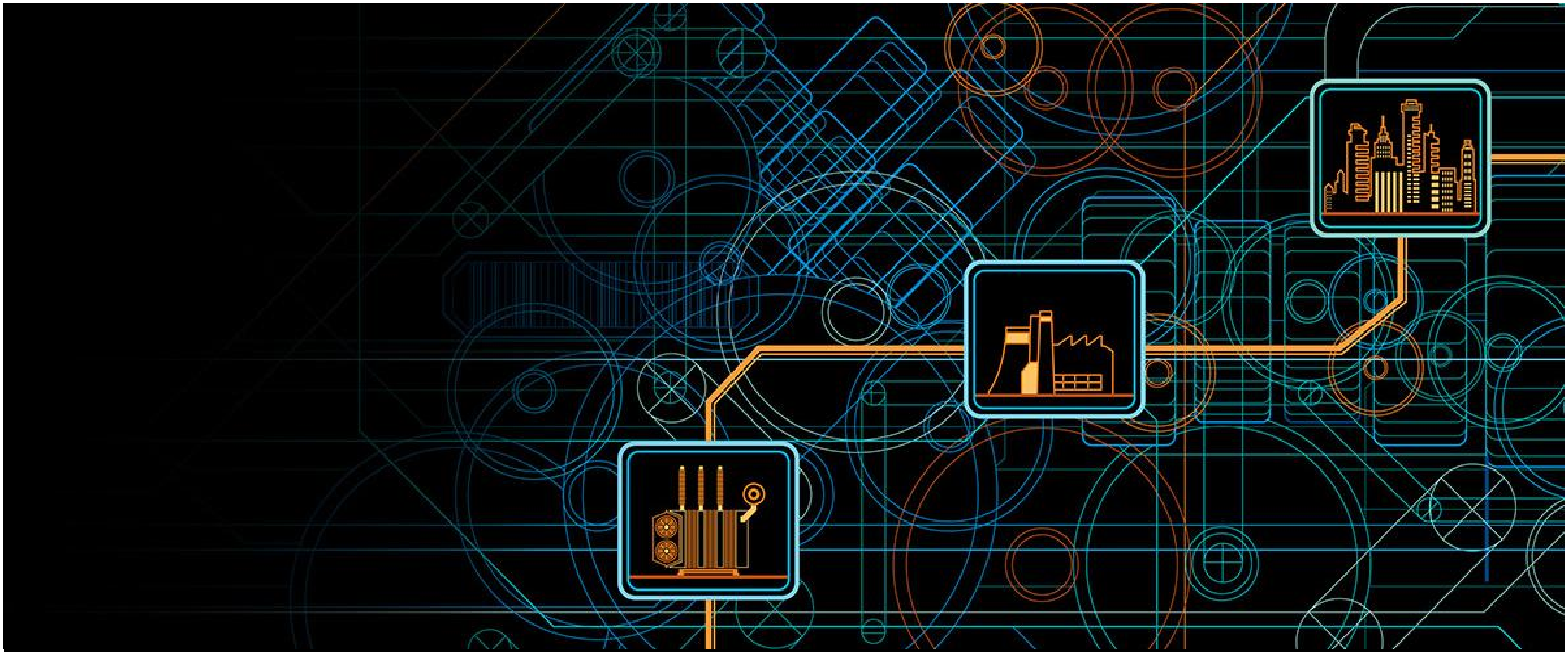
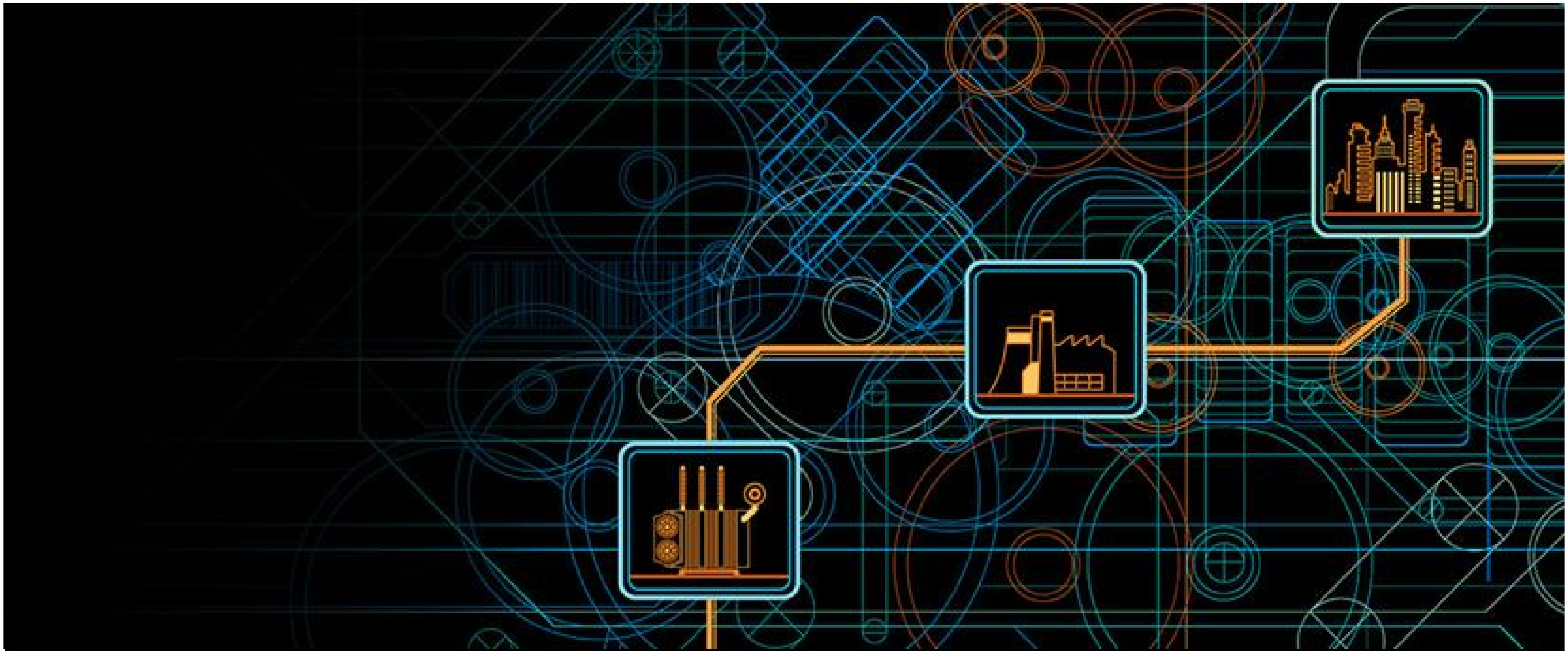


Tejbir Singh – 4th Jul 2017, India – MPPCB Regulator Workshop

CEMS Analyser
Methodology & Technology

Table of Contents
Continuous Emission Monitoring System (CEMS)

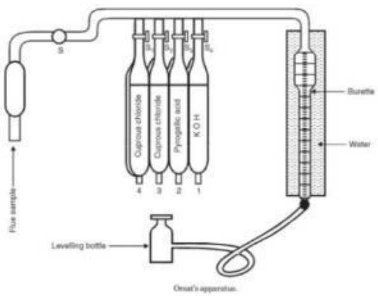


Measurement Techniques - Methodology for CEMS

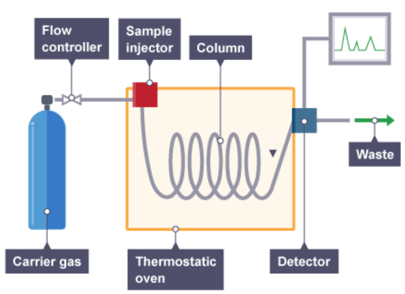
Process Control / How do you measure 1ppm…

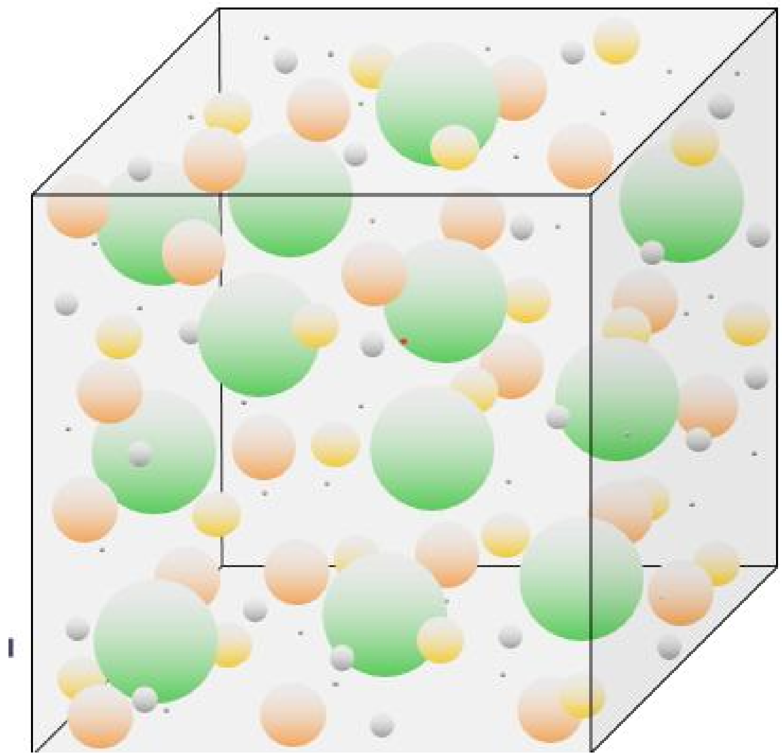
…in a complex gas stream?

Chemical reaction
(e.g. Orsat apparatus)

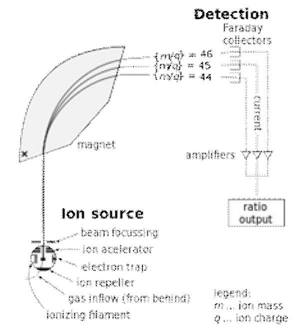


Separate by columns
(Gas Chromatography)





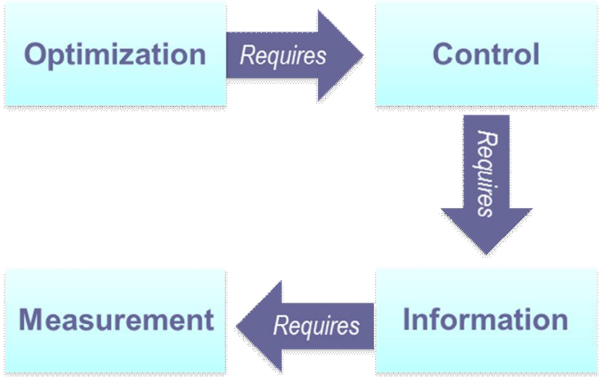
Ionize by mass or FTIR Spectrometry

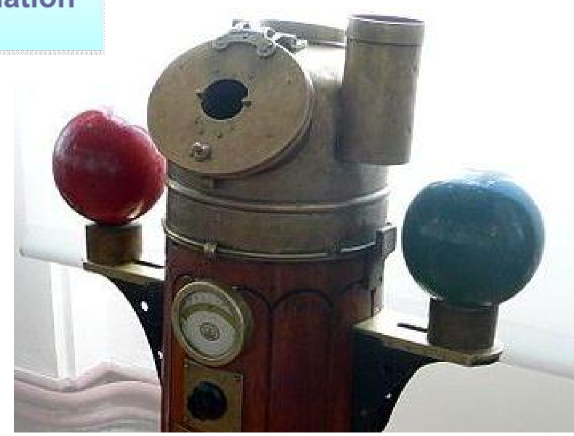


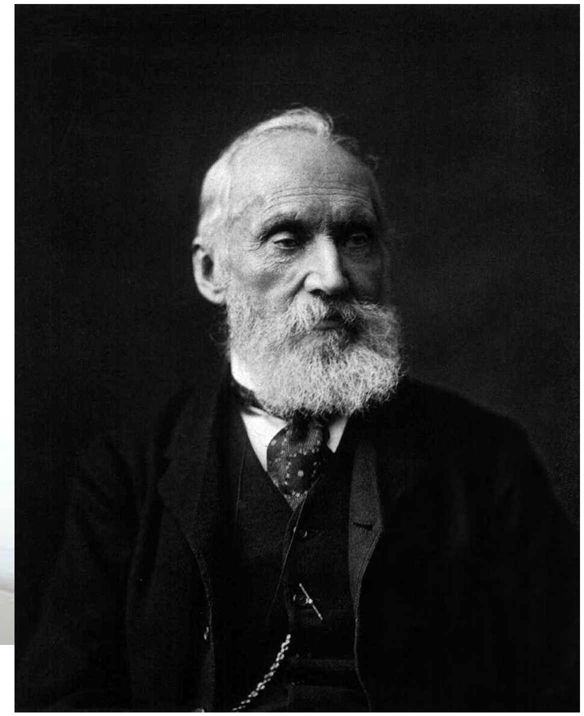
Continuous Gas Analysis (CGA)

Absorption Spectroscopy
Paramagnetism
Thermal conductivity
Flame ionization
Zirconium Dioxide
TDLAS….

William Thomson, 1st Baron Kelvin, 1824-1907

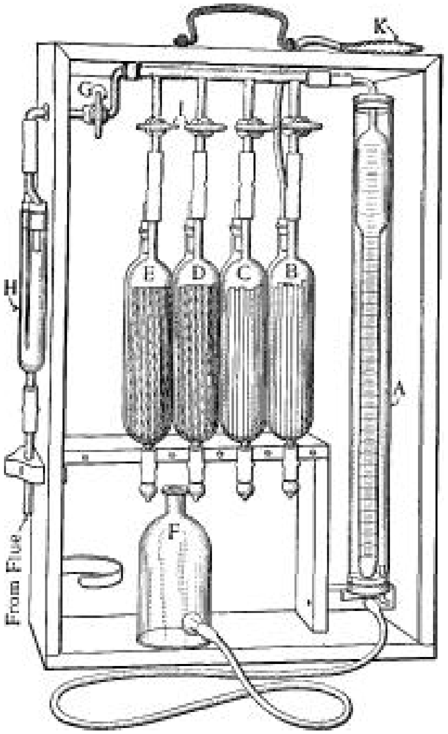




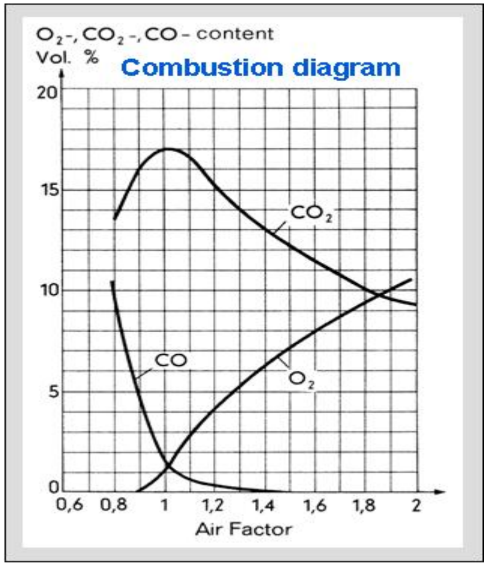


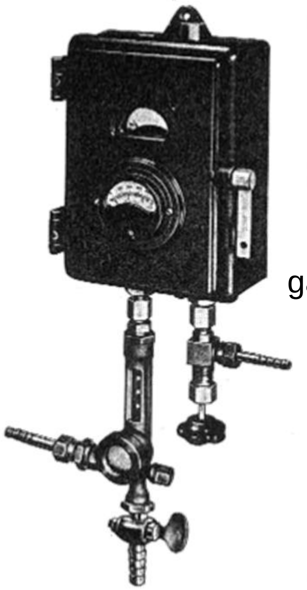
“If you can’t measure it, you can’t improve it”

The first generation of flue gas analyzers
The beginning of continuous gas analysis



ORSAT Off Line

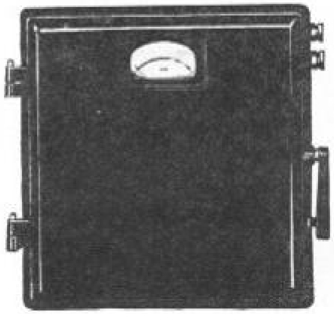




TCD - Caldos 1

Thermal conductivity

gas analyzer used to measure
CO2 ~1935



Paramagnetic - Magnos 1

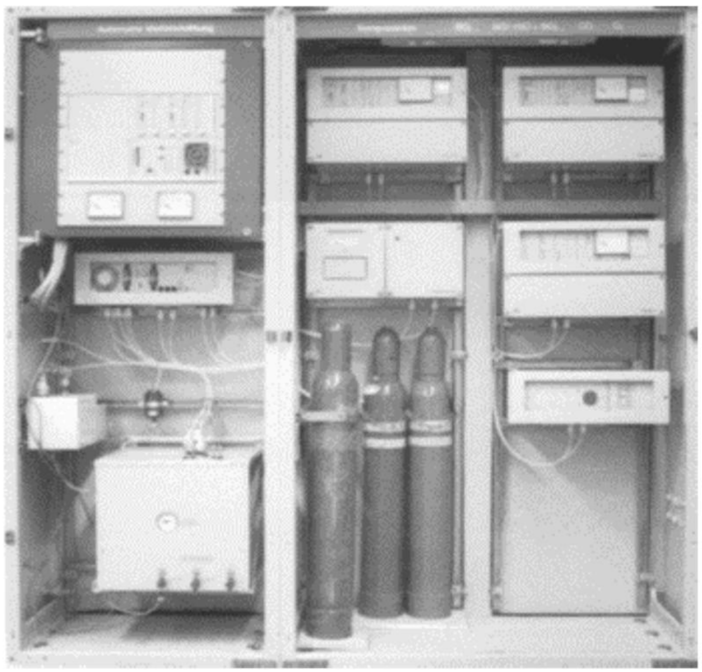
O_2 – measurement

1940

CEMS History Technology System Solution

CO, CO_2, H_2 and O_2 Measuring Throughout Time

	Traditional measuring facility	Modern measuring facility
Analyzers:	4	1
SPS / sol. valves:	1 / 5	Integrated in analyzer / 1
Test gases:	4	None (ambient air & gas cells)
W x H x D:	2600 x 2100 x 600	800 x 2100 x 600
Remote maint.:	-	PC program + Ethernet technology



