Remote temperature monitoring
Thermal imaging with unique capabilities

AXIS
COMMUNICATIONS

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1. Introduction

Axis temperature alarm cameras make it possible to monitor the temperature of an object or an industrial process so that it does not rise above or fall below a certain temperature limit, in order to prevent damage, failure, fire or other hazards.

Unlike ordinary temperature sensors that only measure at one specific point, Axis temperature alarm cameras can be used for remotely monitored surveillance, giving visually 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 such diverse industries as the aircraft and shipping industry, within security and surveillance, and also in public services such as firefighting and law enforcement.

See Section 5, Useful links, 'Some like it hot – Thermal cameras in surveillance', for more information on thermal imaging.

2.1 Thermal radiation wavelengths

Traditional images are produced when visible light is reflected off 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 with greater wavelengths, that is called thermal or infrared radiation. This kind of radiation is not visible to the human eye, however 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. Infrared radiation light with wavelengths of approximately 0.75–1.4 μm, which is just beyond visible light, is called near-infrared light (NIR). Short-wavelength infrared (SWIR) radiation has a wavelength of 1.4–3 μm, and mid-wavelength infrared (MWIR) radiation 3–5 μm. The longest wavelength subregions are long-wavelength infrared (LWIR) radiation with 8–14 μm and far-infrared (FIR) radiation with a wavelength of 15–1,000 μm. Axis thermal cameras work in what is normally denoted as the LWIR region, whereas Axis IR illuminators work in the NIR region. Axis IR illuminators are used for visual cameras, and not together with Axis thermal cameras.
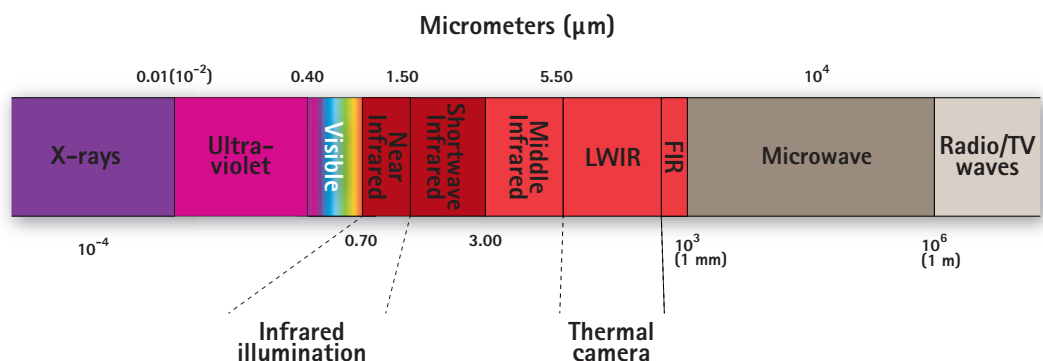

Figure 1: Different wavelength regions in micrometers (μm).

2.2 Radiometry

All objects with a temperature above absolute zero, that is 0 Kelvin (0 K or 273 °C or 459 °F), emit infrared radiation. Even cold objects, such as ice, emit infrared radiation as long as their temperature is above –273 °C. The hotter an object is, the more thermal radiation it will emit. 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 does not only depend 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. The emissivity is highly dependent on material 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 'black body' absorbs all incident radiation and has an e=1, whereas a more reflective material has a lower e. Most materials, such as wood, concrete, stone, human skin and vegetation, have high emissivities (0.9 or higher) in the LWIR region. 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 is, the higher the risk of misinterpreted measurement results will be. To avoid erroneous readings it is important to select the measurement angle of the camera so that reflections are minimized. Generally, if a material behaves like a mirror in the visual spectrum, it generally behaves like a mirror in the LWIR region as well. Such a material may be difficult to monitor as the temperature reading may be influenced by other objects reflected in the monitored object.

