Calibration Procedure

Contents

Preliminary notes

The sequence for this procedure has been set out to optimize the use of your time when performing calibration. Ideally you should read through the entire procedure before embarking on its execution so as to acquire a complete overview of the calibration concept.

The descriptions of the two calibration methods partly overlap. This us a deliberate choice, to make each chapter separate from the other and let you follow the procedure step by step, regardless of the method chosen.

1. Specific Terminology

DL

Digital Level: digital level expressed as a numerical value.

TCam

Camera internal temperature.

SWIR

Short Wave Infra Red.

2. Calibration Purpose

2.1. Temperature Measurement General Principle

Your camera is a "photon counting device". Depending on the amount of photons received, it returns an electrical voltage (in volts) expressed as a digital level (DL). The photon/volt and volt/digital level transfer functions are increasing linear functions.

A non-linear transfer function can convert the digital levels returned by the camera into temperatures. The purpose of calibration is to define this experimental transfer function.

Depending on its type and configuration, the camera is sensitive to a certain range of photons.

2.2. Influential Camera Parameters

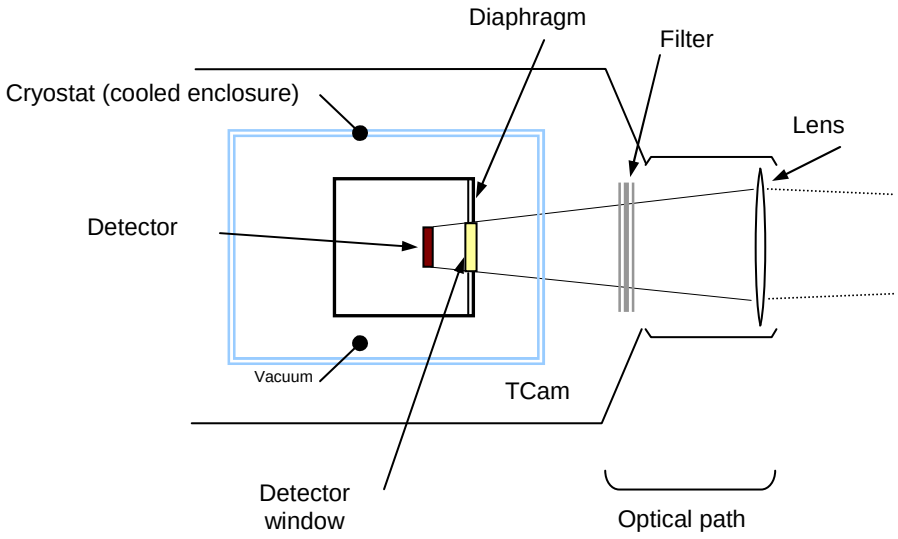
- Sensitivity: this is characterized by the Integration Time and the optical path. It sets the slope for the camera's response curve.
- Level (or offset): this sets the curve's absolute value.

The flow of photons received by the camera is therefore directly dependent on the optical path (filters) and the Integration Time.

The calibration curve therefore depends directly on the optical path and the Integration Time.

Remarks

Unlike conventional picture taking, no provision is made for an adjustable "aperture" parameter when taking measurements with an infrared camera . Detector aperture is fixed - no technology to adjust this parameter currently exists.



The camera's internal temperature (TCam) induces an interference measurement flow on the measurement; this must be compensated for to ensure a precise measurement (refer to subsection 5.2 "Standard FLIR SYSTEMS Calibration).

3. Resources Required for Calibration

3.1. Equipment

Camera calibration is a metrology operation. As such, it can only be performed using temperature measurement standards that provide a validated reference. In infrared applications, the measurement standard is a Black Body.

No calibration is possible without Black Bodies that cover the entire dynamic range.

Before starting calibration, therefore, it is essential to:

- Define the dynamic range
- Check that you have Black Bodies covering the entire dynamic range
- Check that the Black Bodies are calibrated correctly

Note

It is possible to use either a Black Body that is adjustable over the entire dynamic range or several Black Bodies spread over the entire dynamic range.

3.2. Size

Calibration must always be performed at focal length.

What does FLIR SYSTEMS do?

FLIR SYSTEMS has set out a one meter calibration standard lens permitting (a 200 mm lens cannot focus at less than ten meters).

Remark

Any equipment added to the measurement system (e.g. collimator, mirror, etc.) adds to calibration inaccuracies.

These inaccuracies are cumulative.

Warning

Calibration is an extremely rigorous operation. It affects all subsequent measurements.

4. Performing the Operation

4.1. Configuring the Operation

You must firstly define:

- The required dynamic range (e.g. 5℃ to 70℃),
- The Integration Time and any filter matching the dynamic range.

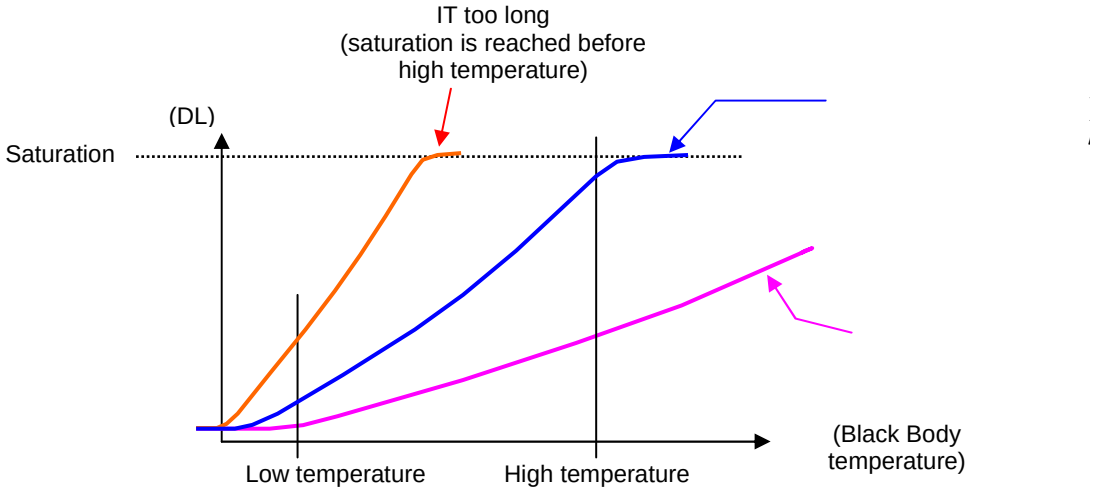
To define the Integration Time:

Start the Altair software.

