

A Simple and Practical Device to Make Feasible the Practical Examinations for Certification in Thermography

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Abstract

This paper describes how a simple and practical device has been developed to make feasible the practical examinations in the process of Certification of Thermography Personnel and how a number of practical situations encountered in the daily routine of the thermographer may be simulated on it.

1. Introduction

It is well known that the results achieved by thermography highly depend on the qualification of a thermographer. The word "qualification" is usually associated to physical attributes, knowledge, skill, training and experience required to a person to perform specific tasks properly [1]. Therefore, when applying thermography, it is essential a qualified thermographer to take full advantage of it. However, how can the end user be sure that an individual is a qualified thermographer?

Certification of Thermography Personnel is a good answer to that question.

Certification of Thermography Personnel is a recognized process to assess and attest the qualification of thermographers, leading to the issuing of a certificate. To be eligible for certification, the thermographer should provide documentary evidence of visual acuity, education, training and experience. After that, one should take examinations, achieve a minimum score to pass them and then be able to obtain the certificate. The examinations may be theoretical (written) or theoretical and practical.

Many organizations and individuals agree that the practical examination is essential to assess the qualification of complete way: "The BINDT however believes that it is imperative that condition monitoring practitioners also be tested for practical competence..." [2], "The candidate's skill of performing the test and interpretation and evaluation of test must be judged during practical exams." [3]. Some certification standards require practical examinations: "The qualification and certification standards [1-9712 and 2-EN473] require that personnel are assessed for practical competence..." [4] and ISO 18436-7 says: "The experience duration in months, not in hours, for Categories I and II may be reduced by 50% when the classification process includes a practical examination" [5].

Following this way of thinking, The Brazilian Society of Non Destructive Testing and Inspection (ABENDI), entity which has developed a certification of thermography in Brazil and its Working Group (WG) responsible for developing the certification process has opted for both examinations in Brazilian certification, the theoretical and practical examinations [6]. The WG has agreed that both examinations would help to assess the qualification of thermographer more strictly. Consequently, a device has been developed to make practical examinations possible. This paper describes how a simple and practical device has been developed to make feasible the practical examinations and how a number of practical situations encountered in the daily routine of a thermographer may be simulated on it.

2. The Thermographic Conditions Simulator - TCS

To make the practical examinations possible, it was necessary to define which of the specimens would be used. At first, the WG cogitated to use real equipment with simulated faults, to test the skill of the thermographer in finding thermal anomalies. For example: a motor with overheated winding, a switch with high contact resistance or gears with frictional heating. However, many specimens would be required to make this approach viable and to achieve a representative sample in the wide range of thermography application.

After considerable speculation and discussion, an alternative approach was presented by FURNAS Company, a member of WG. Instead of assessing the skill of a thermographer in finding thermal anomalies on specific equipment, the new approach was proposing to develop a single specimen, in which it would be possible to assess the skill of thermographer to apply, in practice, the different theoretical concepts involved in the thermography and be able to perform accurate temperature measurements and correct thermal analysis in several situations. The device, named Thermographic Conditions Simulator (TCS) was designed, developed and tested by the authors, at the GES.O laboratory

of the FURNAS Company. It is a simple and portable device, with no buttons, keys or display and is fully computer controlled through a user friendly interface.

The TCS was designed to simulate several situations encountered in routine thermographer, in which the temperature measurement and thermal analysis involving sources of error and/or requiring major theoretical concepts are required, figure 1 shows the device from different angles.

