Timeline of Optical Gas Imaging Regulation in United States and Europe

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2008 USA Environmental Protection Agency AWP (Alternative Work Practice) - Refining

The EPA's Method 21 - Alternative Work Practice (AWP), promulgated December 2008, allows the use of Optical Gas Imaging (OGI) for M21 leak detection, in lieu of the "Sniffer" method

"SUMMARY: Numerous EPA air emissions standards require specific work practices for equipment leak detection and repair. On April 6, 2006, we proposed a voluntary alternative work practice for leak detection and repair using a newly developed technology, ***optical gas imaging."***

- Allows owners or operators to identify leaking equipment using an ***optical gas imaging (OGI)*** instrument instead of the "sniffer method"
  - Allows owners/operators to choose whether to use the AWP in place of the current work practice
  - Owners or operators can decide where and to what extent to use ***OGI*** instead of sniffers.
  - This AWP does not cover non-LDAR components (closed vent systems, leakless equipment, or equipment designated as non-leaking)
- Each facility choosing to use the AWP must also monitor the same equipment with a 40 CFR part 60, Appendix A-7, Method 21 monitor (sniffer) once per year.
- The minimum ***OGI*** detection level of 60g/hr. was removed from the final AWP.
  - All emissions imaged by the ***OGI*** instrument are considered to be leaks.
  - If you can see it with the camera, it's a leak…
- A daily instrument check must be performed to confirm that the optical gas imaging instrument is able to detect leaks at the emission rate specified in the amendatory language.
- Video records of the daily instrument check and the leak survey results must be kept for 5 years.

Reference: http://www.epa.gov/ttn/caaa/t3/fr_notices/ldar_fin_121508.pdf

2008 EUROPE CONCAWE Report - Refining

Concawe was established in 1963 by a small group of leading oil companies to carry out research on environmental issues relevant to the oil industry. Its membership has broadened to include most oil companies operating in Europe.

The scope of Concawe's activities has gradually expanded in line with the development of societal concerns over environmental, health and safety issues. These now cover areas such as fuels quality and emissions, air quality, water quality, soil contamination, waste, occupational health and safety, petroleum product stewardship and cross-country pipeline performance.

In 2008 a Concawe published a report following a trial that was performed in Shell Gothenburg in 2007. During the trial a FLIR GasFindIR Optical Gas Imaging and other complementary technique was tested.

Report Conclusion:

Point Sources:

- Recently developed ***optical gas imaging (OGI) techniques*** permit remote leak detection with hand held, relatively simple to use, cameras. All components can be scanned and surveys can be completed at a much faster rate. An ***OGI leak detection*** survey can identify the 'significant emitters' permitting focused equipment maintenance and subsequent emission reductions. The use of ***OGI cameras*** has been demonstrated to be a viable alternative to sniffing with conventional detectors. The US EPA is currently considering permitting their use as an 'alternative work procedure'. Emission factors have been developed so that average annual emissions for all point source fugitive emissions can be determined from leak detection surveys.

Area Sources:

- It has been proven that the well-established API algorithms for the quantification of annual average emissions from storage are robust, but only if the tanks are properly maintained. However, a tank may be a 'significant emitter' for which the application of the API methodologies is not appropriate. Emissions from floating roof storage tanks result from point sources e.g. leaks from the seals on roof fittings and against the tank shell. It has been demonstrated that ***OGI*** techniques can detect these leak sources, which are otherwise non-identifiable.
- If a tank is a 'significant emitter' it can be identified using either a complex optical technique (DIAL or SOF) or a more cost-effective relatively simple ***OGI*** leak detection survey of tank fittings. The latter also has the advantage that it can identify the precise location of the emission sources (e.g. leaking fittings and/or components) which are causing the tank to be a 'significant emitter'.

Overall Conclusions:

- Relatively simple ***OGI*** equipment can scan all fugitive emission point sources on a process plant, which is not possible using conventional hydrocarbon leak detection instruments. The use of complex optical techniques to determine the total emissions from point emitters (e.g. equipment components) is then not necessary.
- The use of ***OGI*** tank surveys is an alternative, reliable, relatively simple and cost-effective method to identify tank equipment in need of maintenance. Subsequent maintenance enables a tank to be returned to within the bounds of operation for which robust emission estimation algorithms are valid.

