

Industrial and Environmental Online Measurements using FTIR instruments

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 **Gasmeter™**



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Advanced Solutions for Gas Monitoring

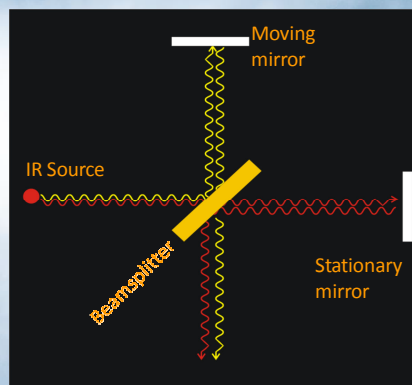
FTIR TECHNOLOGY

FTIR overview

- FTIR (Fourier Transform InfraRed) spectroscopy is a well-established technique for measuring the infrared spectrum across a wide wavelength range rapidly and reliably
- Wavelength range typically 2 – 16 μm
- Scan speeds up to 10 Hz or more
- Excellent Signal-to-Noise ratio and stability afforded by the use of a simple optical modulator (interferometer)
- The measured IR spectra can be used for qualitative and quantitative chemical analysis

Interferometer basics

- Simplified schematic for explaining the operating principle
- Beamsplitter for dividing the incoming IR beam into two parts
- Two plane mirrors for reflecting the two beams back to the beamsplitter where they interfere either constructively or destructively depending on the position of the moving mirror
- Position of moving mirror is expressed as Optical Path Difference (OPD)



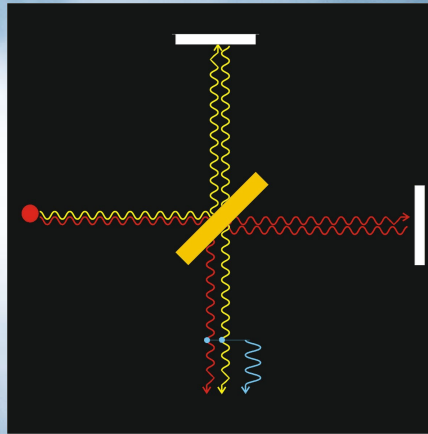
OPD = Distance travelled by red beam
minus distance travelled by yellow beam

Interferometer basics

When moving mirror is in the original position, the two paths are identical and interference is **constructive**

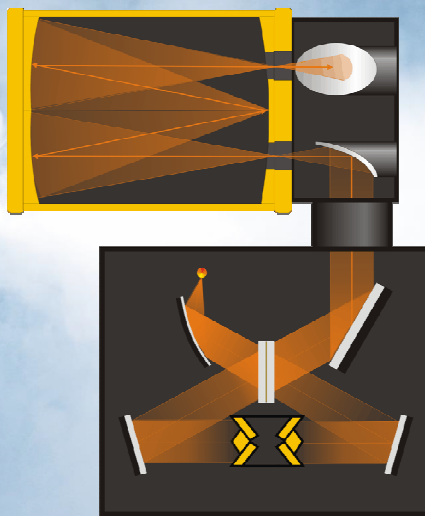
When the moving mirror moves $\frac{1}{4}$ of wavelength, the path difference is $\frac{1}{2}$ wavelength and interference is **destructive**

Mirror moves back and forth at constant velocity – the intensity of the interference signal varies as a sine wave



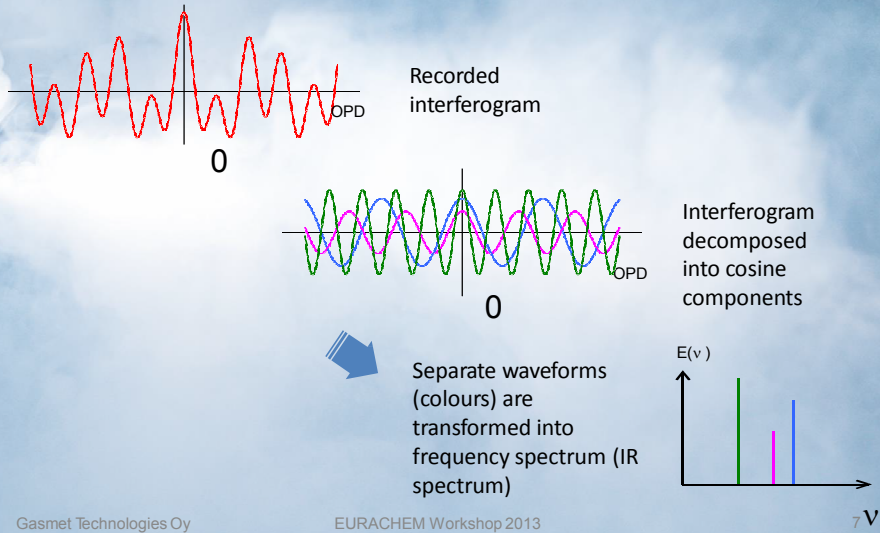
Amplitude of blue wave corresponds to IR signal picked up by detector