Select a frequency. The frequency has little influence but must be defined. FLIR SYSTEMS uses 50 Hz as standard.

Place the Black Body at the maximum dynamic range temperature (70℃ in our example).

Look for the longest possible IT (to optimize sensitivity) without reaching saturation point. The optimum IT corresponds to a digital value of around 13,000.

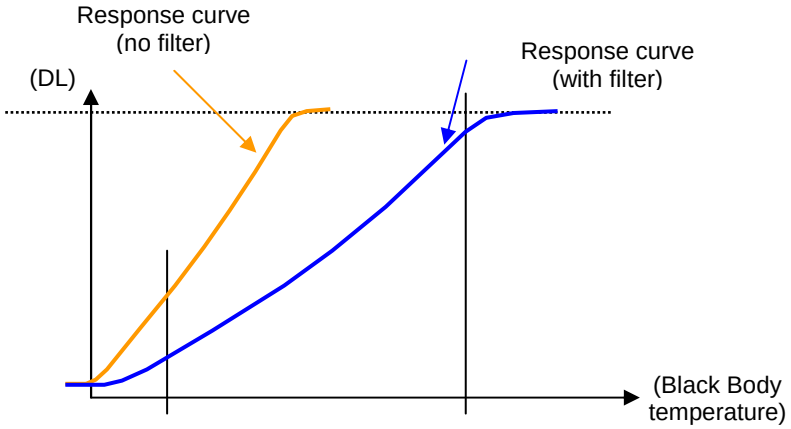


Note

The appearance of the curves depends on the wavelength.

Remark

IT must remain above 20µs. If the IT cannot be reduced sufficiently to drop below saturation level, then a filter will have to be inserted to restrict the photon flow.



4.2. Performing an NUC

As calibration is performed at the focal length, the Black Body reference area only takes up part of the image. We need to be sure that this area is representative of the entire image. A NUC is therefore necessary.

Refer to the NUC procedure (document C0499.D02).

5. Calibration Operating Modes

There are two possible calibration modes: simple calibration and complete calibration.

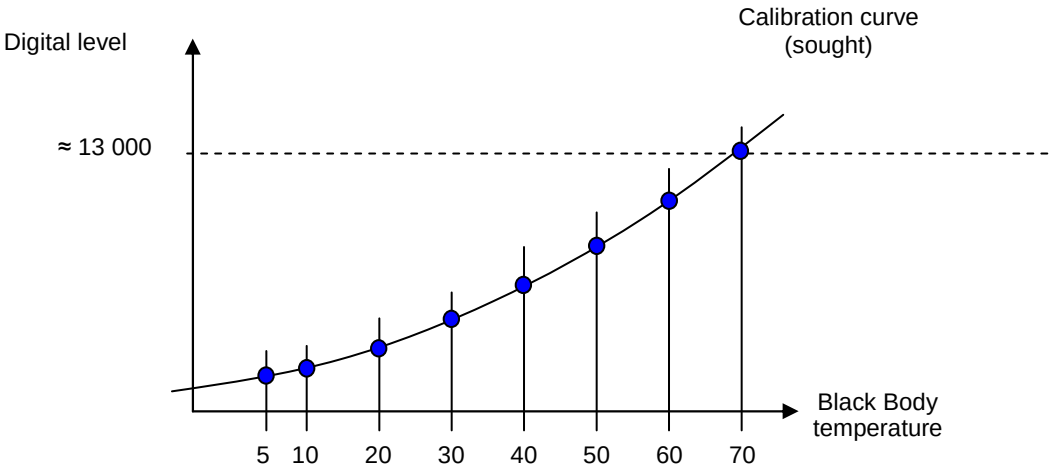
Simple calibration comprises drawing your camera's response curve in relation to a series of known reference temperature points (Black Bodies).

Complete calibration (presented as the standard FLIR SYSTEMS method) pursues the same objective and method, but also allows for the influence of the camera's internal temperature on your measurement.

5.1. Simple Calibration

Principle

To draw the calibration curve, we shall identify points at regular intervals along this curve. Each point will be characterized by a pair of values (black body temperature, digital level returned by the camera).



Example for a 5℃ - 70℃ dynamic range

This calibration method ignores the influence of the camera's internal temperature. It is less accurate than the complete method. However, to reduce the influence of the camera's internal temperature, we recommend working with a temperature-stable camera (after warming up for two hours).

1. For the first measurement point, set the Black Body to the low end of the dynamic range (5℃ in our example).

2. Determine some ten points at regular intervals over the dynamic range (5℃, 10℃, 20℃, 30℃, 40℃, 50℃, 60℃ and 70℃ in the our example) .

3. Place the camera one meter from the Black Body.

4. Focus the camera on the Black Body reference area.

Warning

Depending on the type of lens used, you may need to place the camera very close to the Black Body. Take all necessary care to prevent your lens from overheating (e.g. when using a G1 lens).

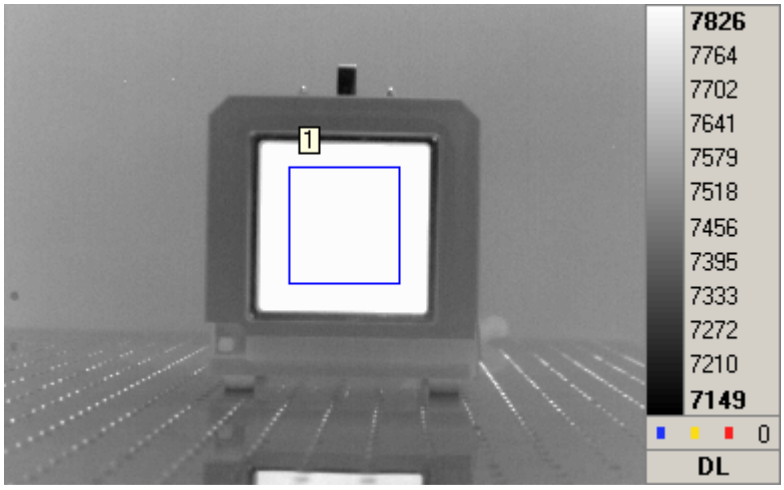
5. Aim the camera to place the Black Body image in the middle of the field.