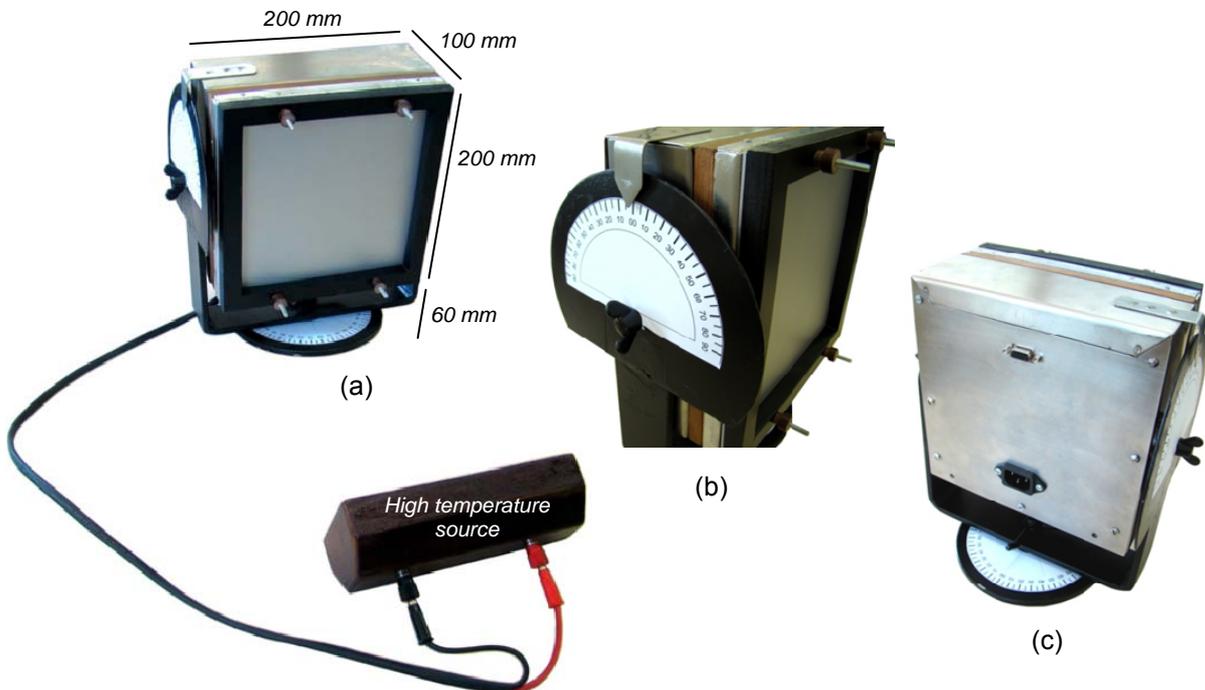


Fig. 1. Thermographic Conditions Simulator: front view (a), side view (b) and rear view (c)

As seen in figure 1, the TCS has a flat area on its front side, which is used as a target in the tests and where the temperature measurements and thermal analysis are carried out (a). In the same picture (a), the apparatus facing it and connected by cable is a source of high temperature. On its side, there is a degree scale for measuring the tilt angle of TCS (b). At last, on the rear panel is the AC input power and the serial communication port (c).

The major features available on TCS are described below:

- Temperature measurements may be performed by heating the front area within a suitable temperature range for the practical examinations;
- It is possible to run emissivity tests by adapting sheets with different emissivities in the target area and in direct contact with it. In addition, the TCS has the ability to rotate vertically and horizontally, allowing testing of angular dependence of emissivity [7];
- focus tests may be carried out by adapting a sheet, similar those used for visual acuity testing, placed a few centimeters away in front of the target area and covered with a material transparent to infrared;
- transmittance tests may be performed with the simple installation of different materials, far few centimeters in front of the target area;
- tests of spatial and measurement resolution may be made by installing a sheet with several holes of different diameters in front of the target area;
- tests related to infrared reflection may be conducted by using the high temperature source, showed in figure 1(a). This source must be positioned such that its emitted radiation is reflected on the TCS target area and reaches the thermographer's camera;
- the high temperature source may also be used as a target point to test the skill of the thermographer to select correctly the temperature range of the camera.

In addition to all the features described above, the developed software allows continuous monitoring of the temperature on the target area and is able to create spreadsheets and graphs versus time from those produced data. The TCS clock may be synchronized with the clock camera of the thermographer. Thereby, all measurements performed by the thermographer may be compared with the data stored on the computer and the results of the entire examination may be documented based on the record produced.

The software may also change the temperature calibration of the TCS according to the calibration of the camera thermographer. This feature allows the assessment of the competence of the candidate is not affected by the camera calibration errors.

2.1. User Interface

The TCS Human Machine Interface (HMI) was developed in Labview and runs on IBM PC compatible with Microsoft Windows platform. The software has an installer program which updates the host computational system as needed, provisioning all the add-ons for perfect working, such as hardware drivers, runtime libraries, icons and links as well. Figure 2 shows the interface as it appears on the computer.

