On-line Moisture Measurement in Biomethane for Injection to Natural Gas Network

Andy Benton

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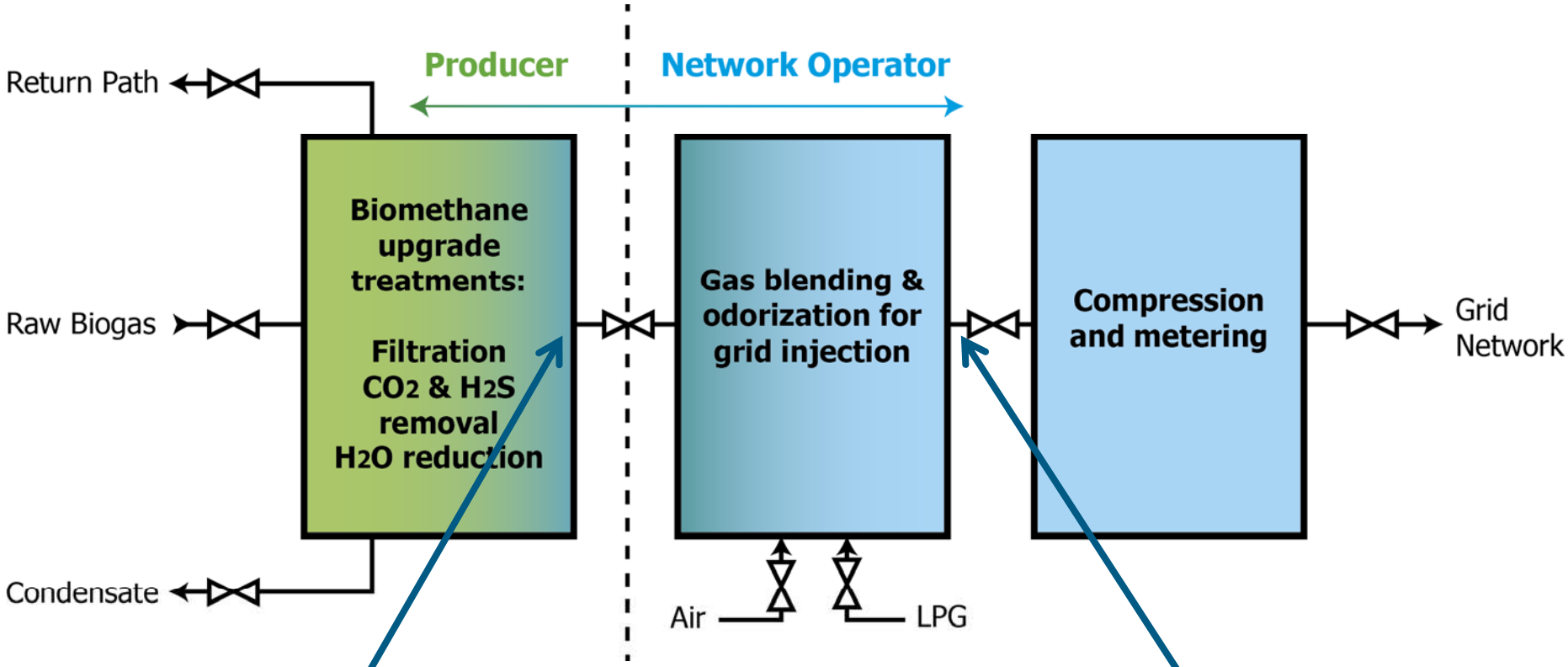
Typical schematic for biomethane



On-line analysis:
O_2, CO_2, H_2S, COS, CH_4, H_2O

On-line analysis:
CV, Wobbe, Density
O_2, CO_2, H_2S, COS, THT, H_2O

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Gas quality standards for network injection biomethane

National specifications currently apply in Europe:

- France (GrDF SBLI001) and Italy (UNI/TR 11537):
  ≤-5°C dew point at process pressure.
- Germany (DVGW G 260):
  Moisture content:
  ≤200mg/m^3 (MOP ≤10 bar)
  ≤50mg/m^3 (MOP >10 bar)

European Standard – In development by CEN/TC:

- prEN 16723-1 and prEN 16726-1:2014

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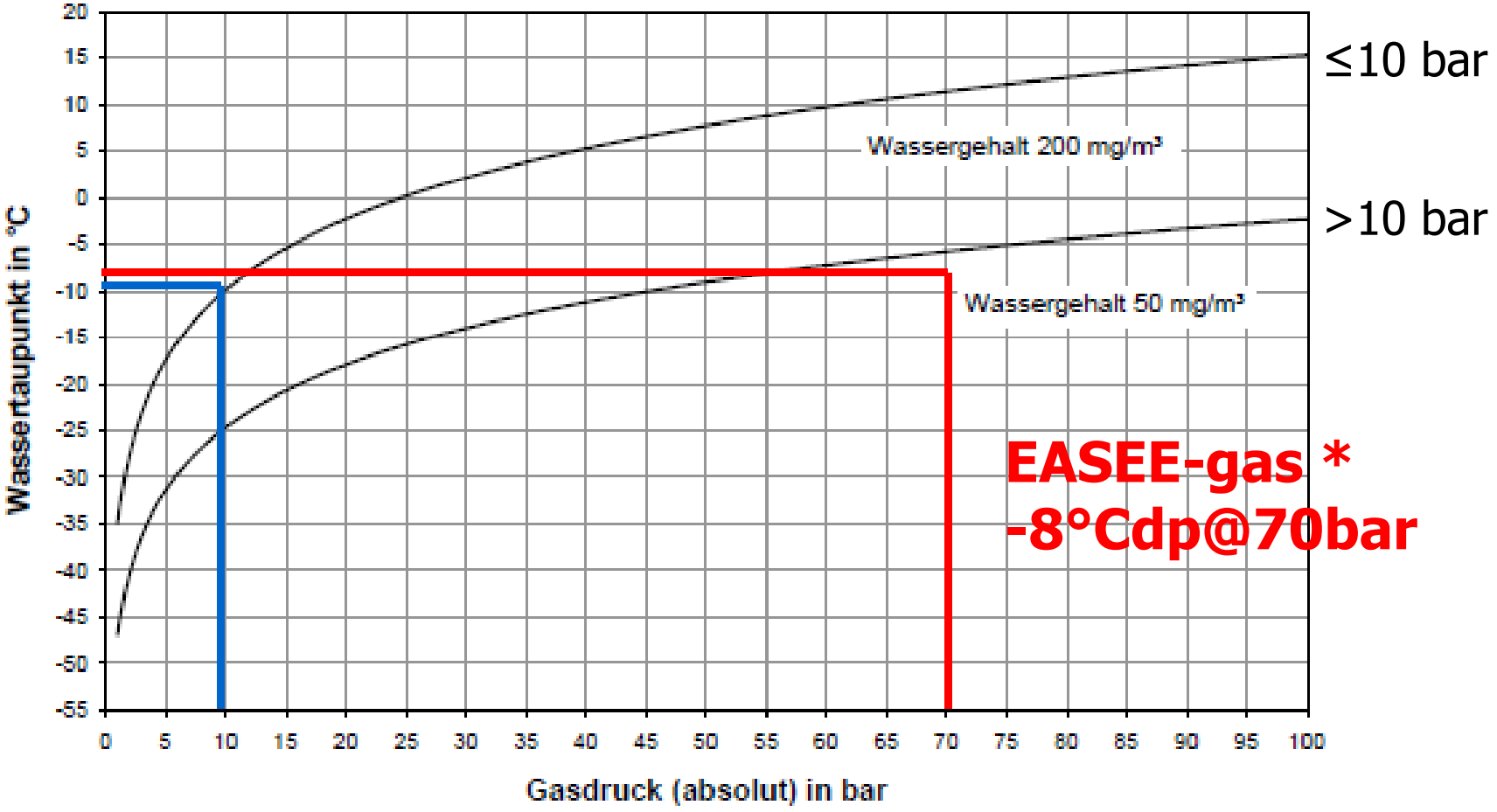
DVGW G 260: Moisture content, mg/m^3
prEN 16726-1:2014 *Gas Infastructure* :
Dew point ≤-8°C at 70 bar