6. Create a calibration project in Altaïr where all the calibration data will be saved. This file will be used as a reference and for subsequent checks.

7. Successively, and for each measurement point, produce a film of around a hundred images.

8. For each film, generate an average of the 100 images ( button). This operation will eliminate virtually all the time noise.

9. Define a valid Black Body measurement area on the image ("Tools\Rectangle" menu).



10. Generate an average over the selected area. The result is a mean digital level for each measurement point.

Label	Min (DL)	Max (DL)	Mean (DL)	Std-Dev...	Emissivity	Surface ...	Color	Label Tip	Lock	Hide	Comment
1	8118	8158	8138.84	5.70	1.00	3304		None			

11. Load the "Calibration File Manager" software from the FLIR SYSTEMS utilities.

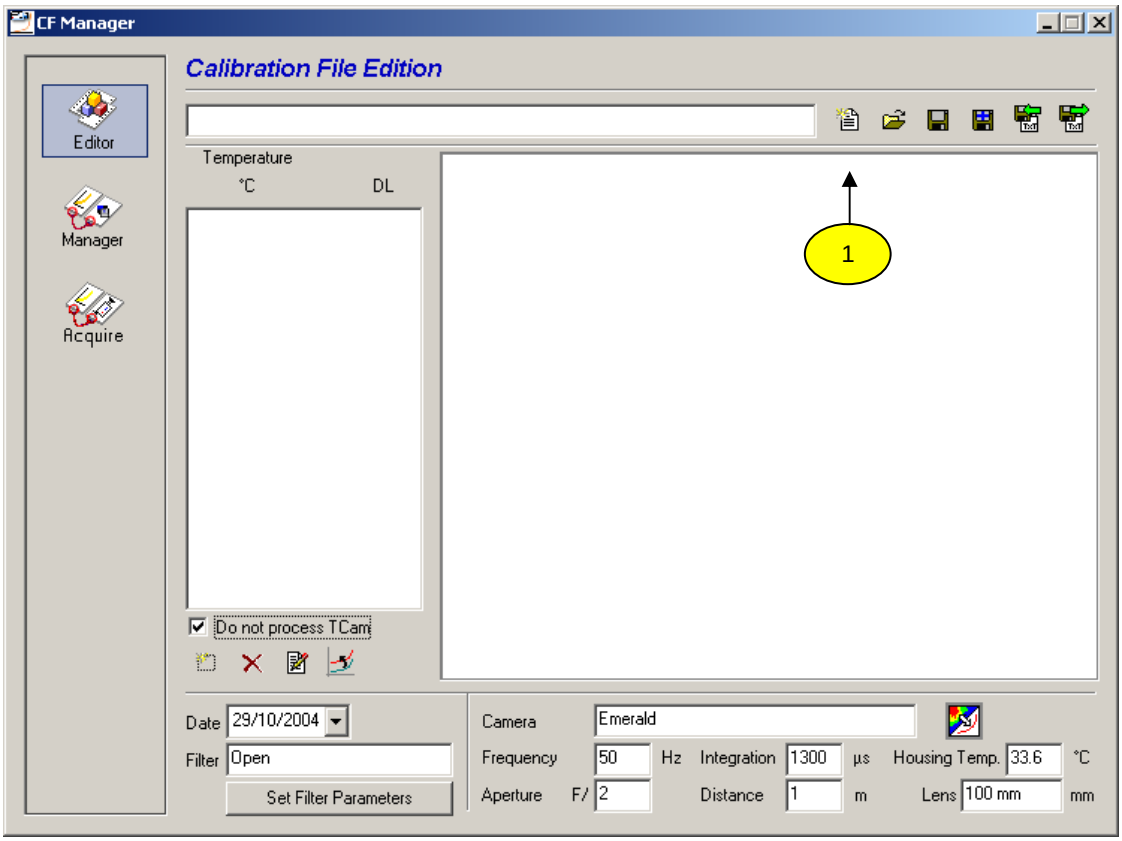
This utility creates the calibration file (*.exp) for interpretation by Altair which can therefore display temperatures directly by applying the transfer function to the digital level measurements.

Note

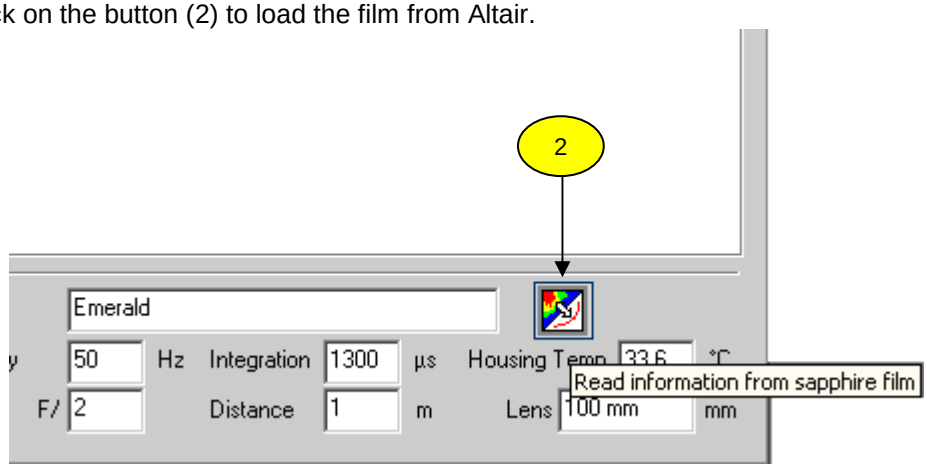
The Altaïr software linearly interpolates the values between two points and extrapolates the values outside the extreme points.

From "Calibration File Manager":

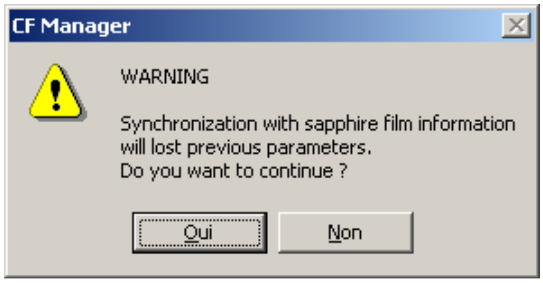
12. Create a new working file (1).