Reference:
https://www.concawe.eu/DocShareNoFrame/docs/1/FIGFKAKDCFIPBAIOCHKFFNLGVEVCBW9N9YBDC3BYGWW3/CEnet/docs/DLS/Rpt_08-6-2008-02481-01-E.pdf

2011 USA Environmental Protection Agency 40 CFR Part 98, Subpart W - Refining

On November 8, 2010, Administrator Jackson signed a rule that finalizes reporting requirements for the petroleum and natural gas industry under 40 CFR Part 98, the regulatory framework for the Greenhouse Gas (GHG) Reporting Program.

This final rule requires petroleum and natural gas facilities that emit 25,000 metric tons or more of carbon dioxide (CO_2) equivalent per year to report annual methane (CH_4) and CO_2 emissions from equipment leaks and venting, and emissions of CO_2, CH_4, and nitrous oxide (N_2O) from gas flaring and from onshore petroleum and natural gas production stationary and portable combustion emissions and combustion emissions from stationary equipment involved in natural gas distribution.

The ruling requires reporting by facilities in specific segments of the petroleum and natural gas industry that emit GHGs ≥25,000 metric tons carbon dioxide equivalent (CO_2e) per year:

- Onshore petroleum and gas production facilities (including EOR CO_2 surface emissions), basin level reporting
- Offshore petroleum and gas production platforms
- Natural gas processing plants
- Natural gas transmission compression
- Underground natural gas storage
- Liquefied natural gas (LNG) storage

- LNG import and export
- Natural gas distribution facilities, owned or operated by Local Distribution Companies (LDCs)

Reporting is at the facility level with data collection beginning on January 1, 2011 and reports will be submitted annually with the first report due to EPA by March 31, 2012, covering 2011 emissions.

Certain reporters may use best available monitoring methods (BAMM) for a limited period during the 2011 data collection year, for some emissions sources, if they meet specific criteria. In cases of extreme or unusual circumstances, EPA may also consider petitions to extend BAMM for covered sources or to allow use of BAMM for sources not specified.

Specific details outlined in the Final Ruling:

- **Transmission storage tanks**. For transmission storage tanks, once per calendar year reporters must monitor the tank vapor vent stack using an ***optical gas imaging instrument***, to view the emissions for 5 minutes.
- **Leak detection and leaker factors** (onshore natural gas processing, onshore natural gas transmission compression, underground natural gas storage, LNG storage, LNG import export, natural gas distribution). Perform a leak detection survey using one of the three following methods:
    - ***Use an optical gas imaging instrument***. The method must be used for all sources that cannot be monitored without elevating personnel more than 2 meters above a support surface.
    - Use an infrared laser beam illuminated instrument.
    - Use Method 21.
- For industry segments where equipment leak detection is required (onshore natural gas processing, onshore natural gas transmission compression, underground natural gas storage, LNG storage and LNG import and export equipment, and natural gas distribution facilities) EPA is including the option to use Method 21 and infrared laser beam illuminated instruments to detect leaks for sources that are accessible. ***Inaccessible equipment leaks and vented emissions are still required to be monitored using an optical gas imaging instrument.***
- EPA received numerous comments on the use of the ***optical gas imaging instrument*** for detecting GHG emissions from equipment leaks. Several commenters expressed support for the use of ***optical gas imaging instruments*** prescribed in the rule, **stating that using this equipment would result in cost savings to industry as it would reduce burden and time by quick survey of all emissions sources at one time.**

Reference: http://www.gpo.gov/fdsys/pkg/FR-2010-11-30/pdf/2010-28655.pdf#page=32

2012 USA Environmental Protection Agency 40 CFR Part 60 Subpart OOOO (QUAD O) - Fracking

The final rules include the first federal air standards for natural gas wells that are hydraulically fractured (Fracking), along with requirements for several other sources of pollution in the oil and gas industry that currently are not regulated at the federal level.

This subpart establishes emission standards and compliance schedules for the control of volatile organic compounds (VOC) and sulfur dioxide (SO2) emissions from affected onshore facilities that commence construction, modification or reconstruction after August 23, 2011.

By introduction of Subpart OOOO (QUAD O), operations that are hydraulically fractured are included within the Environmental Protection Agency regulations. As such the Environmental Protection Agency recommendations of technology for monitoring diffuse VOC emission to air such as OGI are to be used within the hydraulically fractured operations.