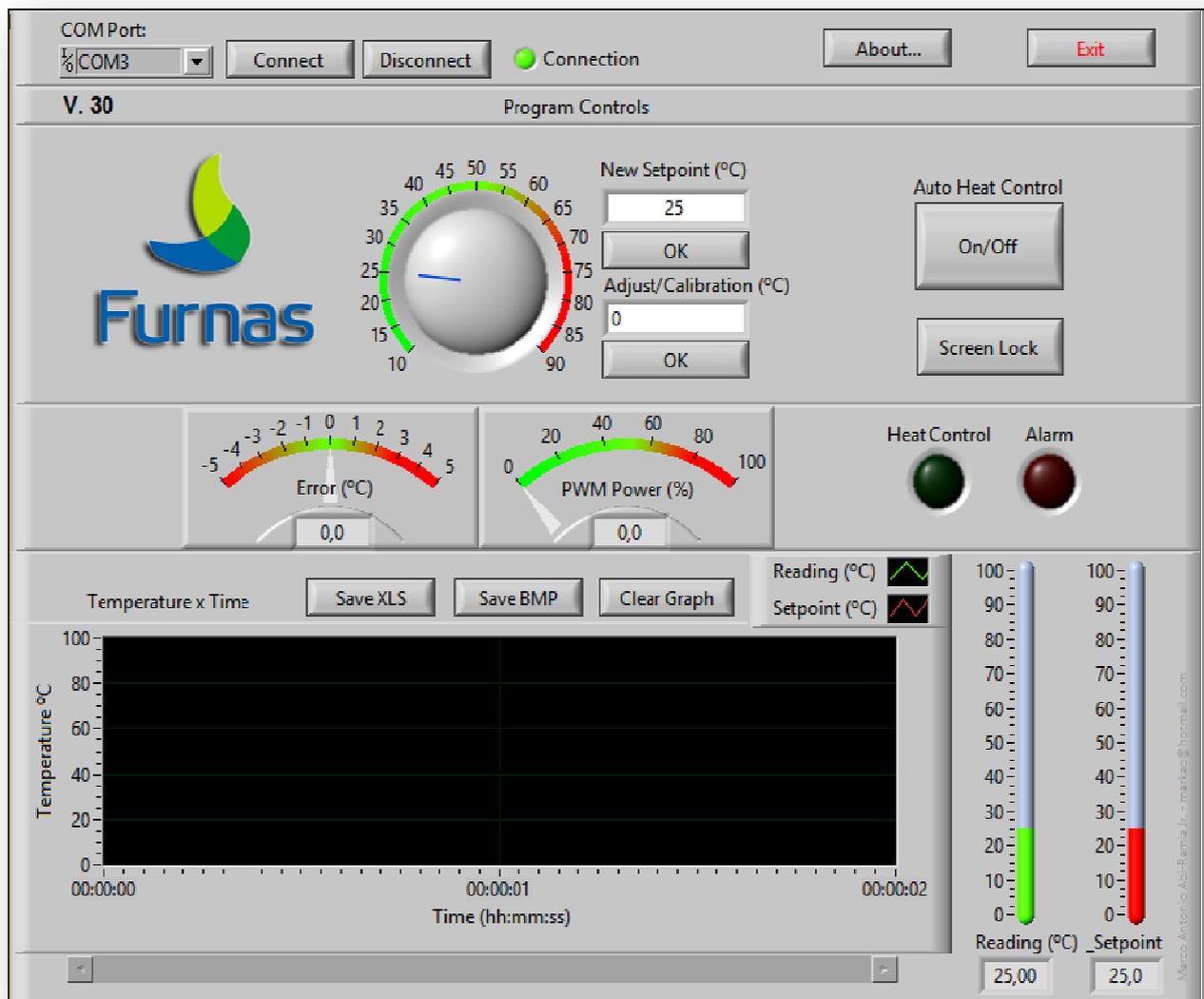


Fig. 2. User interface

The HMI enables users to setup and create a wide range of test conditions by performing a set of adjustments and/or actions such as:

- New Setpoint - sets a temperature on target area;
- Adjust/Calibration - sets a correction factor to adjust the temperature of the target area with the temperature reading of the infrared camera;
- Screen Lock - locks and clears the screen to the thermographer cannot see it;
- Error - shows the difference between the desired temperature and the actual temperature measured on the target area. It should display zero at the stabilization point;
- PWM Power - displays the PWMs duty cycle in % while it works to stabilize the measured temperature to the set point value;
- Heat Control indicator - shows whether the Automatic Control is working or not;
- Alarm indicator – lights up when the TCS has an internal alarm condition;
- Graphical Indicator - shows two traces in a chart: the set point and actual temperature data, over the time axis. It makes a historical registry of the test session;
- Ranges adjust - All the range controls and indicators have maximum and minimum adjustable scale values.
- Data export and auditory - allows the test to be audited graphical and textually logging all the test data. It is possible to save a Bitmap image file and a text file which can be exported to Microsoft Excel.
- Serial communication - the communication between the computer and TCS is via a serial port (COM) and works well with any serial/USB converter.

Part of the LabVIEW block diagram is shown in figure 4.

