CHAMPIONX

ChampionX Aerial Optical Gas Imaging Technology Description

In Support of the ChampionX Alternative Test Method for the New Source Performance Standards and Emission Guidelines for Oil and Natural Gas Operations

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Summary of the AOGI Periodic Screening Program

We propose a periodic screening system based on the ChampionX Aerial OGI (AOGI) technology, a periodic methane emissions screening and monitoring platform.

The AOGI periodic screening program utilizes a high-resolution OGI camera and gimbal installed on a helicopter to provide highly resolved images and videos of methane leaks across oil and gas facilities. This high-fidelity information is provided to operators, enabling them to pinpoint and fix leaks across their sites quickly.

The AOGI platform relies on OGI camera technology that has become standard use across the industry for ground and drone survey programs. This technology operates on absorption spectroscopy and thermography principles to finely detail methane plumes from emission sources. This technology was invented by ChampionX Chairman, David Furry, the founder of OGI technology, in the early 2000s, and the method and technology have been continually developed over the past two decades.

The AOGI platform can detect leaks below <1 kg/hr as prescribed in §60.5398b(b) and Tables 1 and 2.[1,2] Under normal circumstances, AOGI can detect methane leaks as low as 0.281 kg/hr with a probability of detection of 94%.

The AOGI platform requires two personnel to gather the data: one pilot and one senior OGI technician, both of whom have received training to ensure the system is deployed concurring with CHX operating procedures. The platform also requires an OGI and HD camera installed into a gimbal control system and a tablet to navigate flight plans, target emission sources, and screen sites.

After the pilot and OGI technician screen a site, data is retrieved from the helicopter and uploaded to the cloud for long-term storage. A trained professional verifies all detections and non-detections in the office. After verification, all videos are distributed to the site's owner/operator with details on where leaks were found.

After receiving the information from ChampionX, an owner/operator utilizing ChampionX AOGI service will initiate their investigation and repair process. ChampionX assists in this process, providing more context and information about the leak, if necessary.

[1] Table 1 to Subpart OOOOb of Part 60, Title 40
[2] Table 2 to Subpart OOOOb of Part 60, Title 40

Measurement (Detection) Technology System

Sensor Scientific Theory

OGI cameras for the detection of methane emissions use a mid-wave infrared camera.[3] A standard MWIR camera is a quantum semiconductor detector, meaning that for each photon that hits the sensor, an electron from the valence band is excited to a higher energy level, the conduction band. This excitement changes the sensor's current, which is then interpolated and processed in the image. However, in this spectral band, electrons at ambient temperature have enough thermal to overcome the bandgap between the valence and conduction bands. To counter this, the OGI camera detector must be cooled to cryogenic temperatures to ensure that any change in current at the detector is from a photon and not latent thermal energy.

The valence and conduction bands span a spectrum of energy levels, resulting in a wide range of energetic photons that can excite the electrons from the valence band to the conduction band. To compensate for this, OGI cameras have a range of filters that selectively filter for wavelengths corresponding to the target gas molecules. All hydrocarbon gas molecules exhibit unique "fingerprints" in their infrared absorption ranges, meaning each type of molecule absorbs infrared radiation at specific wavelengths. This distinct pattern allows for identifying and differentiating various hydrocarbons, such as methane, using infrared detection technologies.

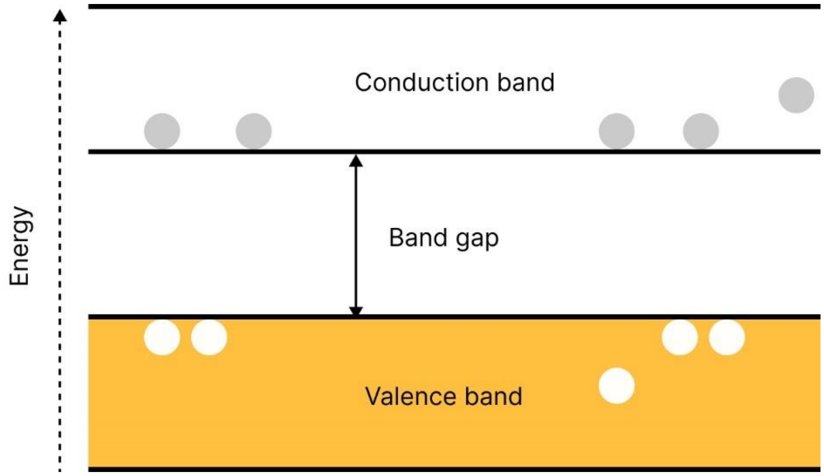

Figure 1. *Diagram depicting the bandgap between the valence and conduction bands. When an electron is excited to the conduction band, it creates a hole in the valence band and an electron in the conduction band, resulting in a measurable current.*