13. Click on the button (2) to load the film from Altair.

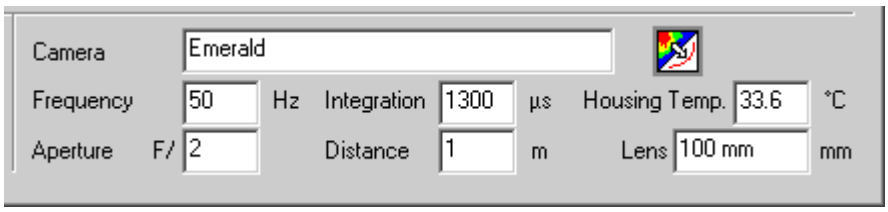


The following window is displayed:



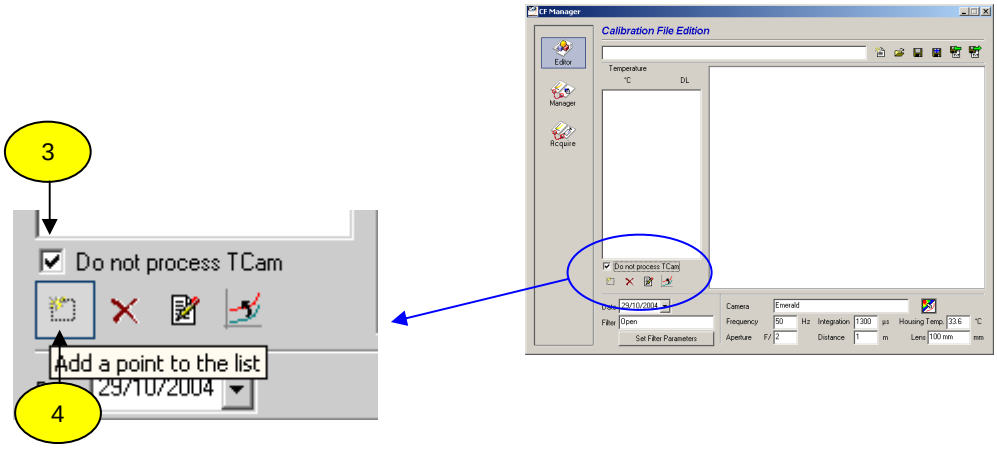
14. Click on "Yes", then select the file (film from Altair) to open.

Note

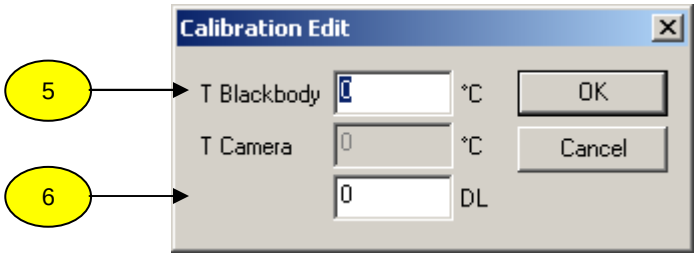


With the film, "Calibration File Manager" loads the camera parameters that were used to generate the film. It displays them at the bottom of the screen.

15. Tick the "Do not process TCam" box (3) (the camera's internal temperature will be ignored), then click on the "Add a point to the list" button (4) for every measurement point.



16. For every measurement point, successively enter:
    - The Black Body temperature (5),
    - The digital level returned by the camera (6).



Reminder

The value to enter is the useful area average (see point 10 above).

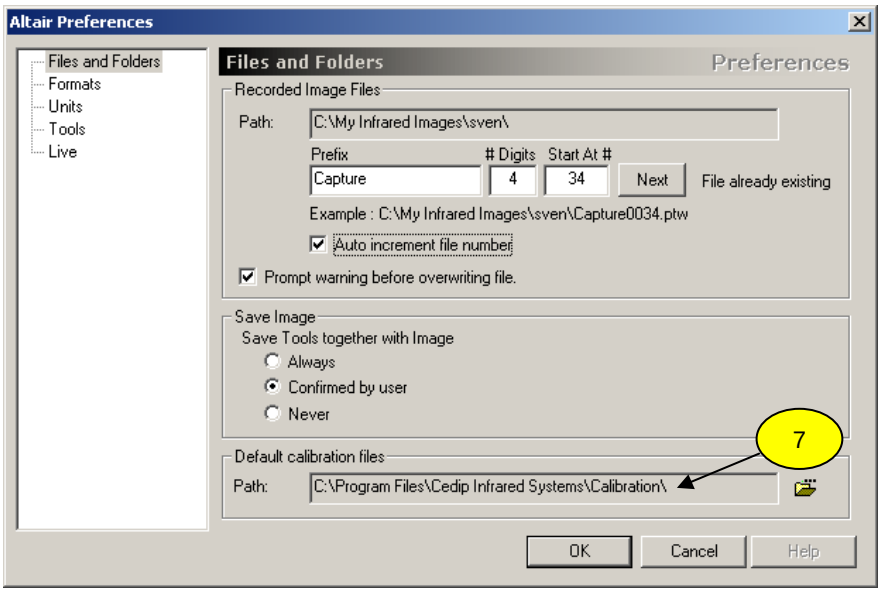
Tip

Take advantage of the time taken for the Black Body temperature to rise to the next measurement point to enter the data for the previous measurement in Calibration File Manager.

Remark

The curve is built as the data is entered. It is always increasing. Any "break" in the curve indicates a data entry error.