*European Association for Streamlining Energy Exchange

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Dehydration processes

- Refrigeration drying:
  - Separation of condensed water vapour at ≈+2°C and ≈10 bar over-pressure.

- Desiccant drying.
  - Water vapour adsorption. Molecular sieve or silica gel.

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Moisture measurement for biomethane

Biomethane production and network injection:

Metal-oxide capacitance dew-point transmitters.

Key points within grid networks receiving biomethane:

TDLAS (Tuneable Diode Laser Absorption Spectroscopy) Moisture Analyser.

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Metal-oxide Capacitance Dew-point Transmitters

Economical solution for integration to biomethane plant

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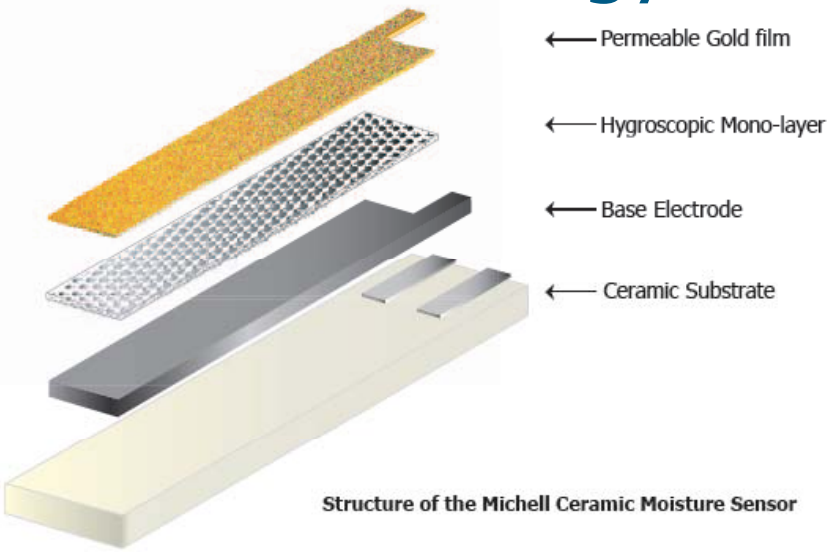
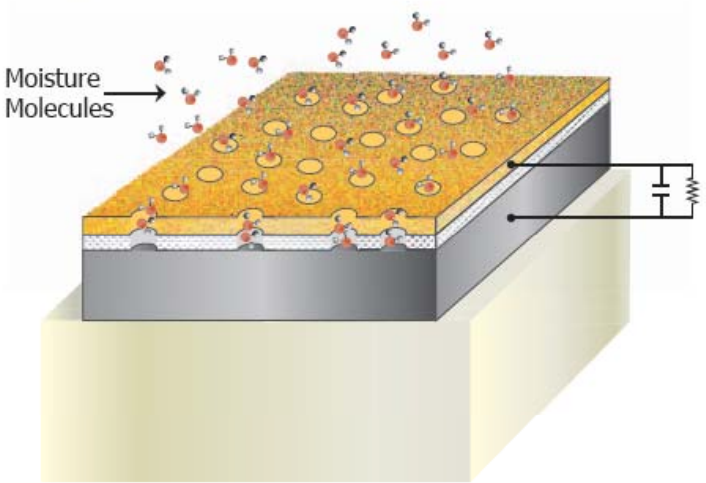
Ceramic metal-oxide sensor technology

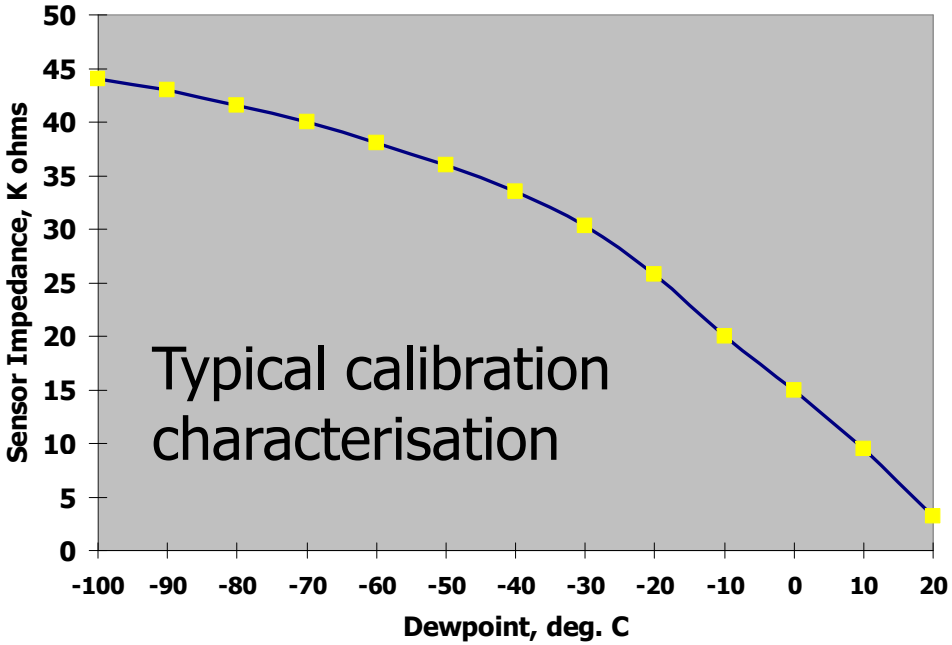


Structure of the Michell Ceramic Moisture Sensor



Operation of the Michell Ceramic Moisture Sensor

- Capacitance sensor with hygroscopic metal-oxide dielectric.
- Porous to adsorb/de-sorb polarised moisture molecules.
- Responds to water vapour pressure which relates directly to dew point temperature