[3] Jane Hodgkinson and Ralph P Tatam 2013 *Meas. Sci. Technol.* **24** 012004

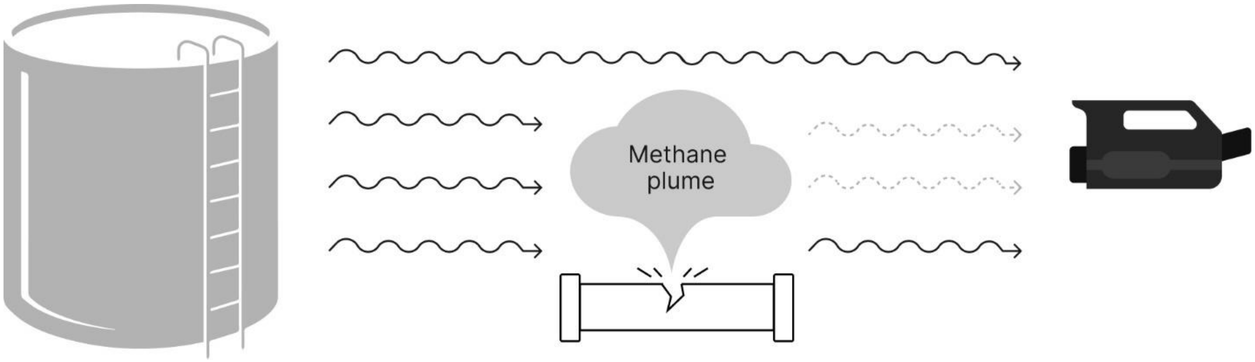

Figure 2. *A diagram describing the high-level principles of OGI thermography. The background gives off infrared radiation, which is then absorbed by the methane plume. The contrast between the light from the background and the light from the methane plume is then visualized in the camera.*

When methane gas is present in the camera's field of view, it absorbs infrared radiation at specific wavelengths that the camera is tuned to detect. This absorption occurs because methane molecules interact with the infrared light, absorbing energy at characteristic "fingerprint" wavelengths unique to methane. As a result, the camera detects a decrease in the intensity of the infrared light at these wavelengths, creating a contrast between the methane plume and the background environment. This contrast allows the camera to visualize the gas as a distinct plume or cloud, making it easily identifiable. The underlying science leverages methane's unique infrared absorption spectra, allowing precise monitoring of methane emissions in various industrial and environmental settings.

OGI cameras can detect very low concentrations of methane. The detection range can be influenced by the distance to the leak, environmental conditions (e.g., temperature, wind), and the temperature contrast between the gas and the background. Advanced OGI cameras like the one used in Aerial OGI can detect methane concentrations as low as a few parts per million, allowing for early detection and mitigation of leaks. Proper calibration and maintenance of the camera also play a critical role in ensuring consistent accuracy and sensitivity in diverse operating conditions.

Description of Physical Instrumentation

OGI Camera and Gimbal

For this application of OGI technology, AOGI attaches the OGI camera to a gimbal on the underside of a helicopter.

Figure 3. *A close shot of the gimbal and OGI camera system installed on a helicopter.*

The gimbal selected for AOGI cameras must have advanced stabilization and 360-degree field of view capabilities. For the ChampionX AOGI, the gimbal can lock onto a target the camera operator sets. The piloting crew monitors these stabilized videos and records them for further verification. The stabilization and targeting system are essential to the operation of the AOGI camera system as it enables the identification and localization of leaks.

Figure 4. *Robinson helicopter (as an example) with an OGI camera and gimbal installed.*

Helicopter

The OGI camera system and gimbal may be installed on various helicopters for this application. Helicopter selection relies on the parameters of the site being inspected. At a minimum, the helicopter must be compliant with safety regulations, capable of carrying two passengers, install the camera system, and be appropriate for the site's prevailing weather and climatic conditions. showing the details of the equipment and how it is installed. For inspections, the aircraft must maintain a stable altitude of at least 100 feet.

Size, power, weight, and type of helicopter may vary based on required flying conditions, such as density altitude requirements.

