

The heat is on

Within the technical data of industrial cameras you will find the range of permissible ambient temperature. Ambient temperature is the temperature of the air around the device at a given distance. Typically the lower limit is set to zero degrees Celsius simply by the fact that we should avoid condensation both inside the camera and on the housing, as it is usually not protected against water ingress. The upper temperature limit is commonly a worst case limit with a margin to be on the safe side. There are further issues to consider – more in this white paper.

Manufacturers of industrial cameras indicate the tolerable operating are as follows.

Permissible ambient temperature:	
- Operation	0 to 45 °C / 30 to 80 %RH
- Storage	-20 to 60 °C / 20 to 90 %RH

Normally a simple check with a thermometer in the same room is sufficient to ensure compliance with this specification. However, as we near the extremes of the range we must adopt a more considered approach. While the permissible range will apply to a family of cameras there will be differences, for example in power consumption and housing design, even within that family.

Even more influential can be the mounting of the cameras. The heat that is generated within the camera must pass internally to the housing and then into the surrounding environment. Good heat dissipation can be achieved by mounting a relatively large contact area of the camera housing directly to a metal structure with high thermal conductance; a good mounting bracket. This will significantly lower the case temperature. Mounting with a smaller contact area or on to a material with poor thermal performance, for example a rubber gasket, will inhibit this heat flow away from the camera. Convection cooling by air flow (or even forced air flow by a fan) is another effective way to lower the **housing temperature**. And it is the housing temperature which indicates how hot it is inside the camera.

Usually we have two critical temperature limits:

- The image sensor and
- the FPGA/memory or glue logic

At component level the industrial image sensors themselves have permissible temperature limits during operation. For example, Sony CMOS sensors are limited to **75 degrees** ambient temperature while some automotive and military image sensors may have higher limits. Industrial grade FPGA/memory and glue logic is limited to **85 degrees** Celsius.

MATRIX VISION offers ET (Extended Temperature) graded cameras which are individually tested to operate flawlessly between two higher individually given limits. Details can be found under this link: <https://www.matrix-vision.com/cougar-x-advanced-features-details/extended-temperature-et.html>

While this option may be appropriate for users requiring this extra performance guarantee, the additional time and expense incurred means that a premium is charged over the normal camera price.

Is there an alternative to special image sensors or special production and QC steps during manufacture?

Yes, of course. Here is what to do if you plan to operate your standard camera out at the extremes of the ambient range. Many MATRIX VISION cameras are equipped with two built-in thermometers. One is mounted next to the image sensor on the sensor board. The other is mounted next to the FPGA on the mainboard. Because of their placement we can assume that we are measuring the immediate ambient temperature around these devices. As we said earlier the limits set down in the camera specification are both general (covering a range of differing cameras within a family) and conservative, allowing plenty of room for fluctuations both unexpected and predictable (day/night, summer/winter, etc.). Users who want to individually test the acceptable temperature limits in their specific installation need only check the status of the built-in temperature monitors already inside the camera.

As long as they remain below the maximum limits of the critical components, it is safe to operate the camera no matter what the local ambient temperature is doing. These component temperature values can be read out via GigE Vision property.

GenICam		Features extra
Device Control		
Device Temperature Selector	Mainboard	
Device Temperature	57.500	

The above reading (of an mvBlueFOX3-1100C) shows that this camera sitting on an office desk without any mounting in a room with 23 degrees Celsius ambient has an internal temperature of 57.5 C (also check the sensor board reading and use whichever value is more critical). That means that there is scope to raise the ambient by another 27.5 degrees before our internal limit is reached, no doubt even more with some sort of metal mounting bracket. Notice that even 27 C above the current ambient of 23 C is already allowing the user to exceed the family specification of 45 C ambient. The camera consumes ~2.5 W so the thermal resistance of a housed camera can be calculated to $R_{Th} \sim 10 \text{ K/W}$.

On the lower limit it is possible to operate the camera below zero (down to -20 degree Celsius) as long as moisture is kept away from condensing on or in the camera. Between housing temperature at

the front flange (see the red reading spot in the photo) and image sensor reading there is a ~10 degree difference, as shown for an mvBlueFOX3-2124G here:

GenICam		Features extracted from
[-] Device Control		
[-] Device Temperature Selector		Sensor
Device Temperature		53.750
[+] Device Clock Selector		Sensor
Device Firmware Version		2.13.460.0
mv Device Firmware Build Date		Sep 21 2016 17:31:28



Simply placing the same camera on a heat sink, as shown, can lower the thermal resistance, by conduction and convection, considerably. Here the temperature is measured again at the same spot (used Hold function of unit):

GenICam		Features extracted from
[-] Device Control		
[-] Device Temperature Selector		Sensor
Device Temperature		46.000
[-] Device Clock Selector		Sensor



Conclusion

The most important temperature measurement for the housed camera is the internal temperature around the image sensor itself and the key components of the processing and memory circuitry. While the permissible ambient temperature range offered in the camera family's data sheets is useful it does offer a conservative estimate of the individual camera's potential suitability in a particular application and installation. By making use of the temperature sensors inside the MATRIX VISION camera it is possible to extend the permissible temperature limits without compromising image quality of camera reliability.

During our tests the upper allowable limits correspond well to 65 degrees Celsius housing temperature which can be used thus as a general alternative to ambient temperature rating.

For board level cameras things become more delicate. We refer to the details in the handbooks of the respective board level models: for example, mvBlueFOX3-M: https://www.matrix-vision.com/manuals/mvBlueFOX3/mvBC_page_important_information.html#mvBC_section_important_operating

Author: Horst A. Mattfeldt, Senior Consultant MATRIX VISION

<https://www.matrix-vision.com>