Reference: http://www.gpo.gov/fdsys/pkg/FR-2012-08-16/pdf/2012-16806.pdf#page=54#

2013 EU Commission IPPC Directive (2008/1/EC) and Industrial Emissions Directive (IED, 2010/75/EU) - Refining

In 2007 a trial was performed using the FLIR OGI technology and a complementary technology. The subsequent report [CONCAWE Report no. 6/08] and conclusion that was produced by CONCAWE makes up some of the fundamentals of the new draft BAT (Best Available Technique) and BREF (Best Available Technique Reference Document to the BAT) as part of the new Directive on industrial emissions 2010/75/EU (IED) with respect to **OGI**.

There are several BREF documents that are relevant to the new IED, reference: http://eippcb.jrc.ec.europa.eu//reference

One of which is *Refining or Mineral Oil and Gas: http://eippcb.jrc.ec.europa.eu//reference/BREF/FD_REF_July_2013online.pdf*

In section *5.1 General BAT conclusions for refining of mineral oil and gas* it concludes under section *5.1.4 Monitoring of emissions to air and key process parameters* the following:

> 6. BAT is to monitor diffuse VOC emissions to air from the entire site by using all of the following techniques:
>
> i. sniffing methods associated with correlation curves for key equipment;
>
> ***ii. optical gas imaging techniques;***
>
> iii. calculations of chronic emissions based on emissions factors periodically (e.g. once every 2 years) validated by measurements.
>
> The screening and quantification of site emissions by periodic campaigns with optical absorption based techniques, such as differential absorption light detection and ranging (DIAL) or solar occultation flux (SOF) is a useful complementary technique.
>
> Description: See Section 5.19.6.
>
> [This BAT conclusion is based on information given in Section 3.26.1.3]

Chapter 5.1.4 is the draft conclusion stating ***optical gas imaging*** is one of three BAT (Best Available Techniques) which **ALL must** be used for monitoring of diffuse VOC emissions.

Section 5.19.6 is the description of the method forming part of the final conclusion with reference to LDAR Program:

- *Optical gas imaging methods:* Optical imaging uses small lightweight hand-held cameras which enable the visualisation of gas leaks in real time, so that they appear as 'smoke' on a video recorder together with the normal image of the component concerned to easily and rapidly locate significant VOC leaks. Active systems produce an image with a backscattered infra red laser light reflected on the component and its surroundings. Passive systems are based on the natural infra red radiation of the equipment and its surroundings.

Section 3.26.1.3 is the information that was gathered and provided by working trails and feedback by end user operators of OGI into the technical working committee.

Under section *3.26 Monitoring* it defines the working areas applicable where Optical Gas Imaging is to be used:

3.26.1.3 Diffuse VOC monitoring

> VOC emissions by refineries come mainly from diffuse emissions. Four major diffuse emissions sources can be identified.
>
> - Fugitive emissions by leaking equipment in the process area, such as valves, flanges, pumps, safety valves, etc. They usually account for 20 – 50 % of the total refinery VOC emission. Emissions may also be high after start-up operations due to a e.g. poorly undertaken tightning of equipment.
> - Crude oil and products storage. External and internal floating roof tanks are emission sources because of evaporative losses that occur during standing storage and withdrawal of liquid from the tank. Emissions from fixed roof tanks are due

to the venting during operations or to breathing due to variation of ambient temperature. Emissions from floating roof tanks occur from losses from seals and roof fittings They typically represent 20 – 40 % of the refinery emissions.

- Loading and unloading facilities, including road tankers, rail tank cars, barges and sea-going vessels. They account for 5 – 10 % of site emissions.
- Waste water treatment plants, where a gradual release of VOC may occur at all water/air interfaces. Depending on VOC reducing techniques applied, WWTPs usually generate 5 –30 % of the total site emissions.

Reference: http://eippcb.jrc.ec.europa.eu//reference/BREF/FD_REF_July_2013online.pdf

2014 USA Fracking - State of Colorado Regulations – Fracking

DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

Air Quality Control Commission

REGULATION NUMBER 3 STATIONARY SOURCE PERMITTING AND AIR POLLUTANT EMISSION NOTICE REQUIREMENTS

5 CCR 1001-5

On February 23, 2014, Colorado's Air Quality Control Commission ("Commission") fully adopted EPA's Standards of Performance for Crude Oil and Natural Gas Production, Transmission, and Distribution found in 40 C.F.R. Part 60, Subpart OOOO ("NSPS OOOO") into Regulation Number 6, Part A; adopted corresponding revisions to its emissions reporting and permitting framework in Regulation Number 3, Parts A, B, and C; and adopted complementary oil and gas control measures in Regulation Number 7. This rulemaking was the culmination of the Commission's October 2012, directive to consider full adoption of EPA's NSPS OOOO. These oil and gas control measures revisions focus on identifying and repairing leaks in the oil and gas sector, but also contain some recordkeeping and reporting requirements. This rulemaking received support from environmental groups and some companies within the oil and gas industry. In addition to extensive VOC reductions, the Regulation Number 7 revisions also regulate methane emissions from the oil and gas industry.