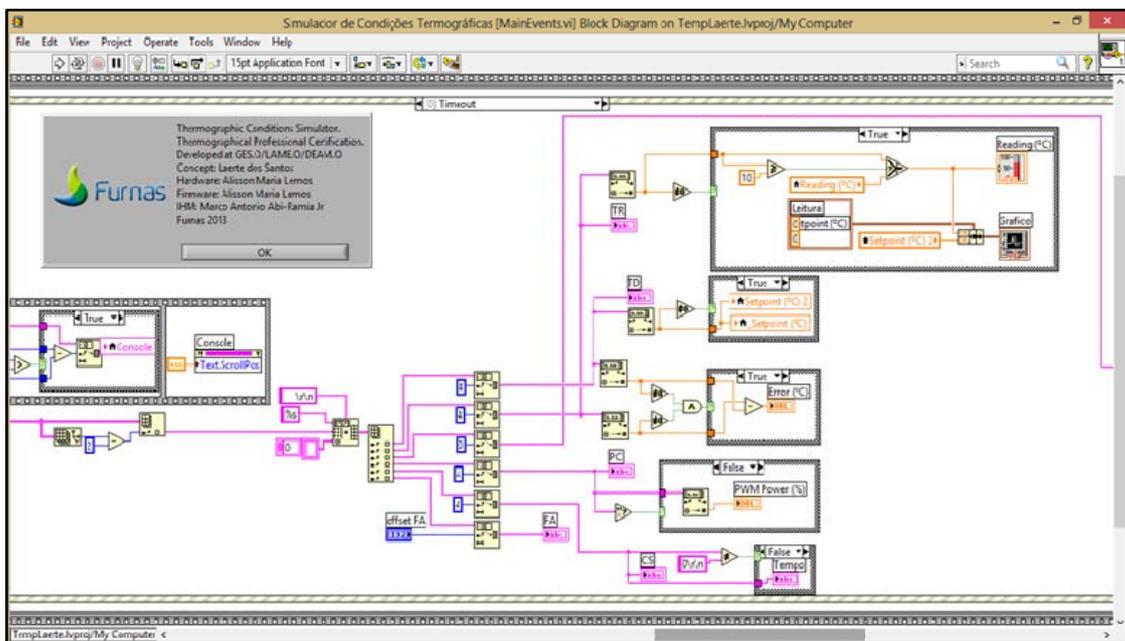


Fig. 4. Part of the LabVIEW block diagram

2.2. Hardware

The TCS basically consists of a microcontroller, a temperature sensor, a precision power resistor, an interface RS-232 and a power supply. Its block diagram is given in figure 5.

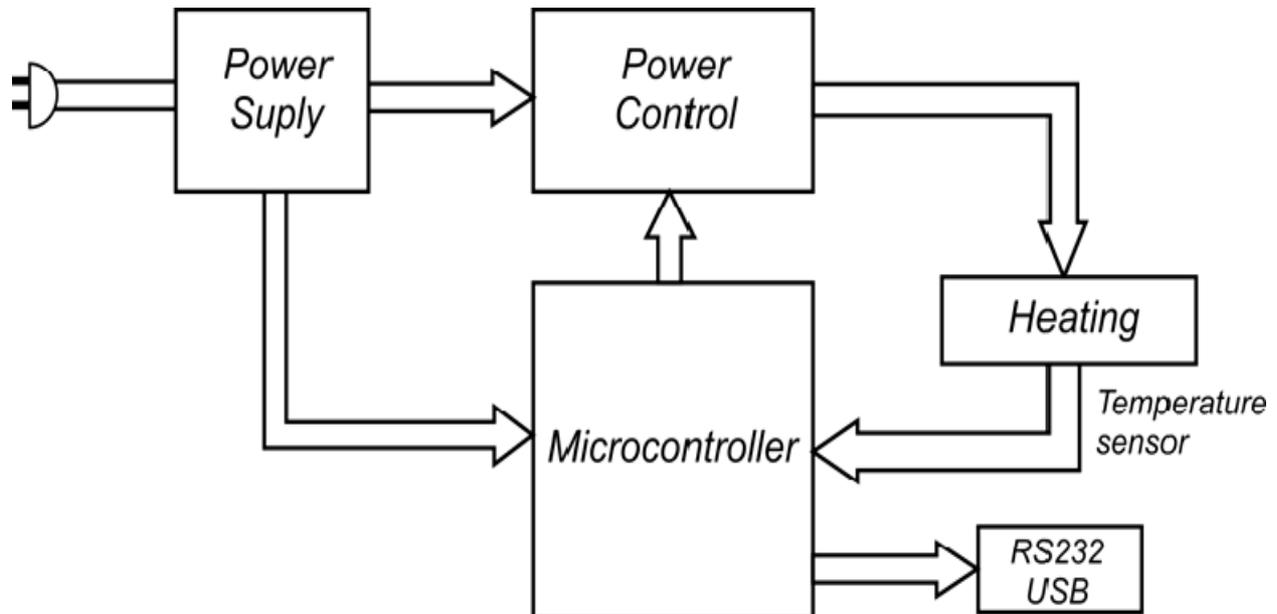


Fig. 5. Block Diagram

The microcontroller acquires the signal from the temperature sensor via an analog to digital converter (ADC) and compares it with the desired value (Set Point). Through a proportional-integral-derivative logic (PID), it calculates an error value as the difference between them and attempts to minimize the error by changing the current applied to the heating resistor.

