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Parallel LDAR campaigns with sniffing and OGI

Summary of the field campaign project

Concawe OGI ad-hoc group

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Outline

- **Program objectives**
- **Work Performed**
  - **Methods used**
  - **Experimental field work**
- **Results: most important observations**
- **Conclusions**

Program Objectives

- **PURPOSE:** Develop technical evidence to support Optical Gas Imaging (OGI, Infra-Red camera) as a **stand-alone** Leak Detection And Repair (LDAR) technique in future permits.
- **WHY:** Both OGI and Sniffing are part of BAT6: monitoring of diffuse VOC emissions to air. The use of OGI as a stand-alone LDAR technique would avoid prescription of more intensive LDAR campaigns (increased frequency and/or combination with sniffing), like in the US. Other OGI benefits:
  - Faster method to find large leaks (improved safety & decreased product losses)
  - Further VOC decreases can be achieved by more frequent OGI campaigns (with lower costs)
  - Can detect inaccessible leaks not reachable by sniffing (e.g. under insulation, not possible to reach without scaffolding, not in the database)
  - In addition to the regular LDAR campaigns, OGI can be used after a start-up to detect possible leaks (e.g. seal leaks)
- **HOW:** Demonstrate equivalence of the OGI technique with the traditional detection method (Sniffing) through parallel campaigns; leak bagging is included to provide independent mass emission estimation

Methods used: leak detection

Leak detection (number of leaks)

- **Sniffing**
  - Performed according to EN15446
  - Leaks are detected by placing the sniffing probe to be within 1-2cm of the point where a leak can occur
  - Measurement = hydrocarbon concentration (vppm)

TVA-1000B (sniffing device - flame ionization detector (FID))

- **OGI**
  - Performed according to the Dutch protocol NTA 8399
  - Leaks are detected by scanning the facilities and detecting hydrocarbon plumes. Scanning at a distance is feasible.

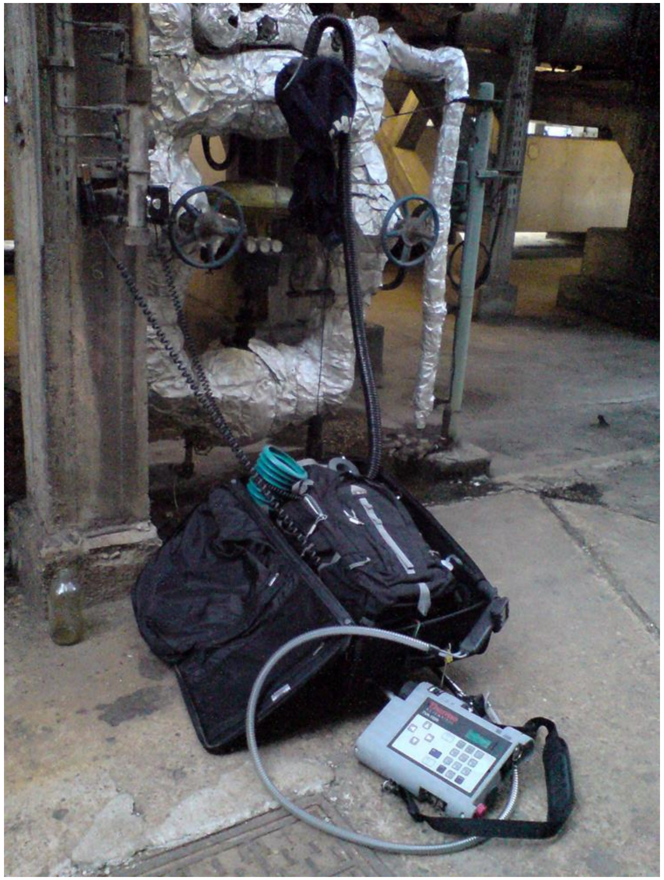
FLIR GF 320 (OGI camera)

- **Both OGI and Sniffing are part of BAT6: monitoring of diffuse VOC emissions to air.**

Methods used: leak mass estimation

Leak quantification (mass of leaks)