In general, Axis temperature alarm cameras 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 temperature alarm cameras measure radiant energy and convert this energy measurement to temperature readings. This way light measurements give corresponding temperature readings and every sensor pixel works as a small thermometer reading the emitted temperature. Axis temperature alarm cameras use a range of default color palettes, see Figure 2.
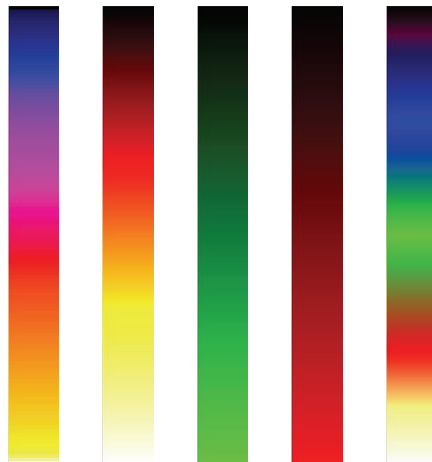

Figure 2: Examples of color palettes in Axis temperature alarm cameras.

The intense colors are so called pseudo-colors, which means that they are not real-life colors but created digitally. Thermal images are generally produced in black and white and then color palettes are used to emphasize temperature differences. The human eye is better at distinguishing between different shades of color than between grey scale colors. Thus with the color palettes, temperature differences are made clearer. The topmost point of the palettes in Figure 2 represents the highest temperatures in the scenes.

3.   Axis temperature alarm cameras

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

Figure 3: To the left an image from an Axis network camera, in the middle an image from an Axis thermal camera, and to the right an image from an Axis temperature alarm camera.

3.1   Camera characteristics

With a selection of different lenses, the detection performance of a temperature alarm camer
a 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 temperature alarm camera depends on the situation at hand. To get maximum performance from such a camera, the measurement conditions must be closely considered. Factors such as the material of the object and its distance to the camera must be observed, as well as the angles and surroundings of the camera. As mentioned in Section 1.3, Emissivity and reflection, 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 temperature alarm cameras feature several unique capabilities. The main feature is of course the possibility to set temperature alarms. There are two different kinds of alarms. The user can set up an upper or lower temperature limit. If the temperature goes beyond the set limit, the alarm is triggered. The user can also restrict how fast a temperature may change. If the temperature increases or decreases too rapidly, the temperature alarm is triggered.
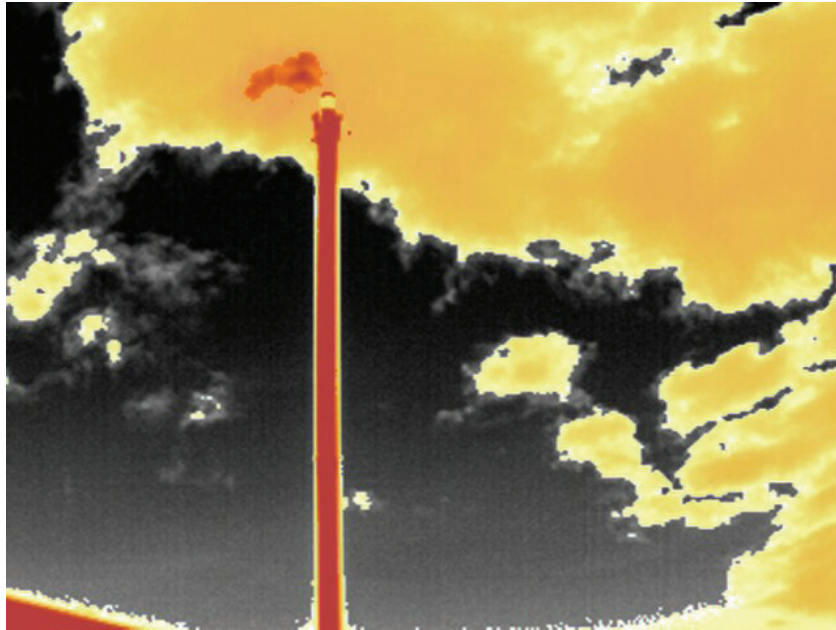
Figure 4: The temperature can be used to control the temperature of the gases expelled.