1980s Analyser cabinet

Modular Automated

Industries Specific gas analysis
Applications – always the right solution

Combustion

Fuel (plant material) $+ O_2 \rightarrow CO_2 + H_2O +$ energy

Applications:

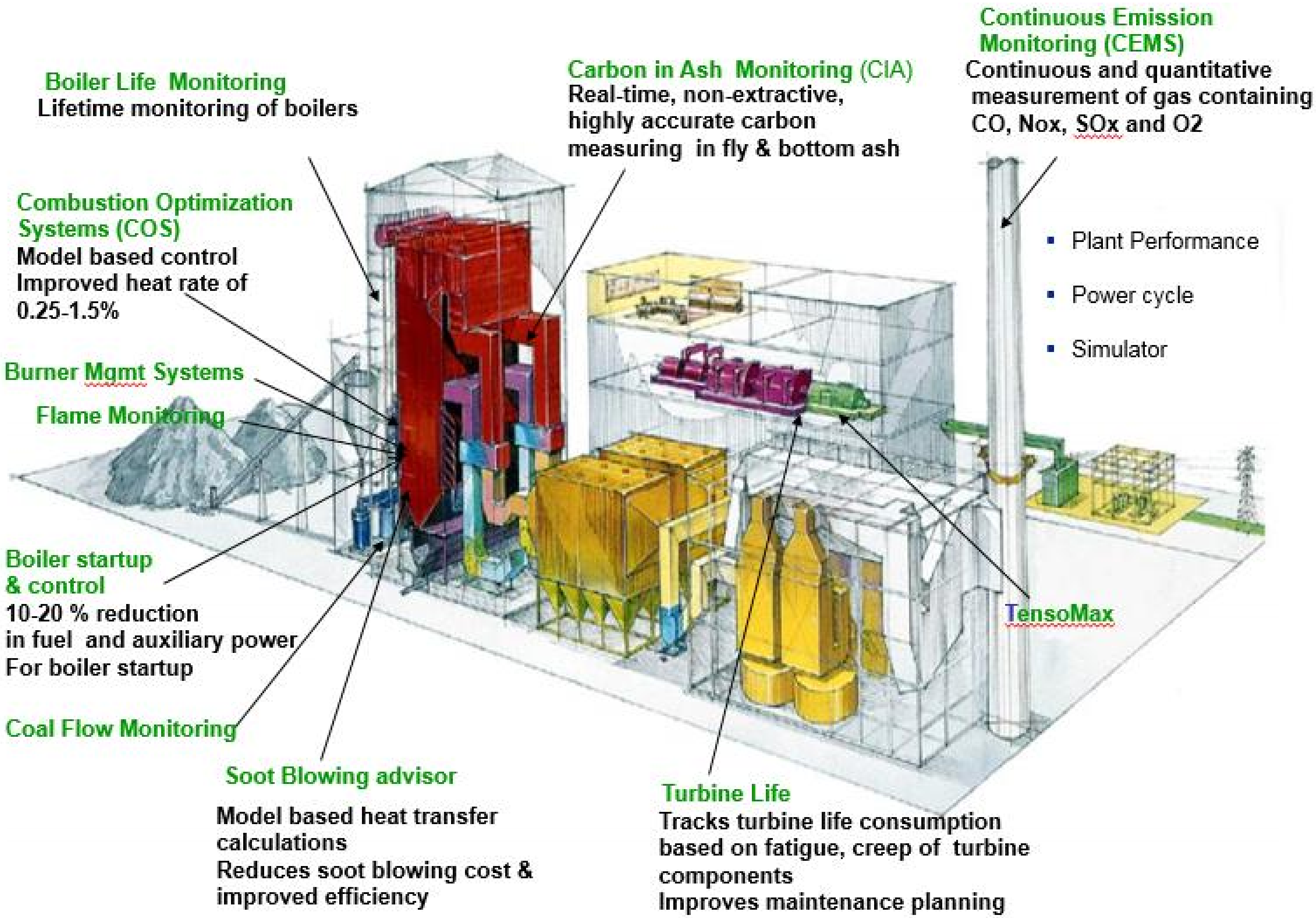
- Emission Monitoring
- Process Control
- Quality Assurance
- Safety Control

Gas Producers	Cement	Chemical & Petrochemical	Metals & Minerals	Power	Oil & Gas	Waste disposal
MARKETS						
TYPICAL APPLICATIONS / MEASURING COMPONENTS						
Air Separation Hydrogen	Kiln Inlet Preheater/Calciner ESP, CEMS	Ammonia Chlorine Nitric Acid Sulfuric Acid Ethylene CEMS	Iron & Steel (Blast Furnace) Aluminum Glass CEMS	Combustion Coal Bin / Mill Turbogenerator CEMS	Inertization Flares CEMS	Combustion Flue gas treatment CEMS
O_2, CO, CO_2, CH_4, H_2, THC, N_2O	CO, CO_2, NOx, SO_2, HCl, HF, NH_3, THC, O_2	H_2, NH_3, Cl_2, CO, NOx, SO_2, O_2 CH_4, C_2H_2, C_2H_4, C_3H_6,..	CO, CO_2, CH_4, O_2	CO, NOx, SO_2, O_2, H_2, CO_2	CH_4, C_2H_2, C_2H_4, C_3H_6,.. CO, NOx, SO_2, O_2	CO, CO_2, NOx, SO_2, HCl, HF, NH_3, THC, O_2

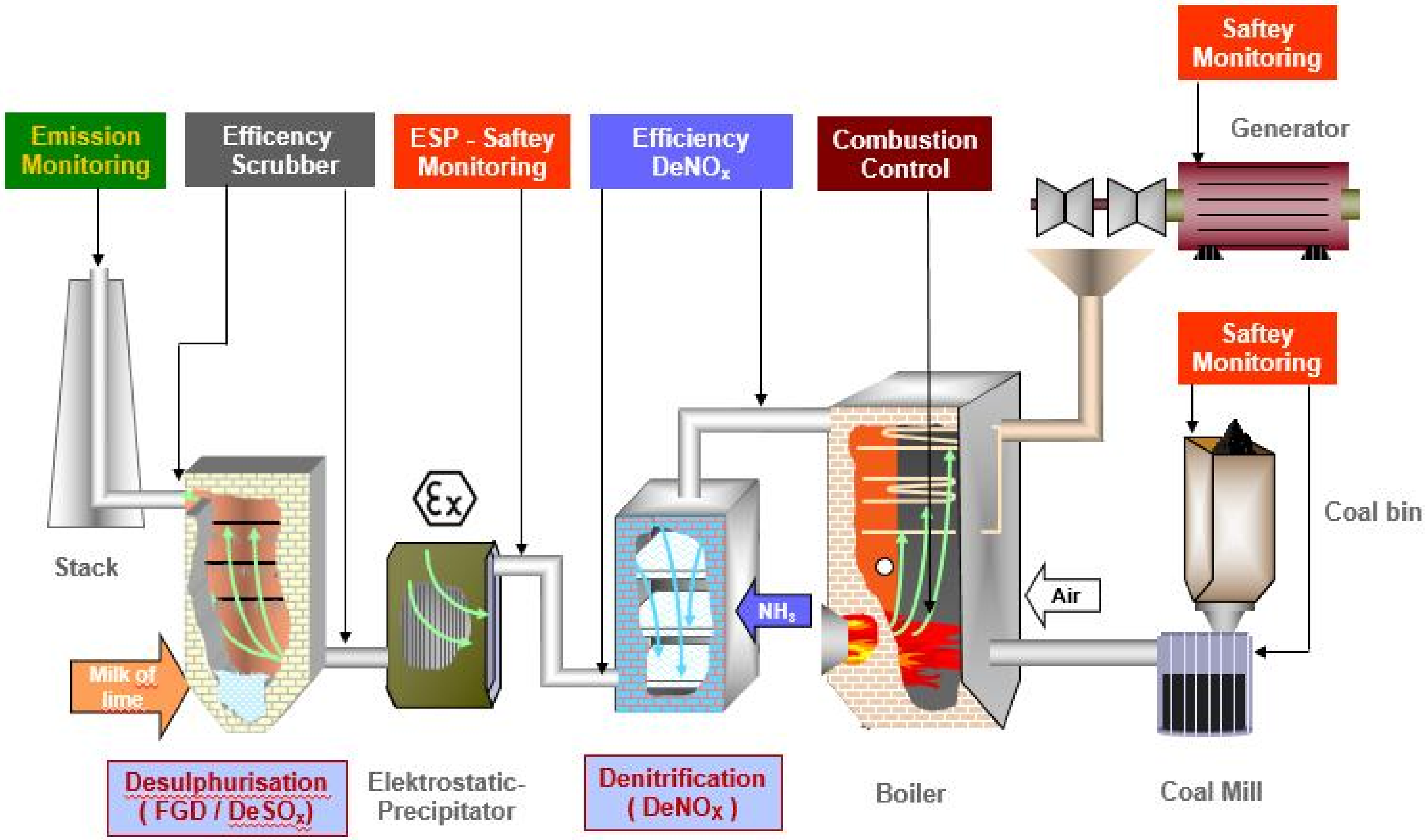
In terms of value, <u>process analyzers</u> can help capture millions in profit !

Therefore ~Technology, Capability, Implementation is Mature !!

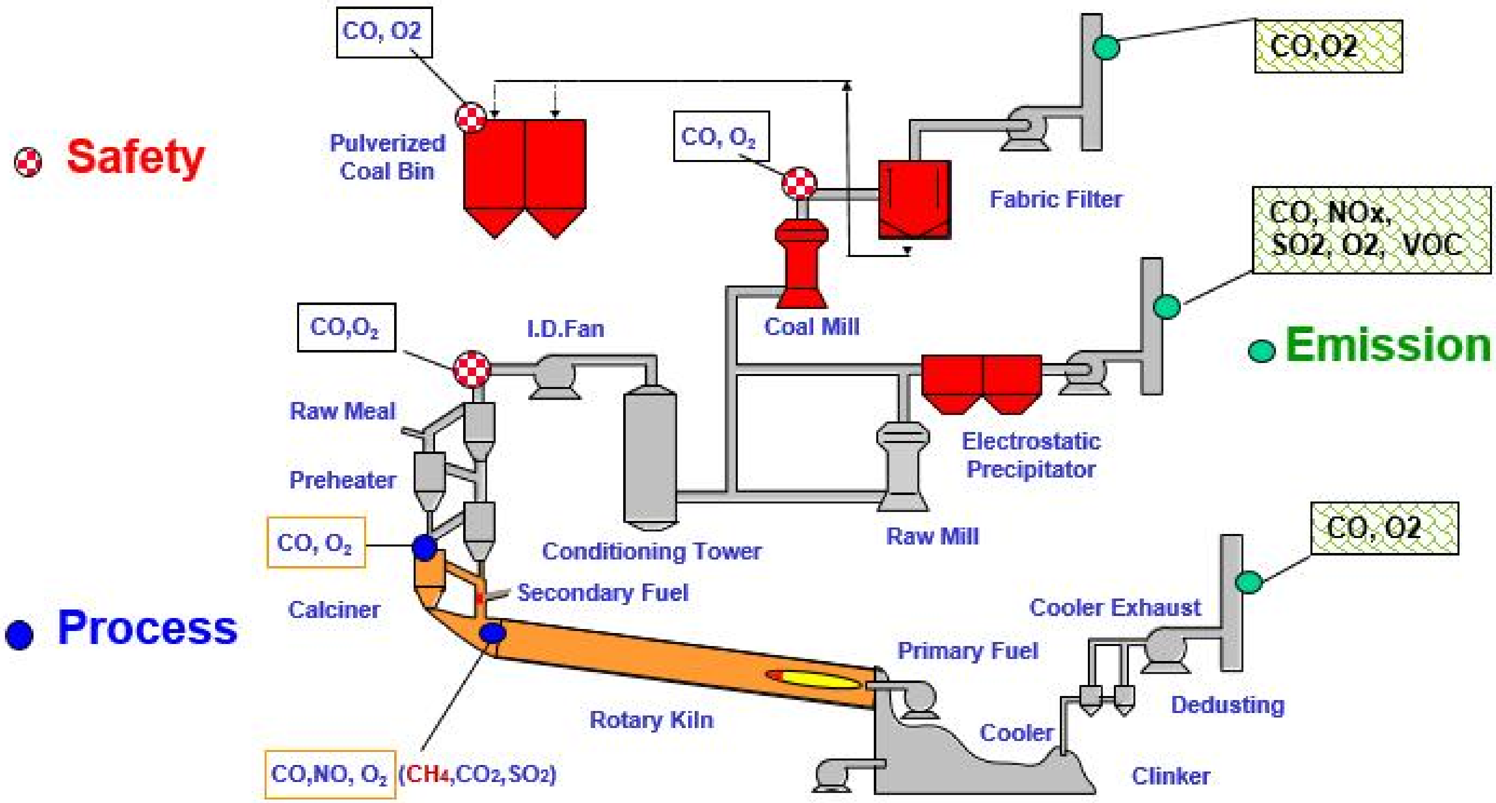
Improving Energy Efficiency ~ Lower Emissions



Coal fired Thermal Power Plant
Measurement Tasks - Example



Integrated Cement Plant Dry Process

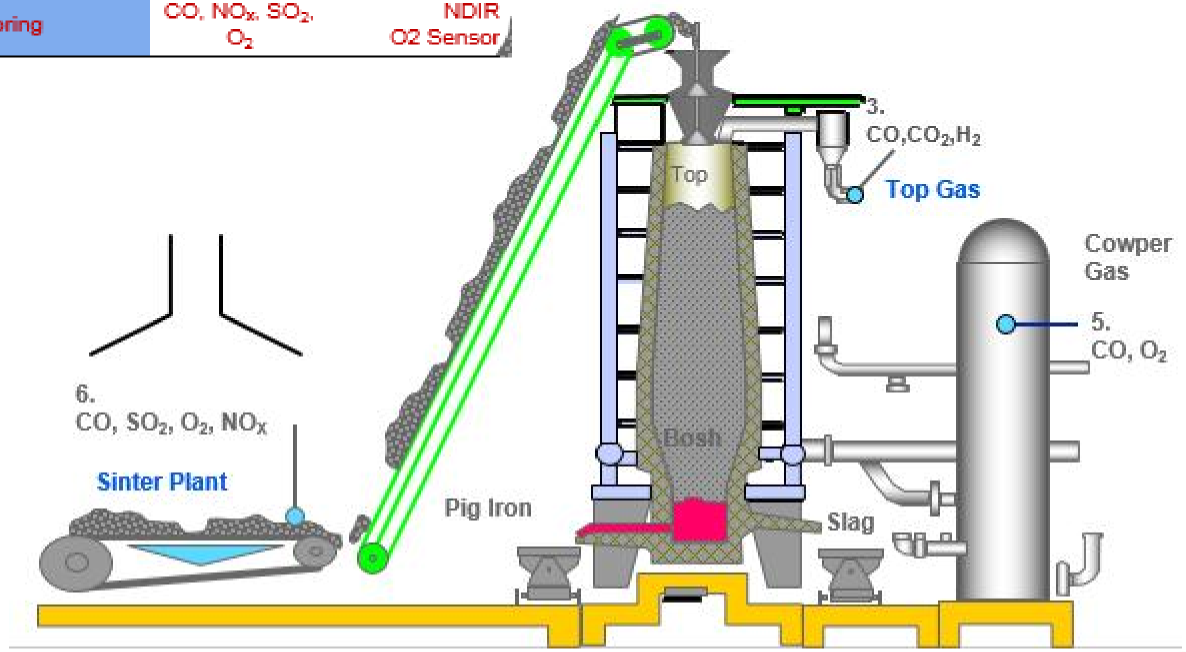


ABB

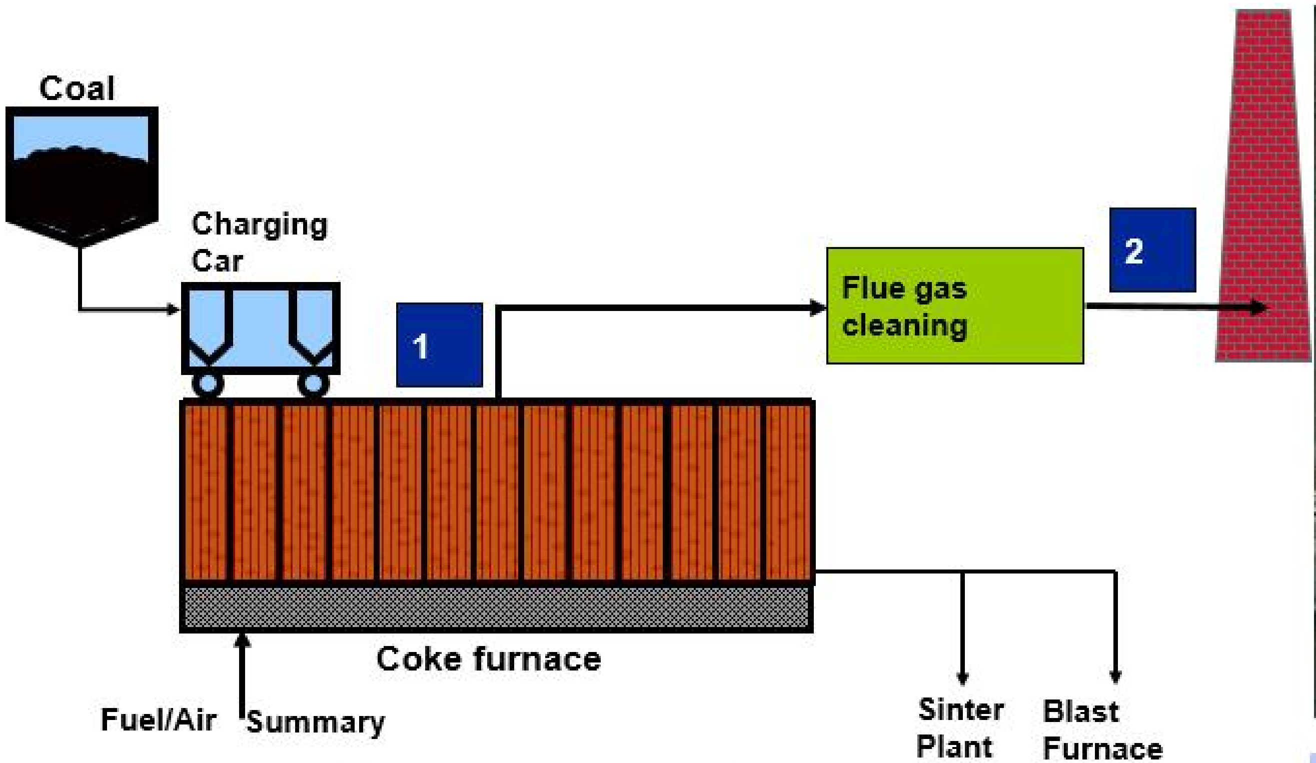
Iron and Steel - Blast furnace

Meas Point	Measuring Task	Measuring Components	Analyzers
1	Transverse Probe (Above Burden / Under Burden) Blast Furnace Optimization	CO, CO_2, H_2, (O_2)	NDIR TCD Para)
2	Riser Tube Measurement Oven Symmetry	CO, CO_2, H_2	NDIR TCD
3	Top Gas Measurement - Gas very dirty	CO, CO_2, H_2	NDIR TCD
4	Top Gas Measurement - Gas semi clean	CO, CO_2, H_2	NDIR TCD
5	Cowper Waste Gas Burner Optimization	CO, O_2	NDIR Para
6	Emission Monitoring	CO, NO_x, SO_2, O_2	NDIR O2 Sensor

