July 18th, 2016

California Air Resources Board
1001 "I" Street
Sacramento, CA 95814

RE: California Code of Regulations, Title 17, Division 3, Chapter 1, Subchapter 10 Climate Change, Article 4. Subarticle 13: Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities

To Whom It May Concern:

FLIR Systems has demonstrated a long history of working collaboratively with the Oil & Gas Industry to offer methane and VOC mitigation solutions that are both efficient and effective at locating sources of fugitive emissions. As the pioneer of Optical Gas Imaging (OGI), we would like to take this opportunity offer our feedback on the specifics outlined in the docket.

Over the past 10 years, we have performed considerable research to gather information from our customer base regarding the effectiveness and affordability of implementing OGI programs across the globe. In doing so, we have found it reasonable to believe that operating a frequent OGI program can be a consistently economical way to realize low abatement costs for methane. This is of course a realization that puts more sales gas into the line, therefore increasing the profitability of the operator.

A specific example comes from one of our customers, Jonah Energy, who has operations in WY (Sublette County). Jonah Energy has publicly stated that their monthly Leak Detection and Repair program using OGI technology has not only been effective, but it has been consistently profitable. The cumulative gas savings realized by the program has exceeded $5 million in the past 6 years, which has more than covered the overall program costs. This includes the Optical Gas Imaging equipment and associated operators, along with all repairs and maintenance, including labor and parts. Recently, Jonah Energy shared their experience in the public comments submitted to the WY Depart of Environmental Quality Air Quality Division, saying[1]:

"Each month, Jonah Energy conducts infrared camera surveys using a FLIR camera at each of our production facility locations. Since the implementation of Jonah Energy's Enhanced Direct Inspection and Maintenance Program in 2010, we have conducted over 16,000 inspections and have repaired thousands of leaks that were identified by the FLIR camera. Based upon a market value of natural gas of $4 per million Btu, the estimated gas savings from the repair of leaks identified exceeded the labor and material cost of repairing the identified leaks. Additionally, an estimate of hundreds of tons of volatile organic compound emissions have been eliminated from being emitted to the atmosphere.

The result of Jonah Energy use EDI&M Program has significantly reduced volatile organic compound and hazardous air pollutant emissions to the Upper Green River Basin airshed, has reduced the amount of sales gas lost due to leaks going undetected resulting in significant sales gas savings, and has reduced the number and severity of enforcement actions from the Wyoming Department of Environmental Quality due to fugitive leaks."

Our experience developing OGI technology, working with personnel from both industry and regulatory agencies, and training hundreds of OGI technicians each year informs the following constructive comments.

Comparing OGI to Method 21

The efficiency of OGI technology is tied to its unique ability to help operators visualize leaks and directly see their source. Due to this fact, the adverse effects of wind (direction and speed) on the emissions plume are less extensive as compared to other approved technologies. Figure 1 below demonstrates a common example where a Method 21 approved device (TVA) is not able to identify a laboratory produced methane leak when wind direction diverts the plume away from the instrument probe.

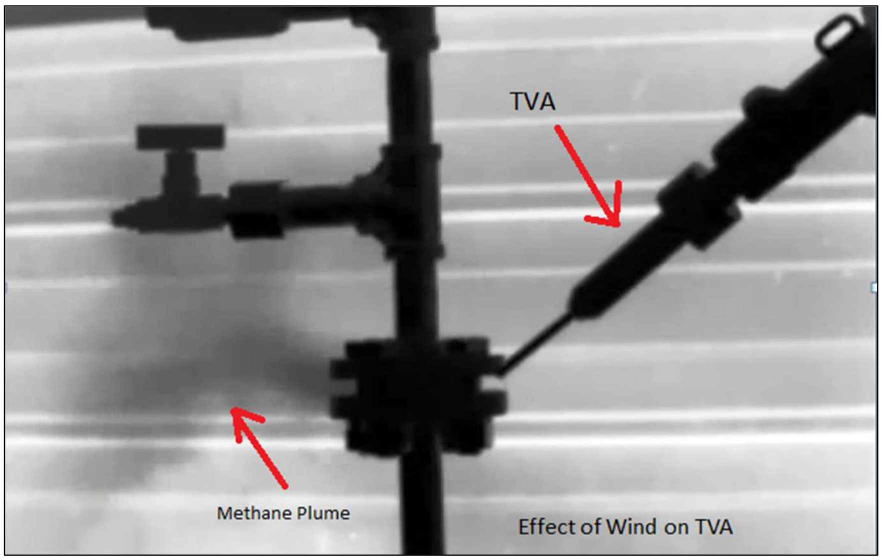


Figure 1–Lab testing shows adverse effects of wind direction on probe-type TVA instrument