- **Direct: High flow sampling (HFS)**
  - New technique to independently quantify leaks
- **Estimated: Method 21**
  - EPA calculation method for the Sniffing LDAR campaigns
  - For pegged (screening values above defined e.g. 100.000 ppm range) values Method 21 provides the same default factor (e.g. 140 g/h for valves)
- **Estimated: OGI leak / no leak**
  - API calculation method for the OGI LDAR campaigns



High Flow Sampler (Baccharach)

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Summary of Experimental Field Work

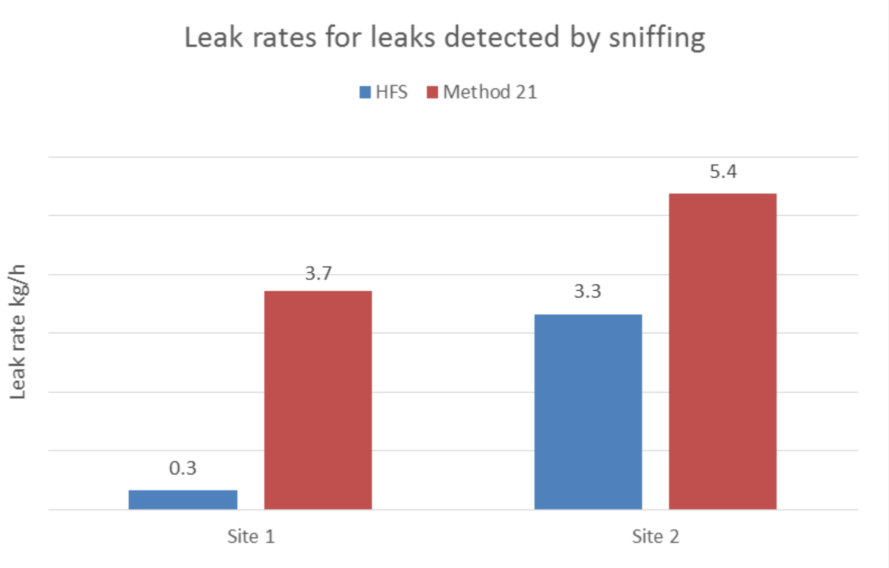
Study	Activities	Where	Objective	Scope: Points surveyed	Scope: Leaks bagged	Methods
Pilot	Parallel survey pilot	Site 1	Test experimental protocol in field trial	4.000	74	Sniffing, OGI, HFS
Full scale	Three parallel surveys, same unit, 3 times, 2-4 months spread	Site 2	Collect enough data for statistical analysis; study leak evolution in time	26.000	214	Sniffing, OGI, HFS, VB*
				5.000 (1)	45	OGI, HFS
				5.000 (1)	114	Sniffing, OGI, HFS
*Field bagging comparison	Vacuum Bagging (VB) and Hi Flow Sampling (HFS)	Site 2	Check accuracy of HFS (as reference for mass flow)	20 leaks bagged by both methods (site 2, campaign #1)		VB, HFS

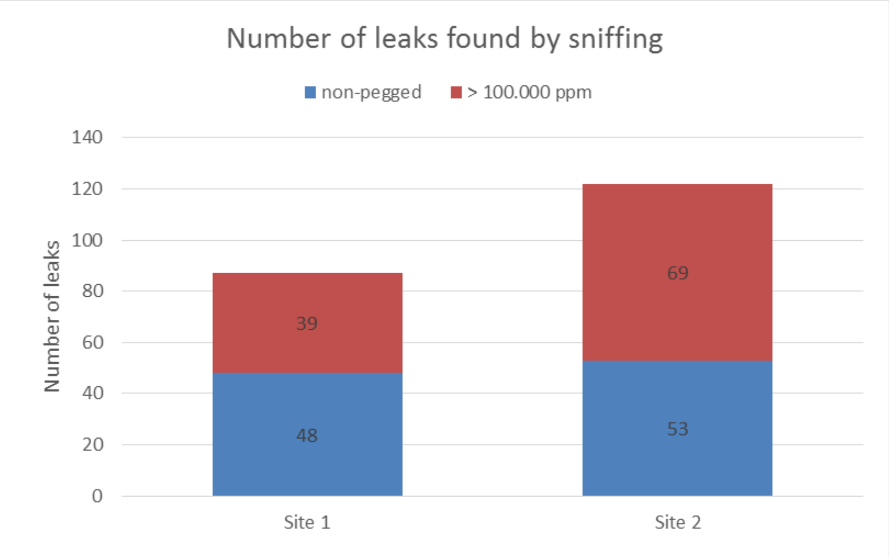
(1) In campaigns #2 and #3 the same sub-set of campaign #1 was surveyed