Gasmet solution

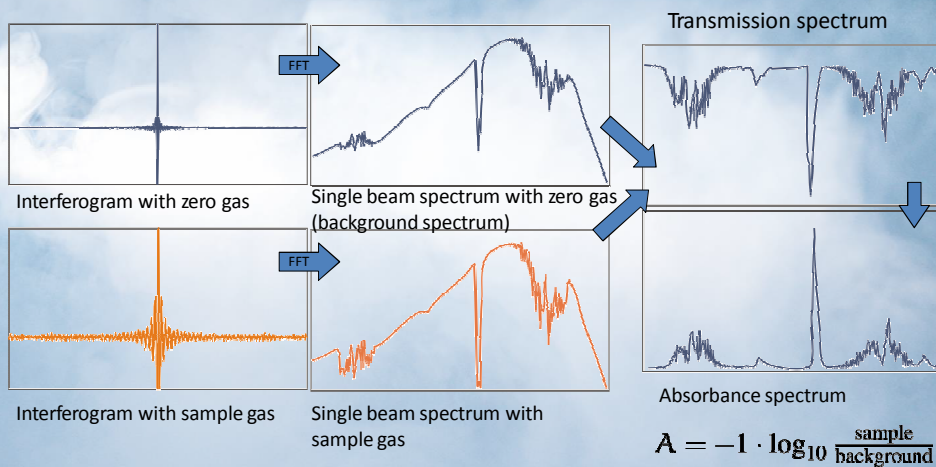


- Permanently aligned GICCOR interferometer
- Moisture resistant optics
- Cube corner moving mirrors for extra stability
- Optimized for its intended task – low resolution measurements with high signal-to-noise ratio (SNR)
- Operating temperature range 0 ... 40 degrees C
- Rugged multi-coated sample cell with heating, withstands corrosive gases

From interferogram to Spectrum



Measuring Sequence



MULTICOMPONENT ANALYSIS

The process from a sample to an analysis result has two phases:

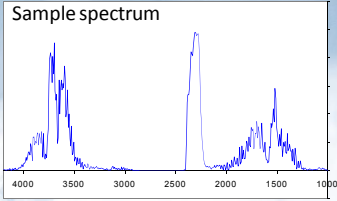
- In the first phase an IR spectrum is measured in the FTIR analyzer's gas sample cell.
- In the second phase, the application library built by Gaset experts or the user is used to analyze the saved sample spectrum.
- In both phases the Gaset corporation's Calcm software is used: in the 1st phase for control of the analyzer, and in the 2nd phase for the mathematical analysis of the sample spectra.

Quantitative IR spectroscopy

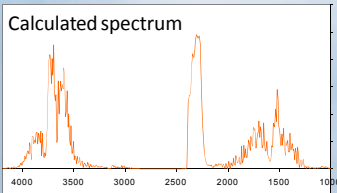
FTIR spectra are suitable for quantitative analysis of multiple gases simultaneously

- Good SNR and spectral stability ensure repeatability of measurement and calibration stability
- Measurement across entire MID-IR range enables most gases to be identified and analysed from a single spectrum
- IR spectra follow Lambert-Beer law and possible nonlinear effects are easily modeled
- In gas phase there is little interaction between molecules and a simple additive model (sample spectra is a sum of component spectra) works well