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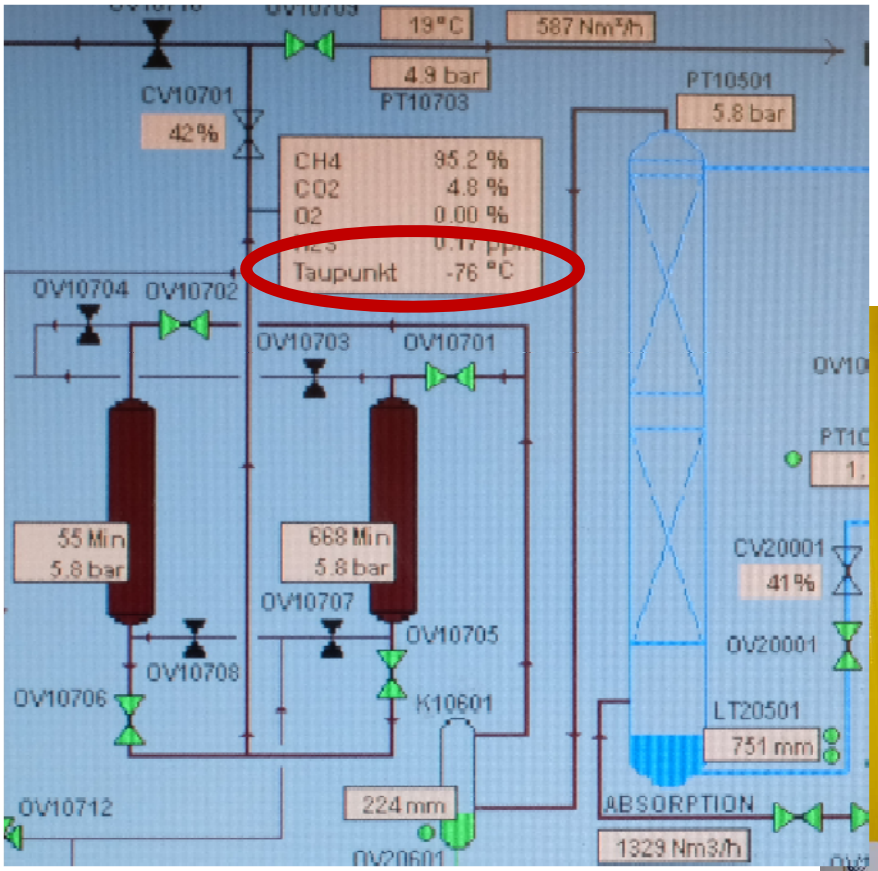
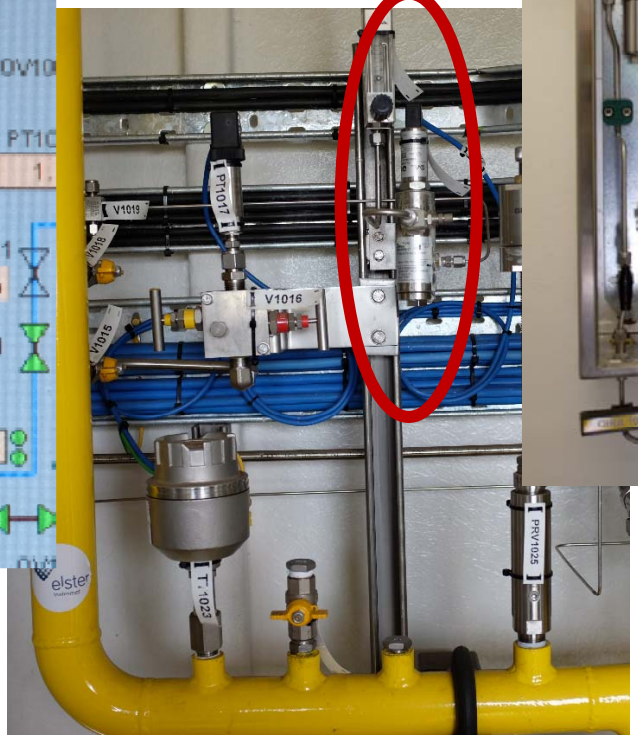
Dew-Point Transmitter installations





Dew-Point temperature at pressure process pressure or converted to moisture content

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TDLAS Moisture Analysis

High accuracy, fast response moisture analysis in natural gas and biomethane

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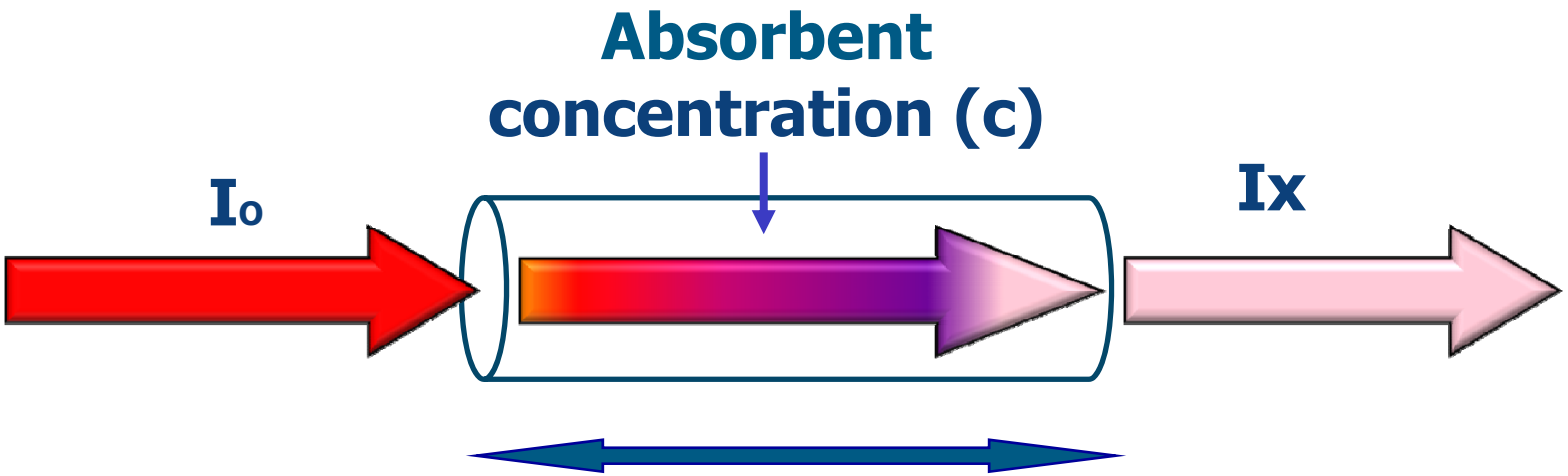
Measurement Principle: Photometric gas absorption



Beer Lambert law*:

$$A = \varepsilon l c$$

A = Absorption (I_0 - I_x)
c = concentration of gas (moisture)
l = pathlength (gas cell length)
ε = extinction coefficient (absorption strength) of gas (moisture)

For known pathlength and molar extinction coefficient, concentration (of moisture) is proportionate to absorption.