Alternatively, the plume is easily detectible with OGI technology since the entire surrounding area is being passively monitored. This of course allows for the operator to actually see the source of the leak, preventing repair errors and eliminating false positives where blowing emissions are present at surrounding components. This concept also lends to the realization that LDAR programs utilizing OGI are considerably more efficient, as the technology allows operators to scan hundreds of components simultaneously[2]. This of course is a critical parameter to consider when scaling up frequent inspections in a cost-effective way.

Additionally, OGI technology has been proven to be more effective at locating leaks in confined spaces and hard to reach areas, reducing the need for scaffolding and man-lifts. Since many components at a well site or compressor station are physically difficult to reach and/or require an operator to be put in harm's way when accessing, an imaging technology has an inherent benefit over probe type instruments that must be submerged within the emissions plume. The Mandatory Reporting of Greenhouse Gases Rule (75 FR 74458) in its inception accurately identified this principal via the following verbiage[3]:

An optical gas imaging instrument must be used for all source types that are inaccessible and cannot be monitored without elevating the monitoring personnel more than 2 meters above a support surface...EPA still requires the use of optical imaging cameras to reach inaccessible emission sources where the reporter cannot use Method 21 compliant leak detection equipment safely.

Lastly, the latest EPA OOOOa Methane Rule (NSPS) and associated Technical Support Document for Optical Gas Imaging Protocol both reference detailed information compiled regarding Optical Gas Imaging, including:

- EPA's Justification for identifying Optical Gas Imaging (OGI) as the "Best Systems for Emissions Reduction"
- Numerous studies comparing OGI to Method 21 and other forms of leak detection
- Performance Tests for OGI in various conditions

The rule validates Optical Gas Imaging as the Best System of Emissions Reduction (BSER) for Oil & Gas well sites, and Compressor Stations (booster/gathering) across the United States, as the following applies to all new/modified equipment:

> The updated NSPS requires that owners/operators of natural gas well sites develop and implement a leaks monitoring plan. Owners/operators must use a technology known as optical gas imaging to conduct a leaks survey. Optical gas imaging equipment uses a special camera to "see" emissions of methane and VOCs.
>
> - Owners/operators may use "Method 21" as an alternative to optical gas imaging. Method 21 is an EPA method for determining VOC emissions from process equipment. The method is based on using a portable VOC monitoring instrument, such as an organic vapor analyzer (sometimes referred to as a "sniffer").

Technical Support Document Appendices, Optical Gas Imaging Protocol (40 CFR part 60, Appendix K), August 11, 2015[4]

Reference to Studies:

STUDY [5] - Directed Inspection and Maintenance Leak Survey at a Gas Fractionation Plant Using Traditional Methods and Optical Gas Imaging. (Picard, D., J. Panek, D. Fashimpaur. 2006)

> The same screening rate inequality was found in a different study by Picard et al.[78] at a gas fractionation plant, where the implementation of OGI technology increased the screening speed nearly 10-fold.[78] For a two person team using Method 21, a rate of 240 components per hour was a reasonable pace. A two person team using OGI increases that rate to 2,300 components per hour.[81] Of the top 10 biggest leakers found during this study, operators only found 5 while using Method 21, but found 8 while using OGI technology (the other 2 leaks having sufficient mass emission rates to be detected by the camera, but were missed by the operator[f]). While the study emphasized the detection performance for the top 10 leaks, there was no comparison of performance over the entire size range of leaks. Additionally, this study found that as compared

STUDY [6]: Smart LDAR: Pipe Dream or Potential Reality? Exxon Mobile Corporation (Reese, D., C. Melvin, and W. Sadik. 2007)

During a study by Reese et al., 2006, it was determined that only two people were required for 2 days to do an OGI technology-assisted facility survey versus four people for 4 days using Method 21.[80] In this study, the authors allowed some leaks that were less than the regulation definition of 10,000 ppm to go unrepaired to evaluate the concern over the potential for leaks at lower mass emission rates to become bigger over time. These equipment leaks were re-surveyed three months after the initial Method 21 survey. Although some leak rates increased over that time, an equivalent amount of leaks decreased, resulting in no net change over time and resulting in the authors unable to find any correlation between leak rate and length of time.