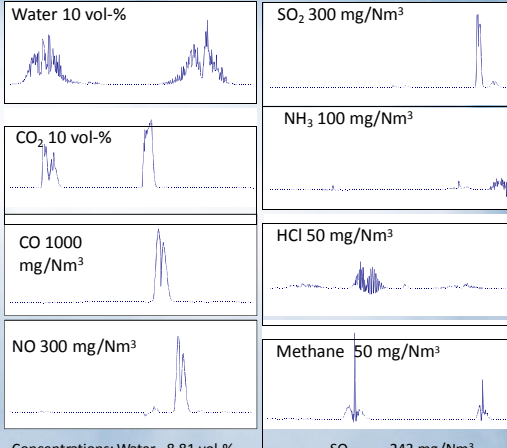
CLS modeling of IR spectra



CALCMET Analysis:
 0.881 * Water 10 vol-%
 1.112 * CO₂ 10 vol-%
 0.995 * CO 1000 mg/Nm³
 0.910 * NO 300 mg/Nm³
 0.810 * SO₂ 300 mg/Nm³
 0.660 * NH₃ 100 mg/Nm³
 0.082 * HCl 50 mg/Nm³
 0.210 * Methane 50 mg/Nm³

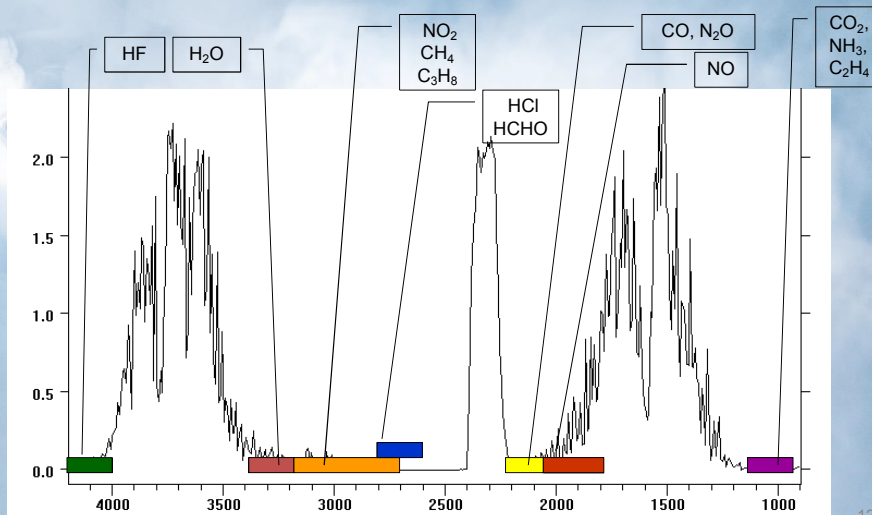


Reference Spectra (not to same scale):



Concentrations: Water	8.81 vol-%	SO ₂	243 mg/Nm ³
CO ₂	11.12 vol-%	NH ₃	66.0 mg/Nm ³
CO	955 mg/Nm ³	HCl	4.1 mg/Nm ³
NO	274 mg/Nm ³	Methane	10.5 mg/Nm ³

Analysis Areas and typical sample spectrum



PORTABLE FTIR GAS ANALYSERS AND APPLICATIONS

Gasmet DX-4000 FTIR 'Hot' Portable System

- Portable FTIR analyzer with heated sample cell (180°C).
- Separate portable sampling system with a diaphragm pump.
- Heated lines (180°C) connect probe to sampling system, and sampling system to analyzer.
- Control and analysis is done by Calcmet software operating on a laptop computer.
- A single system that is easy to use and fast to setup on the field.



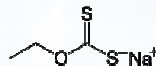
EN 14181's QAL2 measurements

- In large combustion plants (over 50 MW) and waste incineration plants the gas emissions have to be monitored continuously with AMS/CEMS. And these installed monitoring systems must undergo periodic quality assurance tests (QAL2 by authorities, QAL3 by user).
- In Finland, Gasmet's DX-4000 Portable (Hot) FTIR Gas Analyzer is accepted by authorities for the QAL2 comparison measurements.



Nickel and copper recovery at mine site

- The mining industry uses chemicals as 'flotation' agents in the recovery of sulphide minerals containing metallic elements (e.g., copper, nickel, silver, gold) from ore slurries.