* Here simplified for trace moisture measurement

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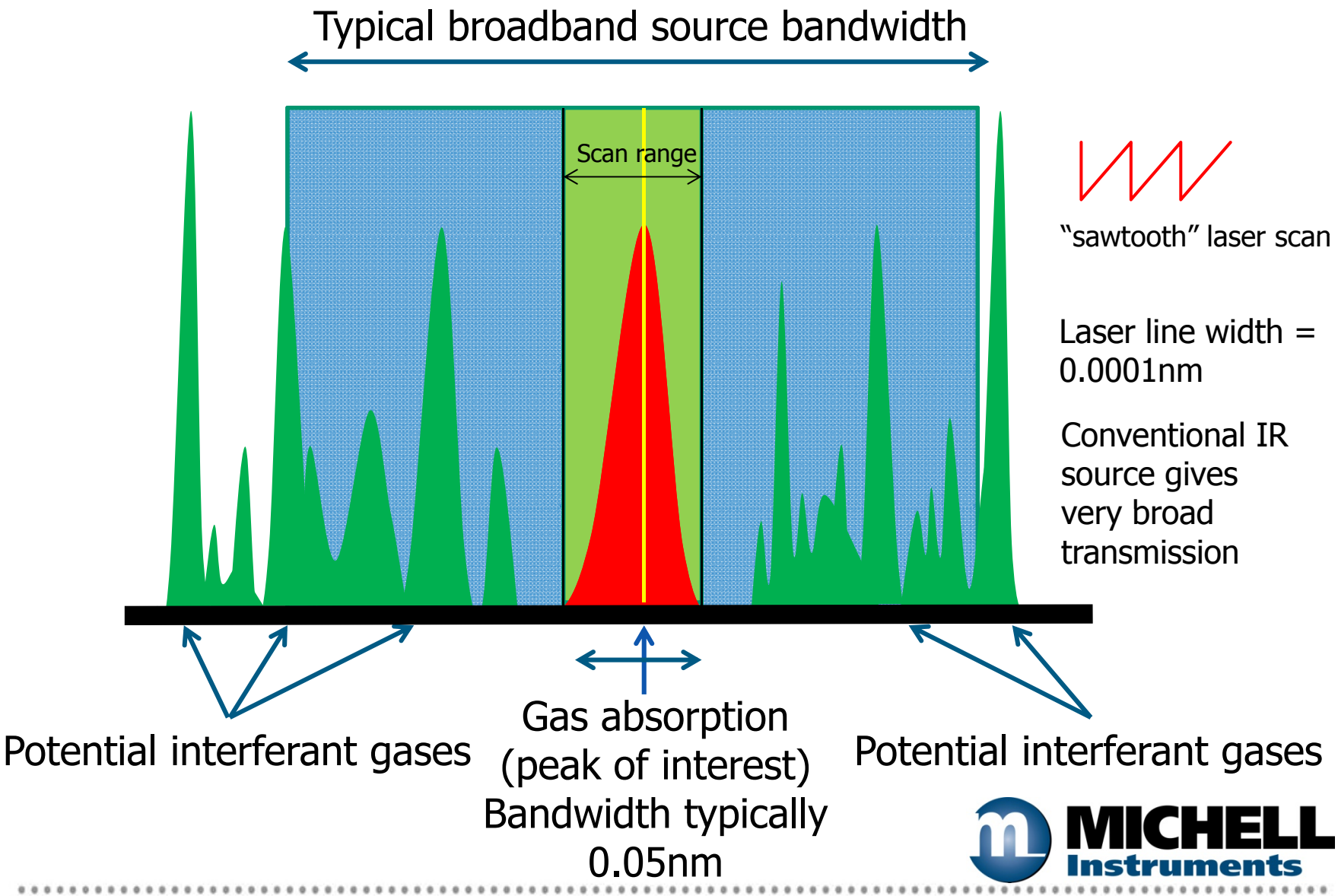
Measurement principle: TDLAS



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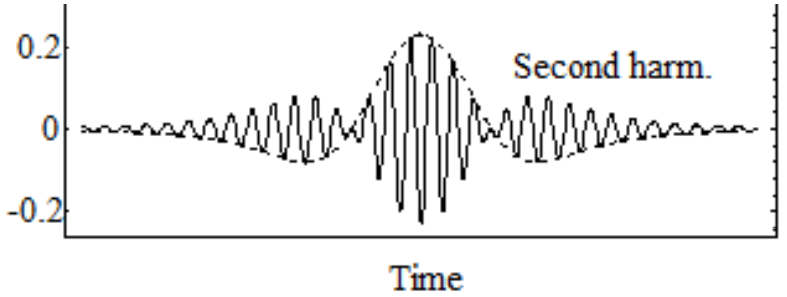
Why TDLAS for moisture measurement?

- Non-contact measurement technique
- Fast response to process moisture changes
- Highly selective and sensitive gas measurement,
  - Accuracy: +/-1ppmV or 1% of reading (whichever is greater)
- Wavelength modulation spectroscopy (WMS):
  - Maximum signal to noise



- Background gas composition compensation:
  - Consistent measurement performance with changing gas.

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Natural gas networks carry gases from multiple and changing sources:

Conventional:

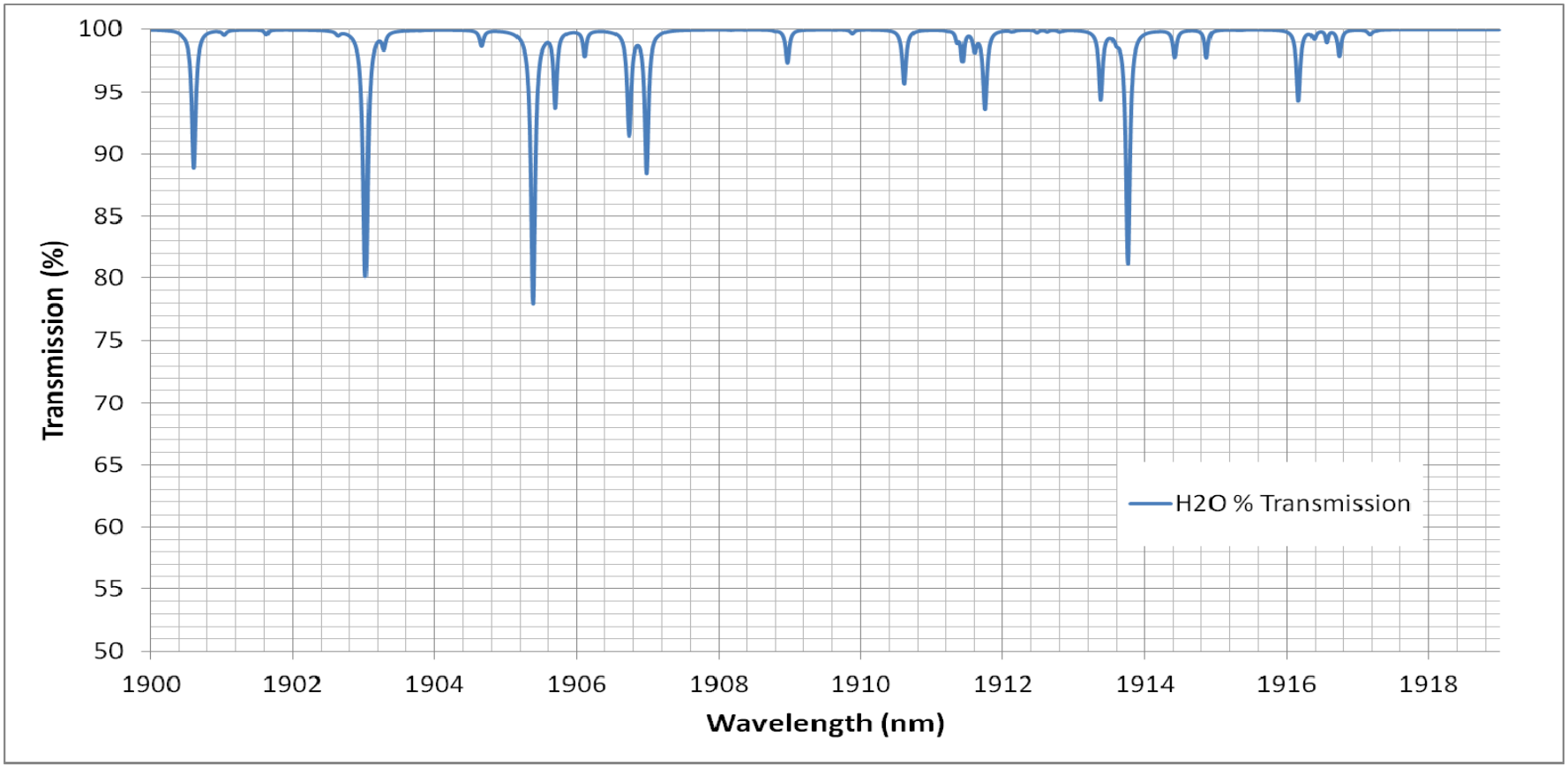
- Natural gas (often from multiple sources)
- LNG and storage gas during demand peaks

Unconventional:

- Biomethane
- Other SNG 'SynGas' including shale gas, coalbed methane
- Hydrogen injection

Conclusion: Analysis of moisture must be unaffected by rapid changes in background composition.

Examples of moisture absorption peaks within the NIR region (HITRAN database).



Unfortunately, other natural gas components absorb NIR.

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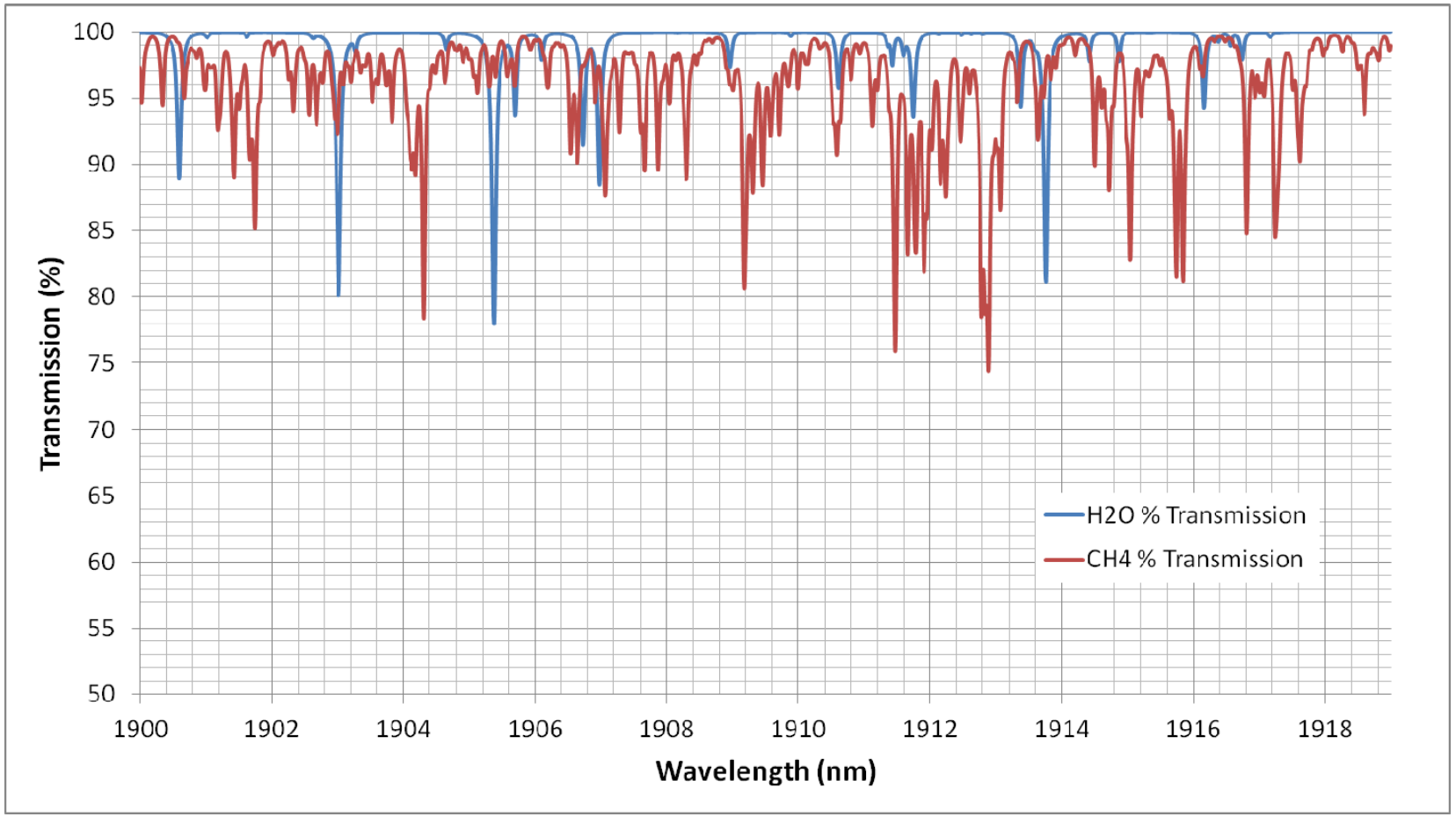
For example, methane also absorbs NIR



Requirement: High sensitivity to moisture content and low sensitivity to methane (and other gas components).