Reese et al. reported that, during the last comparison survey conducted for this study, only one leak was detected with OGI technology and nine leaks were detected with Method 21 independently. In this example, although the Method 21 survey found more leaks, the maximum leak concentration detected by Method 21 was 5,817 ppm. In comparison, the one leak found by OGI technology measured 210,000 ppm; this was the largest leak of the study, and it was not detected via Method 21. Therefore, lower whole-facility emissions can result from the implementation of OGI technology-assisted leak surveys due to the greater probability of a large leak being detected with OGI versus Method 21 only. Reese et al.[80] reached this conclusion after observing that OGI consistently found the larger leaks, although some leaks were missed starting around 6,000 ppm (according to EPA Method 21 measurements) and less.[80] In the study, the authors applied the EPA correlation curves[106] to Method 21 screening values and the API leak/no-leak emission factors[2,3,59,60] to come up with whole facility emission rates of 9,099 pounds per year (lbs/yr) for Method 21 and 7,774 lbs/yr for OGI. This was a difference of about 15%, which was acceptable to the authors.[80] The study authors concluded that the use of OGI technology to assist LDAR surveys results in lower whole-facility emissions versus Method 21 alone and that the amount of emissions released by smaller leaks possibly missed by OGI technology-assisted surveys are offset by the faster identification (and repair) of larger leaks when surveys are conducted on a more frequent basis.

STUDY [7]: Refinery Evaluation of Optical Imaging to Locate Fugitive Emissions (Robinson – AWMA)

2006-2007. Furry et al., 2006; Reese et al., 2007 and Trefiak, 2006 reported for industry on LDAR applications and technology challenges. These reports all agree that the implementation of Method 21 is timely and expensive, while advancing technologies offer promise to streamline and reduce the cost of routine monitoring.[35,80,98] A paper by Robinson et al. in 2007 found that using OGI technology to assist the periodic screening procedures increases the survey rate of equipment dramatically from about 60 pieces of equipment per hour with Method 21 to over 2,000 pieces of equipment per hour with OGI technology and that OGI technology-assisted surveys identified 97% of the total mass emissions detected from leaking sources with Method 21.[85] These studies provided evidence that using OGI technology to assist LDAR programs with their regular equipment surveys promises to be a quicker and more cost-effective method of identifying the largest sources of leaking emissions relative to Method 21 and will increase the amount of total facility fugitive emissions reduction because OGI technology can identify fugitive emissions from all equipment categories, regardless of whether that equipment is mandated for LDAR program compliance or not.

In summary, we believe that the minimal adverse effects of wind, increased inspection efficiency, and inaccessibility of common components would support the agency's allowance of Optical Gas Imaging as fully acceptable alternative to Method 21 for Leak Detection.

Evolution of OGI Technology

Continuous Monitoring

It is important to note that Optical Gas Imaging is continually evolving. Recently, fixed mounted OGI cameras have been developed offering Continuous Emissions Monitoring and Automated Leak Detection in remote areas. Through this technology, operators can autonomously detect, visualize, and pinpoint hydrocarbon and methane leaks in a variety of industrial environments, including underground storage facilities, to streamline operations by protecting profits, improving health & safety standards, and reducing environmental impacts.

Quantification

When analyzing the financial impact of OGI programs, it is relevant to consider the fact that the economic value of the conserved gas commonly exceeds the associated repair cost of the leaking equipment. A recent study by Carbon Limits, Quantifying Cost-effectiveness of Systematic Leak Detection and Repair Programs Using Infrared Cameras[8], sheds light on the finding that 97% of leaks identified with OGI technology are profitable to repair even with the price of natural gas at $3/Mcf. Moreover, 90% of the gas emissions are from leaks that can be repaired with a payback period of less than one year. This study was based on data from 58,421 emissions sources at 4,293 Oil & Gas facilities across the United States and Canada.

This supports the notion that operators are already incentivized to repair leaks that are found with Optical Gas Imaging. Therefore, we believe that it would be reasonable to allow Optical Gas Imaging be an acceptable alternative to Method 21, where a leak found is considered "a leak" with a fixed repair timetable.

If quantification is considered critical information, there is now software technology through Providence Photonics (QL100) available today that enhances Optical Gas Imaging by offering real-time leak rate and volume quantification, which should be considerably more meaningful to operators and regulators than concentration data (ppm). This concept is called quantitative Optical Gas Imaging or qOGI.

