WHITE PAPER

Remote temperature monitoring

Thermal imaging with unique capabilities

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1 Summary

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 very versatile. This is, however, not a requisite. Axis temperature alarm cameras can be used in any generic surveillance system.

2 Introduction

Axis temperature alarm cameras make it possible to monitor objects or industrial processes, to detect if the temperature rises above or falls below the set limits, 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 visual conformation of events at the monitored scene.

3 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 industries such as aircraft, shipping, security and surveillance, and also in public services such as fire fighting and law enforcement.

Please see www.axis.com for more information on thermal imaging.

3.1 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, 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 sub-regions, as detailed in the illustration below. Axis thermal cameras work in what is usually called the Long–wavelength IR region (nr 7).

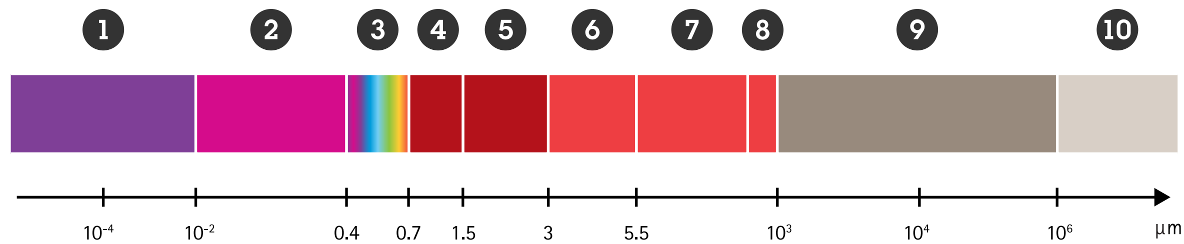

Figure 1. The wavelengths illustrated here are: 1) X-rays, 2) Ultraviolet light, 3) Visible light, 4) Near-infrared radiation (NIR) at approximately 0.75–1.4 µm, 5) Short-wavelength infrared (SWIR) radiation at 1.4–3 µm, 6) Mid-wavelength infrared (MWIR) radiation at 3–5 µm, 7) Long-wavelength infrared (LWIR) radiation at 8–14 µm — this is the region 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 (4), but these are used for visual cameras, and not with Axis thermal cameras.

3.2 Radiometry

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 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.

3.3 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 'black body' 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. 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 generally behaves like a mirror in the LWIR region as well. Such material may be difficult to monitor as the temperature reading may be influenced by other objects reflected by the monitored object.

Axis temperature alarm 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.

3.4 Color palettes

Axis temperature alarm 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 temperature alarm cameras use a range of default color palettes, see the figure below.

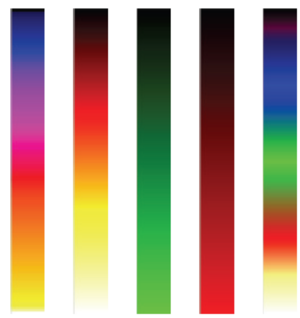

Figure 2. Examples of color palettes in Axis temperature alarm cameras.

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, 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 in the figure represent the highest temperatures measured in the scenes.

4 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 mainly used for detection purposes. 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. An image from a regular Axis network camera.

Figure 4. The same scene as seen by an Axis thermal camera.

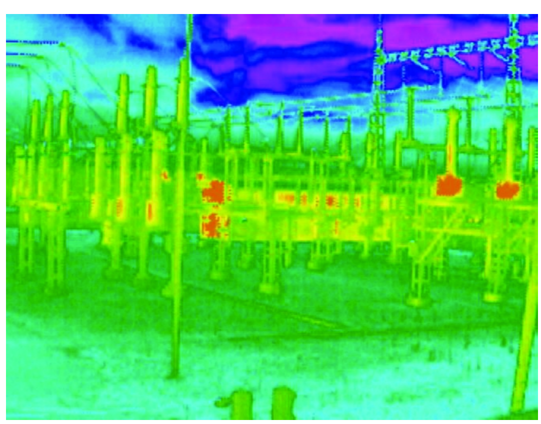

Figure 5. The same scene as seen by an Axis temperature alarm camera.

4.1 Camera characteristics

With a selection of different lenses, the detection performance of a temperature alarm 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.

4.2 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 considered carefully. Factors such as the material of the object and the distance to the camera must be observed, 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.

4.3 Temperature and alarms

Axis temperature alarm cameras feature several unique capabilities. The main feature is, of course, the possibility to set temperature alarms, of which there are two different kinds. The user can configure both upper and lower temperature limits. If the temperature passes a set limit, the alarm is triggered. The user can also set how fast a temperature may change, so that alarms will be triggered if the temperature increases or decreases too quickly.

