Infrared Gas Imaging. A new industrial solution for live imaging and concentration measurement of gases.

Infrared gas detection is a well-developed measurement technology, used in many applications from pollution monitoring to explosion sensing. Whilst much of the infrared gas detection market is mature there has been for some time considerable demand for an affordable and robust technique that can follow and measure clouds of gas in an open atmosphere.

Figure 1. *Jade UC camera used in IR Gas Imaging system*

This article describes a new Infrared Gas Imaging product based upon the CEDIP Jade UC camera (**Figure 1**), that for the first time delivers the sensitivity, cost, reliability and lack of maintenance required of an industrial solution for live imaging and concentration measurement of gases. On an industrial scale the new product has been demonstrated to image clouds of gas, to follow their absorption and diffusion in the open atmosphere, and to measure their concentration. The applications for this new development are numerous. A major area of interest spurned by civil unrest around the world is in Homeland Security where governmental authorities want to address the potential risk of toxic gases introduced and spread by terrorist activists. Also there is strong demand from the oil and gas industry who are looking for techniques to monitor gases such as Methane or Butane during the production cycle and the risk of pollution arising from their storage.

The development and spread of industrial solutions for Infrared Gas Imaging has to date been limited by the cost and availability of imaging sensors that are sensitive enough in the spectral bands of interest to bring significantly added value compared to already existing technologies. Traditionally scientists have used high performance cooled IR cameras, especially those using MCT sensors in order to be sensitive in the 8-12µm spectral region. The cost of these MCT sensors has strongly limited the introduction of IR gas imaging into industrial applications. In addition the required maintenance and risk of failure of the MCT sensors cooling engine has also been a major limiting factor.

However the relatively recent emergence of reasonably priced, high performance microbolometer IR focal plane array detectors looks set to open the door to the industrial applications of Infrared Gas Imaging.. The industrial implementations of the technique also requires intensive image processing capabilities in order to limit the false alarm rate. False alarms have historically arisen due to object motion within the scene or where measurements are taken in bad weather conditions. The sensitivity achieved by new-generation microbolometer IR FPA detectors is now in the range of 50mK with F/1 lenses, which is better that what achieved with single MCT sensors only five years ago.

Detailed below are installed system results from the world's first commercially available IR gas imaging analyser using microbolometer FPA technology made by Bertin Technology (Aix en Provence, France). This innovative system is the result of more than ten years of research partially funded by defence budgets. The Bertin system uses a network of CEDIP Jade UC cameras equipped with a filter wheel with filters chosen to match the characteristic absorption wavelengths of the gas being surveyed.

The Bertin system has already shown great utility for surveillance of gases in high explosive risk areas, for instance in the vicinity of oil refineries and gas production facilities. The gases to be detected in these applications are typically

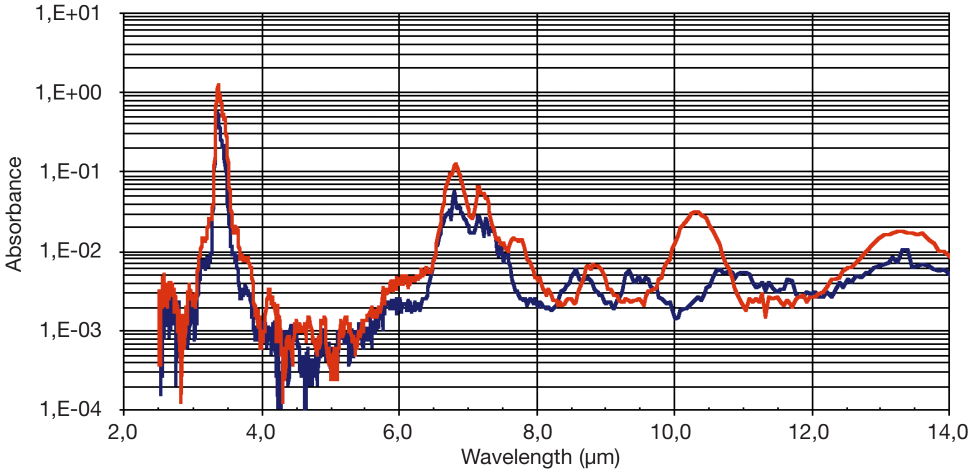

Figure 2. *IR spectra of of Butane (C_4H_{10}) and Propane (C_3H_8).*

butane (C_4H_{10}) and propane (C_3H_8). **Figure 2**, shows the spectral absorption curve for Butane (C_4H_{10}) and Propane (C_3H_8) gases, within the 2.0 to 14.0 micrometers range.