Costs & Availability of OGI Equipment

FLIR Systems is a world leader in the design, manufacture, and marketing of sensor systems that enhance perception and awareness. We are also the pioneer of Optical Gas Imaging (OGI) technology. Recently, the costs and availability of OGI equipment and trained personnel has been brought into question; therefore we would like to take this opportunity to address this concern by offering some insight into how our operations can be scaled and how the technology can be accessed by smaller producers.

Production

With multiple production facilities across the United States and robust financials (2015 Revenue of $1.6B), we are appropriately positioned to scale the production of OGI equipment as needed. The main reason for this is because FLIR is truly vertically integrated, as we own and operate the large majority of our supply chain. This begins with the IR detector and cryo-cooler assembly, which are the core components of an OGI camera. These are both created solely by FLIR and are also used in a wide variety of other imaging, thermography, and security products, including airborne and ground-based surveillance systems. The large majority of these products are Commercial-off-the-shelf (COTS) systems, which require us to have true scalability for spikes in growth across multiple markets.

We have thoroughly reviewed our production capacity of key components and have confirmed that even a 3X increase in demand of GF320/GF300 cameras would fit within the existing production growth plan for cooled sensor engines slated for 2016. Larger increases in demand would not require equipment or infrastructure expansion and could be scaled quickly, likely within the span of time between the finalization of a BLM rule and implementation.

We have been specifically asked by the Alberta Energy Regulator if we could build and deliver an additional 300 GF320/GF300 cameras in the next calendar year. The answer is yes, quite easily, as our current production capacity far exceeds this estimated increase in demand.

Service & Training

Additionally, we have confirmed internally that we can also appropriately scale the associated service of equipment and training of individuals via our Infrared Training Center (ITC). It is important to note that FLIR has service locations all over the world that currently work on thousands of IR cameras every month. We have confirmed internally that we can reallocate resources to handle an increase in service demand fairly easily.

With regards to training, FLIR offers Optical Gas Imaging courses both at our corporate headquarters and locally through engineers and direct employees in the field. Our Infrared Training Center has reported that it would take approximately 30 days to double the monthly amount of individuals trained on Optical Gas Imaging and 60 days to triple the number.

Rental & Leasing

Many options exist for OGI inspections beyond the purchase of an OGI camera. For example, rental cameras are available from FLIR as well as other equipment rental companies that service the industry. Here is quick snapshot of today's GF320 rental rates:

FLIR 7-Day Rental Rate = $3,950
FLIR 3-day Rental Rate = $1,975

It is conservative to estimate that an operator could scan 4 full locations in a day, depending on distance between sites. Therefore, a 7-day rental would allow for a minimum of 28 inspections. This brings the per site cost to ~$141.

Service Providers & Contractors

Over the past 10 years, there have been a large number of service consultants using OGI equipment created throughout the country. This is mostly evident by our internal evaluation of attendees to our frequent and regional OGI training courses. We have seen a considerable shift from in-house operators to third party contractors in recent years.

Additionally, this group can be rapidly expanded through existing training and equipment leasing programs. Furthermore, we have recently seen a transition where many field-service companies are leveraging OGI surveys as a way to re-invent themselves in a market where they already have considerable expertise. We expect this transition to continue with the increased adoption of new inspection technologies, such as Optical Gas Imaging.

Our surveys of FLIR customers that provide consultant services showed average rates of $250-350 per visit. Internal OGI programs showed costs that were lower and in the range of $150-170 per site visit.

In conclusion, we have made great strides over the years to ensure that OGI technology can be accessible at a reasonable and low cost to the industry. Additionally, FLIR is well positioned to swiftly scale our OGI business to meet any new demand, thus ensuring that the necessary equipment and personnel will be available to perform monitoring and inspection programs irrespective of frequency.