These oil and gas control measures are estimated to reduce VOC emissions by approximately 93,500 tons per year and methane/ethane emissions by approximately 65,000 tons per year, at a cost of approximately $42.5 million per year.

Under Section *LDAR (Section XVII.F.)* it clearly outlines the frequency of inspections for Well Production Facility Components:

Table 4 – Well Production Facility Component Inspections				
Thresholds (per XVII.F.4.c.)				
Well production facilities without storage tanks (tpy)	Well production facilities with storage tanks (tpy)	Approved Instrument Monitoring Method Inspection Frequency	AVO Inspection Frequency	Phase-In Schedule
> 0 and ≤ 6	> 0 and ≤ 6	One time	Monthly	January 1, 2016
> 6 and ≤ 12	> 6 and ≤ 12	Annually	Monthly	January 1, 2016
> 12 and ≤ 20	> 12 and ≤ 50	Quarterly	Monthly	January 1, 2015
> 20	> 50	Monthly		January 1, 2015

Section LDAR (Section XVII.F.) also clearly defines:

- The revisions set different thresholds for leaks requiring repair based on the method used to detect the leak. The leak thresholds do not apply to leaks associated with normal equipment operation, such as pneumatic device actuation and crank case ventilation. The ***leak threshold for leaks detected with an IR camera*** or AVO is ***any detectable emission***

Reference: https://www.colorado.gov/pacific/sites/default/files/003_030614-729AM-R3-6-7-fact-sheet-003_1.pdf

2014 EU Commission IPPC Directive (2008/1/EC) and Industrial Emissions Directive (IED, 2010/75/EU) - Chemical

There are several BREF documents that are relevant to the new IED, reference: http://eippcb.jrc.ec.europa.eu//reference

One of which is *Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector:* *http://eippcb.jrc.ec.europa.eu//reference/BREF/CWW_Final_Draft_07_2014.pdf*

Chapter 4 *BEST AVAILABLE TECHNIQUES (BAT) CONCLUSIONS FOR COMMON WASTE WATER/WASTE GAS TREATMENT/MANAGEMENT IN THE CHEMICAL SECTOR,* states the scope of the industries to be covered by this draft regulation:

SCOPE

These BAT conclusions concern the activities specified in Sections 4 and 6.11 of Annex I to Directive 2010/75/EU, namely:

- ***4 Chemical industry;***
- 6.11 Independently operated treatment of waste water not covered by Council Directive 91/271/EEC and discharged by an installation undertaking activities covered under 4 above.

These BAT conclusions also cover the combined treatment of waste water from different origins if the main pollutant load originates from the activities specified in Section 4 of Annex I to Directive 2010/75/EU (i.e. chemical industry).

In particular, these BAT conclusions cover the following issues:

- environmental management systems;
- water saving;
- waste water management, collection, and treatment;
- waste management;
- treatment of waste water sludge with the exception of incineration;
- waste gas management, collection, and treatment;
- flaring;
- ***diffuse emissions of volatile organic compounds (VOC) to air;***
- odour emissions;
- noise emissions

In *Chapter 4.2 Monitoring – BAT 5* it concludes:

BAT 5. BAT is to periodically monitor diffuse VOC emissions to air from relevant sources by using all of the techniques given below.

I. sniffing methods (e.g. with portable instruments according to EN 15446) associated with correlation curves for key equipment;

II. ***optical gas imaging techniques;***

III. calculation of emissions based on emissions factors, periodically validated (e.g. once every two years) by measurements.

For installations where large amounts of VOCs are handled, the three techniques are complementary. The screening and quantification of emissions from the installation by periodic campaigns with optical absorption-based techniques, such as Differential absorption light detection and ranging (DIAL) or Solar occultation flux (SOF), is a useful complementary technique to the techniques I to III.

