TFEV

System for testing fever screening thermographs

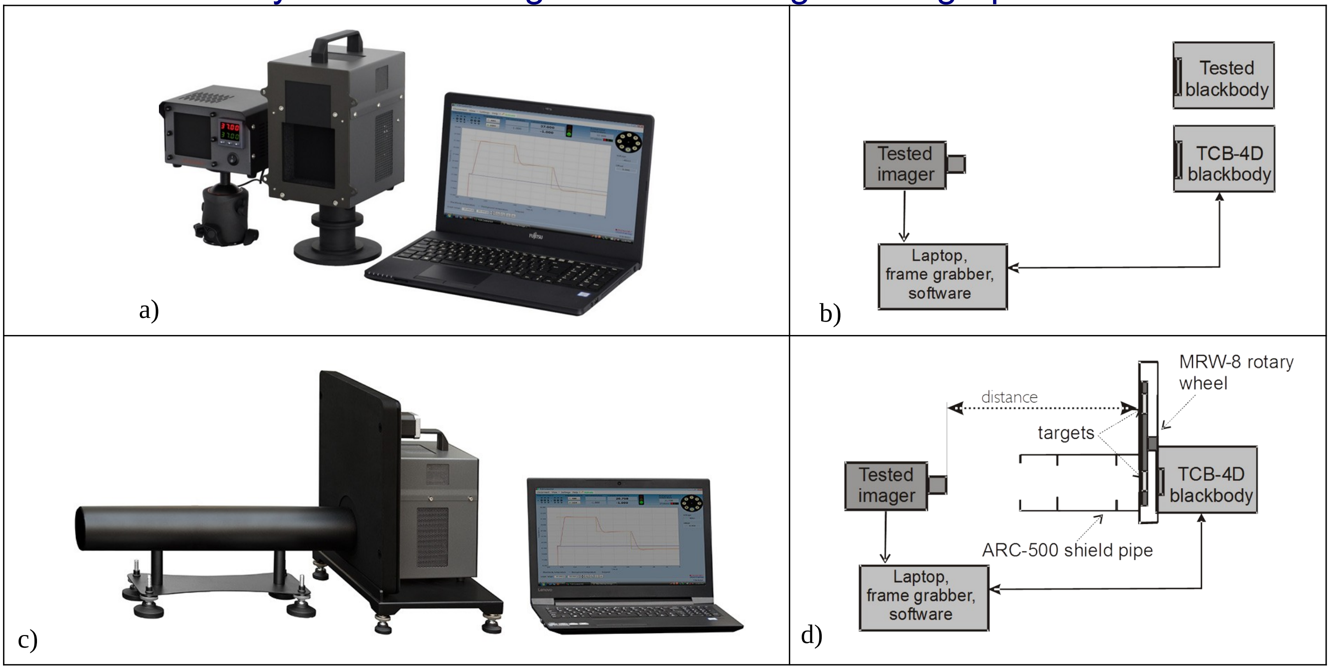

Fig.1. TFEV system: a)photo of TFEV at mode A, b)block diagram of mode A, c)photo of TFEV at mode B, d)block diagram of mode B.

1 Basic information

TFEV is a system for testing fever screening thermographs (measurement thermal camera systems optimized for fever screening). It is a valuable tool to determine real technical abilities to of myriads of fever screening thermal cameras offered on market. TFEV test concept is based on recommendations of the standard IEC 80601-2-59 - "Particular requirements for the basic safety and essential performance of screening thermographs for human febrile temperature screening"

2 How it works?

TFEV is a modular system that can work in two modes: A)high accuracy blackbody of manually regulated size B)motorized image projector capable to project images of some reference targets of variable temperature and size. The blackbody is to simulate different parts of human body (typically eye inner canthus or forehead) for tested thermal camera. It is located at plane where typically tested human and the thermograph external blackbody (part of tested system) should be located during real work.
Image projector (system built by combining blackbody, motorized rotary wheel, set of IR targets, shield pipe, laptop, control/test software) enables fast measurement of critical parameters that characterize performance of tested cameras.

3 What measured parameters?

Mode no 1 is used to measure a series of parameters listed directly by the standard IEC 80601-2-59: uncertainty of camera external blackbody, camera temporal drift, camera measurement spatial non uniformity, camera measurement instability. Measurement of these parameters makes possible to calculate total measurement uncertainty of temperature of large size blackbody type targets similar to human forehead.
Mode no 2 is used to measure a series of parameters that describe system ability to measure accurately temperature of small size blackbody type targets like inner canthus or are commonly accepted to describe general performance of thermal cameras like: ATF[1] (aperiodic transfer function), MRTD (minimal resolvable temperature difference), NETD (noise equivalent temperature difference).
The first parameter is not directly recommended or defined by IEC 80601-2-59 but the standard sets some recommendations on size of camera pixel in order to enable accurate measurement of temperature of small targets like eye inner canthus. The second parameter is directly recommended by IEC 80601-2-59 standard that proposes measurement using another ASTM standard. Finally, the third parameter is not recommended by IEC 80601-2-59 but it was included to proposed list as it it a very popular parameter used to characterize thermal cameras.

[1]ATF function determines minimal angular size of tested square target when temperature can be accurately measured.

