Safety.com,"Infrared thermometers explained" (PDF). http://www.firecraftsafety.com/pdf/IR%20Thermometers%20explained.pdf

[19] Optotherm, Thermal Imaging System for Human Fever Screening. https://www.optotherm.com/ts-comparison.htm

[20] Optotherm Thermo Screen https://www.optotherm.com/Thermoscreen%20Brochure%20Jan%202020.pdf

[21] GUIDE IR236 IR Fever Warning System https://www.guideir.com/product/detail/id/9.html

[22] GUIDE T120H Fever Screening Thermal Camera https://www.guideir.com/product/detail/id/59.html

[23] GUIDE C400M IR Fever Warning System https://www.guideir.com/product/detail/id/60.html

[24] SATIR CK350-F Intelligent Advance Level Fever Screening System https://satir.com/product/ck350-f

[25] Omnisense Sentry MK4 – Mass Fever Screening System https://omnisense-systems.com/products/sentry-mk4-mass-fever-screening-system/#toggle-id-1

[26] FLIR A400/A700 Smart Sensor https://www.flir.com/products/a400-a700-smart-sensor/

[27] FLIR Exx-Series https://www.flir.com/products/flir-a320/

[28] FLIR A320 Tempscreen https://www.flir.com/products/flir-a320/

[29] HIKVIKSON Thermography thermal cameras – Temperature Screening series https://www.hikvision.com/en/products/Thermal-Products/Thermography-thermal-cameras/temperature-screening-series/

[30] Infisense FS256 http://www.infiray.com/FS256.html

[31] InfiRay ITS II 300 http://www.infiray.com/ITS.html

[32] Guidelines: COVID-19 Temperature Screening, Minerals Council of Australia, March 2020 https://minerals.org.au/sites/default/files/200402%20COVID-19%20Temperature%20Screening%20Guidelines.pdf

[33] NSAI COVID-19 Workplace Protection and Improvement Guide, 09 April 2020, https://www.nsai.ie/images/uploads/general/NSAI-Guidelines-for-COVID-19-2020-04-09.pdf

[34] Irish Times, How to screen for Covid-19 is still far from clear, 27 April 2020. https://www.irishtimes.com/news/health/how-to-screen-for-covid-19-is-still-far-from-clear-1.4238396