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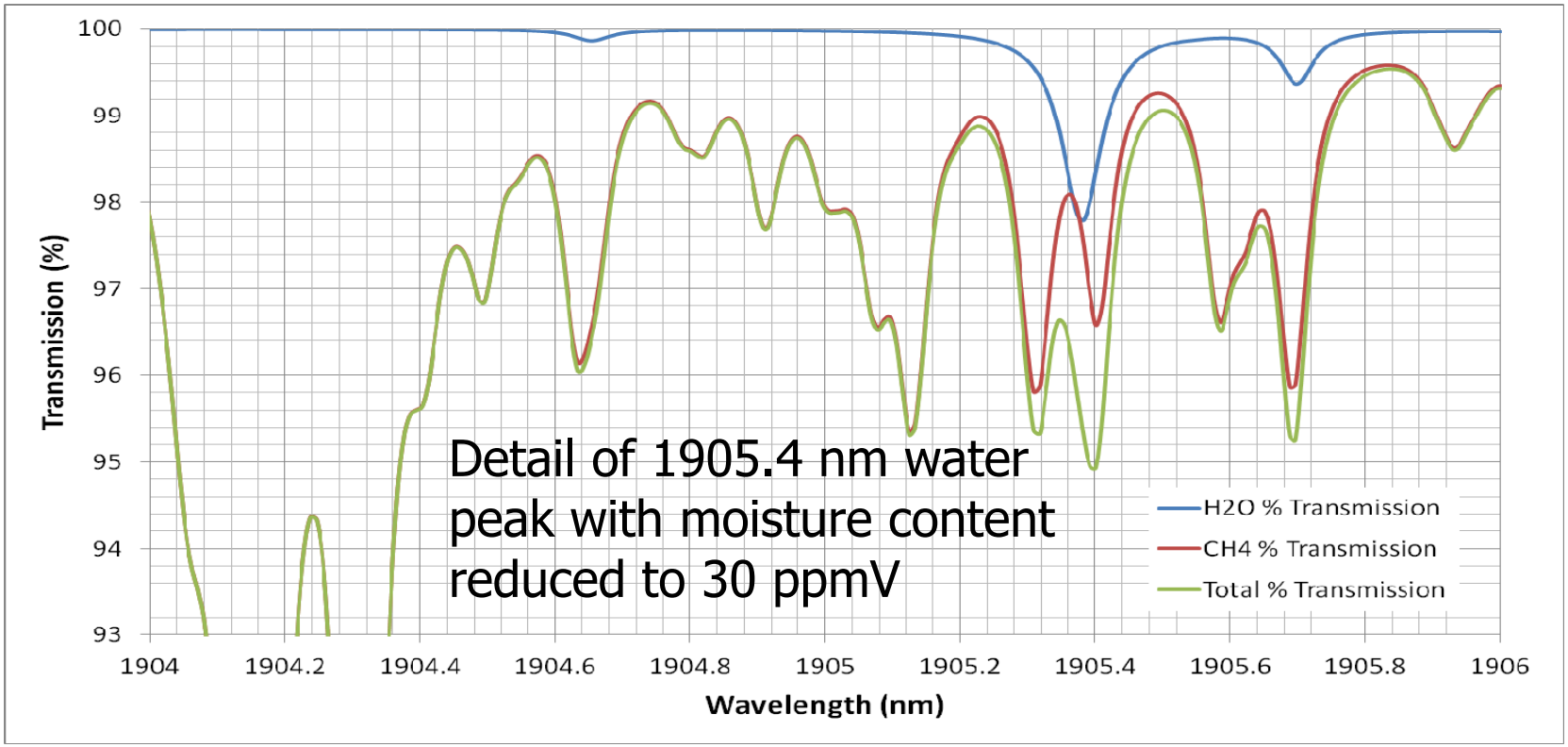
Illustration of spectral interference:



- Defined 'fixed' composition:
  May be possible to 'calibrate out' background offset.
- Variable composition: Requires active compensation.

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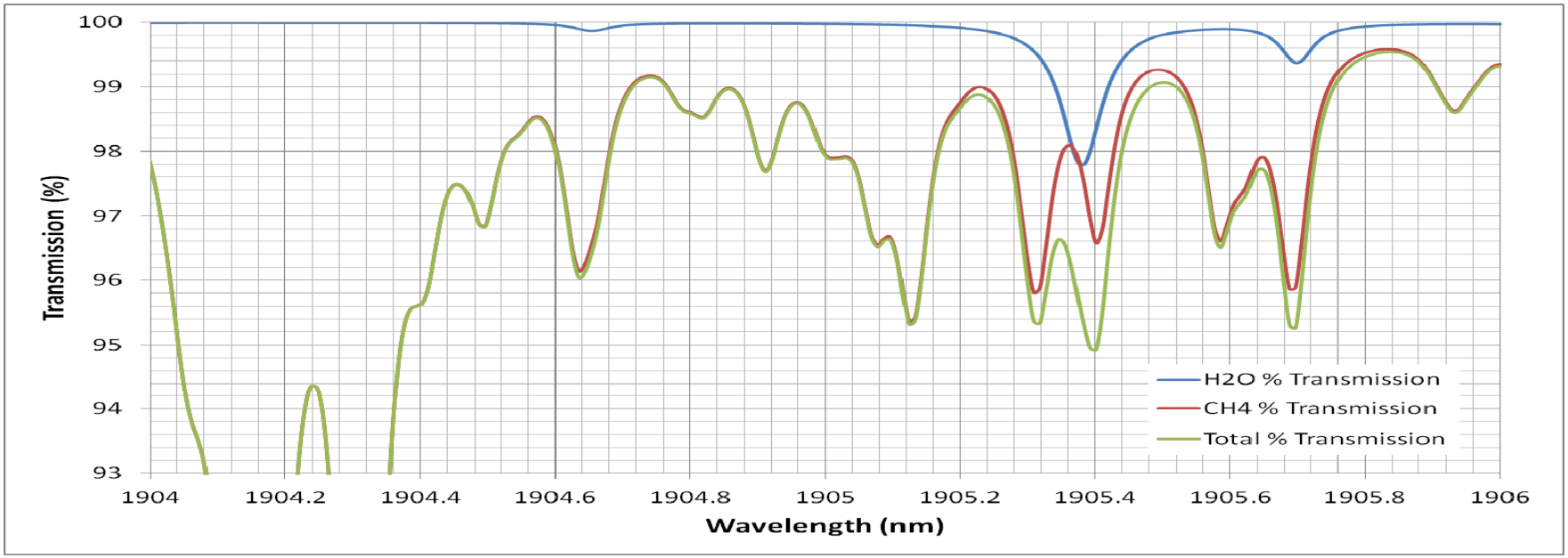
TDLAS: The Michell Approach

- Active compensation requires measurement of composition variations
- For example, measure methane concentration directly:
  - Laser tuned to nearby methane absorption peak
  (with no water interference) as separate secondary measurement.
- Variable methane absorption subtracted from moisture
  Fundamental "clean" detection