The communication between the computer and TCS is bidirectional and upon a proprietary protocol. It is carried through a serial port or a USB cable by using a USB-serial converter.

3. Practical Situations Simulated on TCS

The daily routine of the thermographer requires an understanding of theoretical concepts, the correct handling of the infrared camera and the ability to register the anomalies clearly and precisely. The device allows simulating some important practical situations and assessing the ability of the thermographer on those competencies. Some simulations able to run on TCS are shown next.

Tests relating to emissivity employ different sheets with different emissivities. The sheets are in direct contact with the TCS heated surface.

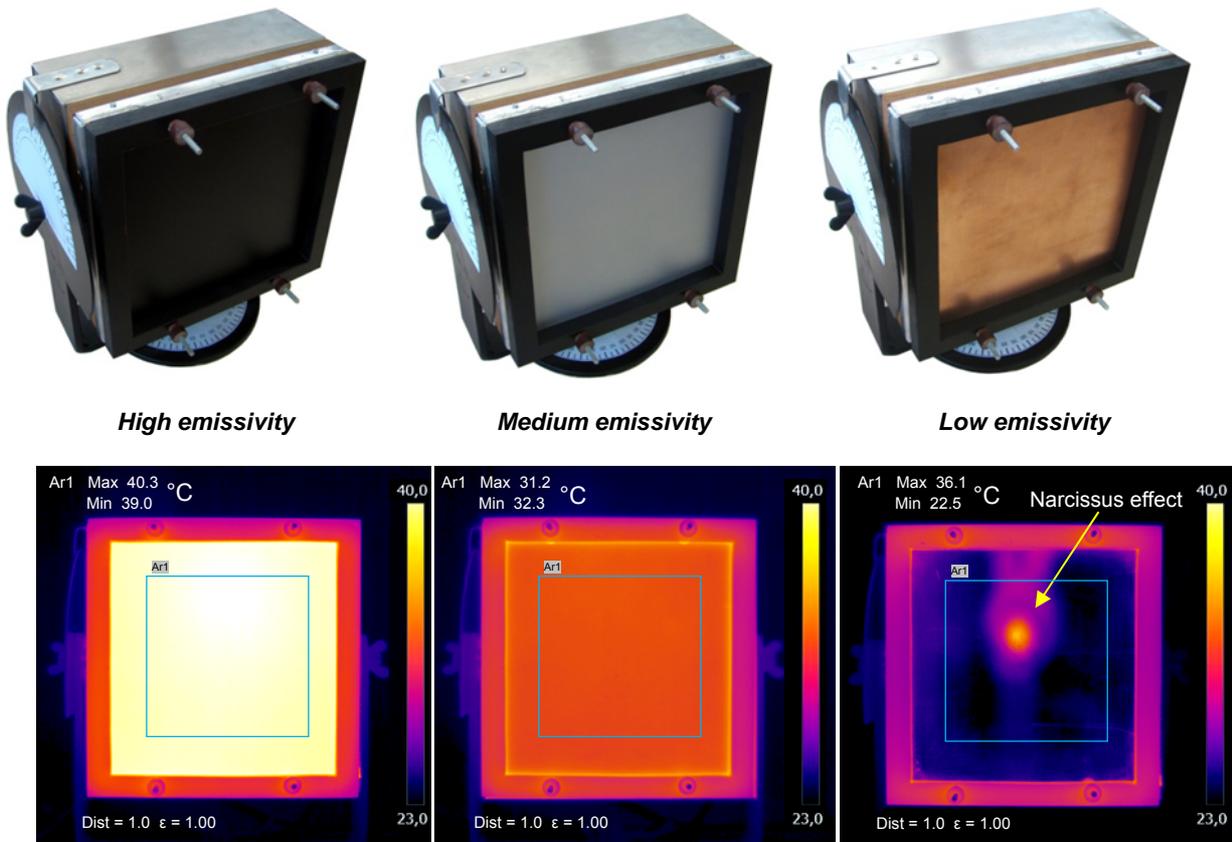


Fig. 6. Different emissivities with photos (above) and their thermograms (below).

Tests of angular dependence of emissivity may be performed with horizontal or vertical rotation of TCS.

