WHITE PAPER

Thermometric cameras

For dependable temperature monitoring

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AXIS COMMUNICATIONS

Summary

Axis thermometric cameras based on thermal imaging are used for remote temperature monitoring of a specific area. They can be used in a wide range of applications, wherever there is a need for monitoring critical assets regardless of weather and light conditions. The special capabilities of these cameras include temperature alarms, multiple polygonal detection areas, isothermal images, and spot temperature reading. Temperature alarms are used to trigger notifications, whereas isothermal images and spot temperature readings are used as visual aids for operators.

Axis thermometric cameras are very versatile and can be complemented by Axis optical cameras. This is, however, not a requisite. Axis thermometric cameras can be used in any generic surveillance system.

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1 Introduction

Axis thermometric cameras make it possible to monitor objects or processes to detect if the temperature rises above or falls below the set limits. This is done in order to prevent damage, failure, fire, or other hazardous situations.

Unlike ordinary temperature sensors that only measure at one specific point, Axis thermometric cameras can be used for remotely monitoring temperature and providing visual conformation of events at the monitored scene.

2 Thermal imaging

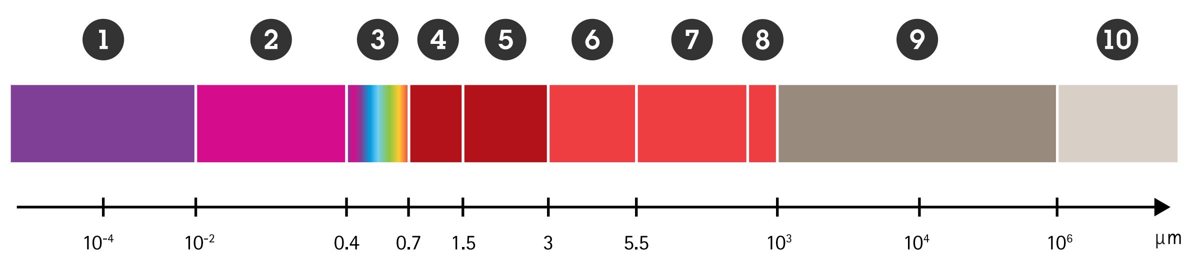
Thermal imaging is becoming increasingly more available as new sensors, new materials, and improved calibration make thermal cameras more affordable, reliable, and versatile. Thermal cameras can be found in sectors such as aviation, shipping, security and surveillance, industrial processes, and in public services such as firefighting and law enforcement.

See *www.axis.com/solutions/thermal-imaging* for more information on thermal imaging.

2.1 Thermal radiation wavelengths

Traditional images are produced when visible light is reflected by different objects. The wavelength range of visible light is approximately 0.38–0.78 µm. Thermal cameras, on the other hand, are designed to detect radiation at greater wavelengths, called thermal or infrared radiation (heat), which are not visible to the human eye. A different type of sensor technology allows the camera to visualize the thermal image in the visual spectrum.

The infrared spectral region is divided into several subregions, as detailed in the illustration below. Axis thermal cameras work in what is usually called the long-wavelength IR region (no. 7 in the illustration).



The subregions of the electromagnetic spectrum illustrated here are:

1 *X-rays*
2 *Ultraviolet light*
3 *Visible light*
4 *Near-infrared (NIR) radiation at approximately 0.75–1.4 µm*
5 *Short-wavelength infrared (SWIR) radiation at 1.4–3 µm*
6 *Mid-wavelength infrared (MWIR) radiation at 3–5 µm*
7 *Long-wavelength infrared (LWIR) radiation at 8–14 µm — used by Axis thermal cameras*
8 *Far-infrared (FIR) radiation at approximately 15–1,000 µm*
9 *Microwave radiation*
10 *Radio/TV wavelengths*

Note that Axis IR illuminators work in the NIR region (no. 4), but these are used for providing optical cameras with light. Illuminators are not needed with Axis thermal cameras because they can operate in complete darkness.