Results (1): Sniffing Method conclusions

The emissions estimated by the EN 15446 factors and correlations are conservative for a facility where no large leaks (e.g. 200 g/h) are present

- Emissions estimated with Method 21 and HFS:
  - Site 1: factor 12 difference
  - Site 2 sub-unit 1: factor of 1.6 difference





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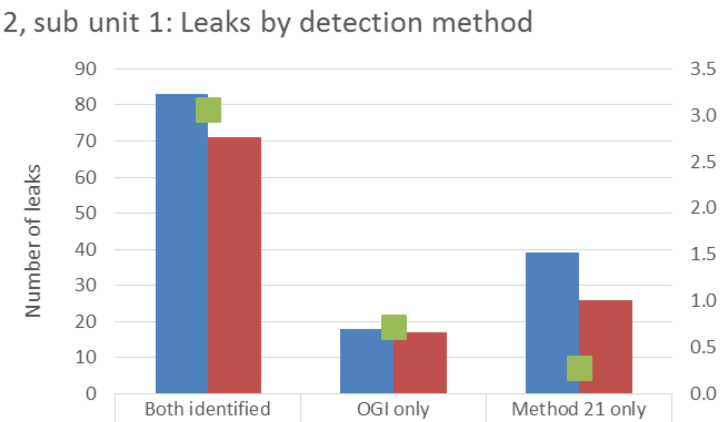
Results (2): Leaks found by each method

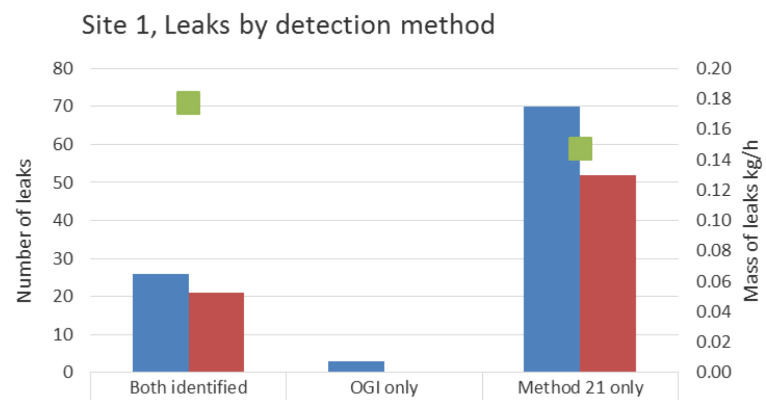
OGI and Sniffing may not find the exact same leaks. However, the "common leaks" found represent the largest portion of the total VOC mass emissions.

OGI was able to detect up to 90% of the total NMVOC mass of accessible leaks in a single campaign. This is comparable to Sniffing, where some leaks are missed (e.g. equipment non-accessible or missing from the LDAR database).

- Mass of accessible OGI leaks (Both identified + OGI only):
  - Site 2 sub-unit 1: 90% of the total mass
  - Site 1: 55% of the total mass