Reference: http://eippcb.jrc.ec.europa.eu//reference/BREF/CWW_Final_Draft_07_2014.pdf

2014 United Kingdom Environmental Agency - Fracking

In July 2014 the Environmental agency published a report titled *Considerations for quantifying fugitive methane releases from shale gas operations*

The report was produced to inform the Environment Agency about the options available for quantifying the amounts of fugitive methane released to air from certain onshore oil and gas operations. The emphasis is on exploratory operations to extract methane from shale by hydraulic fracturing - commonly known as 'shale gas operations' (as in the title).

Hydraulic fracturing for shale gas is one example of using 'unconventional' methods to extract gaseous hydrocarbons. Similar considerations for quantifying fugitive methane apply to other 'unconventional' exploratory operations (e.g. for coal-bed methane), so the report is relevant to 'unconventional gas' operations in general.

The report focuses on methods for monitoring fugitive methane, and on proposing monitoring efforts that are proportionate to a site's characteristics and environmental risks.

Chapter 5 Methane Monitoring Methods

The preceding chapters have provided a structure for identifying methane monitoring requirements. This chapter provides a description of the techniques available for measuring methane levels, and some considerations for their application in the field for studies with a range of objectives.

5.3.1 Continuous measurement technologies

Hand-portable remote infrared – forward-looking infrared and infrared absorption spectroscopy

- The basic ***forward-looking infrared (FLIR) systems*** have become popular for leak detection within the gas industry, replacing the vapour analysers which were used systematically as part of LDAR to check individual compression fittings, valves and flanges. In practice, ***FLIR*** will still be used with other measurement technology to generate required concentration data.
- The main benefit of modern ***FLIR*** is that a captured, real-time image in the visible and infrared range can be displayed on a screen, allowing the operator to see the actual leaks and methane plumes in situ. This improves the speed of leak detection.
- There will be a place for ***FLIR*** in assessing fugitive emissions, as it will allow the screening of the production area for further assessment and can also be used for longer-term surveillance. This equipment can be used in the same way as a handheld video camera; it can highlight gas leaks where other methods, such as complex machinery, cannot.
- There will be a place for ***FLIR*** in assessing fugitive emissions, as it will allow the screening of the production area for further assessment and can also be used for longer-term surveillance

5.3.3 Leak detection and repair

The LDAR process has been improved with the use of new technology, specifically the use of ***IR thermal imaging***. The standard ***IR technology*** is adjusted so that the detector is tuned to a specific wavelength at which a methane leak will show up as a visible image. This advance has improved the speed of the LDAR process and, depending on the system, whole process areas can be scanned.

Chapter 7.0 Example monitoring programs

7.2 On-site monitoring in the hydrocarbons industry

More recently, ***handheld forward-looking infrared (FLIR) camera systems*** have become more widely used as a state-of-the art system for identifying leaks and unexpectedly high discharges

Reference:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/325988/Considerations_for_quantifying_fugitive_methane_releases_from_shale_gas_operations.pdf

2014 EU Commission IPPC Directive (2008/1/EC) and Industrial Emissions Directive (IED, 2010/75/EU) – Refining

On 9th October 2014 the EU Commission published the final *Commission Implementing Decision establishing best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council on industrial emissions, for the refining of mineral oil and gas.*

BAT 6 (Best Available Technique):

BAT 6.BAT is to monitor diffuse VOC emissions to air from the entire site by using all of the following techniques:

(i) sniffing methods associated with correlation curves for key equipment;
(ii) optical gas imaging techniques;
(iii) calculations of chronic emissions based on emissions factors periodically (e.g. once every two years) validated by measurements. The screening and quantification of site emissions by periodic campaigns with optical absorption-based techniques, such as differential absorption light detection and ranging (DIAL) or solar occultation flux (SOF) is a useful complementary technique. Description See Section 1.20.6.

Section 1.20.6. Volatile organic compounds (VOC)

LDAR (leak detection and repair) programme. An LDAR (leak detection and repair) programme is a structured approach to reduce fugitive VOC emissions by detection and subsequent repair or replacement of leaking components. Currently, sniffing (described by EN 15446) and optical gas imaging methods are available for the identification of the leaks.

- Optical gas imaging methods: Optical imaging uses small lightweight hand- held cameras which enable the visualisation of gas leaks in real time, so that they appear as 'smoke' on a video recorder together with the normal image of the component concerned to easily and rapidly locate significant VOC leaks. Active systems produce an image with a back-scattered infrared laser light reflected on the component and its surroundings. Passive systems are based on the natural infrared radiation of the equipment and its surroundings 28.10.2014 L 307/80 Official Journal of the European Union EN

Reference: http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32014D0738&from=EN