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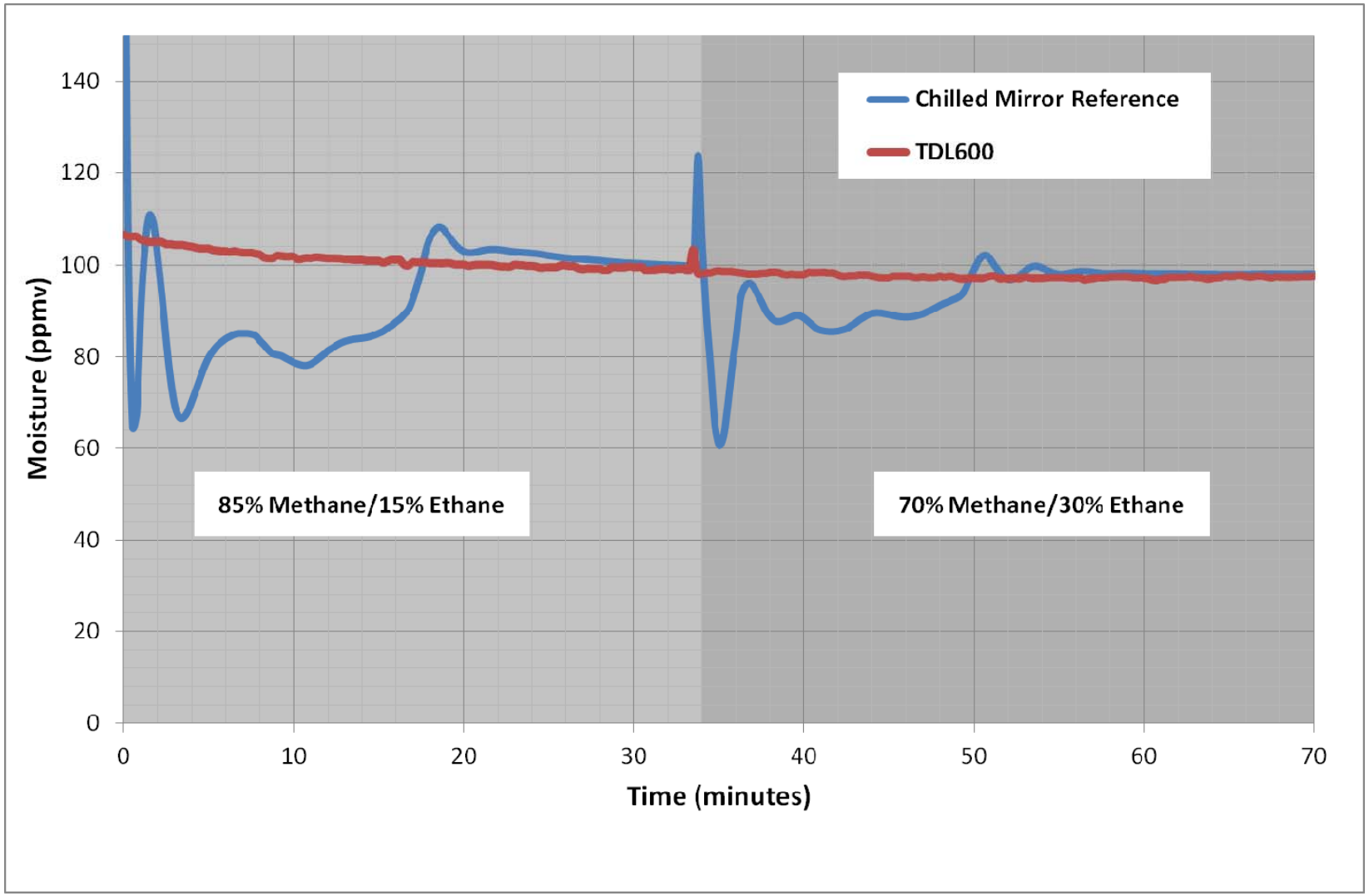
Dynamic composition compensation



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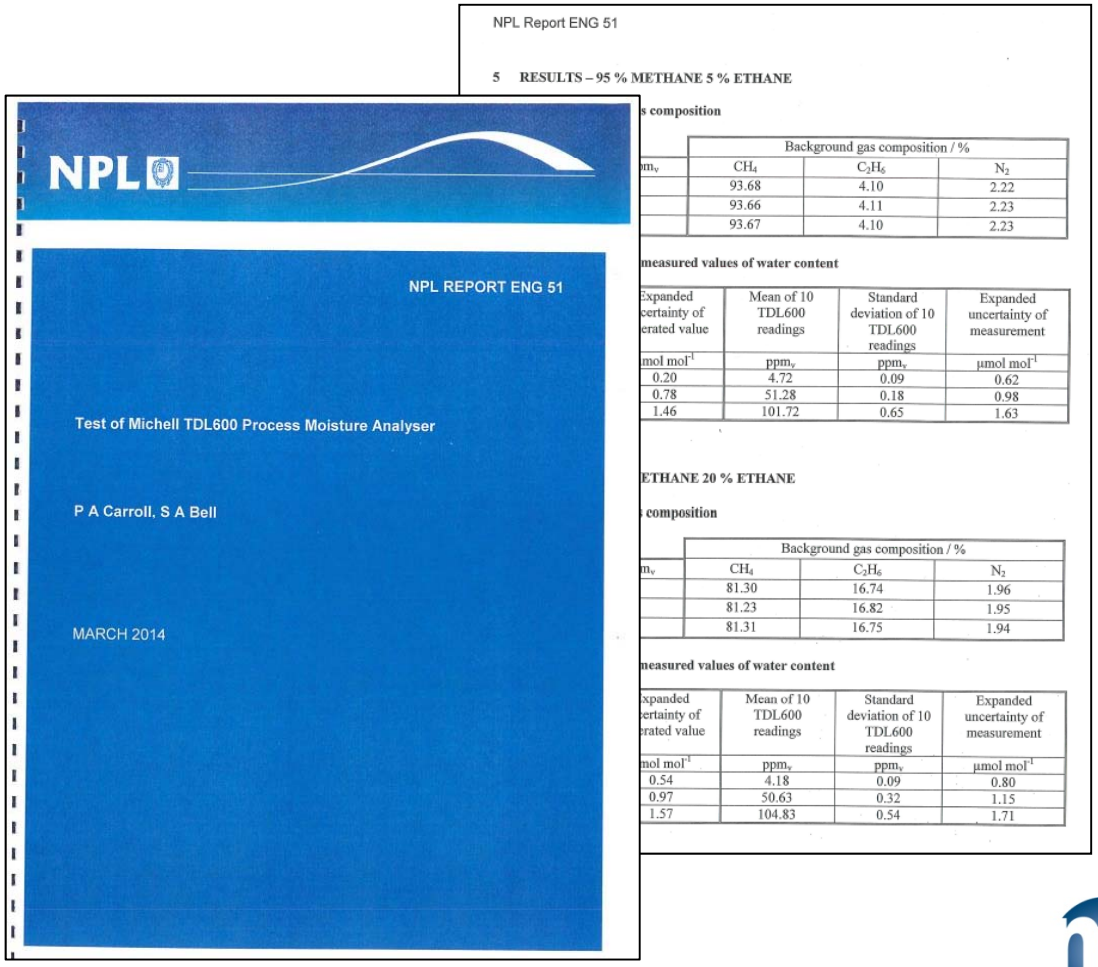
Independent testing: National Physical Laboratory