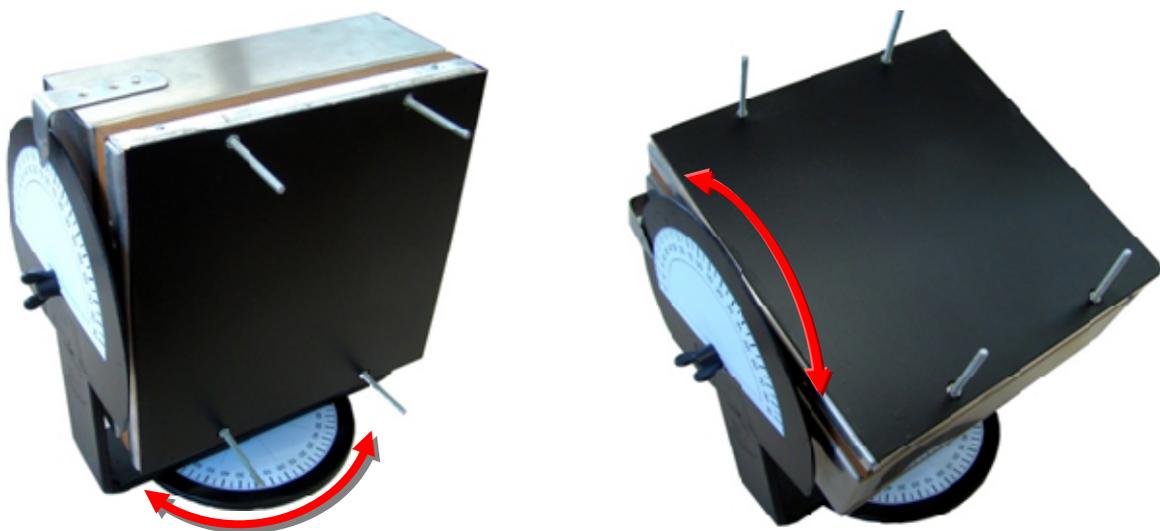


Fig. 7. Angular dependence of emissivity - Horizontal and vertical spin.

Tests of spatial and measurement resolution using a sheet perforated with several orifices of different diameters.

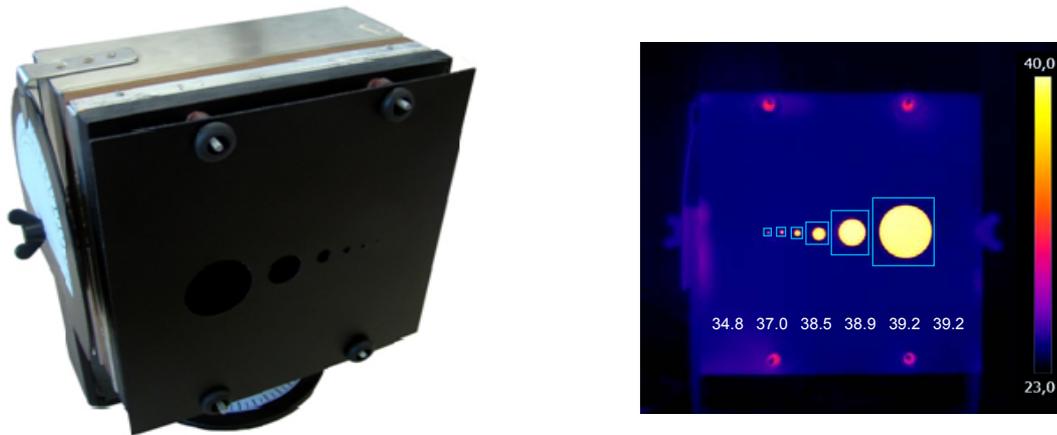


Fig. 8. Test of spatial and measurement resolution - Photo (left) and its thermogram (right).

Tests related to infrared reflection may be conducted by using a high temperature source positioned, such that, its emitted radiation is reflected in the TCS target area and reaches the thermographer's camera.