3.4 Isothermal palettes

Isothermal imaging makes it possible to configure highlighted temperature-spans in the image. This makes it easier to interpret what takes place in the scene. Axis temperature alarm cameras make this possible through isothermal palettes where, unlike traditional color palettes, temperature can be set. The palettes are fixed, but it is possible to adjust the temperatures for the different color ranges, so that a critical temperature will stand out.
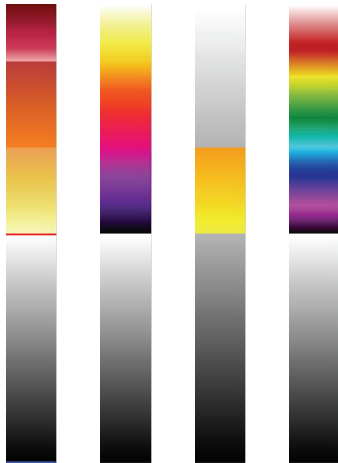

Figure 5. Examples of isothermal palettes in Axis temperature alarm cameras.

The isothermal palettes have limits called Upper, Middle and Lower that define where the different temperature ranges start, see Figure 6. Lower denotes the temperature where the colored part of the palette will start. Middle and Upper denote the start of these temperatures ranges.

Figure 6. The Lower, Middle and Upper limits of an isothermal palette.

Isothermal palettes are used only to highlight specific temperatures as a visual aid for an operator. If, for example, the Lower limit is set at a temperature that is critical for a certain object, all temperatures above it 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.
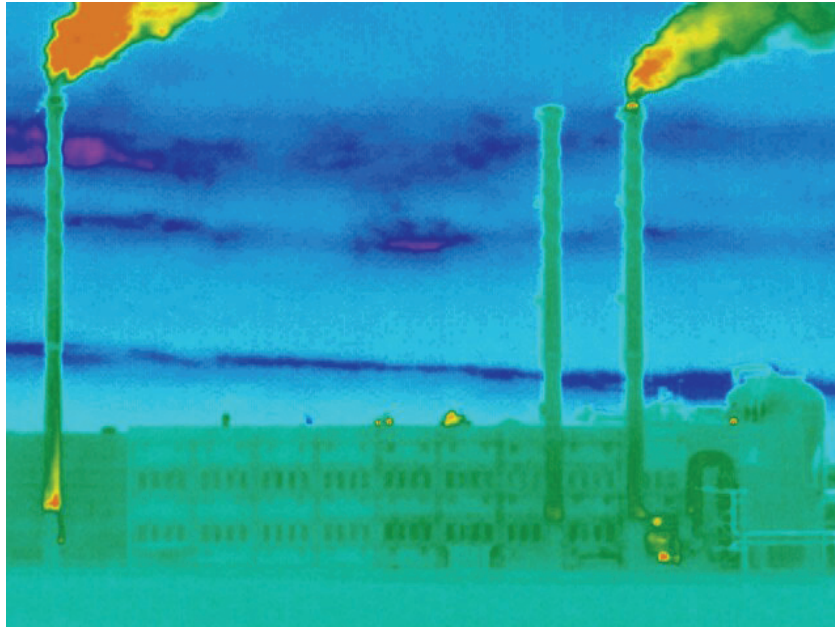

Figure 7. Using the 'Rainbow'-isothermal palette it is possible to highlight the temperature span and easy identify if a surface reaches a defined temperature.