NPL

NPL REPORT ENG 51

Test of Michell TDL600 Process Moisture Analyser

P A Carroll, S A Bell

MARCH 2014

NPL Report ENG 51

5 RESULTS – 95 % METHANE 5 % ETHANE

s composition

	Background gas composition / %		
ppm_v	CH_4	C_2H_6	N_2
	93.68	4.10	2.22
	93.66	4.11	2.23
	93.67	4.10	2.23

measured values of water content

Expanded certainty of erated value	Mean of 10 TDL600 readings	Standard deviation of 10 TDL600 readings	Expanded uncertainty of measurement
mol mol^{-1}	ppm_v	ppm_v	µmol mol^{-1}
0.20	4.72	0.09	0.62
0.78	51.28	0.18	0.98
1.46	101.72	0.65	1.63

ETHANE 20 % ETHANE

composition

	Background gas composition / %		
m_v	CH_4	C_2H_6	N_2
	81.30	16.74	1.96
	81.23	16.82	1.95
	81.31	16.75	1.94

measured values of water content

Expanded certainty of erated value	Mean of 10 TDL600 readings	Standard deviation of 10 TDL600 readings	Expanded uncertainty of measurement
mol mol^{-1}	ppm_v	ppm_v	µmol mol^{-1}
0.54	4.18	0.09	0.80
0.97	50.63	0.32	1.15
1.57	104.83	0.54	1.71

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Table 1 – Background gas composition

	Background gas composition / %		
Nominal water content / ppm_v	CH_4	C_2H_6	N_2
5	93.68	4.10	2.22
50	93.66	4.11	2.23
100	93.67	4.10	2.23

Table 2 – Generated and measured values of water content

Generated amount fraction of water / µmol mol^{-1}	Expanded uncertainty of generated value	Mean of 10 TDL600 readings	Standard deviation of 10 TDL600 readings	Expanded uncertainty of measurement
	µmol mol^{-1}	ppm_v	ppm_v	µmol mol^{-1}
4.75	0.20	4.72	0.09	0.62
49.38	0.78	51.28	0.18	0.98
100.36	1.46	101.72	0.65	1.63

Network gas downstream of biomethane injection in periods of low demand.

Tested against the NPL multi-gas multi-pressure humidity generator.

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Table 3 – Background gas composition

	Background gas composition / %		
Nominal water content / ppm_v	CH_4	C_2H_6	N_2
5	81.30	16.74	1.96
50	81.23	16.82	1.95
100	81.31	16.75	1.94

Table 4 – Generated and measured values of water content

Generated amount fraction of water / $\mu mol\ mol^{-1}$	Expanded uncertainty of generated value	Mean of 10 TDL600 readings	Standard deviation of 10 TDL600 readings	Expanded uncertainty of measurement
	$\mu mol\ mol^{-1}$	ppm_v	ppm_v	$\mu mol\ mol^{-1}$
5.16	0.54	4.18	0.09	0.80
49.84	0.97	50.63	0.32	1.15
104.28	1.57	104.83	0.54	1.71

‘Rich’ natural gas

Tested against the NPL multi-gas multi-pressure humidity generator.

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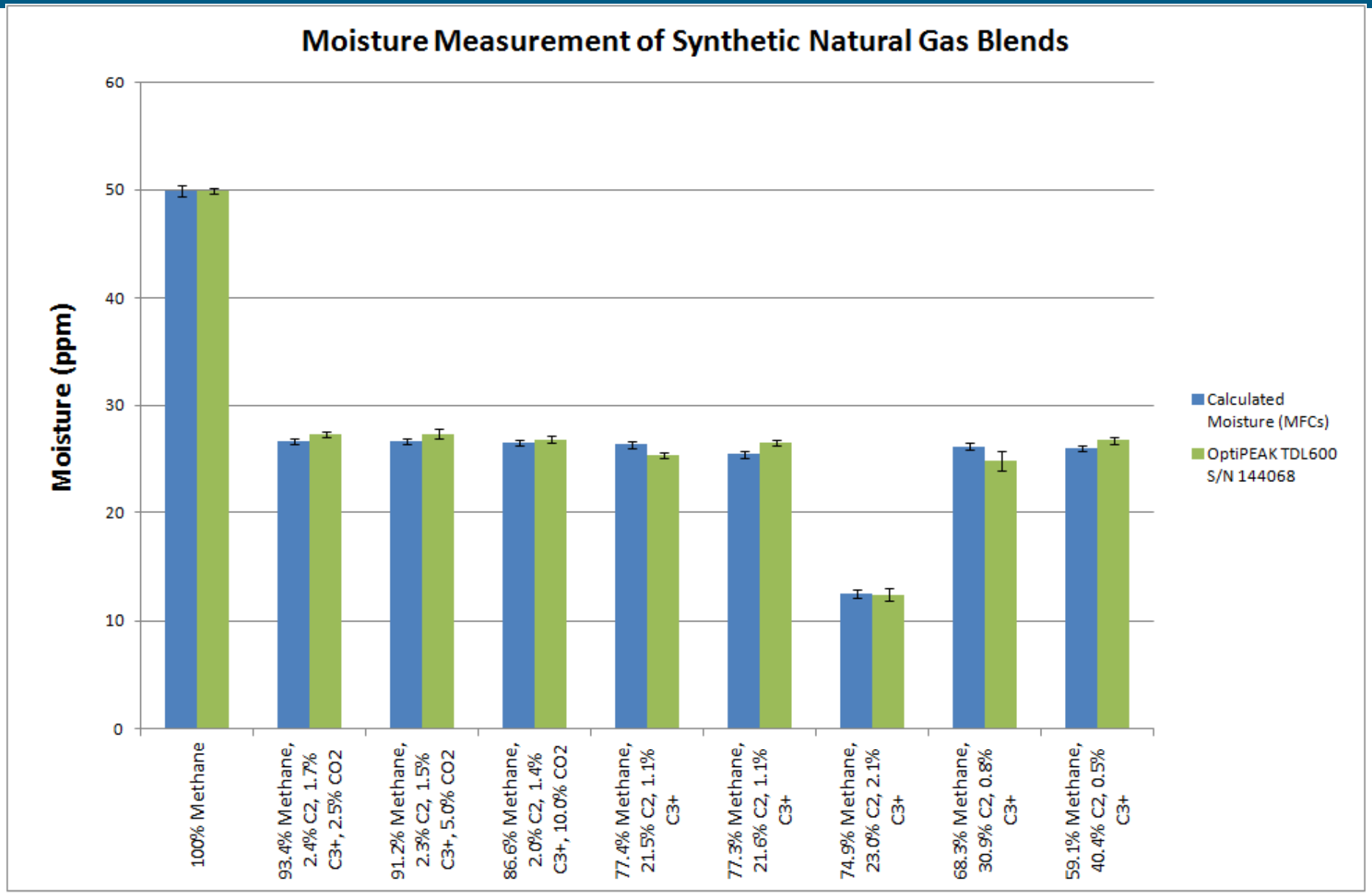

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TDLAS Moisture Analyser Installations

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Thank you

Any Questions?

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