2.2 Thermometry

Any object with a temperature above absolute zero (0 Kelvin or -273 °C or -459 °F) will emit infrared radiation. Even ice emits infrared radiation as long as its temperature is above -273 °C. The hotter an object is, the more thermal radiation it emits. The greater the temperature difference between an object and its surroundings, the clearer the thermal images will be. However, the contrast of a thermal image depends not only on the temperature, but also on the emissivity of the object.

2.3 Emissivity and reflection

The emissivity (e) of a material is a measure of its ability to absorb and emit radiant thermal energy. Emissivity is highly dependent on the material's properties, such as thermal conductivity, which is a measure of how well a material conducts heat. All radiation absorbed by a surface must eventually be emitted from that surface.

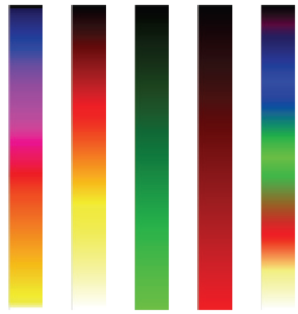
All materials have an emissivity between 0 and 1. A so-called *blackbody* absorbs all incident (incoming) radiation and has an e=1, whereas a more reflective material has a lower e-value. Most materials, such as wood, concrete, stone, human skin, and vegetation, have high emissivity (0.9 or higher) in the LWIR region of the electromagnetic spectrum. Most metals on the other hand, have a low emissivity (0.6 or lower) dependent on their surface finish – the shinier the surface is, the lower the emissivity will be.

Thermal radiation that is not absorbed by a material will be reflected. The higher the reflected energy, the higher the risk of misinterpreted measurement results. To avoid erroneous readings, it is important to select the measurement angle of the camera so that reflections are minimized. In general, if a material behaves like a mirror in the visual spectrum, it behaves like a mirror in the LWIR region as well. Such materials may be difficult to monitor as the temperature reading may be influenced by other objects reflected by the monitored object.

Axis thermometric cameras generally work best with objects with a high emissivity (above 0.9), but objects with a lower emissivity (above 0.5) may be considered if the measurement setup is carefully chosen.

2.4 Color palettes

Axis thermometric cameras measure radiant energy and convert this measurement into temperature readings. In this way, light measurements give corresponding temperature readings and every sensor pixel acts as a tiny thermometer reading the emitted temperature. Axis thermometric cameras use a range of default color palettes.



Examples of color palettes in Axis thermometric cameras.

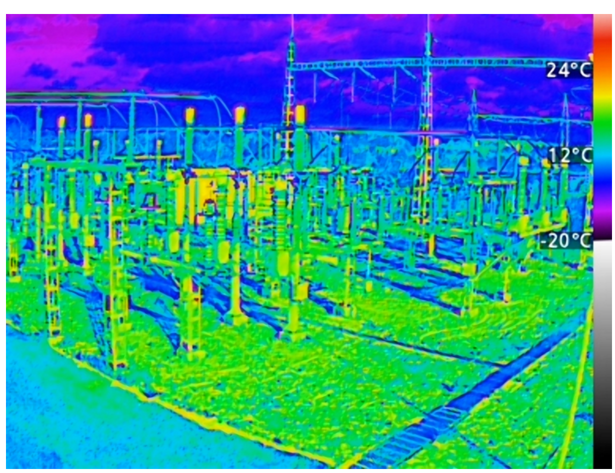
The intense colors are digitally created pseudocolors, which means that they are not the true colors of the scene. Thermal images are generally produced in black and white, but as the human eye is better at distinguishing between different shades of color than shades of grey, color palettes are used to emphasize the temperature differences. The upper ranges of the palettes represent the highest temperatures measured in the scenes.

3 Axis thermometric cameras

Both Axis thermal cameras and Axis thermometric cameras are based on thermal imaging and use the same sensor technology. Axis thermal cameras are mainly used for surveillance purposes. Axis thermometric cameras are used for temperature monitoring with the possibility to set temperature alarms but can also be used for detection.

Image from an Axis optical camera.

The same scene as seen by an Axis thermal camera using a B/W palette.