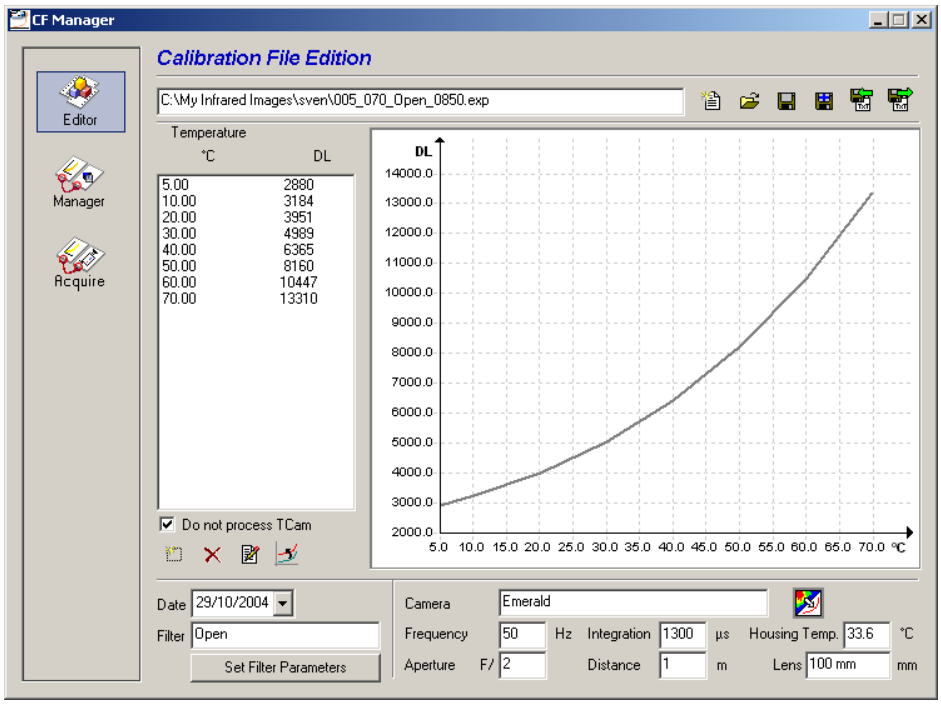
17. Once all the points have been entered, record the calibration file (button). The file's storage location must be the one defined in Altair (7) so that it can be taken into account for future measurements.



Tip

Prefer calibration filenames that include the parameters used (range, filter, IT). Example: 005_070_Open_0850.exp.

The "Calibration File Manager" screen looks like this:



5.2. FLIR SYSTEMS Standard Calibration

To improve the measurement reproduction capability (and increase its accuracy), this calibration method will measure the influence of the camera's internal temperature on the reference measurement and calculate corrections to be made to your future measurements.

To achieve this, the calibration program will use the "TCam" parameter, representing the camera's internal temperature. This parameter is updated every ten seconds.

Principle

For every Black Body reference temperature, at least two measurements are taken with different camera temperatures. Arrangements should therefore be made to vary camera temperature.

Tip

FLIR SYSTEMS uses climatic chambers to reduce the camera's internal temperature by 15℃ between the two series of measurements.

5.2.1. First Series of Measurements

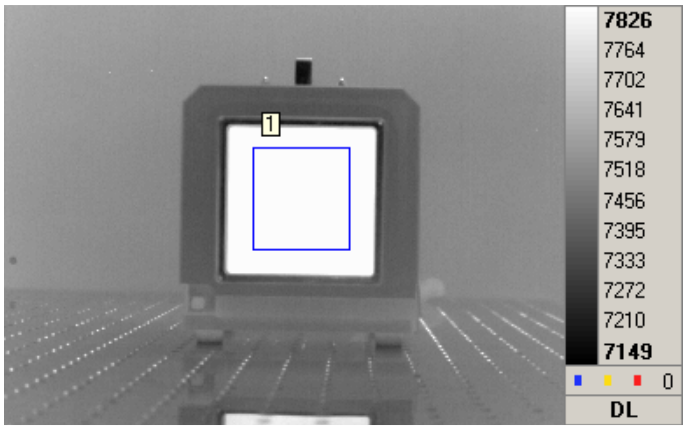
1. For the first measurement point, set the Black Body to the low end of the dynamic range (5℃ in our example).
2. Determine some ten points at regular intervals over the dynamic range (5℃, 10℃, 20℃, 30℃, 40℃, 50℃, 60℃ and 70℃ in our example).
3. Place the camera one meter away from the Black Body.
4. Focus the camera on the Black Body reference area.

Warning

Depending on the type of lens used, you may need to place the camera very close to the Black Body. Take all necessary care to prevent the lens from overheating (e.g. when using a G1 lens).

5. Aim the camera to place the Black Body image in the middle of the field.
6. Create a calibration project in Altaïr where all of the calibration data will be saved. This file will be used as a reference and for subsequent checks
7. Successively, and for each measurement point, produce a film of around a hundred images.
8. For each film, generate an average of the 100 images ( button). This operation will eliminate virtually all of the time noise.

9. Define a valid Black Body measurement area on the image ("Tools\Rectangle" menu).



10. Generate an average over the selected area. The result is a mean digital level for each measurement point.

Label	Min (DL)	Max (DL)	Mean (DL)	Std-Dev...	Emissivity	Surface ...	Color	Label Tip	Lock	Hide	Comment
1	8118	8158	8138.84	5.70	1.00	3304		None			

11. Load the "Calibration File Manager" software from the FLIR SYSTEMS utilities.

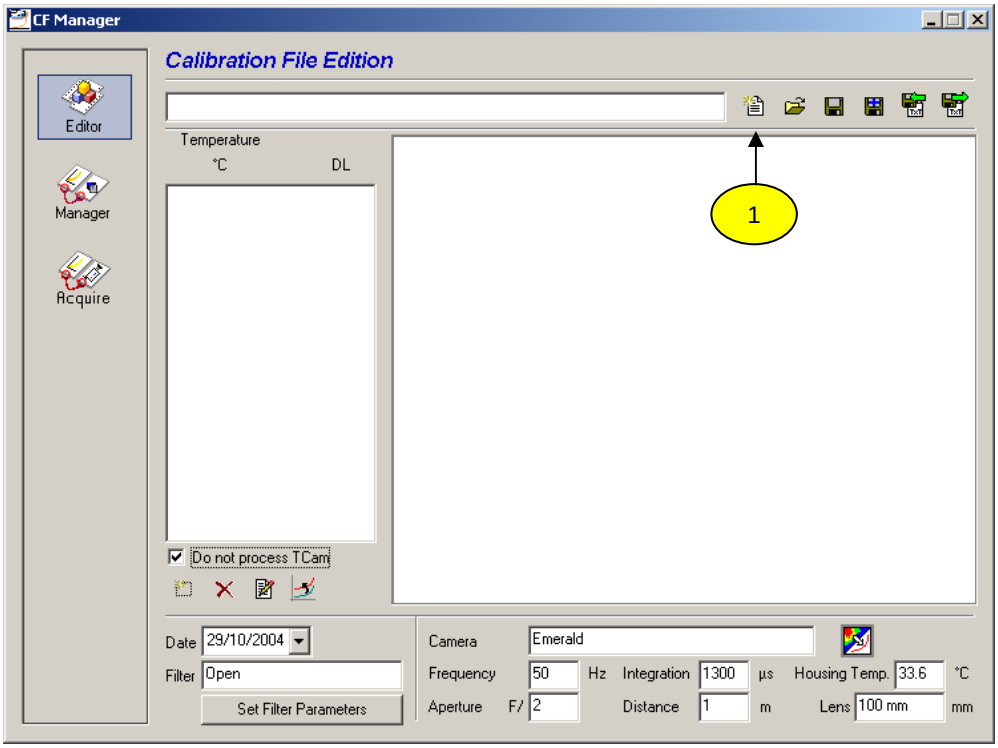
This utility creates the calibration file (*.exp) for interpretation by Altair which can therefore display temperatures directly by applying the transfer function to the digital level measurements.