1. **Reduction of Ore, Quality of Iron, Leakages of Cooling System**
2. **Combustion Control**
3. **Emission Monitoring**



Coke Furnace / Sintering Plant / Reheating Furnaces…
Coke Owen - Process Flow Diagram

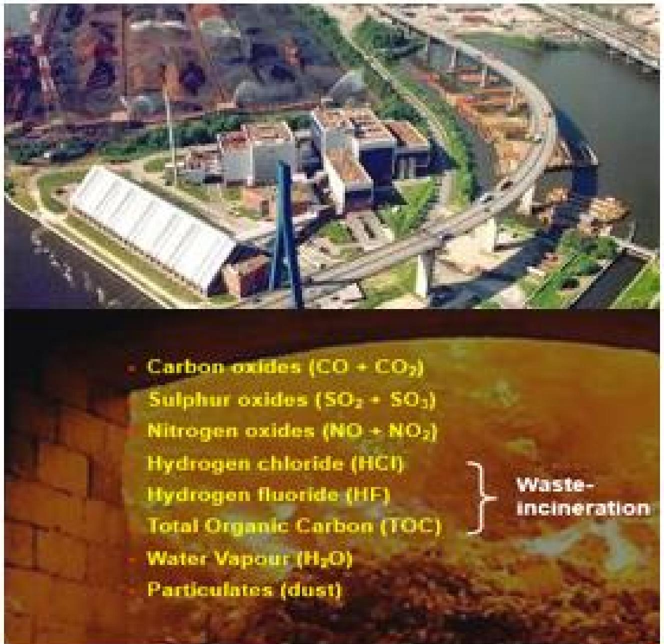


Tar & Volatile Matter !

Measuring Point	Measuring Task	Measuring Components	Analyzers
1	Process Optimization	CO, CO_2, O_2	NDIR Paramagnetic
2	Emission Monitoring	CO, NO_x, SO_2, O_2	NDIR Paramagnetic

ABB

Incineration Process
CEMS Applications – Complex Cocktail



Municipal Waste Incinerators

- Biomedical waste incineration
- Waste pyrolysis
- Gasification

Hazardous Waste Incinerators

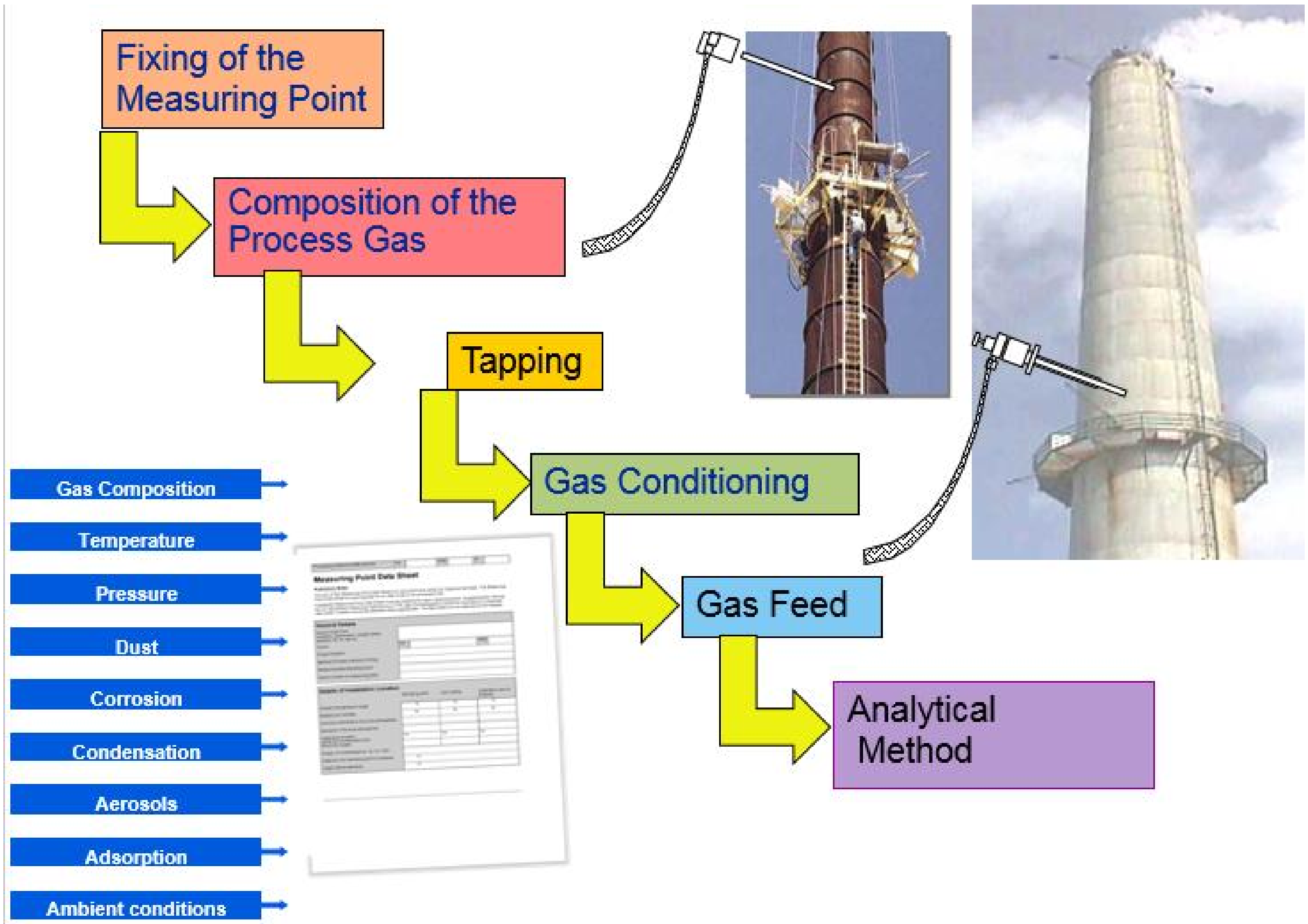
- Cement plants
- Thermal treatment of contaminated soils
- Incinerators plants

Process Plants

- Muncipal Waste / Bio Mass to Power

Hydro Chloride	HCl
Ammonia	NH3
Nitrogen oxides	NOx
Sulphur dioxide	SO2
Carbon monoxide	CO
Carbon dioxide	CO2
Water vapor H2O	
Oxygen	O2
Volatile Organic Carbon	VOC
Hydro Flouride	HF
Mercury	HgO
Dust	SPM

Analyser technology Process to Emission



Source Emissions Summary ~ CEMS in Industry

1. Each Industry / Process is different

- Fuel and Process are diferent eg.
  - High Dust / Ash Content / Tar & Napthalenes
  - Corrosive components, High Moisture
  - Flamable Gases / Interefering Background Gases

2. Custom Design – Matched to Process

- Understanding of Process and its Flue gas composition and other dynamics are Critical for right selection and execution / performance.
- **Cement Kiln Stack** : Alternative fuels -Petcoke, Agri waste, Municpal Waste, Tyres, etc – Creates gases like HCL / HF, NH3, VOC, etc. Nox Reductions. Regulation needs to catch up to global standards.
- **Ferilizer Plant** : Prilling Tower NH3 : Saturated Flue gas with very low ppm NH3, Stack Dia 20 mtr with no openings, turblance, Urea flakes, measurment near the top – Techniques Hot Wet ~ UV / FTIR
- **Steel Plants** : Coke Owen Batteries – Flue gas contains high Tar & Volatiles like Napthalenes – Very Challanging – requires dosing.
- **Captive Power Plants / Boilers** : Multi Fuels in petcoke SO2 goes upto 2000+ ppm levels, corrosive Arosols.

3. Stack Audit for exact Flue Gas Compositions : Mandatory for Plant.

No one Technology fits all and important to recognise process dynamics flue gas data & Matching right Solutions.

What is Common Understaning or Misconception ?

We Need an Online Montoring for Pollution Board !!

Sir, What do you want /Exact requirement ? Based on yr Experience...

CO, SO_2, NOx, NH_3

1. What is the Gas to be measured ?

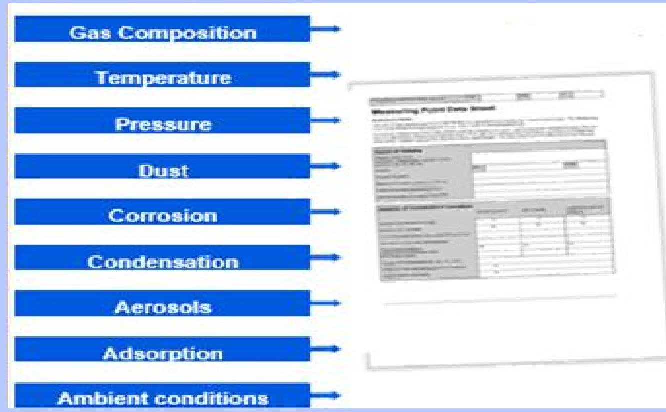
2. What Measuring Range ?

3. Need your Stack Gas Lab Analysis report ?

4. Plant Site Location / Utilities etc required

5. Data Connectivity..existing or New req.

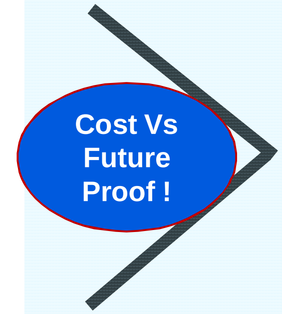
Questionnaire / Checklist !! – Scientific Way



Particulate Matter
HF (Fluoride)
NH_3 (Ammonia)
SO_2 (Sulphur Dioxide)
NO_X (Oxides of Nitrogen)
Cl_2 (Chlorine)
HCL (Hydro Chloric acid)
CO (Carbon Monoxide)
CO_2 (Carbon Dioxide)
TOC (Total Organic Compounds)

Process parameters:, Temperature, Pressure, Flow, Moisture Content, O_2 (Oxygen), etc

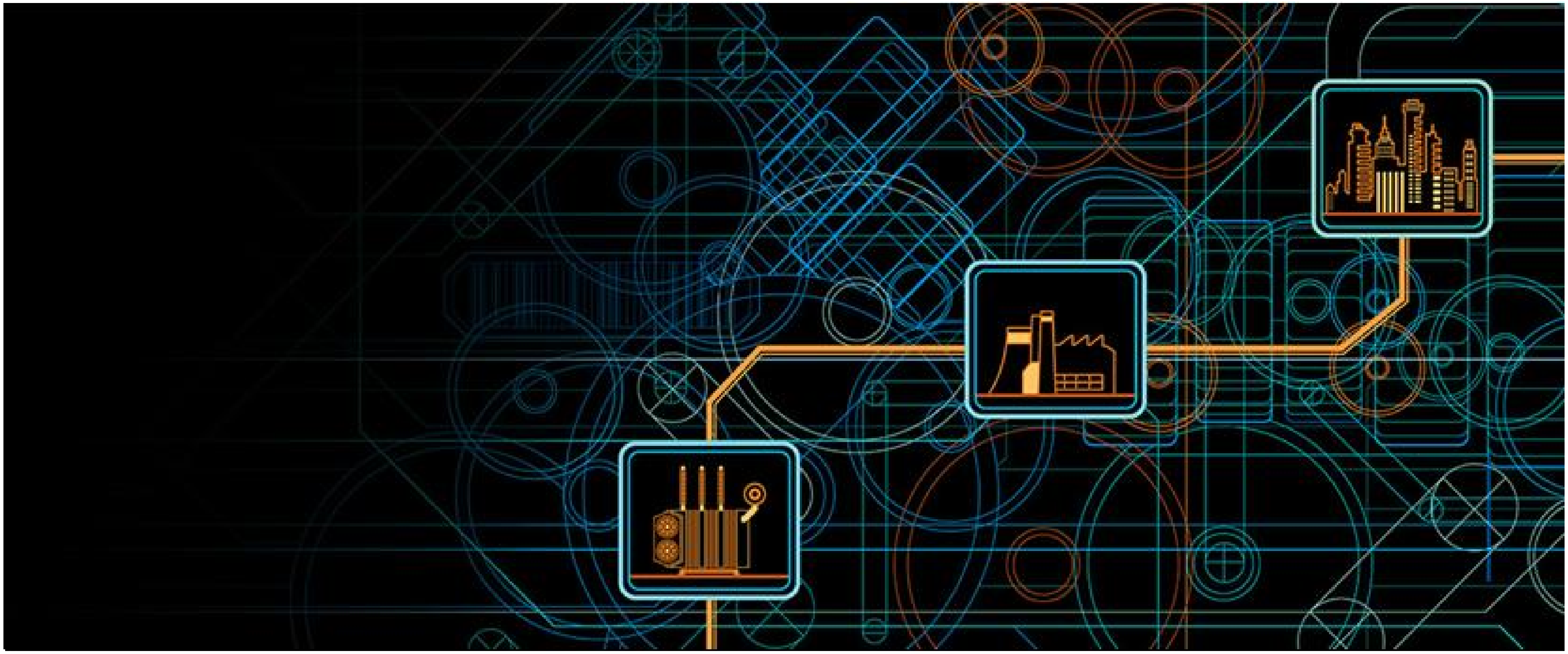
B A T Approach



Certifications ?

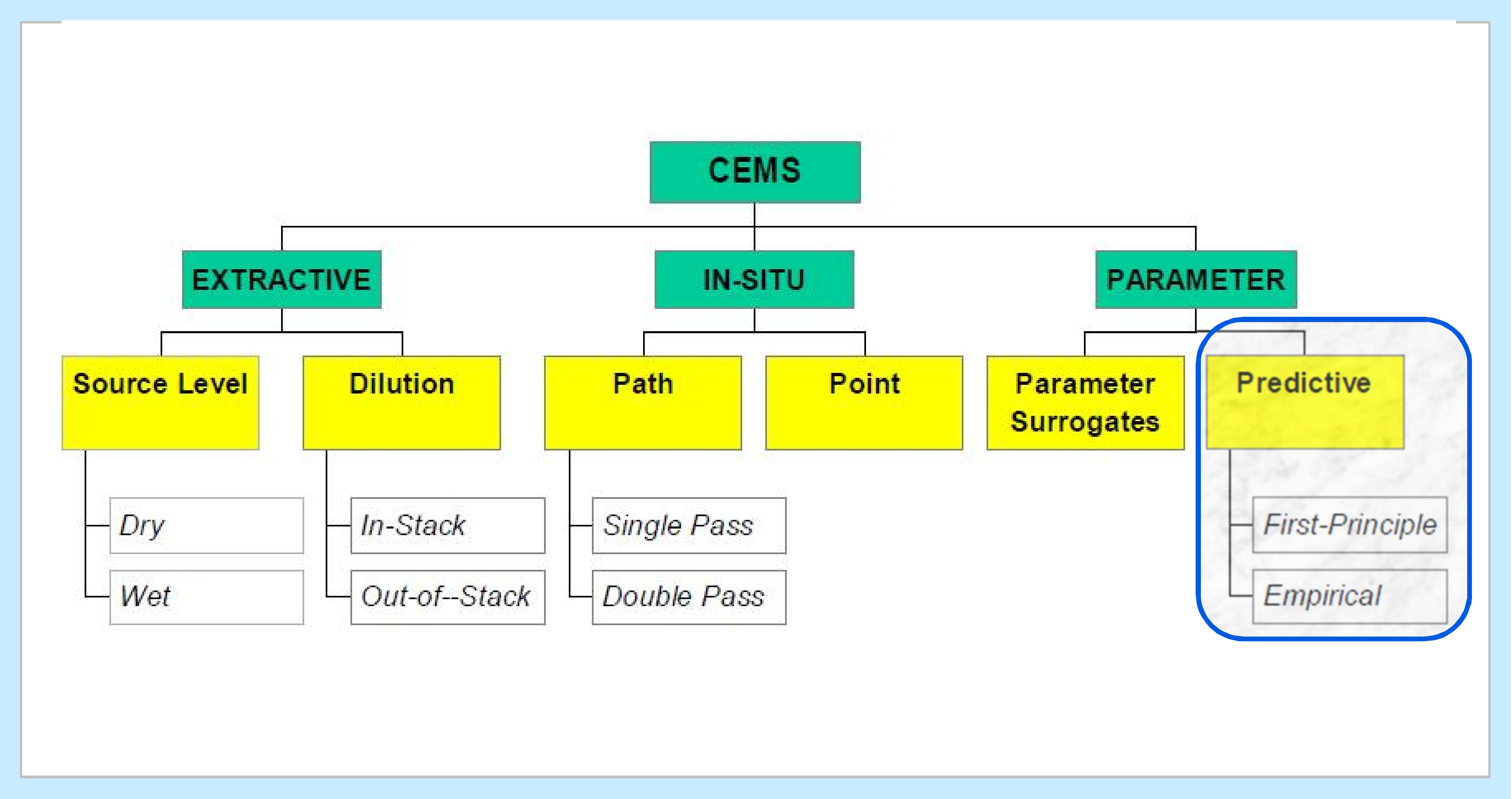
Do not Re-invent the Wheel !!