A similar scene as seen by an Axis thermometric camera using a rainbow isothermal palette. The camera detects and measures infrared radiation and converts the result to temperature readings. The different temperatures are also visualized using a color palette.

3.1 Camera characteristics

With a selection of different lenses, the detection performance of a thermometric camera can be optimized to meet most application requirements. A lens with a shorter focal length can be used for a wider field of view, whereas a lens with a longer focal length can be used to monitor an object at a greater distance.

3.2 Accuracy

The measurement accuracy of a thermometric camera depends on the conditions. To get maximum performance, factors such as the material of the object and the distance to the camera must be carefully considered, as well as the angles and surroundings of the camera. As mentioned in the section on emissivity, reflections and material properties may influence readings. How well the emissivity is known is crucial to the accuracy of the measurement. In general, a lower emissivity will give a lower degree of accuracy. Accuracy may also be reduced by poor weather conditions, such as fog, snow, and rain.

3.3 Temperature and alarms

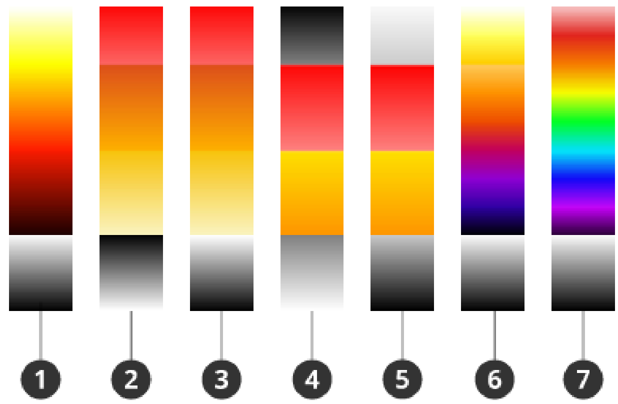
Axis thermometric cameras feature several unique capabilities. The main feature is the possibility to set temperature alarms, of which there are two kinds. You can configure whether actions should be triggered based on the highest, lowest, or the average temperature in a detection area. If the temperature passes a set limit, the alarm is triggered. You can also set how fast a temperature may change, so that notifications will be triggered if the temperature increases or decreases too quickly.

You can choose to show the detection areas and their temperatures in the video stream.

A thermometric camera will trigger alarms when the temperature within the detection areas passes user-defined limits. The use case here is a recycling facility where the detection areas (bounded by green lines) are concentrated to large piles of waste material due to their fire risk.

3.4 Isothermal palettes

Isothermal imaging makes it possible to configure highlighted temperature spans in the image, making it easier to interpret what is happening in the scene. Axis thermometric cameras make this possible through isothermal palettes. The palettes are fixed, but you can adjust the temperatures for the different color ranges, so that a critical temperature will stand out.



Isothermal palettes in Axis thermometric cameras:

1. *Iso-Axis-WH*
2. *Iso-Fire-BH*
3. *Iso-Fire-WH*
4. *Iso-MidRange-BH*
5. *Iso-MidRange-WH*
6. *Iso-Planck-WH*
7. *Iso-Rainbow-BH*

With isothermal palettes you set limits to isolate specific colors to specific temperature levels. The *low level* indicates the temperature at which the colored part of the palette starts. *Mid level* and *high level* indicate the temperatures at which these temperature ranges start.

The limits that indicate the lowest temperature in each temperature range of an isothermal palette:

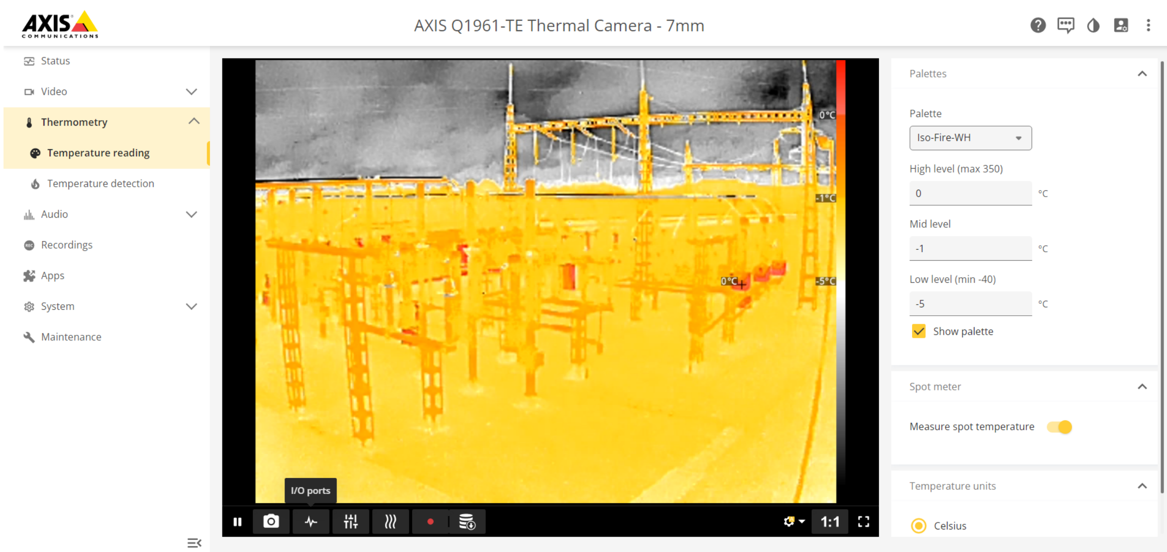
1. *High level*
2. *Mid level*
3. *Low level*

Isothermal palettes are used only to highlight specific temperatures as a visual aid for an operator. If, for example, the *low level* limit is set at a temperature that is critical for a certain object, all temperatures above that point will stand out. In the event of a temperature alarm, the operator will rapidly be able to see whether the alarm is false, since the isothermal image will show whether it was the critical object or something else that triggered the alarm.

3.5 Spot temperature reading

Another capability is the *spot temperature*. This means that you can click anywhere in the image to get a temperature reading of that specific spot.

As with isothermal palettes, the spot temperature is used only as a visual aid for an operator.



Screenshot from AXIS Q1961-TE Thermal Camera. The user has clicked to see the temperature of a specific spot.

3.6 Metadata

In Axis thermometric cameras, the thermometric data is added to the camera's event stream. This makes the data easy to extract and use in other applications. The data includes alarm information, temperatures (maximum, minimum, and average) in the detection areas, and coordinates for the maximum and minimum temperatures.

4 Application areas

Axis thermometric cameras can be used in a wide range of applications where there is a need for temperature monitoring, for example:

- power generating facilities such as gas and water turbines, as well as connected switchgear
- other critical electrical equipment, such as transformers and sub-stations
- fire hazard areas, such as coal piles, recycling facilities, storage sites, and silos
- industrial processes, in order to avoid overheating in equipment.

Thermal imaging can tackle a number of issues by, for example, predicting failures, locating problem areas, and checking the condition of insulation. Thermal imaging is well-suited for predicting failures since it can indicate problem areas before the issue becomes visible or before machinery stops working. Predictions may include overheated parts before they break down or start burning, blocked pipes before they burst, or poorly fastened joints that may be coming loose.

There are several other application areas for thermal imaging. In tank level detection, the temperature difference between the tank itself and its contents makes the tank level visible. Thermal imaging can also be used to improve energy efficiency, for example by detecting heat loss from pipes with gaps in the insulation, thus saving energy and cutting costs.

Power plants, electrical sub-stations, and waste management sites are some of the application areas for Axis thermometric cameras.

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About Axis Communications

Axis enables a smarter and safer world by creating solutions for improving security and business performance. As a network technology company and industry leader, Axis offers solutions in video surveillance, access control, intercom, and audio systems. They are enhanced by intelligent analytics applications and supported by high-quality training.

Axis has around 4,000 dedicated employees in over 50 countries and collaborates with technology and system integration partners worldwide to deliver customer solutions. Axis was founded in 1984, and the headquarters are in Lund, Sweden