Note

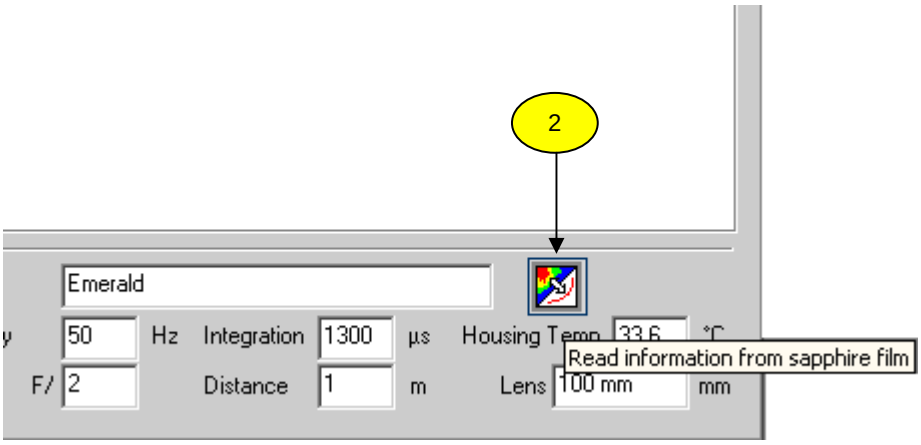
The software linearly interpolates the values between two points and extrapolates the values outside the extreme points.

From "Calibration File Manager":

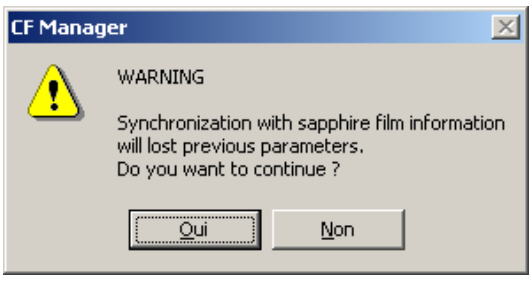
12. Create a new working file (1)



13. Click on the button (2) to load the film from Altair.

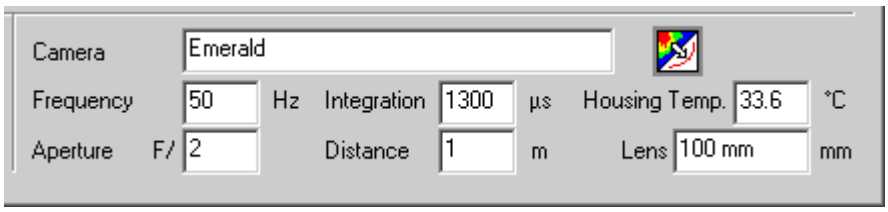


The following window is displayed:



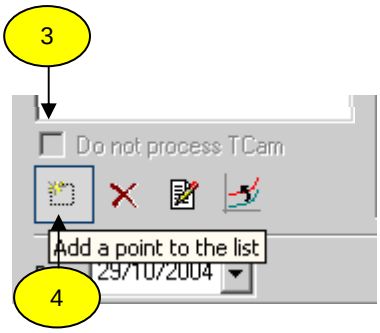
14. Click on "Yes", then select the file (film from Altair) to open.

Note

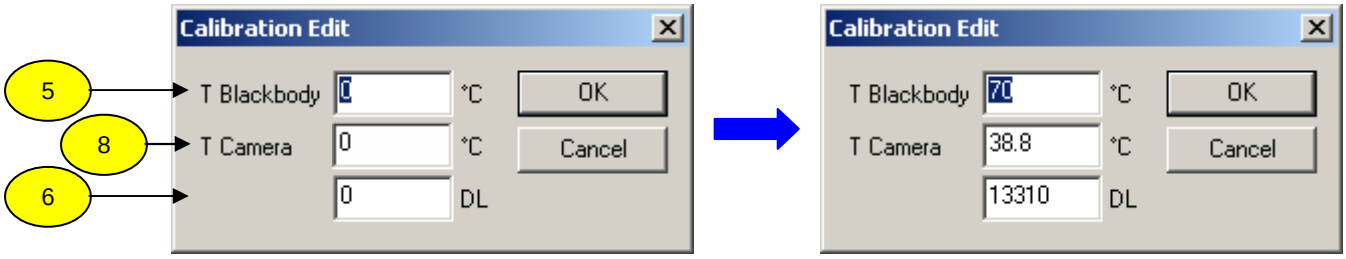


With the film, "Calibration File Manager" loads the camera parameters that were used to generate the film and displays them at the bottom of the screen.

15. Untick the "Do not process TCam" box (3) (the camera's internal temperature will now be taken into account), then click on the "Add a point to the list" button (4) for every measurement point.



16. For every measurement point, enter successively:
    - The Black Body temperature (5),
    - The camera temperature (8),
    - The digital level returned by the camera (6).