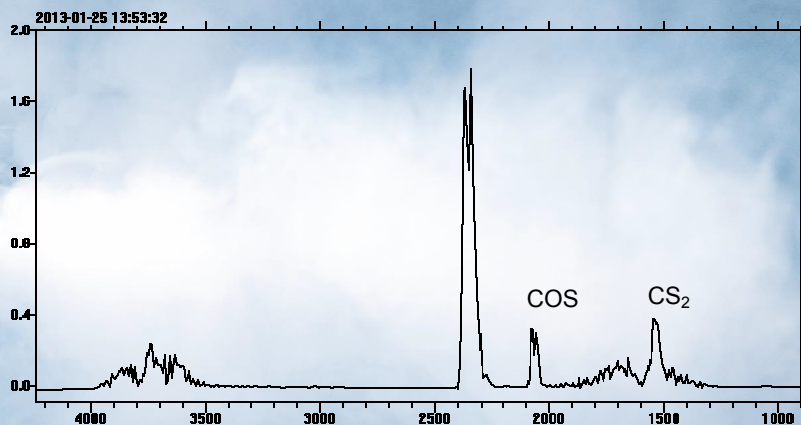


- Sodium Ethyl Xanthate (SEX) is one of most common flotation agents. It decomposes to Ethanol and either Carbon Disulfide CS₂ or Carbonyl Sulfide COS, toxic gases with very low allowed exposure limits. Both must be monitored in indoor air at the enriching plant

Nickel and copper recovery at mine site

- Xanthate solution is stored in tanks, which need periodic cleaning due to sludge buildup as the chemical decomposes over time
- Removing the sludge releases sulfur containing gases (CS_2 , COS) and the cleaning interval varies from 3 to 12 months.
- In the actual flotation process, workers involved in checking flows, the head tank or in adjusting and monitoring the pulp levels in the flotation process could be exposed to CS_2 .
- There are no low-cost reliable gas sensors for CS_2 and COS , portable FTIR (DX4040) is a good choice
- H_2S has to be monitored for personnel safety, so an additional personal monitor should be worn

Spectrum



Dry air with COS and CS_2
Straightforward analysis, low ppm concentrations produce high absorbance peaks

STATIONARY FTIR ANALYSERS AND APPLICATIONS

Hospital application

- Installation at Mater Dei Hospital in Malta
- Case study to follow after customer has installed a reporting system to complement analyser
- Calcmet software was modified to meet customer requirements

Line	Description	CO2	N2O	DESFL	SEVOFL	ISOFL
1	OP THEATRE 1	3.63	0.27	0.000	0.000	0.000
2	OP THEATRE 2	2.46	0.47	0.000	0.004	0.000
3	OP THEATRE 3	2.27	0.71	0.000	0.000	0.000
4	OP THEATRE 4	2.46	0.49	0.000	0.000	0.015
5	OP THEATRE 5	0.97	0.00	0.000	0.005	0.000
6	OP THEATRE 6	2.90	0.51	0.000	0.001	0.000
7	OP THEATRE 7	2.26	0.57	0.000	0.001	0.000
8	OP THEATRE 8	2.51	0.59	0.000	0.000	0.000
9	OP THEATRE 9	2.59	1.59	0.000	0.000	0.000
10	OP THEATRE 10	1.84	20.24	0.000	0.000	0.000
11	OP THEATRE 11	1.52	0.59	0.000	0.000	0.000
12	OP THEATRE 12	1.13	21.34	0.000	0.000	0.000
13	OP THEATRE 13	3.16	4.60	0.000	0.000	0.000
14	OP THEATRE 14	4.88	0.50	0.000	0.011	0.000
15	OP THEATRE 15	1.24	13.40	0.000	0.000	0.000
16	OP THEATRE 16	2.06	22.18	0.000	0.000	0.000
17	OP THEATRE 17	5.16	0.57	0.000	0.000	0.000
18	OP THEATRE 18	0.80	0.00	0.000	0.000	0.000
19	OP THEATRE 19	4.93	7.45	0.000	0.000	0.000
20	MAIN RECOVERY 1	36.30	20.65	0.000	0.001	0.000
21	MAIN RECOVERY 2	0.87	0.50	0.000	0.014	0.000
22	MAIN RECOVERY 3	0.76	0.80	0.000	0.023	0.000
23	ENDOSCOPY ROOM 1	2.20	0.04	0.000	0.001	0.000
24	ENDOSCOPY ROOM 2	0.70	0.36	0.013	0.000	0.000
25	ENDOSCOPY ROOM 3	1.87	17.52	0.000	0.005	0.000
26	Litho room	2.84	0.11	0.000	0.000	0.000
27	Endoscopy II room	4.21	10.50	0.003	0.000	0.000
28	Daycare recovery 1	11.24	0.00	0.000	0.001	0.000
29	Daycare recovery 2	3.40	0.21	0.000	0.000	0.000
30	Daycare recovery 3	1.84	21.24	0.000	0.000	0.000
31		-	-	-	-	-
32		-	-	-	-	-