3.5 Spot temperature reading

Another capability is so called 'spot temperature', where the camera measures the temperature of 9 pixels (3×3) anywhere in the image where the user clicks. The user can adjust the emissivity setting depending on the object, to get a more precise reading. As with isothermal palettes, spot temperature is used only as a visual aid for an operator.
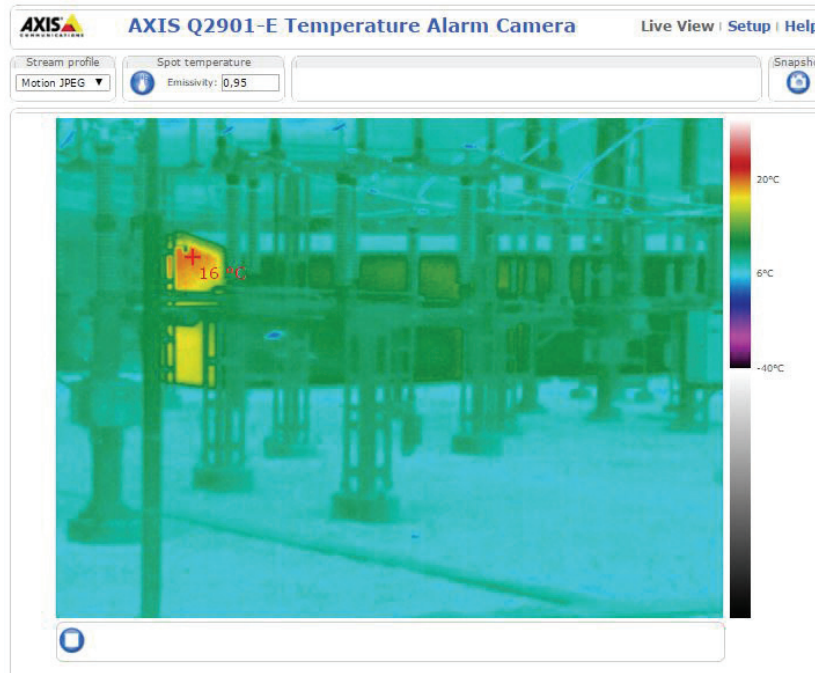

Figure 8: Screenshot from AXIS Q2901-E Temperature Alarm Camera. Clicking on the desired area provides with the Spot temperature reading.

4. Application areas

Axis temperature alarm cameras can be used in a wide range of application areas where there is a need for temperature monitoring, such as:
> power generating facilities, such as switchgears, gas and water turbines
> other critical electrical equipment, such as transformers and electrical sub-stations
> fire hazard areas, such as coal piles, dump sites, storage sites and silos
> industrial processes involving self-igniting materials, such as dust or flour

With thermal imaging a number of issues can be tackled, such as predicting failures, locating problem areas and checking the condition of insulation. Thermal imaging is well suited for predicting failures since it can indicate a number of problem areas before the issue become visible to the eye or before machinery stops working. Predictions may include overheated parts before they break down or start burning, blocked pipes before they burst, or insufficiently fastened connections that may come loose.

Tank level detection, where the temperature difference between the tank itself and its contents makes the tank level visible, and environmental friendly energy efficiency are other application areas for thermal imaging. By detecting temperature leaks from pipes where there are gaps in the insulation, thermal imaging can help companies save energy.

Figure 9: Power plants, electrical sub-stations and fuel tanks are some of the application areas for Axis temperature alarm cameras.

5. Conclusion

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

Axis temperature alarm cameras may be complemented by Axis network cameras, which makes them most versatile. This is, however, not a requisite. Axis temperature alarm cameras can be used in any generic surveillance system.

6. Useful links

For more information, see the following links:

Axis Communications – 'Axis thermal network cameras – Reliable detection – 24 hours a day, seven days a week':
www.axis.com/products/video/camera/thermal/technology.htm

Axis Communications – 'Some like it hot – Thermal cameras in surveillance':
www.axis.com/files/whitepaper/wp_axis_thermal_cameras_en_37661_0912_lo.pdf

Axis Communications – 'Thermal network cameras – Performance considerations for intelligent video':
www.axis.com/files/whitepaper/wp_thermal_cams_en_45266_1111_lo.pdf

Axis Communications – 'Emissivity values for some common materials':
www.axis.com/products/q29_series/

About Axis Communications

Axis offers intelligent security solutions that enable a smarter, safer world. As the global market leader in network video, Axis is driving the industry by continually launching innovative network products based on an open platform - delivering high value to customers through a global partner network. Axis has long-term relationships with partners and provides them with knowledge and ground-breaking network products in existing and new markets.

Axis has more than 1,800 dedicated employees in more than 40 countries around the world, supported by a network of over 70,000 partners across 179 countries. Founded in 1984, Axis is a Sweden-based company listed on NASDAQ Stockholm under the ticker AXIS.

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