The chosen measurement peak for Butane is the strong absorption near 10.5µm that is positioned within the optimal spectral response of the microbolometer array. Other strong Butane spectral absorptions such as the peak near 7µm was not used as air is not transparent in this region and will by itself introduce strong signal attenuation. The spectral response of Propane is more difficult to detect since, as it can be seen, the gas does not absorb as strongly as Butane but rather offers two suitable smaller peaks centred near 8.5µm and 9.5µm.

Once detection wavelengths have been selected and set-up for the gas or gases to be surveyed, an industrial system must then demonstrate measurement robustness and reliability. To achieve this typically requires the implementation of sophisticated image processing techniques to both minimise the false alarm rate and enhance the signal-to-noise ratio. False alarms arise in Infrared Gas Imaging mainly due to motion of objects within the field of view. These objects are typically pedestrians, vehicles or animals. Dedicated spatial and temporal image filtering procedures have been developed and implemented by Bertin Technology to eliminate all these artefacts. The signal-to-noise enhancement features are based on image averaging techniques.

Figure 3 shows the Bertin system in place when observing a large industrial oil and gas site. The Infrared Gas Imaging system is linked to a computer which performs real time image processing and shows a new image of the gas cloud and its concentration every one second.

Figure 3. *The Bertin system shown observing an oil & gas production site.*

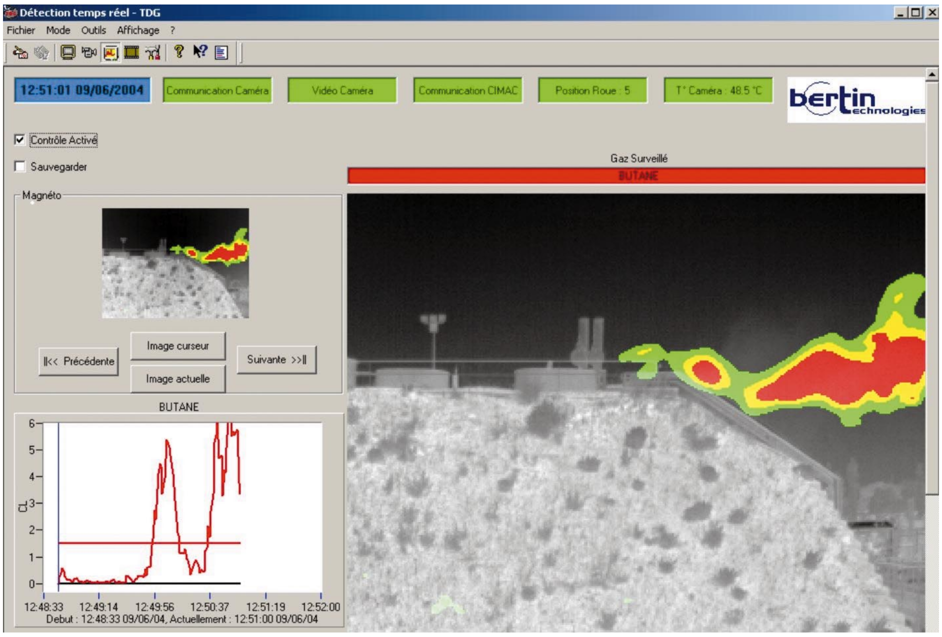

Figure 4. *Screen shot showing analysis of a Methane gas cloud.*

Figure 4 is a screen shot of the main computer screen where the image of the gas is illustrated in colour against the black and white background. The gas concentration in the cloud is also given.

Conclusions

Recent advances in microbolometer based IR focal plane array detector technology have opened the door to the realisation of the potential for Infrared Gas Imaging in a wide range of industrial and security applications.