Hospital application

- N₂O (laughing gas) and anaesthetic gases are monitored continuously in 30 separate rooms/locations
- Tight limit values:
 - N₂O: 2 ppm
 - Fluranes 0.5 ppm
- Short measuring times:
 - Measuring time 10 s
 - Flush time 20 ... 120 seconds depending on line length
 - Cycle time 33 minutes for 30 lines
- Analysis works quite well, only few false alarms
- Scatter in flurane and N2O readings < 0.1 ppm at 10 sec measuring time
- Very easy matrix (clean air with controlled humidity levels)

Line	Description	CO2	N2O	DESFL	SEVOFL	ISOFL
1	OP THEATRE 1	3.88	0.23	0.000	0.000	0.000
2	OP THEATRE 2	2.46	0.47	0.000	0.004	0.000
3	OP THEATRE 3	2.27	0.71	0.000	0.000	0.000
4	OP THEATRE 4	2.40	3.87	0.000	0.000	0.015
5	OP THEATRE 5	0.98	0.50	0.000	0.005	0.000
6	OP THEATRE 6	3.90	0.51	0.000	0.001	0.000
7	OP THEATRE 7	2.06	0.53	0.000	0.001	0.000
8	OP THEATRE 8	2.51	0.59	0.000	0.000	0.000
9	OP THEATRE 9	2.88	1.36	0.000	0.000	0.000
10	OP THEATRE 10	1.24	23.24	0.000	0.000	0.000
11	OP THEATRE 11	3.32	0.58	0.000	0.000	0.000
12	OP THEATRE 12	1.37	21.31	0.000	0.000	0.000
13	OP THEATRE 13	3.88	0.80	0.000	0.000	0.000
14	OP THEATRE 14	4.04	0.50	0.000	0.011	0.000
15	OP THEATRE 15	1.34	13.49	0.000	0.000	0.000
16	OP THEATRE 16	2.00	02.20	0.000	0.000	0.000
17	OP THEATRE 17	5.16	0.55	0.000	0.000	0.000
18	OP THEATRE 18	0.99	02.98	0.000	0.000	0.000
19	OP THEATRE 19	4.83	7.65	0.000	0.000	0.000
20	MAIN RECOVERY 1	26.30	26.61	0.000	0.001	0.000
21	MAIN RECOVERY 2	0.82	0.86	0.000	0.014	0.000
22	MAIN RECOVERY 3	0.78	0.80	0.000	0.013	0.000
23	ENDOSCOPY ROOM 1	2.30	0.64	0.000	0.002	0.000
24	ENDOSCOPY ROOM 2	0.70	0.36	0.015	0.000	0.000
25	ENDOSCOPY ROOM 3	1.83	17.25	0.000	0.005	0.000
26	LIN Unit room	3.91	0.12	0.000	0.007	0.000
27	Endoscopy 11 room	4.21	10.50	0.003	0.000	0.000
28	Daycare recovery 1	11.24	0.60	0.006	0.002	0.000
29	Daycare recovery 2	3.46	0.22	0.000	0.000	0.000
30	Daycare recovery 3	3.16	22.24	0.000	0.000	0.000
31	-	-	-	-	-	-
32	-	-	-	-	-	-

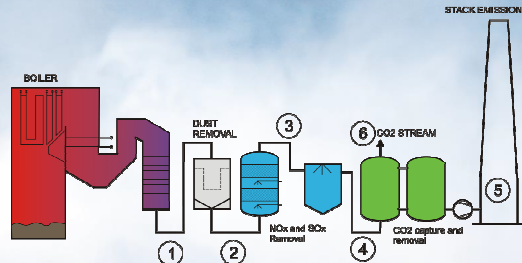
Gasmet Continuous Emissions Monitoring (CEM) System

- Measures and analyses hot, moist and corrosive sample gases.
- Gasmet's CX-4000 FTIR analyzer
 - Heated to 180°C
 - Sample cell optical path can be set according to customer's demand. Standard is 5.0 m.
- Fully automated measurement system, which can also be operated manually.
- Analog and digital inputs and outputs provided by standard.
 - System alarms also as relays.



CERTIFICATE NO: SIRA MC 030014/00

Gasmeter Continuous Emissions Monitoring (CEM) System



- Main applications include emissions monitoring and process gas monitoring :
 - In waste incineration plants, all the demanded gas components can be monitored with a single measurement system
 - In coal-fired power plants with CO₂ capture and storage (MEA emission monitoring)
 - In biomass power plants monitoring of formaldehyde
 - Multiple users in factories in the chemical industry