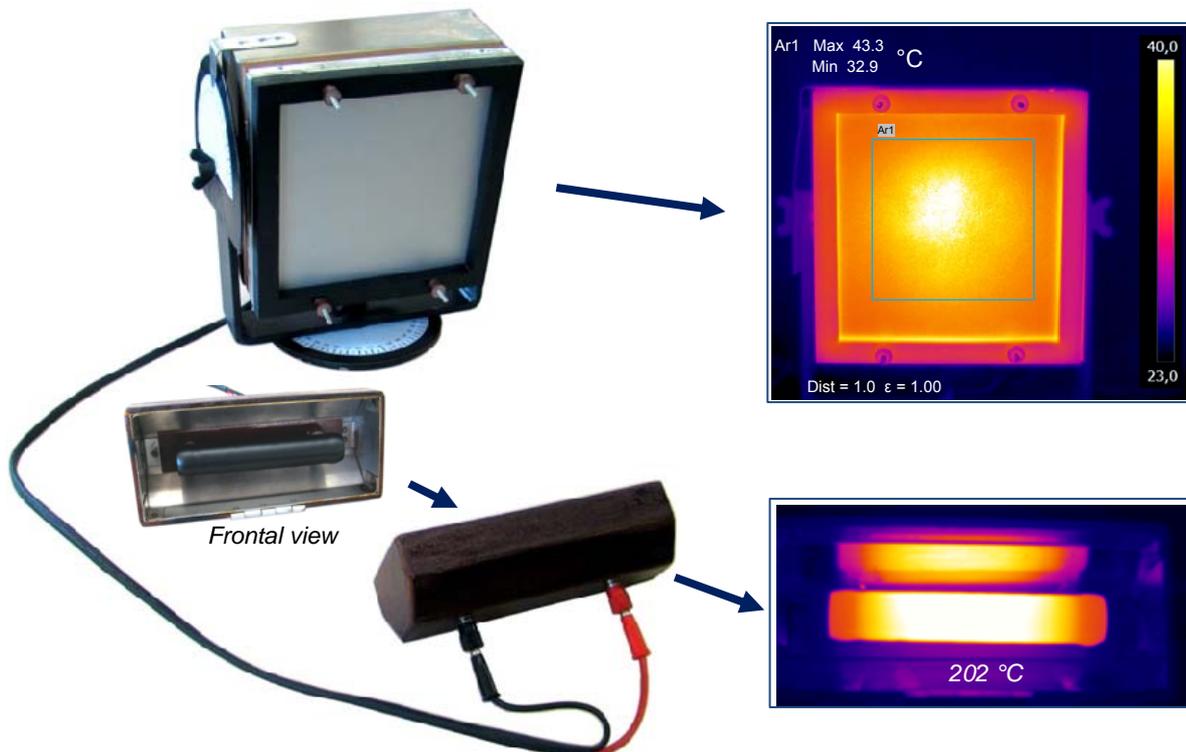


Fig. 9. Infrared reflection - Photos (left) and their thermograms (right).

Transmittance tests may be performed with the simple installation of different materials, far few centimeters in front of the target area.