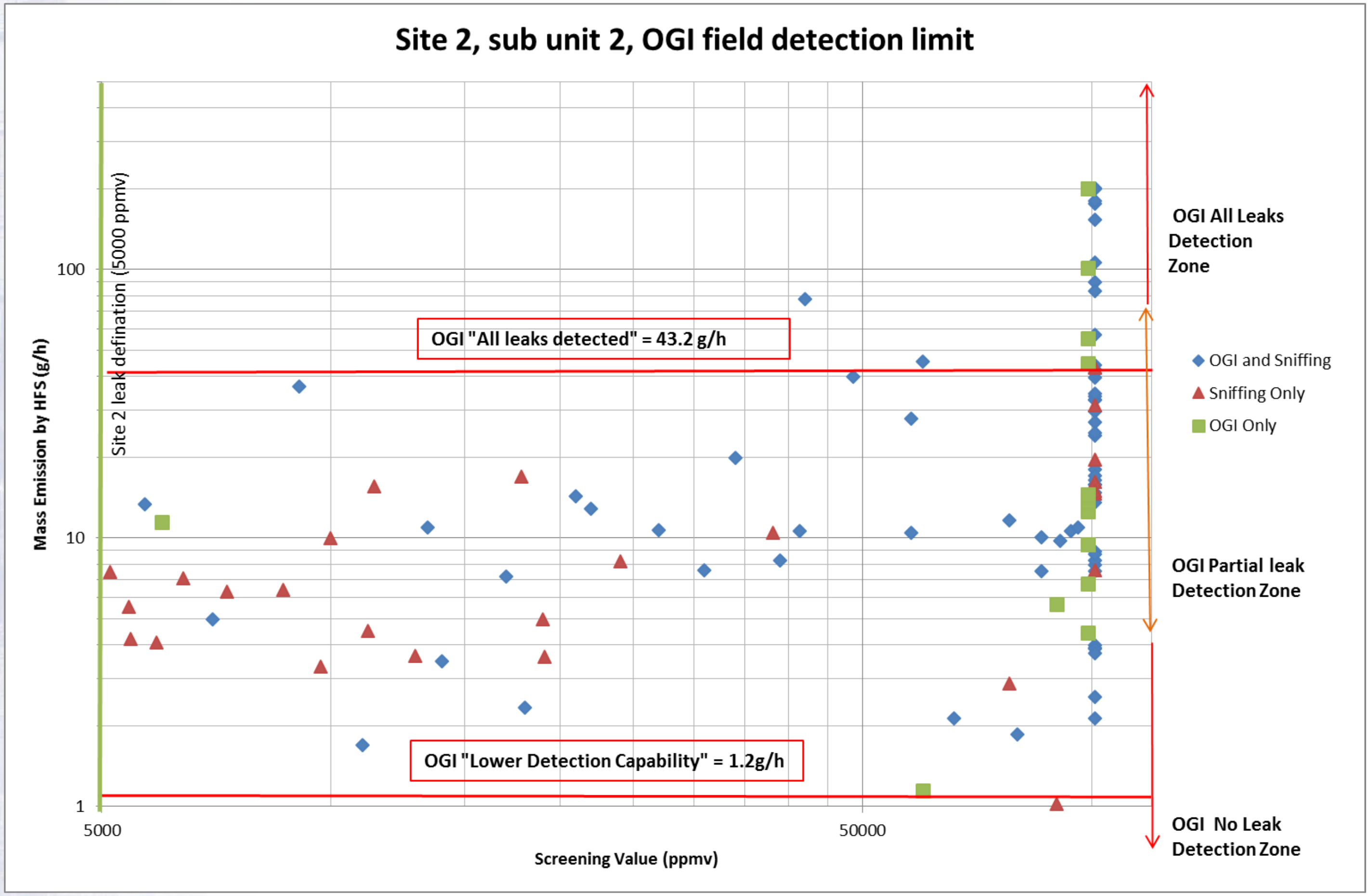
	Both identified	OGI only	Method 21 only
Total number of leaks detected	83	18	39
Number of leaks bagged	71	17	26
Mass of bagged leaks kg/h	3.1	0.7	0.3



	Both identified	OGI only	Method 21 only
Number of leaks detected	26	3	70
Number of leaks bagged	21	0	52
Mass of bagged leaks kg/h	0.18	0	0.15

Results (3): OGI field detection limit

In real conditions, the OGI detection limit cannot be defined by one single number. For the Concawe survey (Site 2 sub-unit 1, Campaign 3), OGI detected all leaks above 43 g/h and 80 % of the leaks above 1 g/h