Figure 5. *The handheld controller for the OGI camera and gimbal system.*

Gimbal Controller

The gimbal controller allows the senior OGI technician to tune the camera settings, adjust the camera orientation, and lock onto emission sources.

In-air Screen

The in-air screen shows the camera's view, including timestamps, camera settings, camera modes, and camera orientation.

In-air Tablet and/or Computer

The tablet provides in-flight information, including maps and flight plans, to the pilot and senior OGI technician.

Figure 6. *On the left, the screen shows the live OGI image from the camera mounted to the helicopter. On the right, the tablet depicts the helicopter's flight path.*

Computer

The AOGI system requires a computer to upload the image and video files to the cloud, verify and confirm detections and non-detections, and send files to owner/operators.

Type of Measurement

AOGI is a remote, airborne method that uses a mid-wave infrared detector that generates an optical gas image based on the light hitting the detector. The camera then processes the signal to generate an optical image showing the target gas's plume, in this case, methane. Methane for the AOGI application is not quantified. Visual estimates are provided to operators when necessary, such as for estimated large leaks (>30 kg/hr or leaks that may be a safety hazard.

Detection Limit

The mass emission rate minimum detection limit is 0.28 kg/hr with a probability of detection of 91% by the in-field operator, and 94% with in-office verification. Leaks smaller than 0.28 kg/hr are also detected and reported to operators when found.

Detection limits were experimentally found via in-situ controlled releases on a wellpad in the Permian basin, using a third-party entity to evaluate the AOGI platform. The experiment included three types of tests:

1) An lower limit “step-down” test to validate the minimum detection threshold for the AOGI based on actual field conditions.
2) A semi-blind release point test randomly varied the leak rate and location between three separate release points to validate the ability to find and determine leaks

3) A semi-blind release point test randomly varied the leaks' location between three separate release points while the leak rate was held constant to validate the ability to find and determine leaks.[4]

Application Limitations

AOGI requires certain operating conditions to maintain the method's operating envelope, safety, and probability of detection higher than 90% for methane mass emission rates of equal to or less than 1 kg/hr.

Altitude

The altitude and distance from the emission source affects the ability of the AOGI platform to detect methane leaks. The AOGI platform maintains a height of 100-200 feet during surveys. Operators will adjust altitude based on conditions and ability to detect leaks.

Density Altitude

Density altitude does not directly affect the measurement system. Density altitude must be monitored to ensure safe operation of the helicopter hosting the AOGI platform.

Delta T

As OGI cameras depend on the thermal contrast (delta T) between the background and the methane plume, adequate delta Ts must be observed when performing periodic screenings with the AOGI platform.

Sun-level

When performing a periodic screening, the sun can cast shadows or be in direct view of the lens. The pilot and OGI technician should plan their flight paths, adjust the angle of approach, and modify their camera settings to minimize interference from shadows and the sun.

How the Measurement Technology Is Converted to a Mass Emission Rate

Not applicable. AOGI camera has a minimum detection limit of 0.28 kg/hr with a probability of detection of 94%, surpassing the EPA's lowest detection threshold of ≤1 kg/hr with a probability of detection of 90%.

[4] For more information, see Report in Confidential Business Information

How All Data Collected and Generated by the Measurement System Are Handled and Stored

Data is stored locally on the OGI camera as flyovers occur. The data gathered includes time, location, zoom level, altitude, camera orientation, helicopter speed, zoom level, and camera mode. Meteorological data is collected from the nearest weather station, or SOOFIE anemometer data, to determine wind speed and temperature. After the flight, data is then uploaded and backed up to a cloud service. The raw videos are stored in the cloud within the company's folder and sorted by location and date.

The data is then processed by a trained analyst to verify that all in-air detections are true positives and to review in-air non-detections to confirm no false negatives or positives. Once processed, the trained analyst sorts these videos and transfers the video files of detections to the operator to initiate investigations and repair process within 2 calendar days of the screening event.

Description of the Spatial Resolution of the Technology

AOGI uses a high-resolution mid-wave infrared camera capable of imaging the methane plume from a leak. The system has a built-in GPS antenna capable of identifying location accuracy, a range finder, accelerometer, and gyroscope to determine the orientation of the unit. This method uses this information to provide the exact location of the leak alongside the video, commentary on the leaking equipment, and the site identification number, enabling operators to pinpoint a leak at the component level and identify emissions within a radius smaller than 0.5 meters.