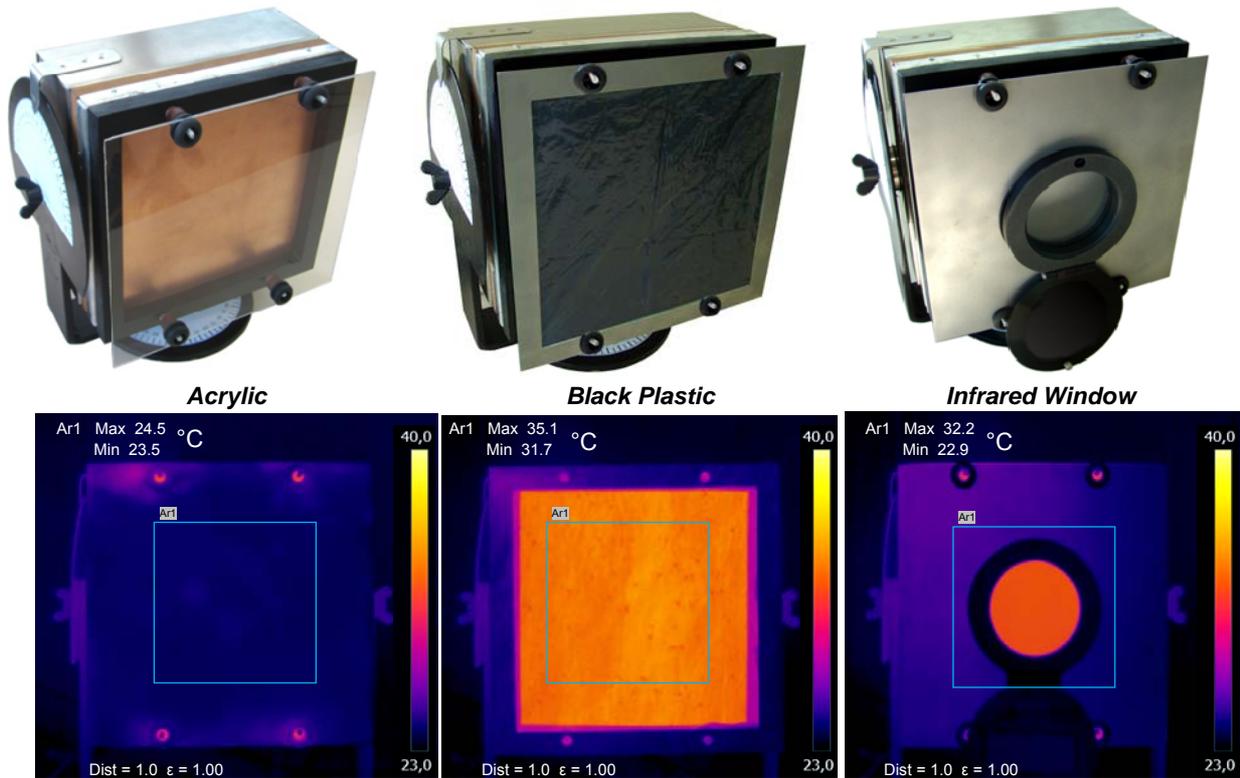


Fig. 10. Different transmittances, photos (above) and their thermograms (below).

Focus tests may be carried out by adapting a sheet, similar those used for visual acuity testing, placed a few centimeters away in front of the target area and covered with a material transparent to infrared.

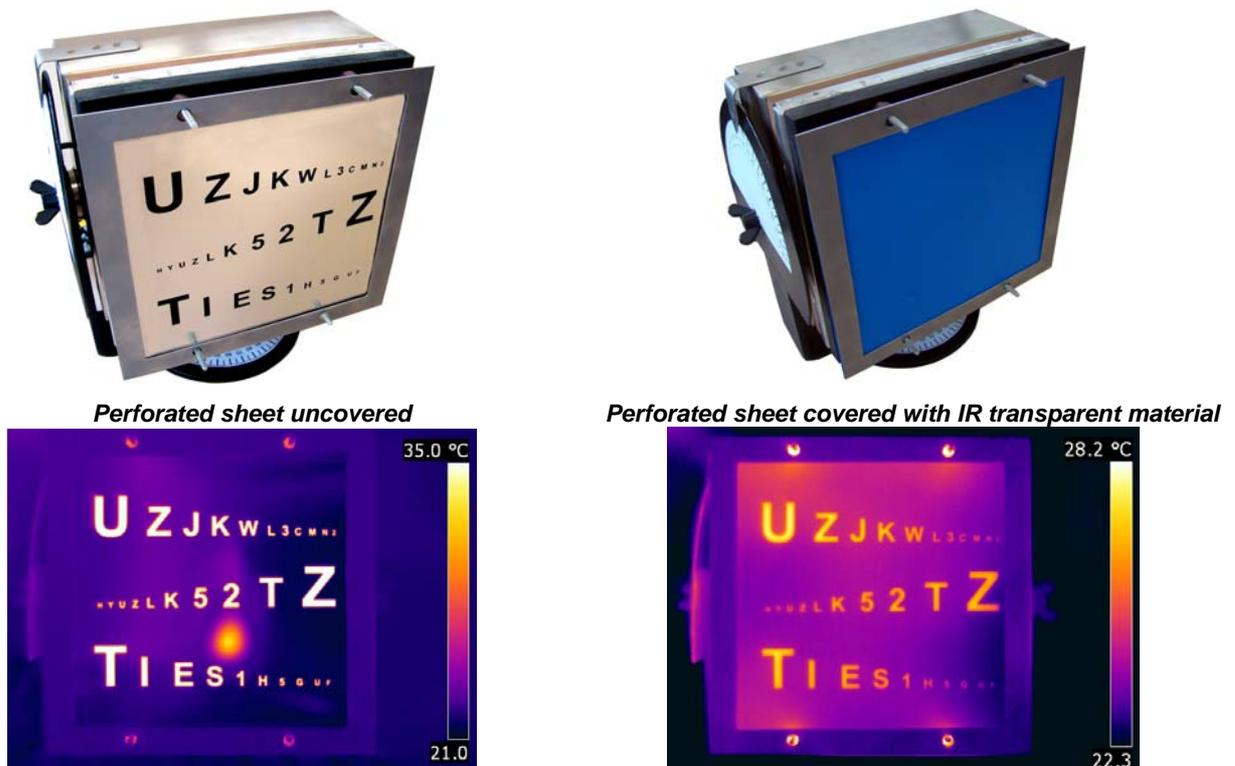


Fig. 11. Perforated sheet, photos (above) and their thermograms (below).

4. Conclusion

In a world where reliable service is increasingly demanded, it becomes necessary to establish a reliable and recognized process of personnel certification to assess and attest the qualification of thermographer. In the process of evaluating the qualifications, the practice examinations help assess more rigorously the thermographer competence. In order for the practical examinations be performed, it is necessary that specimens be developed. This paper shows the Brazilian experience on developing a simple and practical device which can help implement the practical examinations.

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