Why?



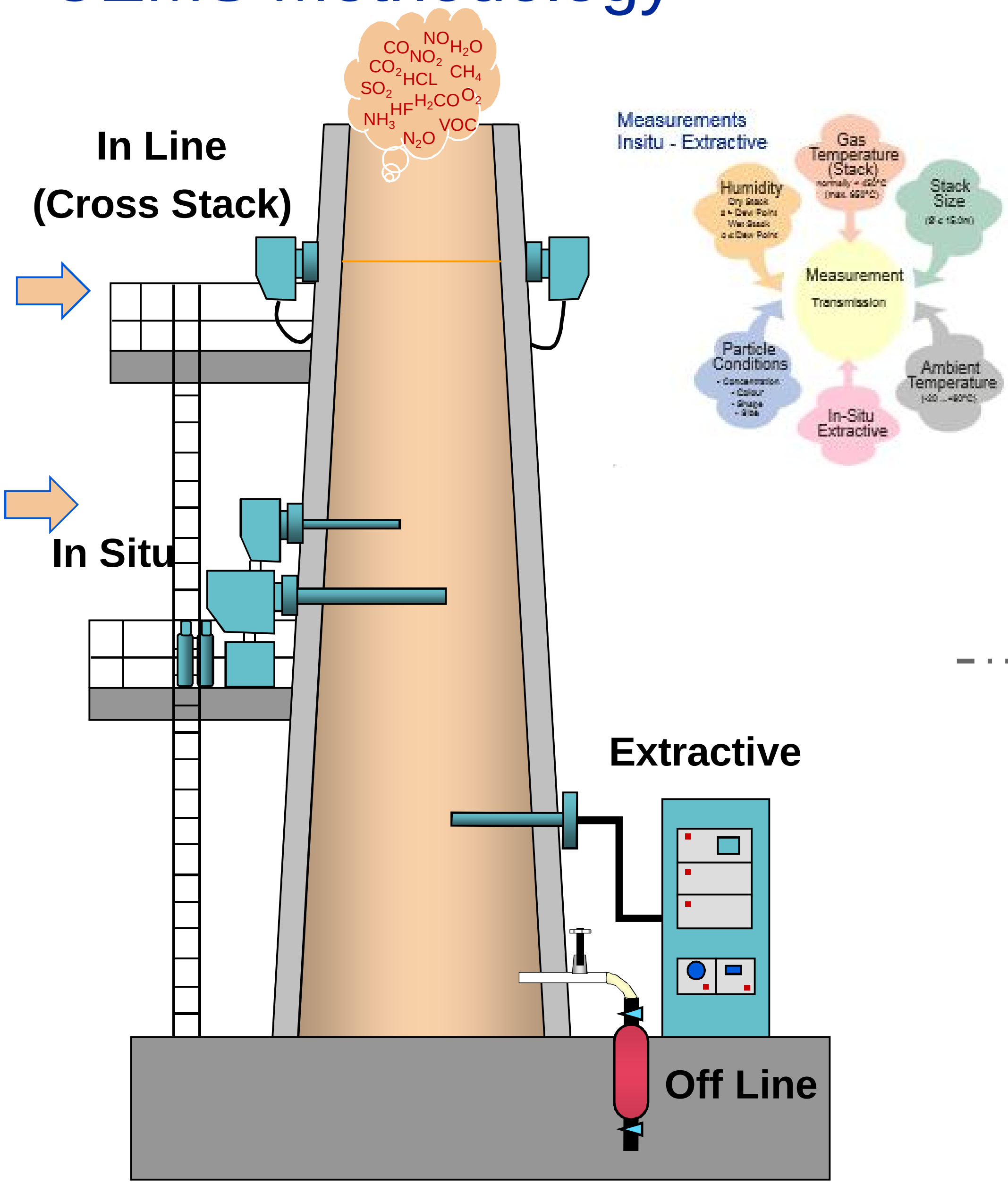
Measurement Techniques - Methodology for CEMS

Introduction
Zooming on CEMS / PEMS



Source: "***EPA Handbook – Continuous Emission Monitoring Systems for Non-criteria Pollutants***", 1997

CEMS Methodology



Off-line (At-line)

- Discontinuous measurement, e.g. laboratory, Orsat apparatus

In-line/In-situ

- Continuous measurement directly in the stack/process

On-line – Extractive measurement

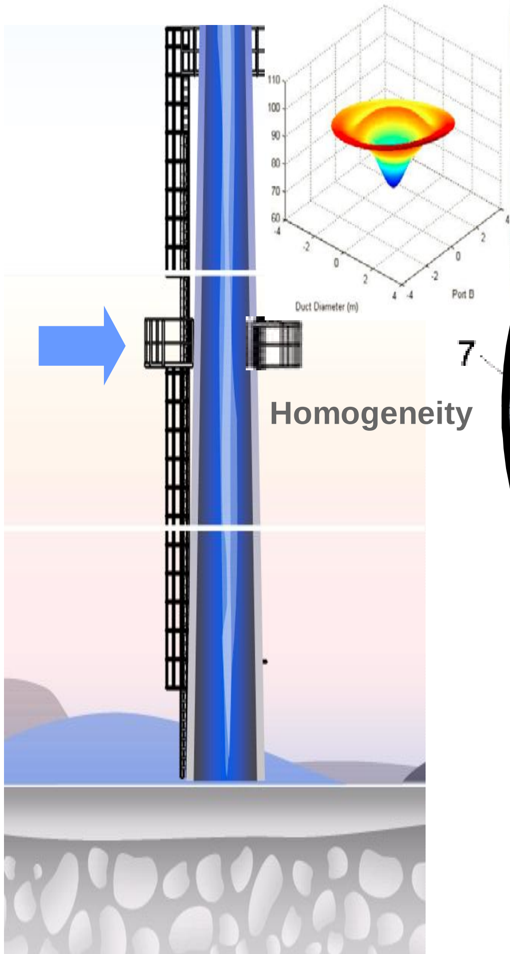
- Continuous measurement

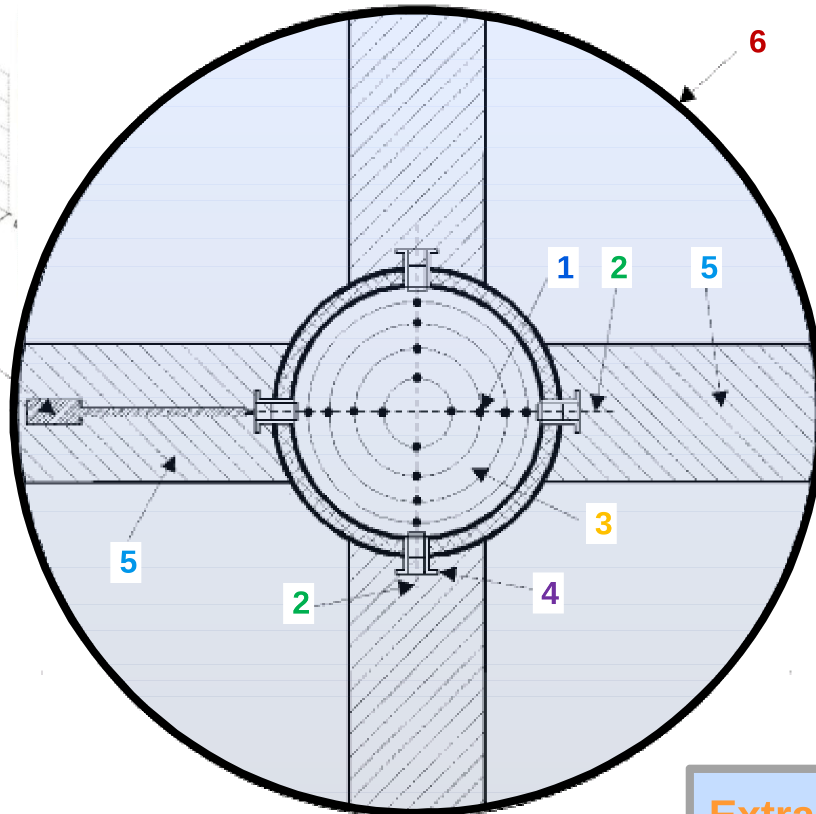
Dilution Type - Extractive

- Sampling and conditioning of the sample gas feeding to the analyzer

ABB

Illustration of Terms - EN 15259
Measurement Plane – Old - New Stacks Challanges !





Top View

1. Measurement point
2. Measurement line
3. Measurement plane
4. Measurement port
5. Working platform
6. Measurement site
7. Manual sampling train

Extractive system - (2X Dia)

Insitu system - (8X Dia)

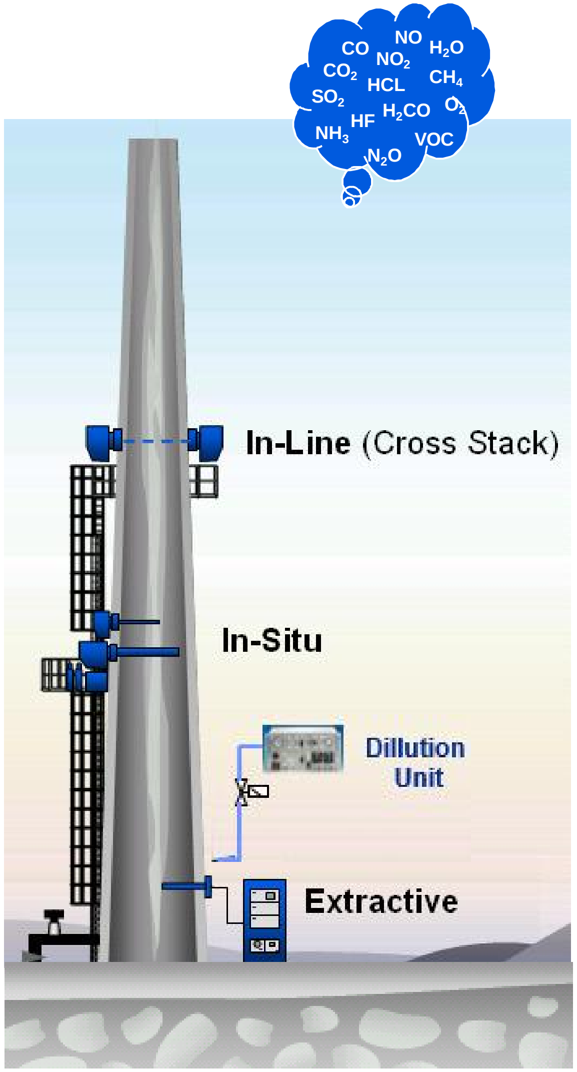
$$C_{Corrected} = C_{Raw\ value} \times \frac{21 - O_{2\ Reference}}{21 - O_{2\ measured}}$$

CEMS
Various Applied Methods

TÜV
TÜV Rheinland Group

MCERTS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY



Cold / Dry – Measurements ► **Extractive / On-Line**

- Combustion Control
- Emission monitoring

Hot / Wet – Measurements ► **Extractive / On-Line**

- Process Control
- Emission monitoring

Dilution – Measurements ► **Extractive**

Cross Stack – Measurements ► **In-Line**

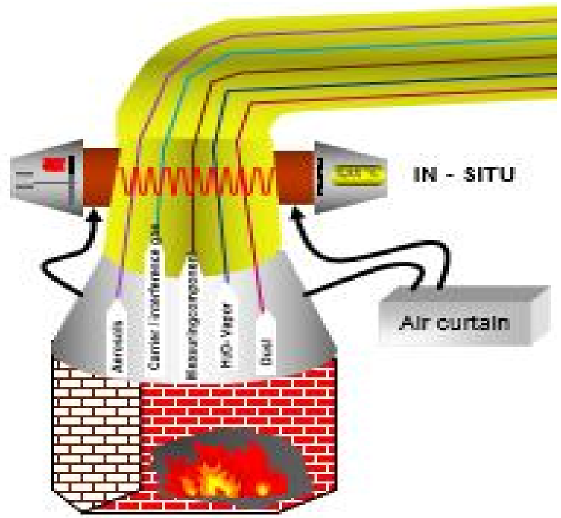
- Laser based measurement

In-Situ – Measurements ► **In-Line**

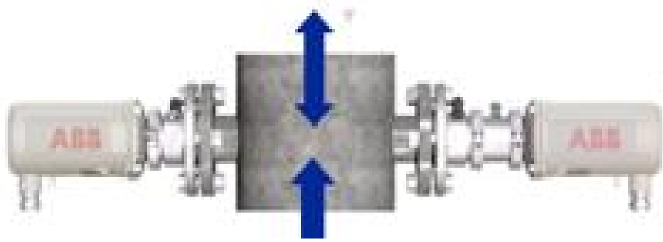
- Dust monitoring

ABB

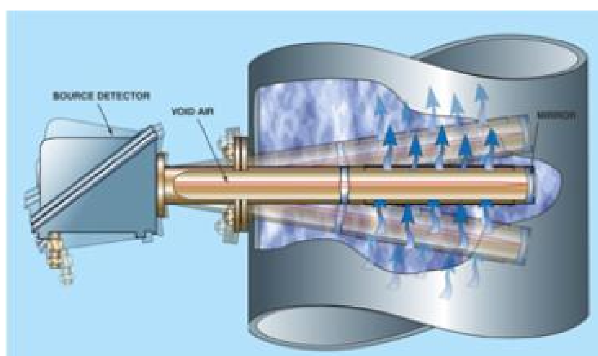
In-situ System Components
Example Cross Duct - Dust Monitor / CEMS



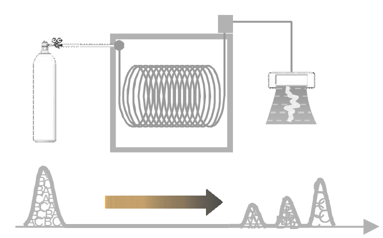
Cross Duct Type CEMS
PM / Gases



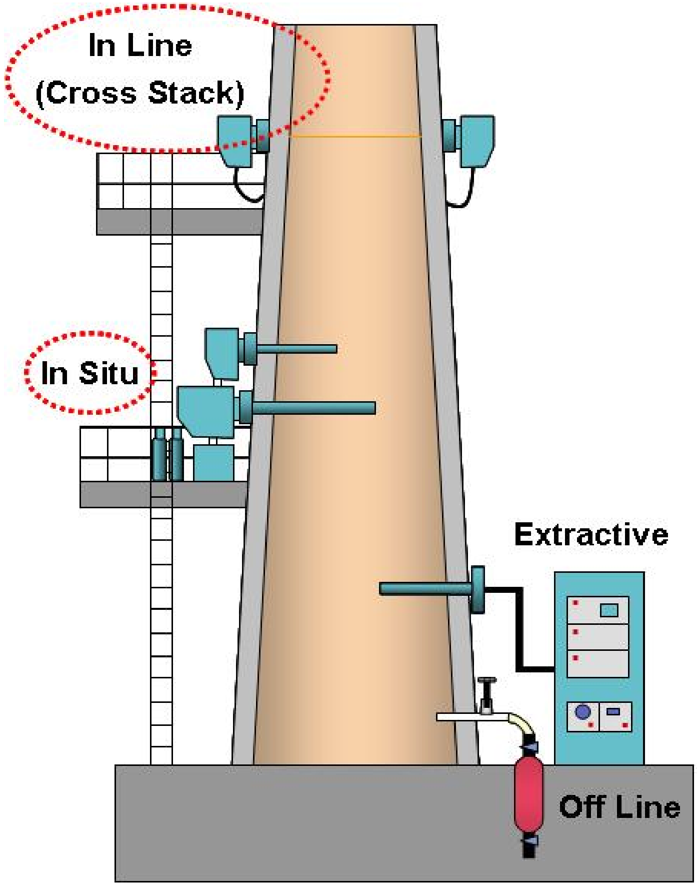
Cross Duct TDLS / Lazer for special gases like HCL/HF/NH3 / H2S, etc



Insitu Probe Types



In-line (In-situ) principle



Advantages

-Direct installation into the process

-Direct detection of changing concentrations

-No delay in measurement

Disadvantages

-Detector exposed directly to temperature and pressure

-Specialized alignment / Mounting /Spacing

-No or less protection to dust and high temperatures

-Difficult installation, e.g. top of a stack etc.

-Multi component meas. is Complex and costlier

-Online Corrections of Moisture, T,P, Flow, H2O and not K factors.

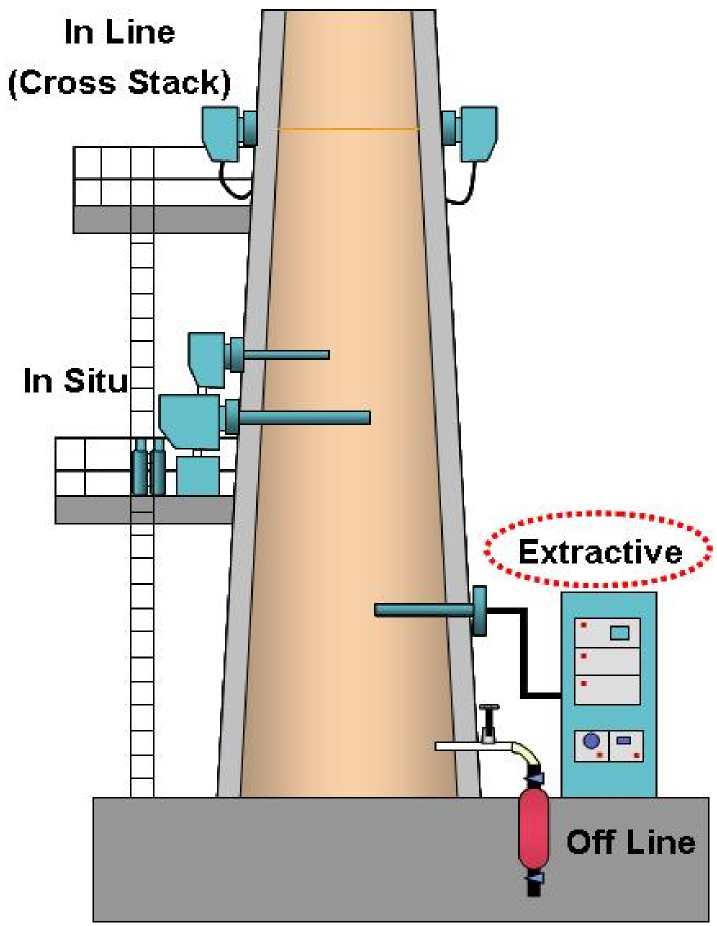
-Calibration Cylinders Arrangement on stack

-Technical Skills expert required on top of stack to trouble shoot !