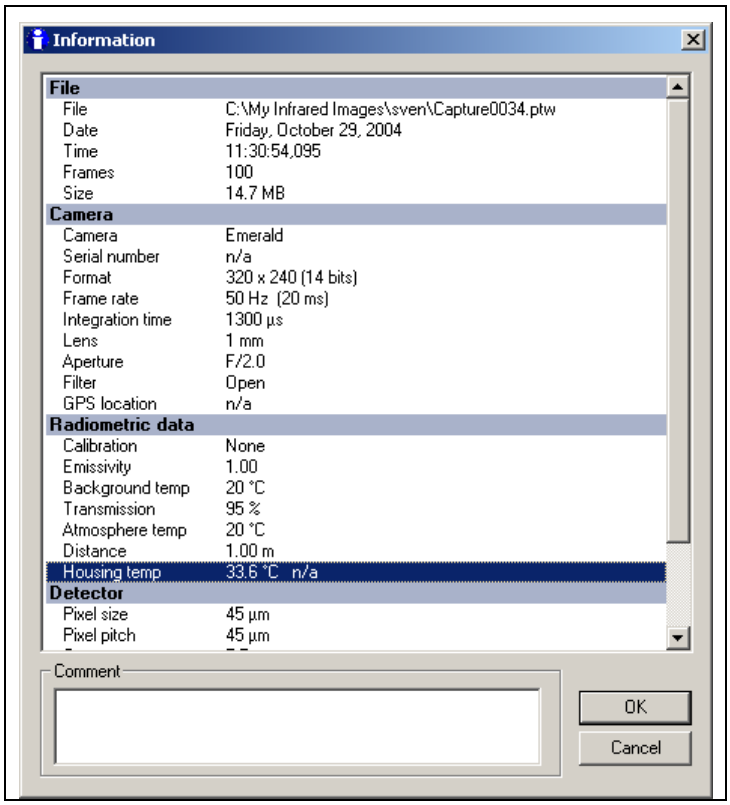
Reminder

The value to enter is the useful area average (see point 10 above).

Remarks

If you have already performed a simple calibration, you can reuse the corresponding file and complete the data entries with the camera temperature. This is recorded on the film.

To find it, bring up the "General Information" menu (or click on the button or press Ctrl + i) in Altair. The camera's internal temperature at the time of the measurement is shown on the "Housing temp" line.



The curve is built as the data is entered. It is always increasing. Any "break" in the curve indicates a data entry error.

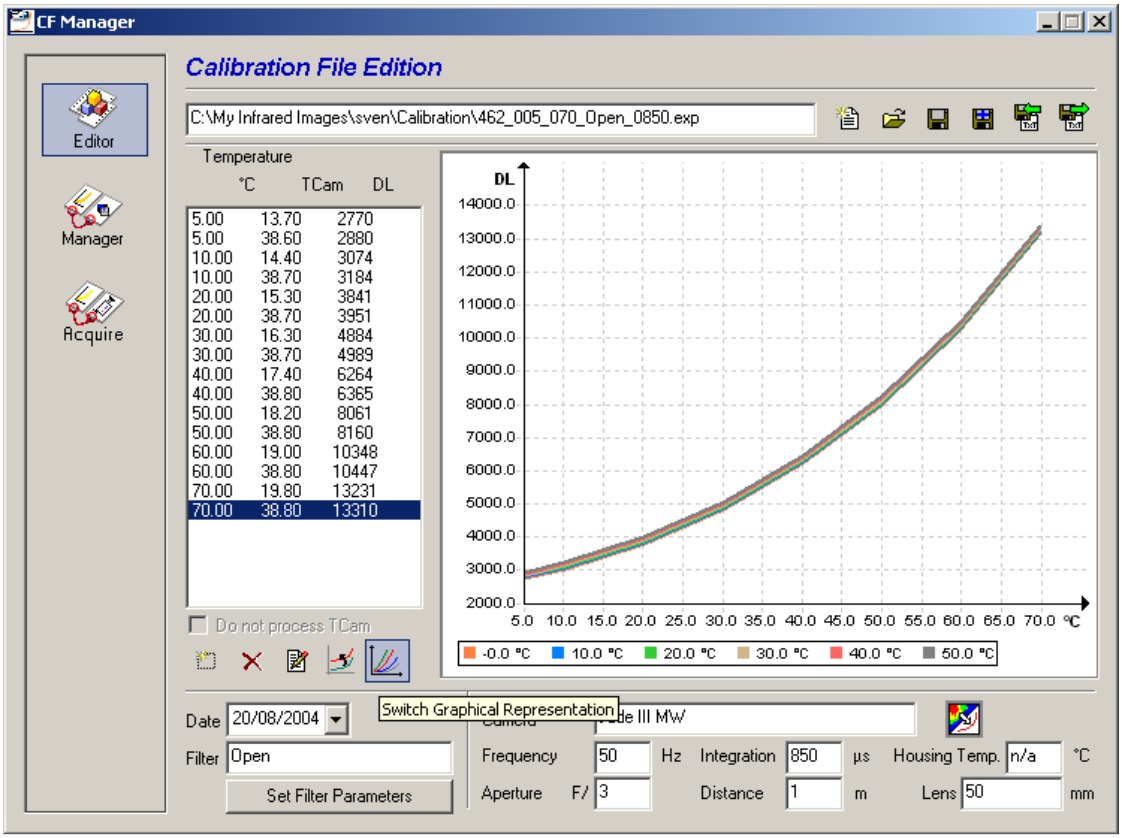
5.2.2. Second Set of Measurements

Change the camera's internal temperature (e.g. by placing it in a climate chamber) and repeat the measurements described starting from point 7 up to point 16.

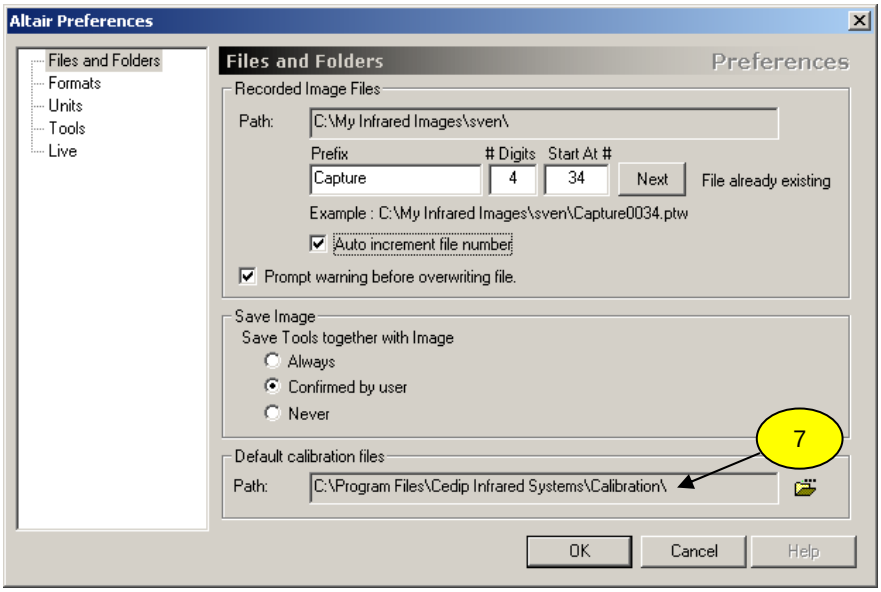
Warning

The Black Body temperature reference points must be strictly identical to the ones used for the first curve.