4 How is built?

TFEV is a modular system built from a series of blocks:

1. TCB-4D blackbody
2. Blackbody adapter
3. Set of large square targets for TCB-4D blackbody
4. MRW-8 motorized rotary wheel
5. set of six square targets (measurement of minimal acceptable target size) for MRW-8 wheel
6. set of six four bar targets (measurement of MRTD) for MRW-8 wheel
7. frame grabber (type depends on tested camera)
8. PC set
9. tripod
10. MB1 mechanical base
11. MB2 mechanical base
12. TCB Control program
13. TAM program,
14. CDT660HR collimator.

The heart of TFEV is TCB-4D blackbody. It is ultra high accuracy area blackbody (https://www.inframet.com/Data_sheets/TCB.pdf) that can very accurately simulate human body of the same emissivity.
Medical thermal imagers typically do tests human targets located in short distance. Therefore collimators that simulate far away targets located in optical infinity are typically not needed. However, Inframet offers also optional CDT660HR collimator to make possible simulation of far away targets.

5 Medical basics

Ability for fast, non contact and precision detection of humans having high temperature of body core is critical detecting febrile humans and prevention of fever-producing infectious diseases like coronovirus.
On the basis of experience with SARS epidemic it is typical that a person having body core temperature 38ºC or above is considered as febrile and should be treated as potentially infected. It should be noted that this level of alarm is only 1ºC higher over temperature of average perfectly healthy person. Healthy persons of increased metabolism or more agitated having temperature as high as 37.5ºC can occur too. Therefore, precision detection of febrile humans is a challenge.

Classical contact methods of measuring body core temperature (measurement of rectal temperature and oesophageal temperature) cannot be used due to too slow test speed and risk of infection caused by direct contact with the thermometer. Therefore non-contact methods are needed to determine temperature of human body core on basis of measured temperature of some external body parts. Medical experiments have shown that temperature of the inner canthus is best correlated with temperature of body core and such measurement is recommended by both standards and scientific papers devoted to fever screening. However, non contact measurement of temperature of the inner canthus is difficult due to small size of this part of human body. Therefore measurement of temperature of human forehead is often used but this temperature is not well correlated with temperature of body core and additionally varies strongly on environment conditions.

6 Market situation

Market for fever screening devices is dominated by low cost non contact infrared thermometers used for measurement of forehead temperature. Low price is a big advantage of these devices but their practical efficiency is low. Alarm temperature threshold must be set high in order to avoid high number of false alarms caused by high temperature measurement error (±1ºC for typical units) and variability of forehead temperature depending on environment conditions. In addition test procedure is slow and generates infection risk for test team due to short distance to tested persons.

Measurement thermal cameras offer much higher potential due to ability to generate detail image of human face from safe distance of several meters at a fraction of a second. These cameras used for fever screening can be divided into three groups: 1) general purpose measurement thermal cameras, 2) measurement thermal cameras for research applications, 3) fever screening thermographs. It should be noted that all these imaging systems are advertised as tools for fever screening.

Manufacturers of general purpose measurement thermal cameras typically declare in data sheets temperature measurement accuracy/stability at level ±2ºC. Practically it means that these cameras are almost useless for fever screening application due to too low accuracy/stability. In spite of very limited effectiveness of these cameras, some unscrupulous distributors are taking advantage of the high demand to sell such thermal cameras designed for industrial use as fever screening medical tools.

Research grade measurement thermal cameras of typical measurement accuracy/stability at level ±1ºC offer higher potential as fever screening tools. However, accuracy/stability is still too poor to achieve high fever test sensitivity (test result is positive for febrile person having increased temperature) and specificity (test result is negative for non febrile person having normal temperature of body core).

High sensitivity/specificity of fever screening tests can be achieved only when using the third group of measurement thermal cameras called in professional literature as fever screening thermographs.

The screening thermographs (different names related to fever detection are also used in literature) are basically typical measurement thermal cameras with additional blackbody located in camera FOV in order to increase accuracy of measurement of temperature distribution on faces of tested humans. Use of external reference blackbody in camera FOV enables to achieve significantly much better accuracy of temperature distribution on human face comparing to typical measurement thermal camera and. Level of ±0.2ºC is declared in data sheet of some fever screening thermographs. However, this quite accurate measurements can be achieved only if a number of of requirements on design and use of screening thermographs are met. Therefore IEC 80601-2-59 standard (IEC 80601-2-59:2017 Particular requirements for the basic safety and essential performance of screening thermographs for human febrile temperature screening) presents a set of requirements on uncertainty of external temperature reference source, temporal drift, non-uniformity in FOV, non-stability, minimum resolvable temperature difference and image resolution of the screening thermographs. Only thermographs that fulfill these requirements can offer acceptable sensitivity/specificity of fever screening tests.

Market reality is that majority of screening thermographs available commercially do not fulfill requirements of IEC 80601-2-59 standard. There is a series of scientific papers that show poor performance of commercial screening thermographs due to their limited technical specifications or incorrect use. It looks also that some manufacturers of screening thermographs are not even aware that there are standards that give recommendations on design and use of these measuring systems. However, due to huge demand for screening thermographs because of coronavirus pandemic even low performance screening thermographs are sold. Therefore ability to determine quality of offered fever screening thermographs is extremely important for potential users.

7 Why TFEV test systems?

TFEV system enables verification of potential performance of fever screening thermographs offered on international market. It makes possible precision determination of accuracy of temperature measurement of parts of human body, especially temperature of inner canthus of human eye.

TFEV system can be also very useful for manufacturers or scientific institutes that carry our research on development of new measurement thermal cameras for fever screening or other medical applications.

Version 1.4

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