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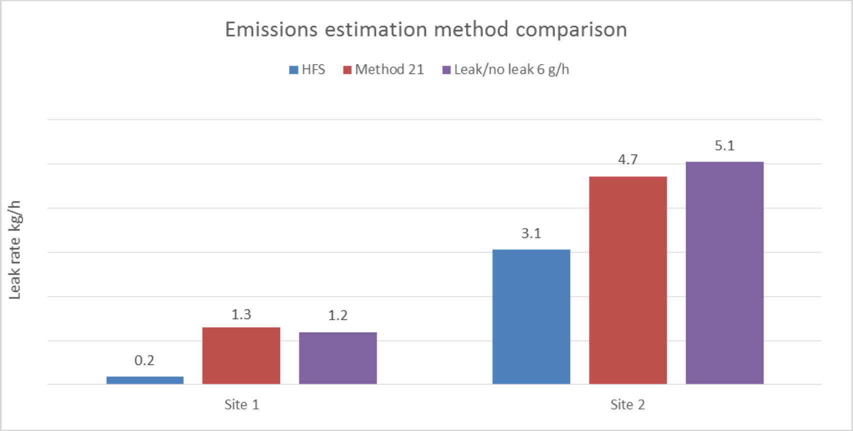
Results (4): leak estimation factors with OGI

Concawe recommends using the 6 g/h factors from the API study (*) to get a good estimation of the site VOC emissions with LDAR surveys using OGI



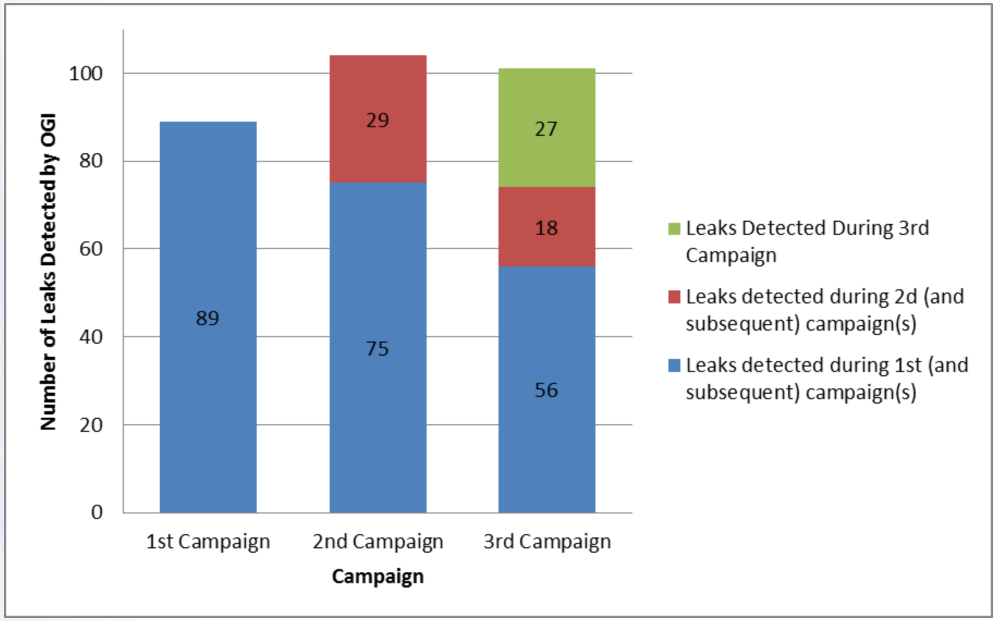
Component Type	Emission Factors (g/hr) for Specified Leak Definitions				
Leak Definition - Instrument Detection Limit (g/hr)		3	6	30	60
Valves	No-Leak	0.019	0.043	0.17	0.27
	Leak	55	73	140	200
Pumps	No-Leak	0.096	0.13	0.59	0.75
	Leak	140	160	310	350
Flanges	No-Leak	0.0026	0.0041	0.01	0.014
	Leak	29	45	88	120
All Components	No-Leak	0.007	0.014	0.051	0.081
	Leak	56	75	150	210

Table reference: **DERIVATION OF NEW EMISSION FACTORS FOR QUANTIFICATION OF MASS EMISSIONS WHEN USING OPTICAL GAS IMAGING FOR DETECTING LEAKS, AWMA Journal 2007**

(*) recommended factors for OGI surveys (API)

Results (5): OGI leaks per campaign

Successive campaigns show that some additional leaks are found and some previous leaks are not detected again.