-Approach / Platform / Ladder Challenges / Lifts !

-CPCB Lab Calibration Checks !!

On-line (Direct extractive) principle



Advantages

-Simple Probe Installation on Stack

-Sampling Automated - No manual sampling necessary

-Heated Sample line – Prefabricated for negligible maintenance

-Easy access for maintenance at the analyzer

-Multi component measurement possible

-Easy calibration, built in Cal Cell options

-Modern prefabricated Heated Line are leak proof Self Regulating – hardly any maintenance

-Multi Stack / Chutes meas with one system – Normalized Measurement

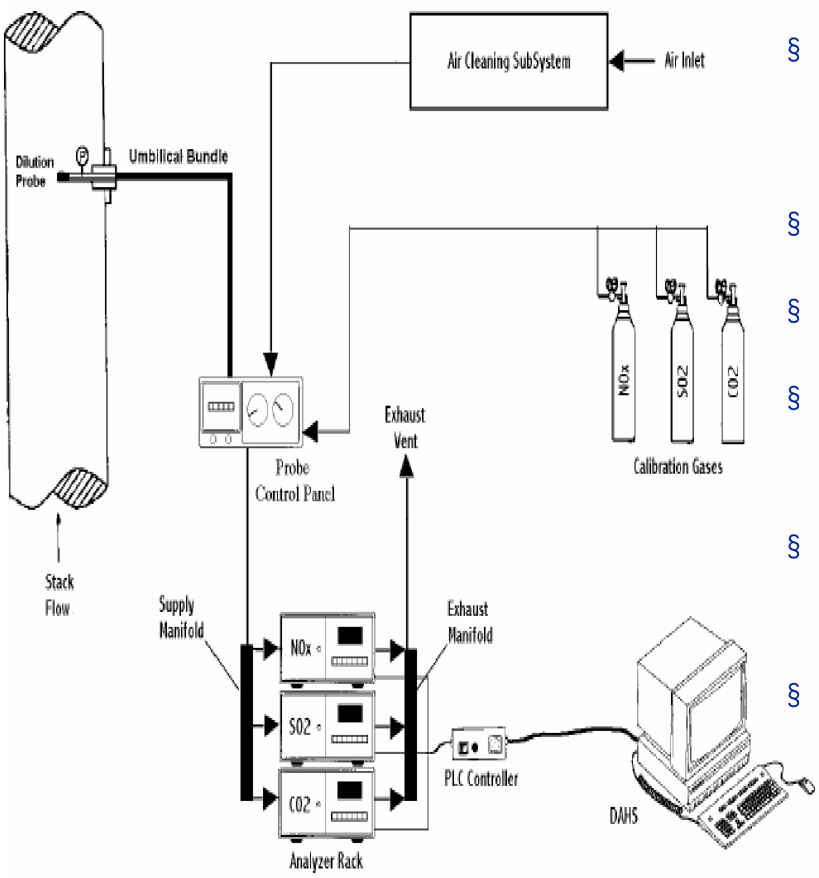
- Proven Process to Stack

Disadvantages

- Additional effort for sampling and conditioning / Installation

-Longer response times in absence of fast loop

Extractive – Dilution Type
eg. CLD (Chemiluminecense)

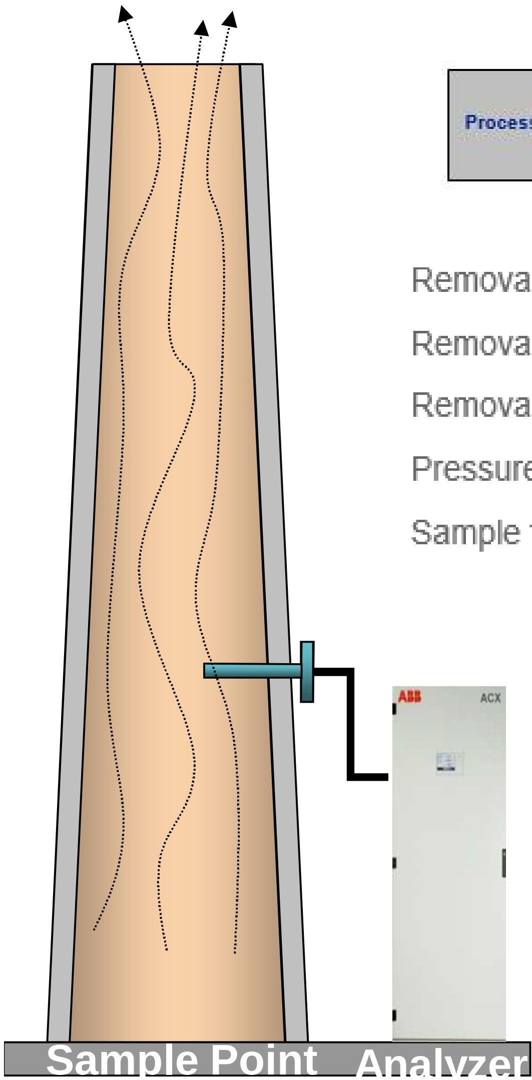


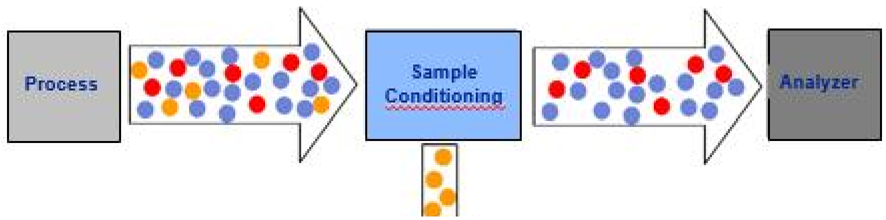
Source: Thermo

Dilution Measurements (Extractive)

- Sample gas diluted with air in a specific ratio
  - Typically 20:1 up to 100:1
- No measuring components in the dilution air !!
- Complex pneumatic system
- Influenced by temperature , pressure, viscosity, Dusty environmet
- All effects and influences increase depending on the dilution ratio
- Technology popular in the USA
  - Simulates pollution values in the Ambient
  - Calbiration gases need to be at Probe inlet
  - Analyser Technologies : CLD (Chemiluminecense, UV Fluro – **PPB/Low PPM sensors –** Originally Lab sensors to Ambient Air Measurmeents.

On-line CEMS method – Extractive Dry





Removal of solids (dust etc.)

Removal of condensable components (e.g. H_2O)

Removal of corrosive components and interfering components

Pressure reduction

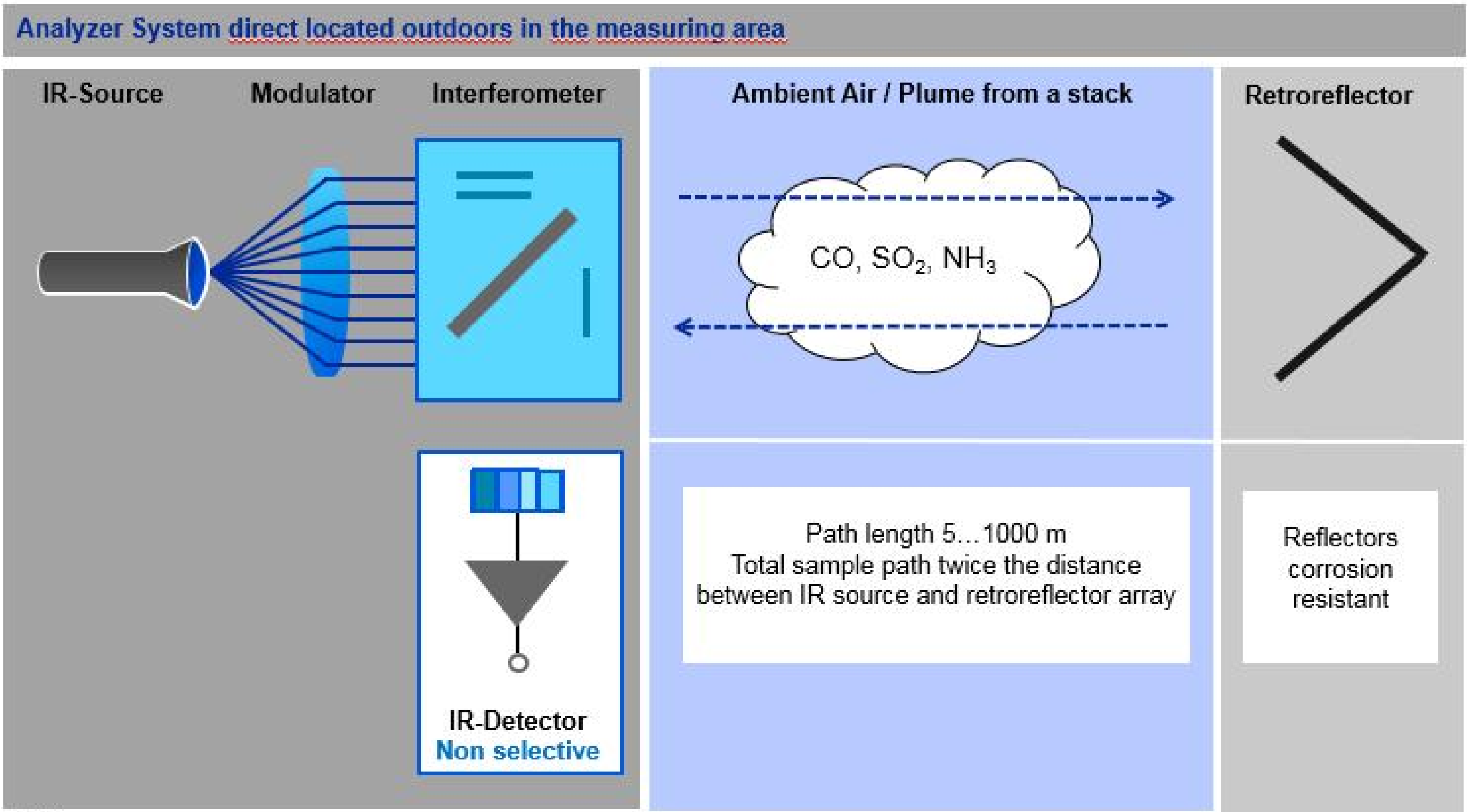
Sample transport

Direct Extractive Technology dominates Harsh / Critical Process measurement like Control, Optimization, Safety measurements !

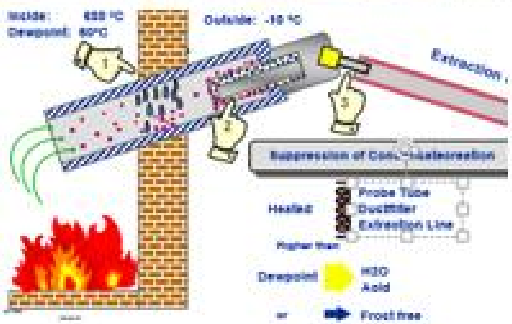
Industries: Cement, Steel, Refinery-Petrochem, Chemical & Fertilizer, Power, etc

Same proven technology continues for CEMS !!

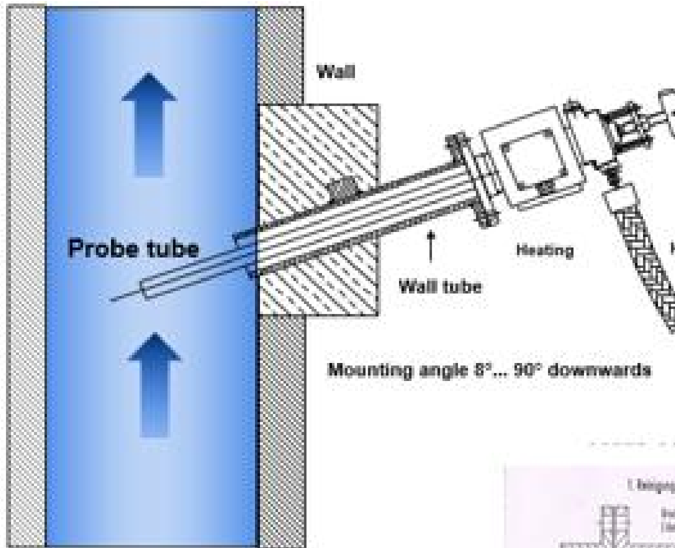
Continuous Operating Methods
Open Path Multi-Gas Analyzer – eg. FTIR, DOAS



Gas Sampling Probe – Modular Sampling

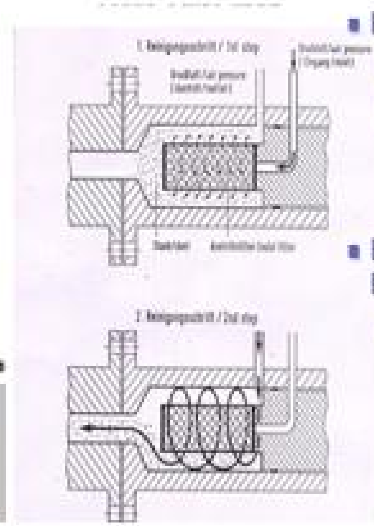


Process parameter:
- Temperature
- Dewpoint H2O [°C]
- Sulphuric Aerosole Acid dewpoint [°C]
- Dust / Ash Content
- Corrosive components
- Process flow velocity

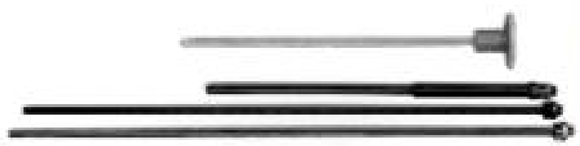


One single sample point required for all measured components

With Auto Blow Back Facility



- Filter Element specs
  - CERAMIC, 3 Micron filter size
  - Efficiency: 99.99% by weight
- Back Purging / Scavenging Filter Assembly
  - Dual Stage Cleaning Cycle due to HIGH Dust Load at Economiser.

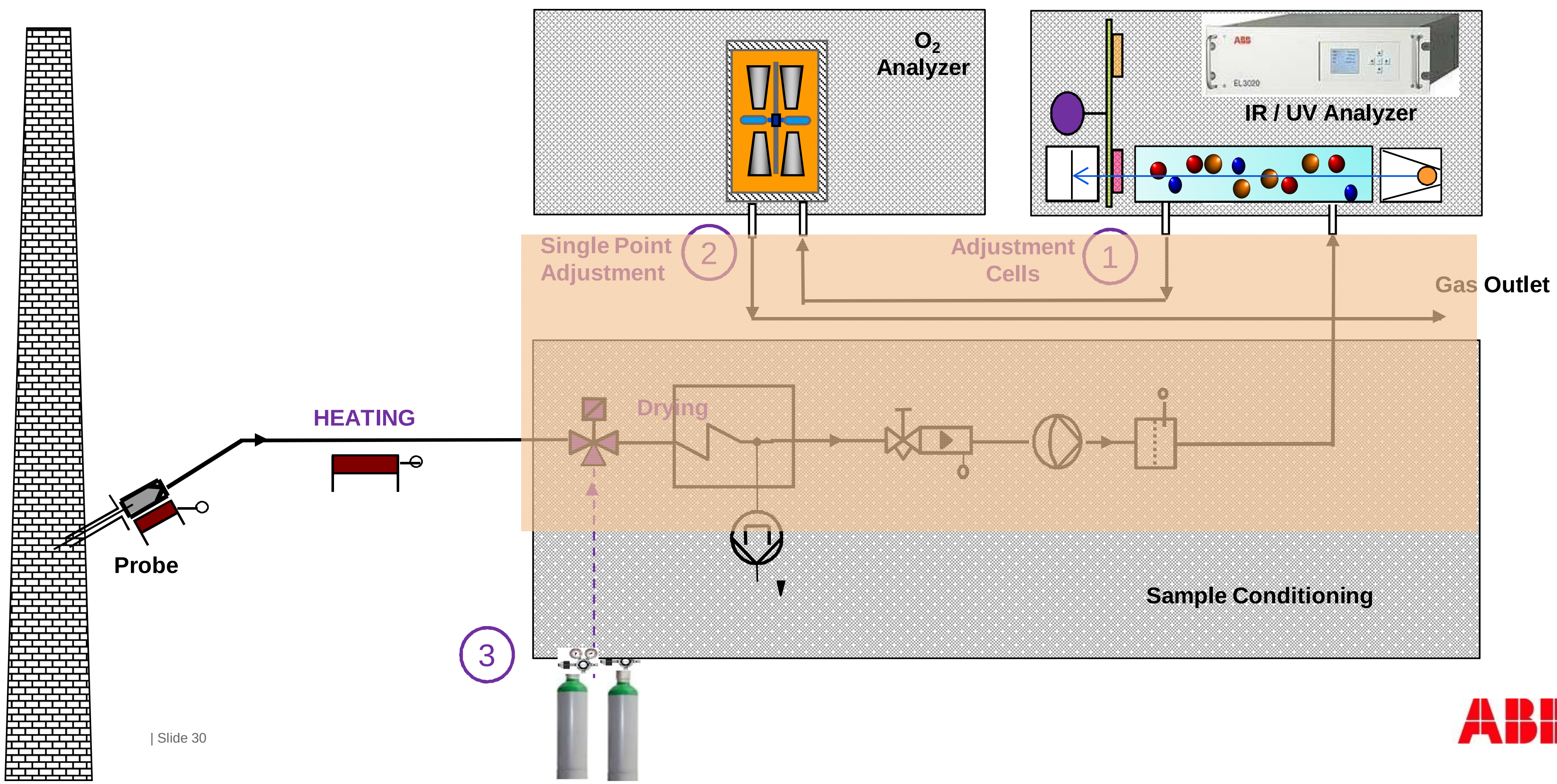


Different Probe Types – Metallurgy for Hi Temp, Corrosive, etc

High temperature ~ 600 – 1000+ °C
Dust content max. ~ 150 g/m³

Hot Wet extractive operating CEMS
System Design

Stack	Sampling ≥ 180°C	Sample Line ≥ 180°C	Sample Conditioning ≥ 180°C	Analyzer ≥ 180°C	Exhaust



Measuring Methods
Typical Techniques

Methodology	Principle / Technology	Typically Gases measured	Key Points
Insitu – Cross Duct	IR / UV	CO, SO2, NO	Exposed to Flue Gas – T,P, H2O, PM
Insitu Cross Duct	TDLS (Lazer)	HF, HCL, NH3, H2S, HCN	Exposed to Flue Gas – T,P, H2O, PM
Insitu Folded beam	IR / UV	NDIR, NDUV	Exposed to Flue Gas – T,P, H2O, PM
Extractive – Dry	IR / UV	CO,CO2, SO2, NOx, VOC	Simplified Probe Heated Filter - Auto Clean
Extractive – Hot Wet (Heated)	FTIR/UV	NH3, HCL, HF, SO2,NO, VOC	Simplified Probe filter - Auto Clean
Extractive – Dilution	IR/CLD/UV Fluro	CO,SO2,NOx	Exposed Probe– T,P, H2O, PM

Unregulated methods like Electrochemical / LEL detectors packaged as Analysers !!!