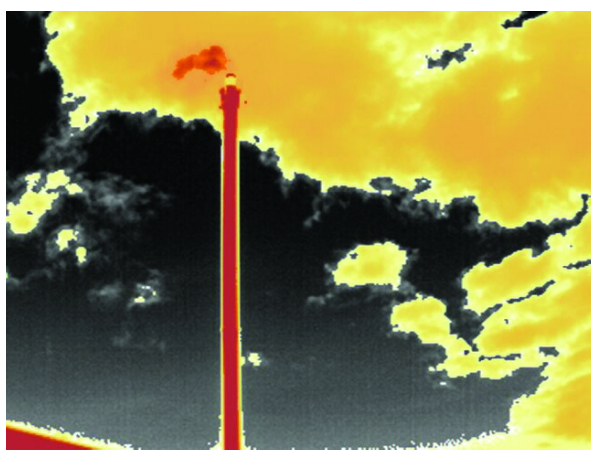

Figure 6. The temperature can be used to check the temperature of the expelled gases.

4.4 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 temperature alarm cameras make this possible through isothermal palettes, which 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.

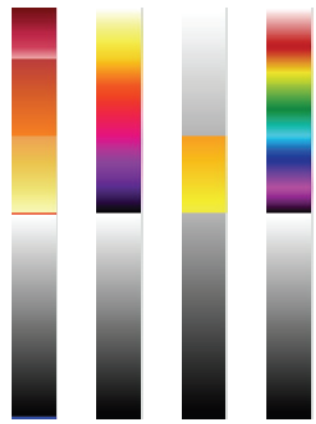

Figure 7. Examples of isothermal palettes in Axis temperature alarm cameras.

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

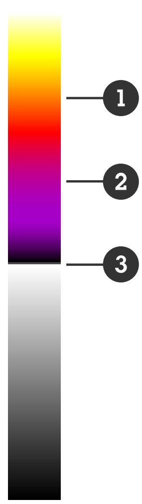

Figure 8. The Upper (1), Middle (2) and Lower (3) limits of an isothermal palette.

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 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.

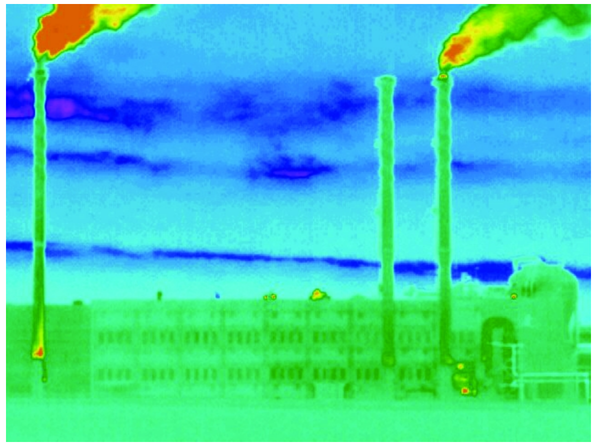

Figure 9. Using the 'Rainbow' isothermal palette it is possible to highlight the temperature span and easily see if a surface reaches a defined temperature.

4.5 Spot temperature reading

Another capability is the 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, the spot temperature is used only as a visual aid for an operator.

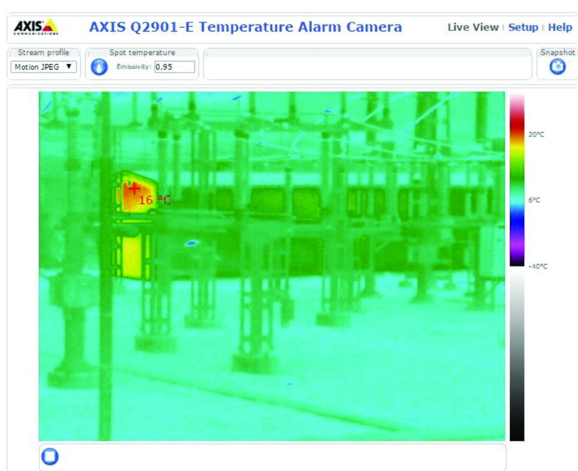

Figure 10. Screenshot from AXIS Q2901-E Temperature Alarm Camera. Clicking on the desired area gives the spot temperature reading.

5 Application areas

Axis temperature alarm 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, dump sites, storage sites and silos
- industrial processes involving self-igniting materials, such as dust or flour

Thermal imaging can tackle a number of issues, 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 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.

Figure 11. Power plants, electrical sub-stations and fuel tanks are some of the application areas for Axis temperature alarm cameras.

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About Axis Communications

Axis enables a smarter and safer world by creating network solutions that provide insights for improving security and new ways of doing business. As the industry leader in network video, Axis offers products and services for video surveillance and analytics, access control, intercom and audio systems. Axis has more than 3,800 dedicated employees in over 50 countries and collaborates with partners worldwide to deliver customer solutions. Axis was founded in 1984 and has its headquarters in Lund, Sweden.

For more information about Axis, please visit our website *axis.com*.