Remark: unexpected shut-down between 2nd and 3rd campaign

Summary & Conclusions (1)

- Both OGI and Sniffing are part of BAT6: monitoring of diffuse VOC emissions to air.
- In the parallel field campaigns both methods missed some of the leaks but a large fraction of the mass of the leaks was found by both methods. However,
  - OGI is/was a faster method
    - OGI: 2000 points per day can be surveyed
    - Sniffing: 500 points per day can be surveyed
  - OGI is/was able to find leaks which are "Sniffing in-accessible", e.g.
    - Not possible to reach without scaffolding or under insulation
    - Not in the Sniffing database

Summary & Conclusions (2)

- OGI cameras have been improved and nowadays relatively low detection limits can be achieved
  - Lower detection limit for the OGI camera in the field campaigns was around 1g/h and a major part of the leaks above that limit were found by OGI
  - In the lab test the lowest leak detectable by OGI was 0,2 g/h
- Emissions estimated by the Method 21 factors and correlations are conservative for a facility where no large leaks are present
- Using the 6 g/h OGI leak/no leak factors gives a fair (and sometimes conservative) VOC estimate
- OGI can be used as a stand-alone method for the LDAR campaigns

Back-up

REF BREF BAT conclusions

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.

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Accepted LDAR methods in EU, Refining & Chemical sectors

	Belgium /NL (*)	France	UK	Italy	Norway	Spain
Accepted LDAR method	Sniffing (EN15446)	Sniffing (EN15446) (***)	Sniffing or OGI	Sniffing + OGI (combined)	Sniffing or OGI	Sniffing (EN15446)
Legislation	national	permit	national (refinery)	national	permit	permit
Database of components	required	required	optional	required	optional	required
Frequency of surveys	100%/year to 20%/year - Component type - Leak %	20%/year (average)	Permit defined	Minimum 100%/year	Permit defined	Permit defined
Leak threshold	1000 ppm	5000 ppm 10000 ppm	Permit defined	10000 ppm (3000 ppm**)	Permit defined	10000 ppm
Repair timing (simple)	1 month (B) 2 months (NL)	3 months	Permit defined	2 weeks	Permit defined	Permit defined
Repair timing (final)	3 months (total time); keep list of postponed repairs	1 year (or next stop if not possible)	Permit defined	at next stop (latest); keep list of postponed repairs	Permit defined	Permit defined

(*) similar regulations (though different in some details)
(**) Post IED permit renewals
(***) OGI was accepted at some sites for all equipment

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Comparison sniffing/OGI (1)

Technique	Sniffing	Gas Imaging
Detection device	Hand-held FID or PID	Hand-held gas imaging camera
Detection mode	Concentration measurement at every potential leak point in the field. The sniffing probe needs to be within 1-2cm of the point where a leak can occur.	Scanning of facilities and detection of plumes. Scanning at a distance is feasible.
Applicability	All plants handling volatile hydrocarbons, particularly facilities where piping systems are easily accessible. Plants handling highly toxic substances for which very small leaks must be detected.	All plants handling volatile hydrocarbons, particularly larger facilities or facilities where many potential leak points are covered by insulation or are not easily accessible.
Result	Concentration (ppm) in the immediate vicinity of the leak	Video where leaks appear as plumes
Detection limit	Depends on the nature of substances. Can detect also very low concentrations (a few ppm) provided a suitable instrument is used.	Depends on the nature of substances. 1 to 10 g/h for aliphatic hydrocarbons and benzene.
Reliability	Occurrence of false positives (tiny leak with high ppm) and false negatives (large leak with low ppm)	If performed by a skilled operator, all leaks above the detection threshold will be consistently detected

Comparison sniffing/OGI (2)

Technique	Sniffing	Gas Imaging
Limitations	Accessibility: need to have close-range access to potential leak points Not suitable for items covered by insulation Not practical for components that are out of reach Will detect only leaks of items included in the scope of the survey program	Depends on the detection limit for the substances being emitted No limitation for accessibility. Leaks under insulation are normally detected Surveys include all potential leak sources
Detector cost	5,000 to 20,000 €	70,000 to 100,000 €
Survey manpower	500 components per day per surveyor, very labor-intensive	1,500 to 2,000 components per day for 2-people team
Emission quantification	Correlations between ppm measured and kg/h leak rate; quantification of individual leaks not reliable	Leak-no leak factors applied to all potential leak points; quantification of individual leaks not possible
System requirements	Emission calculation requires a database of all potential leak points	Emission calculation requires a detailed count of the number of equipment. For speciation of emissions a database may be needed.