Performance Methods for OGI Technology

There are many types of IR cameras produced today that visualize light in a wide variety of wavelengths within the IR spectrum, most of which are not tuned to see any type of hydrocarbon gas. We recommend that the agency consider a detailed definition of "Optical Gas Imaging" to ensure that the equipment used for leak detection surveys is intended for methane and hydrocarbon gas detection. For example, Optical Gas Imaging can be defines as *an instrument that employs spectral wavelength filtering and an array of infrared detectors to visualize the infrared absorption of hydrocarbons and other gaseous compounds.*

Also, we recommend that the agency consider instituting an equipment performance verification method to ensure the IR camera used is specifically capable of imaging methane or other hydrocarbon gases at a flow rate that aligns with the agency's goals. A comprehensive and verifiable method would be the NECL method proposed in the Draft Technical Support Document Appendices, Optical Gas Imaging Protocol (40 CFR Part 60, Appendix K), August 11, 2015 which states:

"Similar to the way in which the noise equivalent temperature difference (NETD) is used to characterize the performance of thermometric instruments by defining the smallest amount of temperature difference that can be definitively measured above noise levels (like the limit of detection in analytical chemistry), the NECL describes the performance limitations for OGI cameras in terms of the lowest ppm•m that can be detected above the baseline noise."

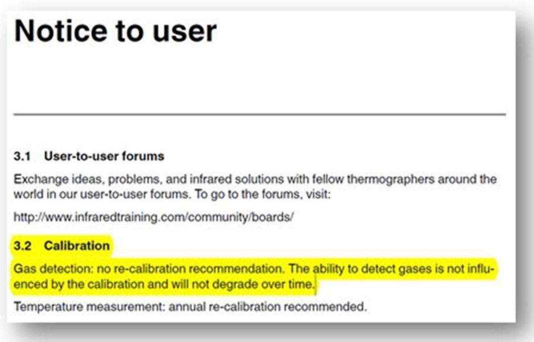
We fully support the NECL approach, as it is the most comprehensive method for comparing Optical Gas Imaging equipment and verifying their ability to visualize a particular gas of interest.

Additionally, this is a performance method that could be certified by the manufacturer upon production, thereby reducing the burden on industry.

Calibration Requirements

It is important to note that there is no periodic calibration required for Optical Gas Imaging technology when used as a tool for gas detection. Previous references to calibration requirements was intended for operators using the camera for temperature measurement activities (i.e. electrical/mechanical inspections). If the system is used solely for gas detection, there is no manufacturer's re-calibration recommendation.

We have updated our manual to communicate this more effectively.



Notice to user

3.1 User-to-user forums

Exchange ideas, problems, and infrared solutions with fellow thermographers around the world in our user-to-user forums. To go to the forums, visit:

http://www.infraredtraining.com/community/boards/

3.2 Calibration

Gas detection: no re-calibration recommendation. The ability to detect gases is not influenced by the calibration and will not degrade over time.

Temperature measurement: annual re-calibration recommended.

Here is a link to the latest FLIR GFXXX Series manual for reference:
http://support.flir.com/DocDownload/app/RssDocDownload.aspx?ID=20296

Daily Instrument Check

In the past, there have been references to a Daily Instrument Check for Optical Gas Imaging equipment. It is extremely important to note that as long as an OGI system turns on and is outputting an image, it will see gas with the same sensitivity and detection limit as it did on its manufacturing date. This is mainly due to the fact that the internal "cold-filter" that allows an OGI system to target the absorption characteristics of hydrocarbon gases does not degrade or change properties over time. Only systems that quantify emissions should require a periodic instrument check, as they need to verify that there has not been any measurable drift to an existing calibration. Therefore, a daily instrument check for OGI equipment would unnecessarily increase the cost of implementing an OGI program, while offering no value in exchange.

In summary, we are pleased that OGI technology is recognized as an acceptable screening tool, but believe that the details outlined above justifies consideration for Optical Gas Imaging to be adopted as a fully acceptable alternative to Method 21 for Leak Detection.

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Thank you greatly for providing the opportunity for us to submit comments to the proposed ARB rule.

Sincerely,

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(2) *Conoco Philips PILOT STUDY: Optical Leak Detection & Measurement, October 2006*
(3) *Mandatory Reporting of Greenhouse Gases Rule (74 FR 56260)*
(4) *Technical Support Document Appendices, Optical Gas Imaging Protocol (40 CFR part 60, Appendix K), August 11, 2015 - https://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2010-0505-4949*
(5) *Directed Inspection and Maintenance Leak Survey at a Gas Fractionation Plant Using Traditional Methods and Optical Gas Imaging. (Picard, D., J. Panek, D. Fashimpaur. 2006)*
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(7) *Refinery Evaluation of Optical Imaging to Locate Fugitive Emissions (Robinson – AWMA)*
(8) Carbon Limits, *Quantifying Cost-effectiveness of Systematic Leak Detection and Repair Programs Using Infrared Cameras.* March 2014