Lab Technique / Aging / Decay Life / Drifts !!

Normalisation in CEMS
Conversion to standard conditions

Standard conditions means conversion of measured data to normalized conditions at 0°C, 1013 hPa, dry flue gas and specific O_2 content.

$$mg/Nm^3 = mg/Om^3 \; \frac{t + 273{,}15}{273{,}15} \cdot \frac{1013}{1013 + p} \cdot \frac{100}{100 - H_2O} \cdot \frac{21 - O_{2,\,st\;Ref.}}{21 - O_{2\;Stack}}$$

mg/Nm³ : mg / Normalized m³ (Standardized value)

mg/Om³ : mg / Operation m³ (Measuring value)

$O_{2\ Ref.}$: Oxygen concentration - Reference value

$O_{2\ Stack}$: Oxygen concentration - Stack

H_2O : Water vapour concentation

T : Temperature in °C

P : Pressure in hPa (mbar) • Diff. between static pressure of the sample gas & standard pressure

Base Values used for Standardizing Formula				
Measurement Principle	**Temperature**	**Pressure**	**Water**	**Oxygen**
Cold / Dry	**No**	**No**	**No**	**Yes**
Hot / Wet	**No**	**No**	**Yes**	**Yes**
In-Situ Cross stack	**Yes**	**Yes**	**Yes**	**Yes**

§ **Cold / Dry**
Test gases are introduced at standard conditions (0°C and 1013 hPa).
Requires no conversion of *t & p. The test gas is measured at the same conditions as the flue gas.*
Sample & test gas will be moistured to the water dew point of the cooler (e.g. +3°C = 0,75 Vol%).

§ **Hot / Wet :** Test gases are introduced at standard conditions (0°C and 1013 hPa)
Requires no conversion of t & p.

Summary on CEMS Methodology

1. Many Methodoligies – Insitu / Extractive

- Remember – there is no fit and forget solution so go with reliable proven technology
- Measurements – Notified Pollutant gases & online measurement of Dilutants like O2.
- Certified Emission Analyserseg. TUV/MCERT for Assurance levels as its adds security for Legal / Compliance Environment.

2. Other Factors to Note

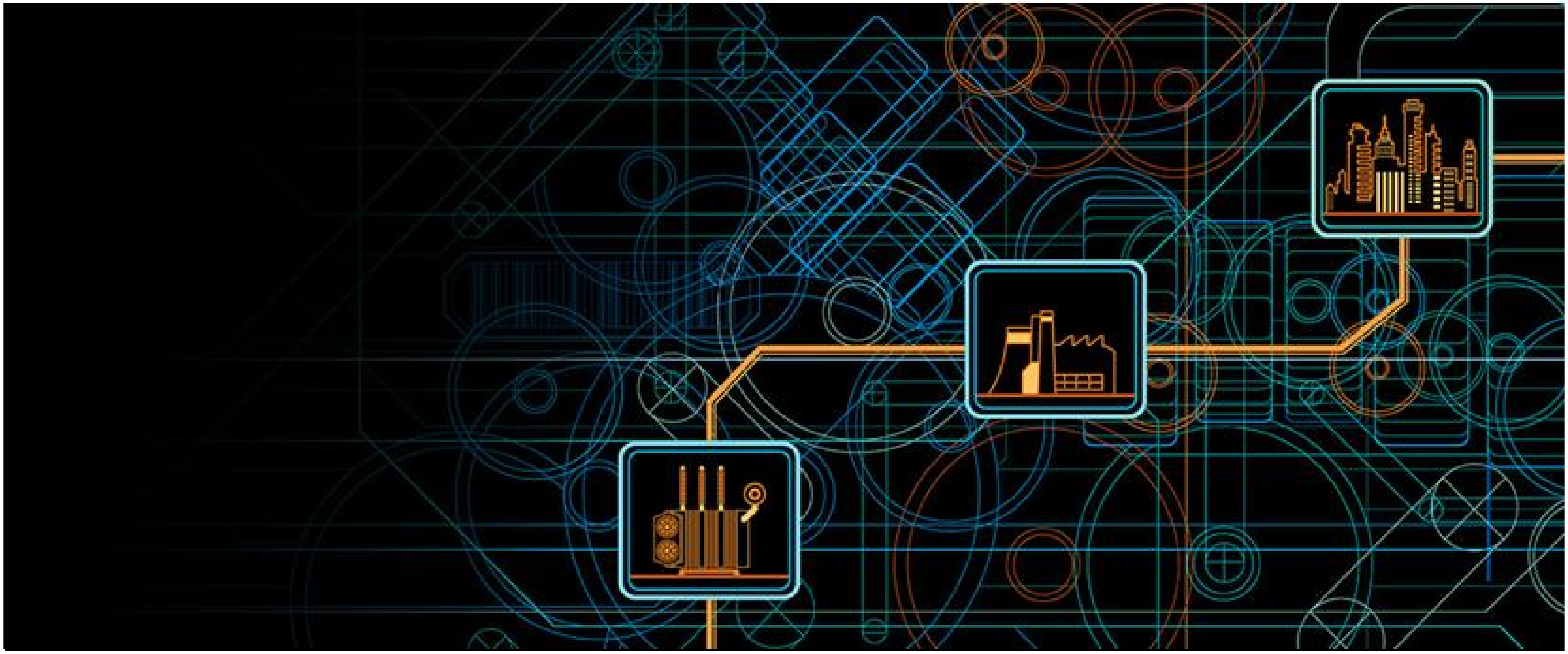
- Factor the India Specific Challanges like fuels High Ash Coal / High Sulfur Petcoke ~ What works in process should work in stack !
- Ambient Conditions on top of Stack
- Straight Runs / Platforms availability
- Old Stacks – Porus / Weak / Availability of openings – Single vs Diametrically opposite, etc.
- Ease of Maintenance ~ Field mounted vs Controlled Aircon Mounted

3. Calibrations

- Factor Cost of Calibrations
- Regulatory req may require Daily / Monthly /Quaterly Calibration Checks – Significant Impact !!

4. Plant Operator Data

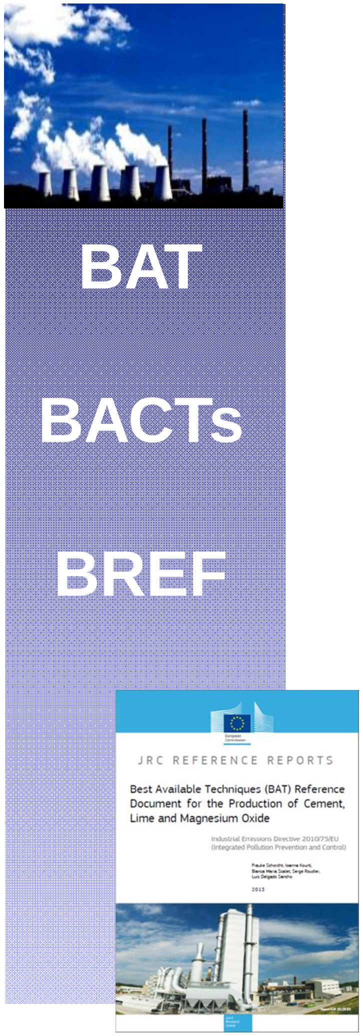
– Actual Flue Gas data – is Key to correct selection



Measurement Techniques
Best Available Technologies (BAT) for for CEMS

IED - Industrial Emission - EU Directive 2010/75/EU

Best Available Techniques • BAT and BREF Documents



Permittance for Waste Incinerators, Power Plants, Cement Plants

- Permittance based on Best Available Techniques - BAT
- Updated, if new BAT Conclusions adopted - BATCs
- BAT is not limited to CEM → Main criteria for BAT
  - Use of low-waste technology
  - Consumption and nature of raw material
  - Energy efficiency
  - Preventiton and reduction of emissions
  - BAT - AELs → Achievable Emission Limits
- BREF → Best Available Techniques Reference Document

Extract of Pollutants to be monitored at Waste Incineration Plants				
Pollutant component	Daily Emission Limit Value ELV 1)	Half - hourly average values	Certified ABB Products	Remark
CO	50 mg/Nm³	100 mg/Nm³	EL3000 / AO2000 / ACF	Range typ ELV*1,5
SO_2	50 mg/Nm³	200 mg/Nm³	EL3000 / AO2000 / ACF	
NO_x ($NO + NO_2$)	200 mg/Nm³	400 mg/Nm³	EL3000 / AO2000 / ACF	Sum of NO+NO_2, NO_2 sep. if > 5% of NO

Summary • EU Legislative Requirements

Scientific Approach

Plant requirements Directive 2010/75/EU IED	Measurement requirements according to EN 15259	Testing & Approval according to EN 15267	Quality Assurance according to EN 14181
• BAT - AELs • Availability • Permission criteria • Environment Inspections	• Sites • Sections • Plane • Points	• Performance test • Quality Management • Test reports • Certification	• QAL1 - Suitability Test • QAL2 - Test at site • QAL3 - Monitoring • AST

Different gas species – different physical properties
Different measuring methods needed

Infrared spectroscopy

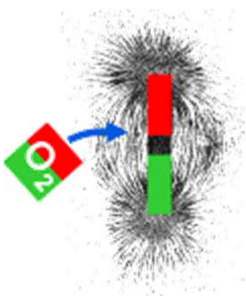
Selective absorption of IR light

Typical gases: CO_2, CO, NO, SO_2, C_2H_4, NH_3

Ultraviolet spectroscopy

Selective absorption of UV light

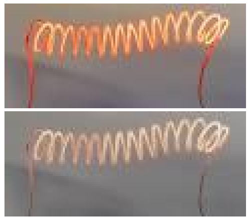
Typical gases: NO, NO_2, SO_2, Cl_2, NH_3



Magnetic susceptibility

Measurement of paramagnetic O_2

Thermal conductivity



Measurement of differences in thermal conductivities

Typical gases: H_2, He

Flame ionization

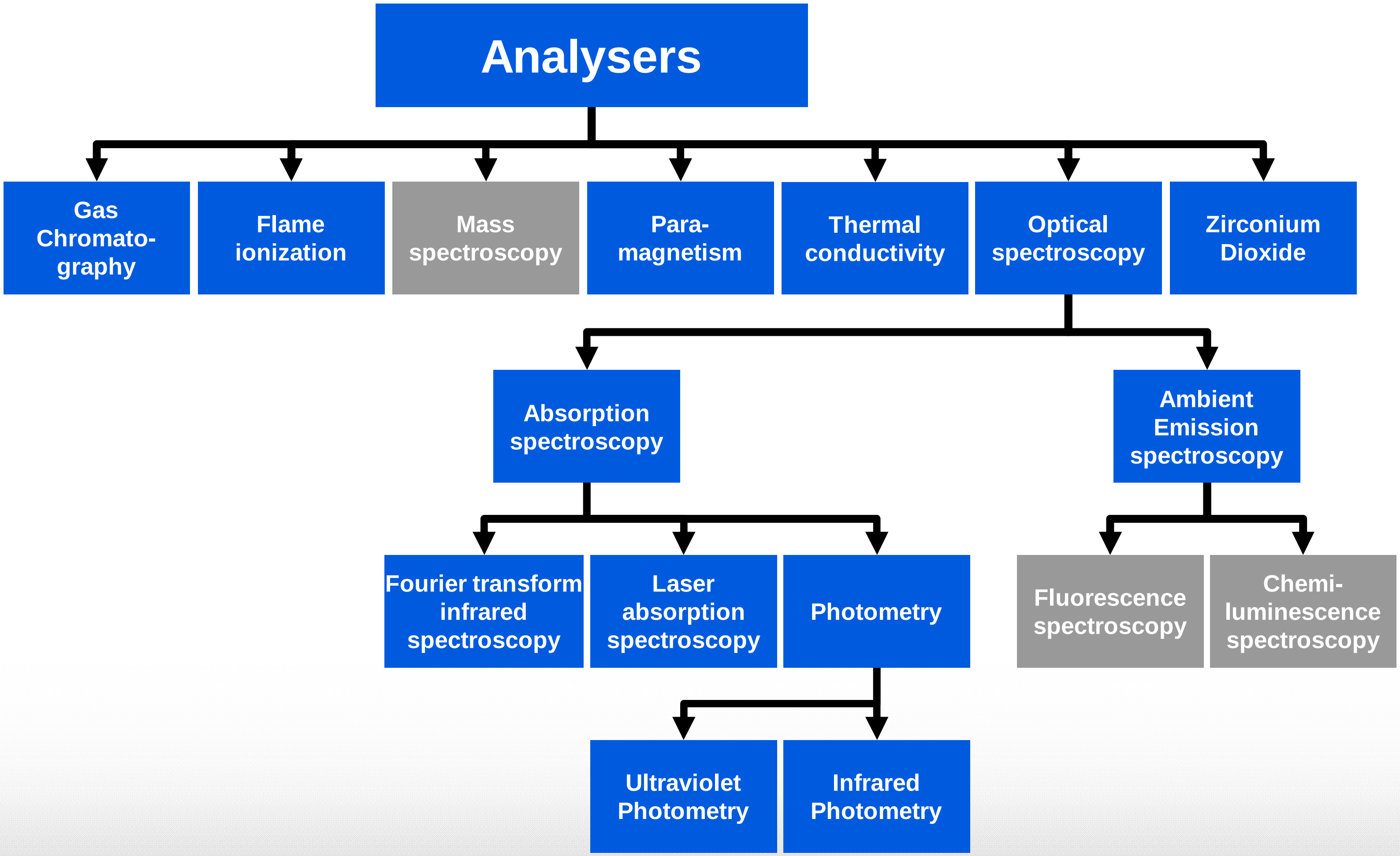
Ionization of organic compounds in a hydrogen flame

Typical gases: all kind of organic compounds, e.g. CH_4, C_3H_8

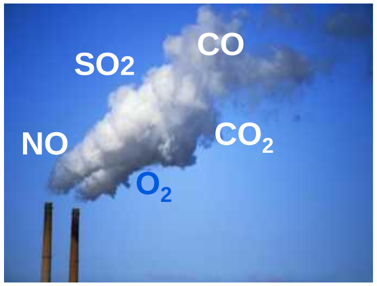
TDLAS (Tunable Lazer Diode)

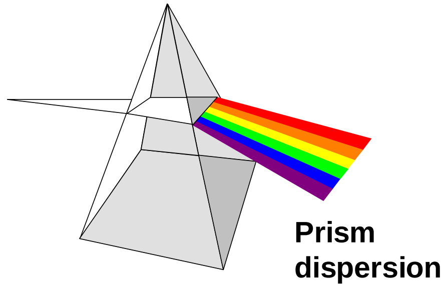
FTIR Spectroscopy

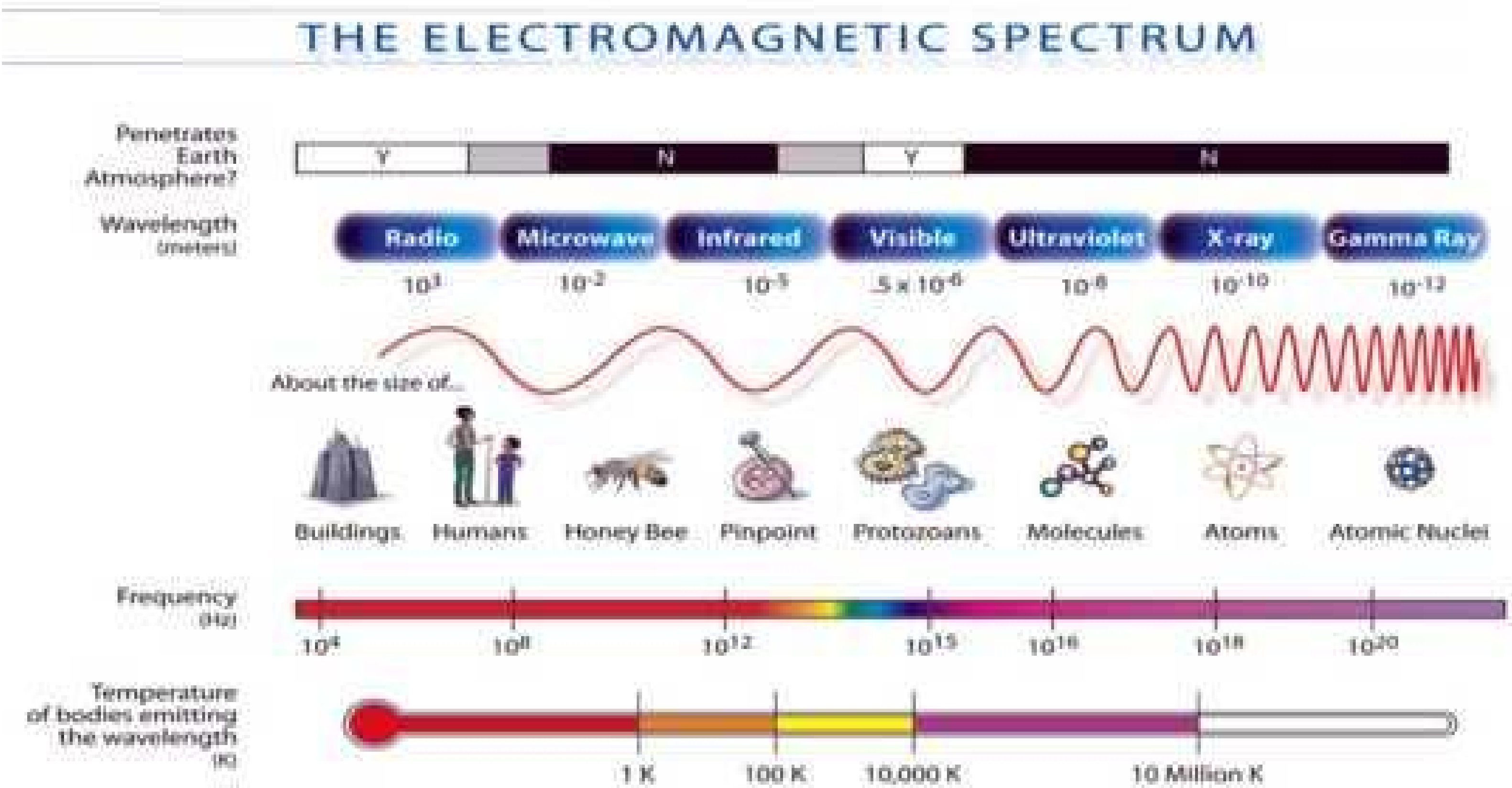
Gas analyzers
Technology Tree



Electromagnetic Spectrum







Multi Modular Analyzers – Plug & Play
Lower Cost of Ownership with Flexibility

Analyzer modules which are suitable for practically any measuring task:

- **Photometry (UV, IR)**
  - **Uras26**
  - **Limas11**

- **Thermal Conductivity (TCD)**
  - **Caldos27**
  - **Caldos25**

Disruptive Electrochemical

- **Paramagnetic Oxygen (Paramag)**
  - **Magnos206**
  - **Magnos27**

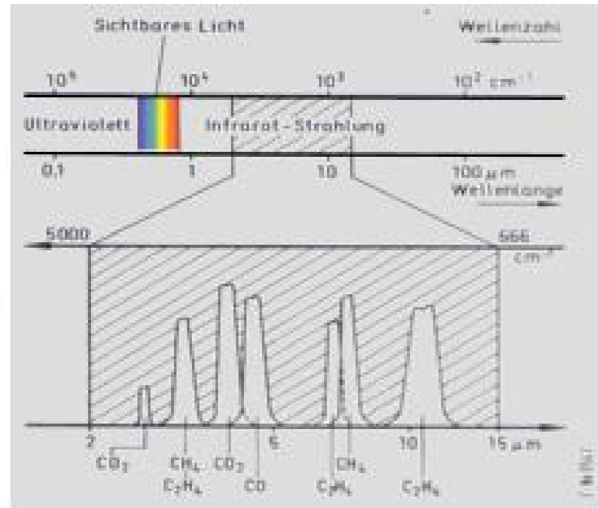
- **ZrO_2 (Zirconia)**

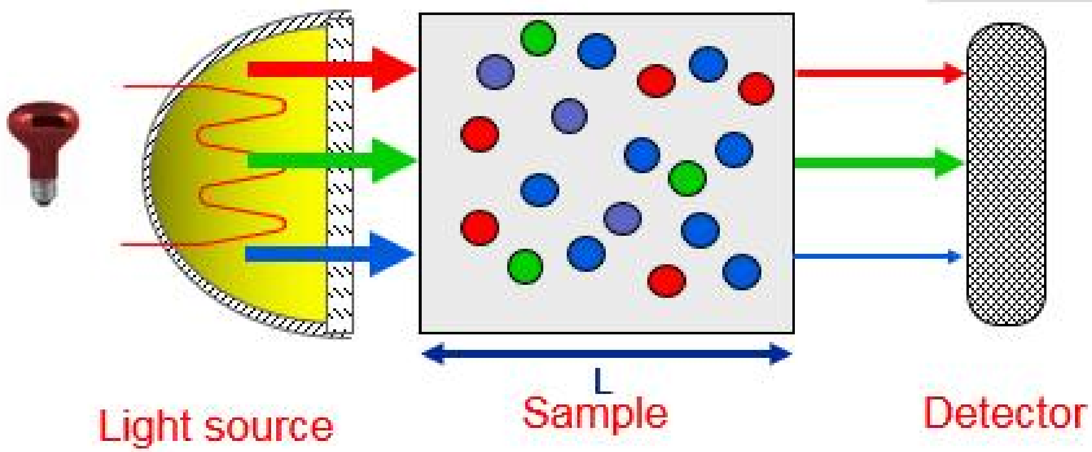
- **Flame Ionization (FID)**
  - **Fidas**

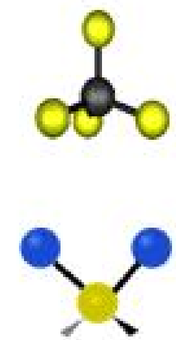
- **Laser In-Situ**
  TDLS

Photometer Widely used IR
Basics

- Radiation (e.g. light) is energy
- Selective absorption of radiation at specific wavelengths
- Absorption proportional to the concentration of gas molecules

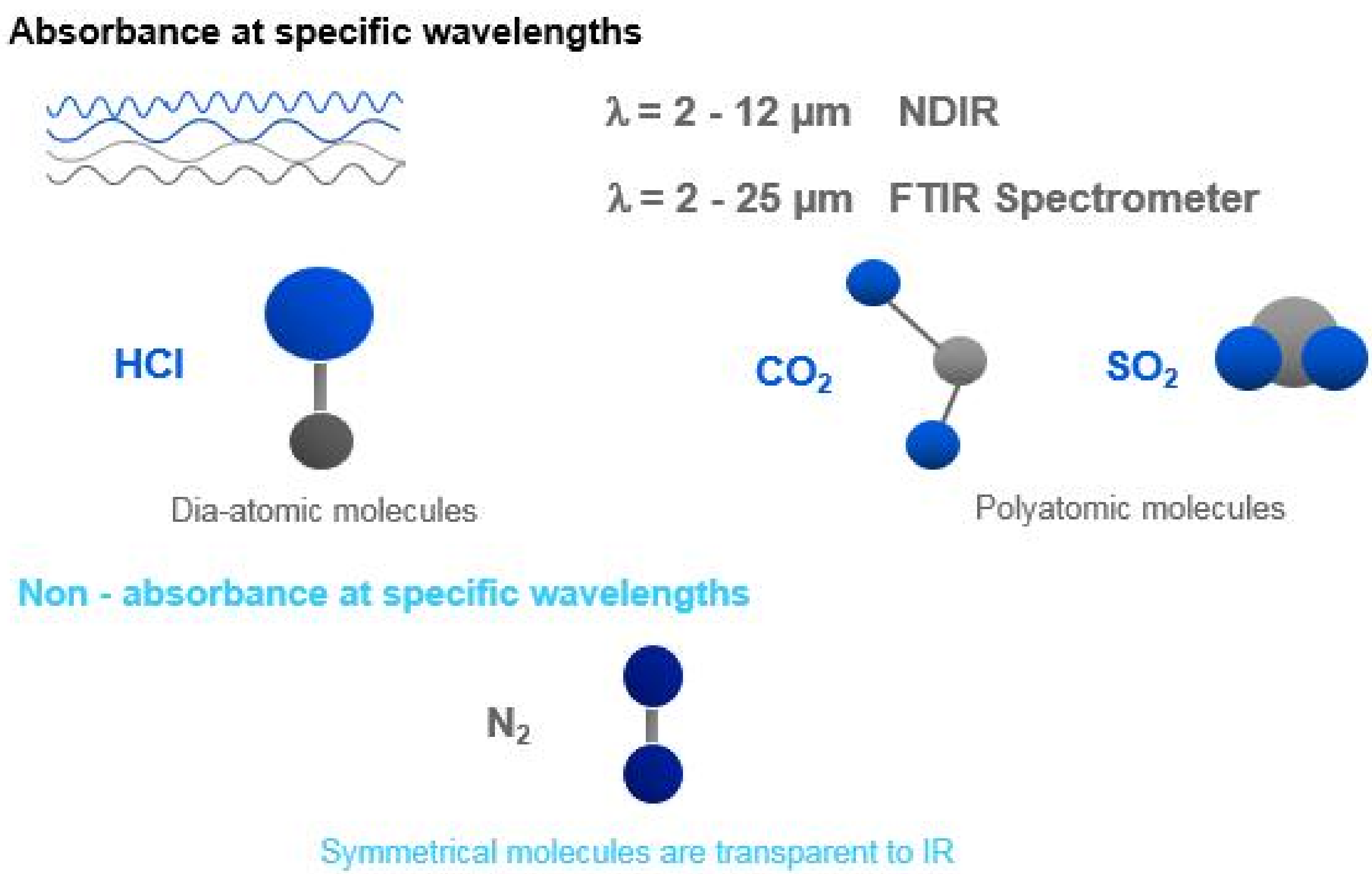






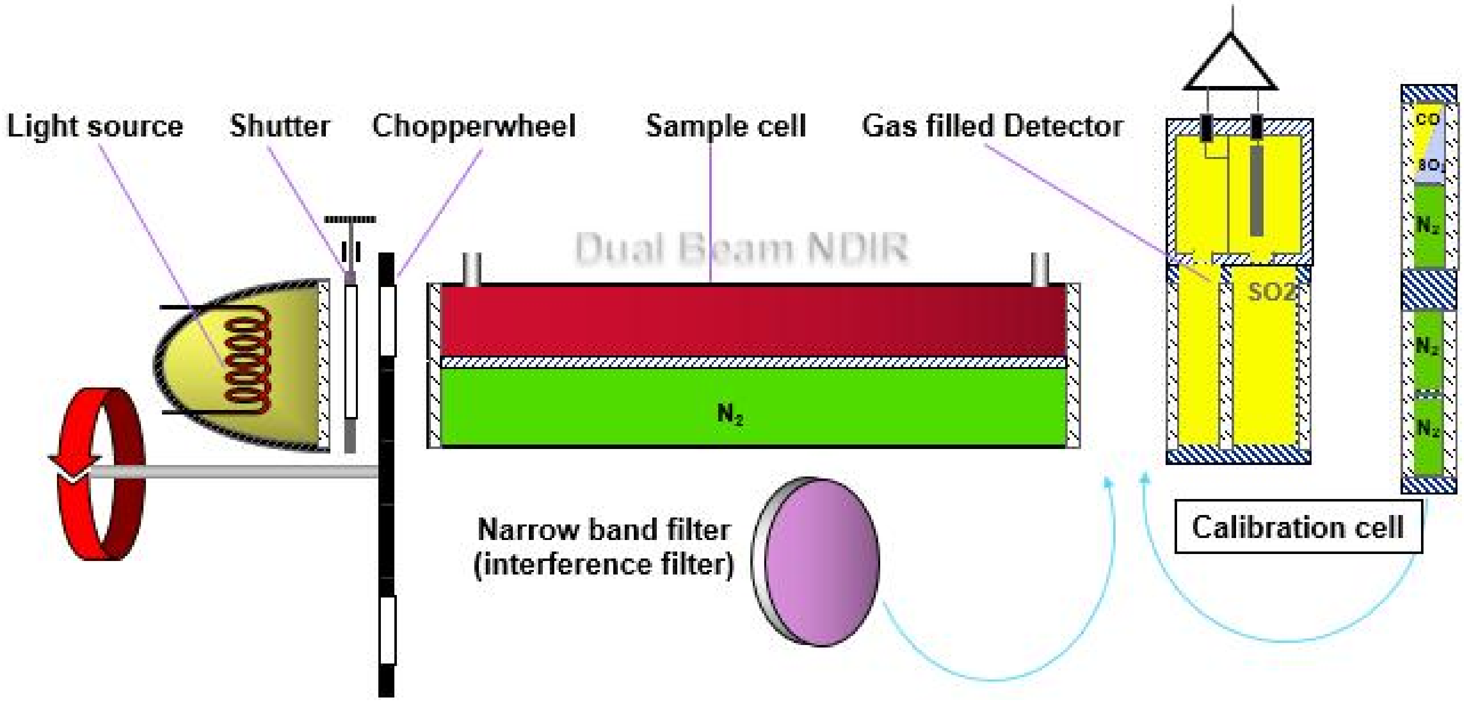
Length of optical path (L) affects measurement sensitivity

Measuring method of NDIR / FTIR
Absorbance of molecules in the IR Spectrum



Dual Beam NDIR Photometer - Most Popular CO/CO2/NO/SO2/CH4, etc

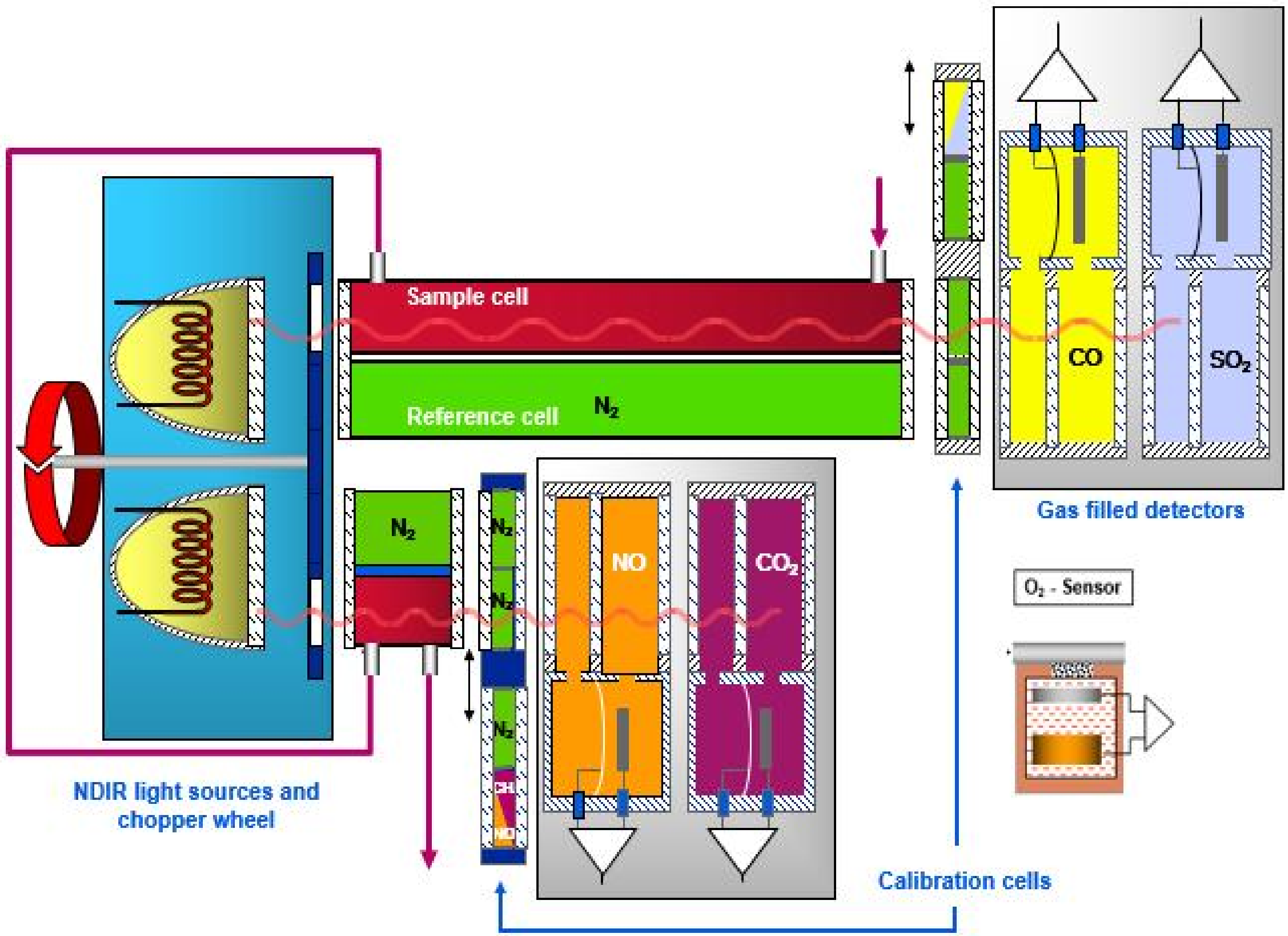
optional with interference filter and calibration cell



HIGH END NDIR ANALYSERS BASED ON DUAL BEAM **NDIR** : IR Radiation is Modulated through Sample Cell Measurement Chamber and References Side for Lowest Drifts Long Term Stability, Lower Cross Interference from Background gases.