A range of correspondence curves is then available showing Digital Level/Black Body Temperature.



17. Once all the points have been entered, record the calibration file (button). The file's storage location must be the one defined in Altair (7) so that it can be taken into account for future measurements.



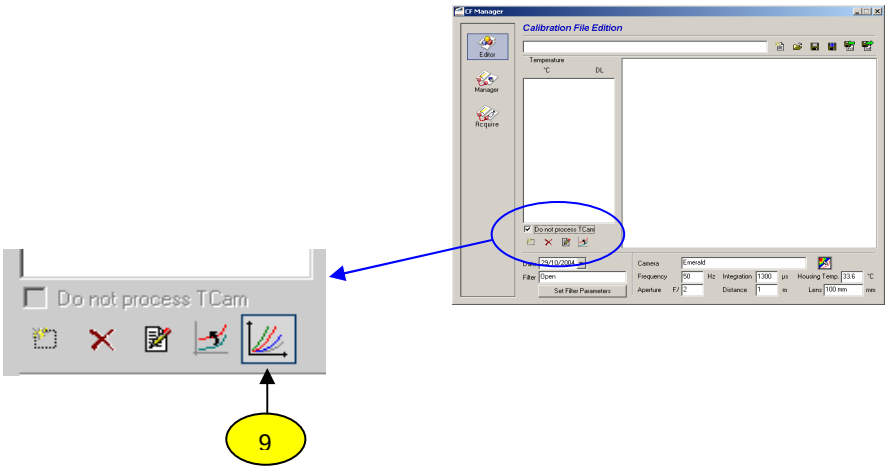
Tip

Prefer calibration filenames that include the parameters used (range, filter, IT). Example: 005_070_Open_0850.exp.

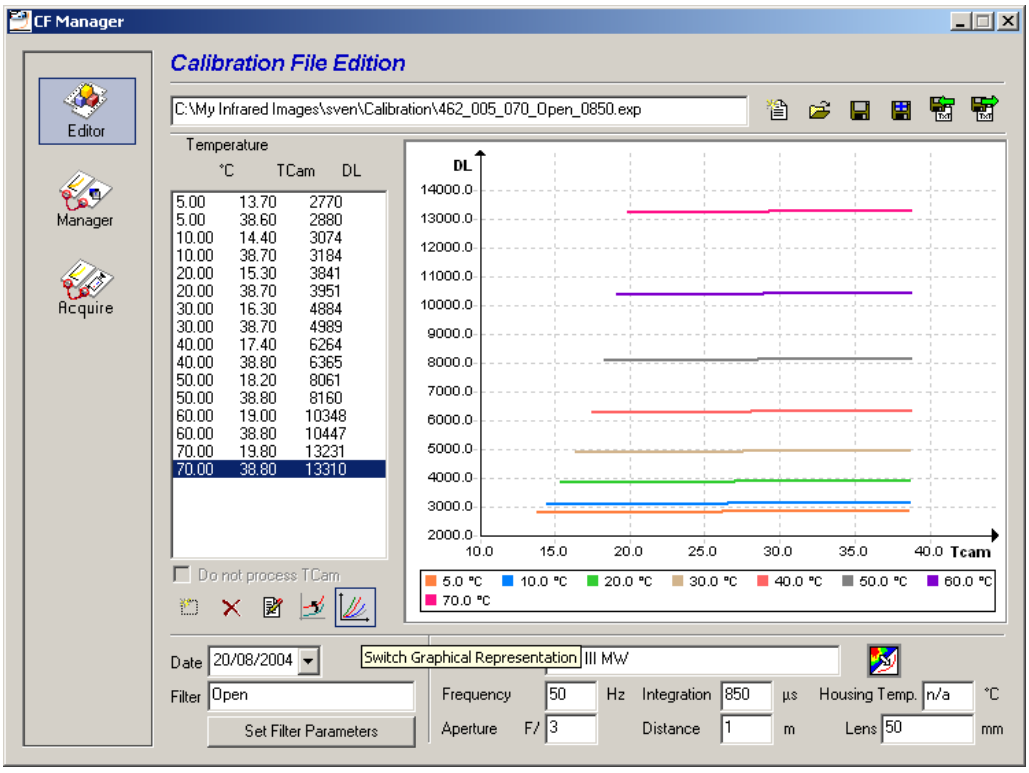
A series of measurements (digital levels) is stored in relation to two evolving parameters (reference temperature and the camera temperature). Two representations are possible:

- The digital level returned depending on the Black Body temperature (one curve per camera temperature) - refer to the screen capture on the previous page.
- The digital level returned depending on the camera's internal temperature (one curve per Black Body temperature value).

Use the button (9) to toggle between the two representation modes.



The following screen shows the digital level curves depending on camera temperature. Each curve corresponds to a Black Body temperature.



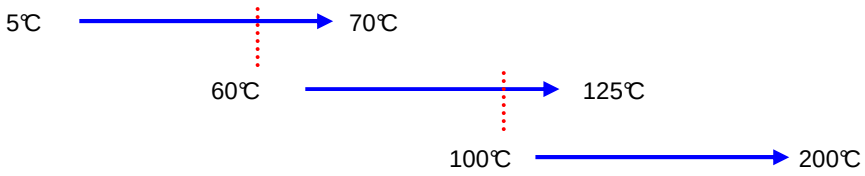
Tip

We recommend performing the entire calibration process as quickly as possible, in line with the constraints placed on your equipment, so as to limit the influence of uncontrollable environmental parameters (like the relative humidity of the air).

Remark

The camera's temperature changes during the measurement process. This is normal. This variation is taken into account to establish the calibration curve.

In the case of multi-IT usage, provision should be made for calibration overlap. For example:



The aim is to check curve consistency.

Warning

Non-linear responses are obtained when working in the SWIR band. More than two different camera temperatures should be used to achieve correct calibration.