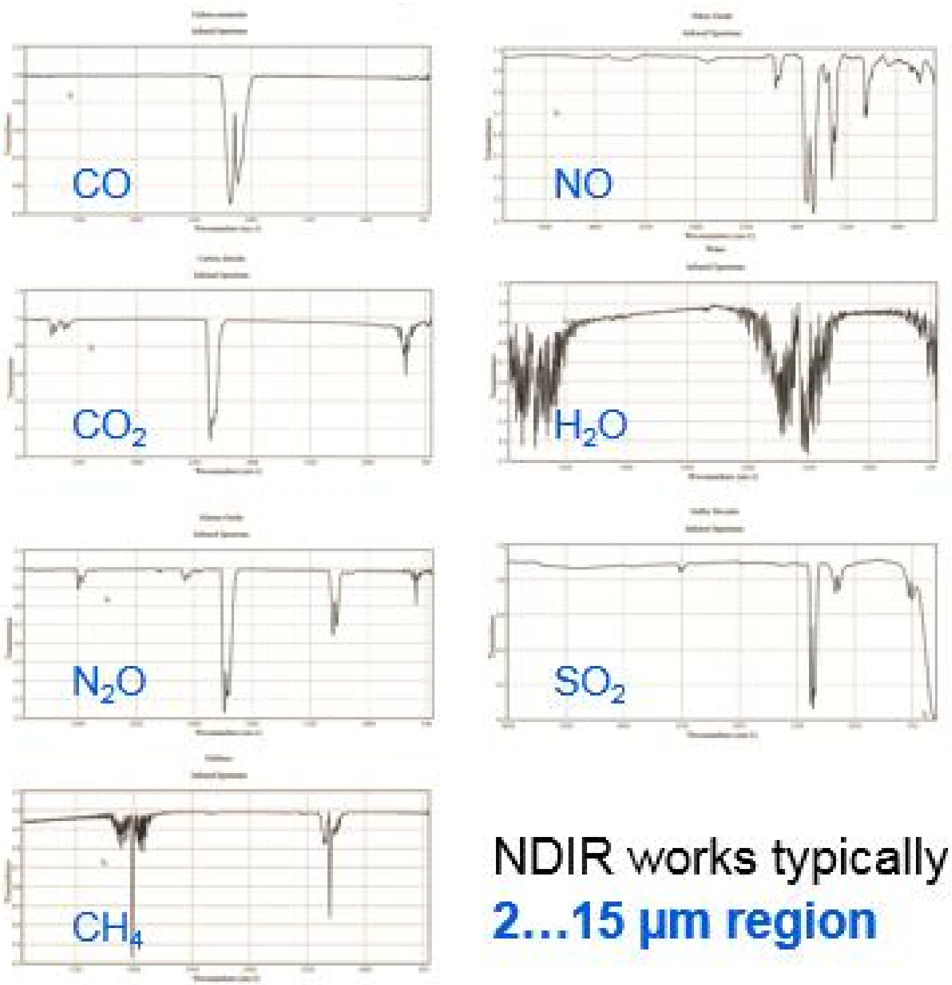
- Single Beam : Dual Beam : GFC : IFC Type NDIR

Dual Beam NDIR Photometer
5 Measuring Components with O2



Fingerprint spectra

CO has an **absorption band of between 4 and 5 µm**

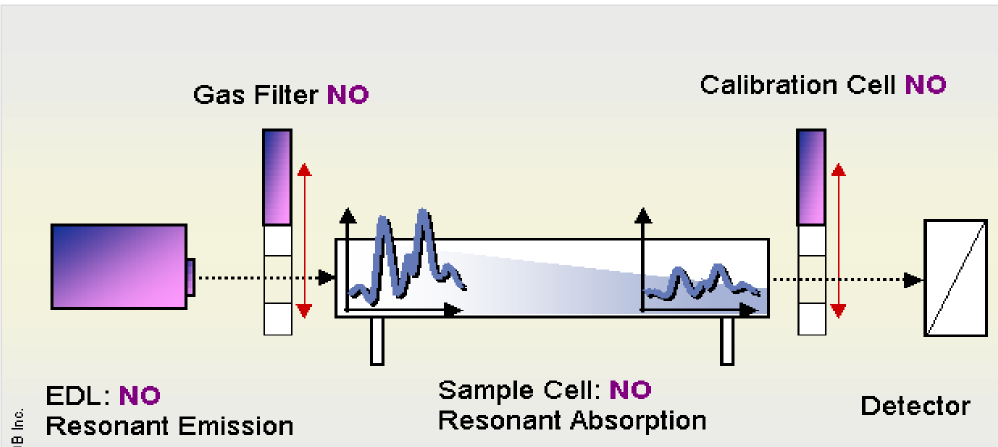


NO has an **absorption band of between 5 and 6 µm**

H_2O has **various absorption bands in the range of 2…15 µm**

NDIR works typically in the **2…15 µm region**

UV Photometer
The measuring principles



Non-**d**ispersive **UV** spectroscopy (NDUV) for NO_2 and SO_2 measurement

Selection of wavelength with interference filter

Highly selective measuring method:

Transparent to H_2O

UV Lamp – Limited Life / Costs

When UV for SO2 with NO+ NO2 – Very low

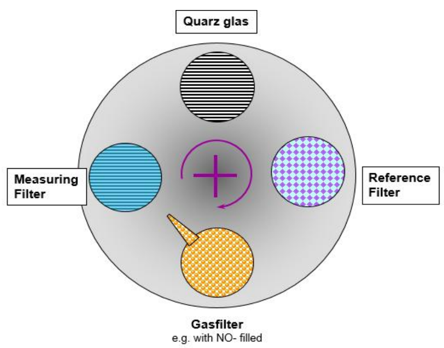
ges eg 25 to 50ppm ranges in high moisture

kground

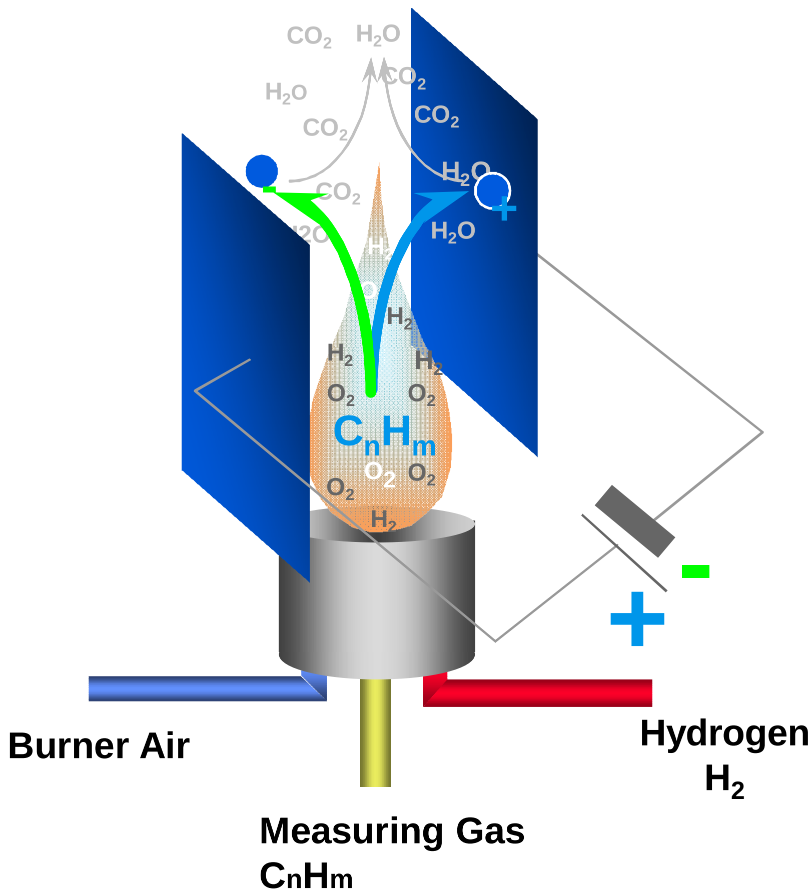
rosive applications eg Chloroalkali

Typical eg: SO2, NO+NO2, NH3, CL2, H2S, COS

Industry	*Process*	*Component*
Power & Waste	CEM	NO, NO2, SO2
Power & Waste	DeNOx	NO, NO2, NH3
Chemical	Sulfuric Acid	SO2
Chemical	Nitric Acid	NO, NO2
Chemical	Chlorine	Cl2
Oil & Gas	Biogas Purification	H2S
Oil & Gas	Natural Gas	H2S
Oil & Gas	Refinery – SRU CEM	SO2
Textile	CEM	SO2, H2S, COS
Automotive	Exhaust Gases	NO, NO2



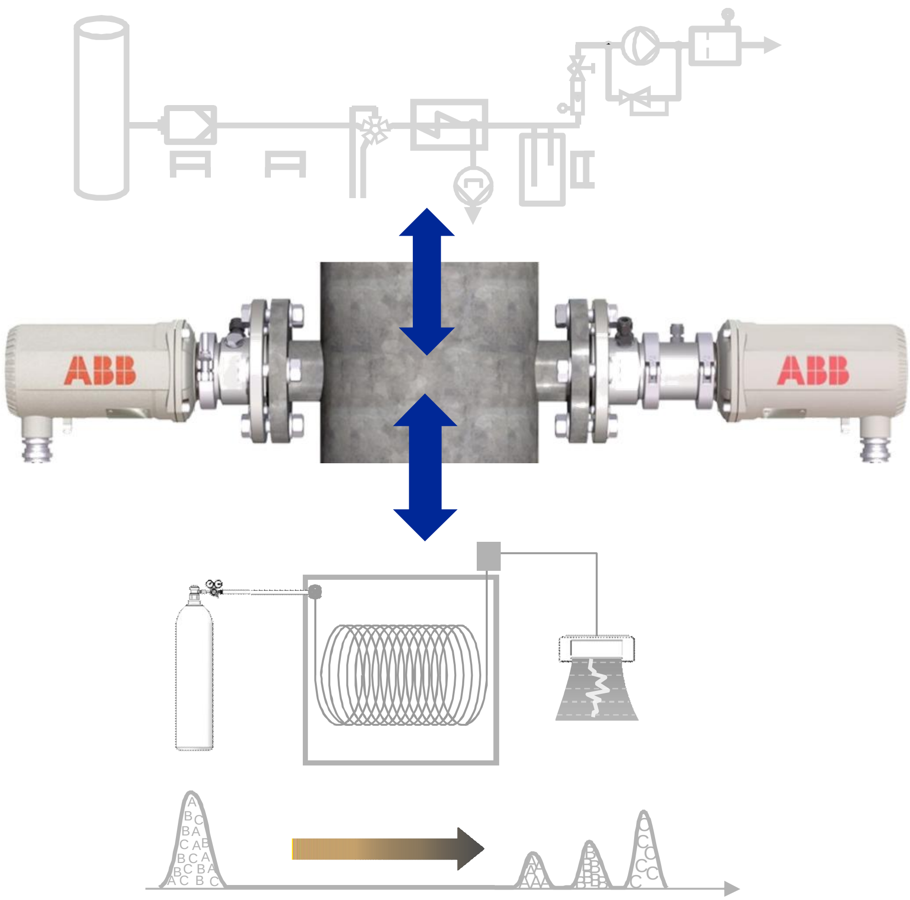
FID – VOC (CnHm)
Measuring Principle - Selective



- Based on the ionization of hydrocarbon molecules in a hydrogen diffusion flame (FID)
- Ions are measured via electrodes within an electrical field.
- Ions are attracted to the electrodes and induce a current.
- The resultant current measured corresponds to the proportion of reduced carbon atoms in the flame.

Fast and direct – TDLS (Lazer)
Tunable Diode Lazer Spectroscopy

Gas	Tmax °C	Pmax bar
O_2	1500	10
HCl	300	2
NH_3	400	1.5
HF	300	2
H_2S	300	1.5
CO	1500	3
CO_2	1500	3
H_20	1500	1.5
HCN	300	2
CH_4	300	2



No sample transport or conditioning

- TDLS (is directly installed at the process (in situ).
- A sample transport or conditioning, like used in extractive systems, is not required.

Fast response

- TDLS is suitable for fast measurements with a typical response time of 2 seconds.
- TDLS allows better loop control and is ideally suited for process optimization and safety measurements.

On Line FTIR Spectrometer ~ HOT - WET

- **Hydrogen Chloride** **HCl**
- **Hydrogen Fluoride** **HF**
- **Volatile Hydro-Carbons** **VOC**
- **Ammonia** **NH_3**
- **Sulfur Dioxide** **SO_2**
- **Nitrogen Oxides** **NO**
- **Nitrous Oxide** **N_2O**
- **Carbon Monoxide** **CO**
- **Carbon Dioxide** **CO_2**
- **Oxygen** **O_2**

Why measuring hot (180°C)?

- Some gas are easily lost by condensation
- To prevent acid condensation hot design (180°C)

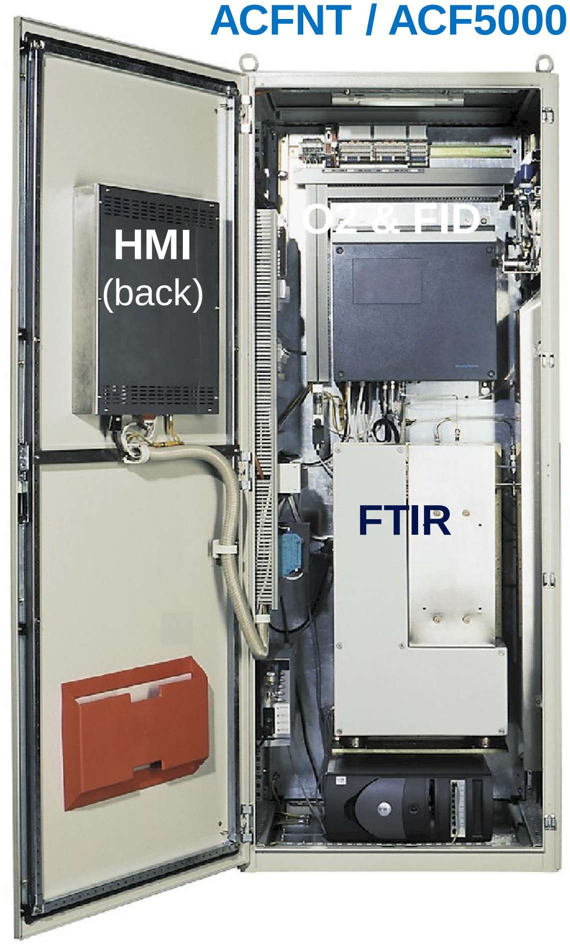
Certified for CEM applications

- EU – TÜV
- UK - MCERTS
- US – EPA compliant

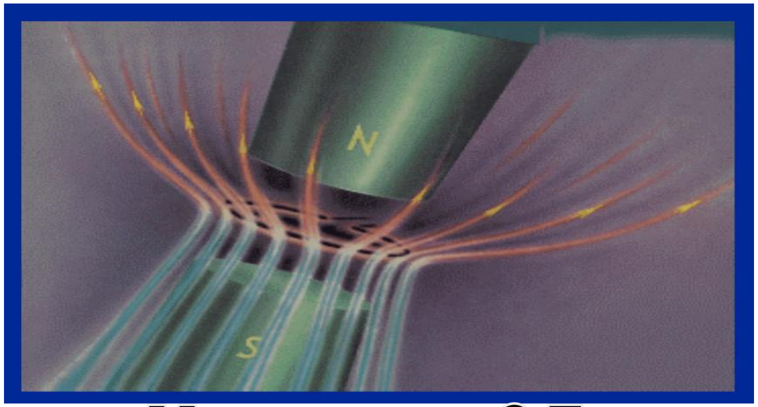
All Analyzers from a single Supplier

- FTIR Wishbone interferometer (mechanics) with lifetime warranty
- ZrO_2 Measurement
- Flame Ionisation Detector

ACFNT / ACF5000

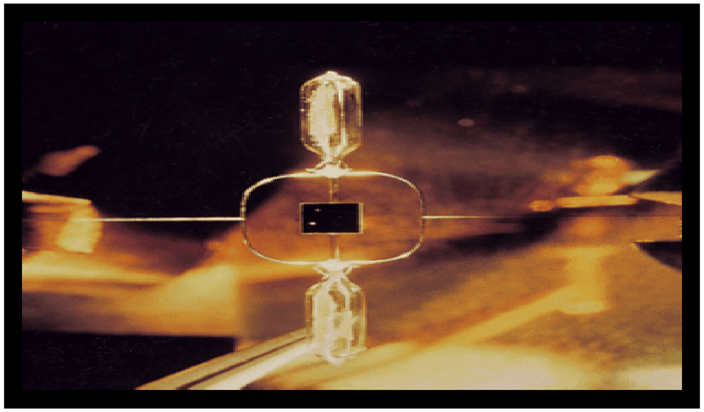


Oxygen Analyser Modules



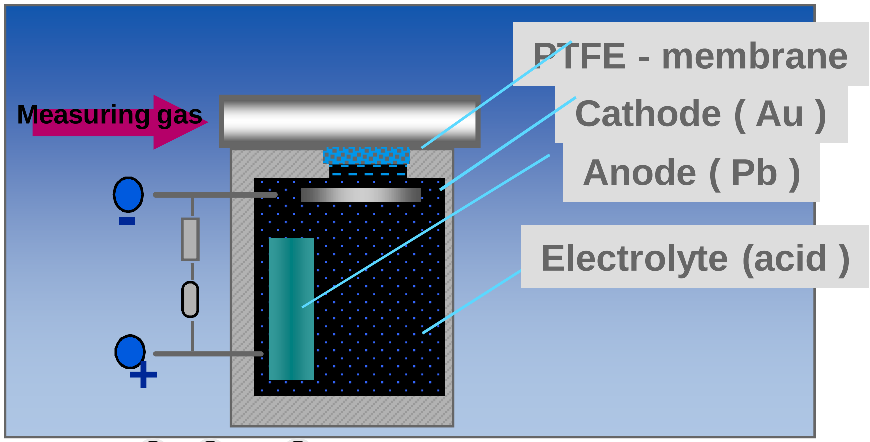
Magnos 27

Thermo Magnetic ~ Non Flowing Reference



Magnos 206

Magneto Mechanical Dumbell~ Non Flowing Reference



O2 Sensor

ABB

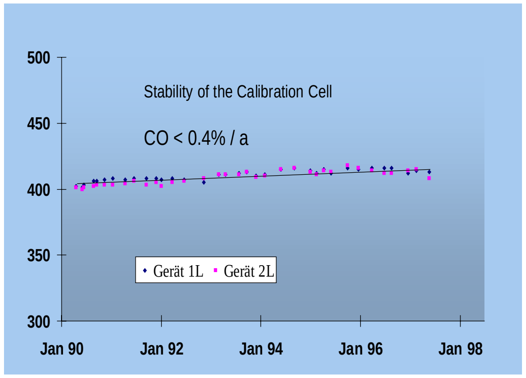
Examples for Suitable Measuring Methods
BAT – Best Available Technique by Regulators

Component	Tightest emission limit	Typical approved measuring methods
CO	50 mg/m³	FTIR, NDIR
SO2	50 mg/m³	FTIR, NDIR, NDUV
NO	133 mg/m³	FTIR, NDIR, NDUV
VOC	10 mg/m³	FID / FTIR
HCl / HF / NH3	10 mg/m³	FTIR, TDLAS, CRDS/ICOS (Hot Wet Technique)
NH3	10 mg/m³	FTIR, TDLAS, CRDS/ICOS (Hot Wet Technique)
O2 (as reference)		Paramagnetic, Electrochemical

Challenges : Cottage Solutions eg. LEL Detectors boxed in as a online Analysers

Dual Beam - NDIR Analyzer $CO/CO_2/SO_2/NO_x$
Industry Benchmark – Stability & Calibration Reference !

Linearity Deviation	: ≤ 1% of span
Repeatability	: ≤ 0.5% of span
Zero Drift	: ≤ 1% of span / Week
Span Drift	: ≤ 1% of Meas. Value / Week
Detection limit	: ≤ 0.5% of span
Response Time	: ≤ 2.5 sec at sample flow 60L/Hr
Position Effect	: No influence effect
Supply Variation	: 85 - 250 VAC, 48-63 Hz.

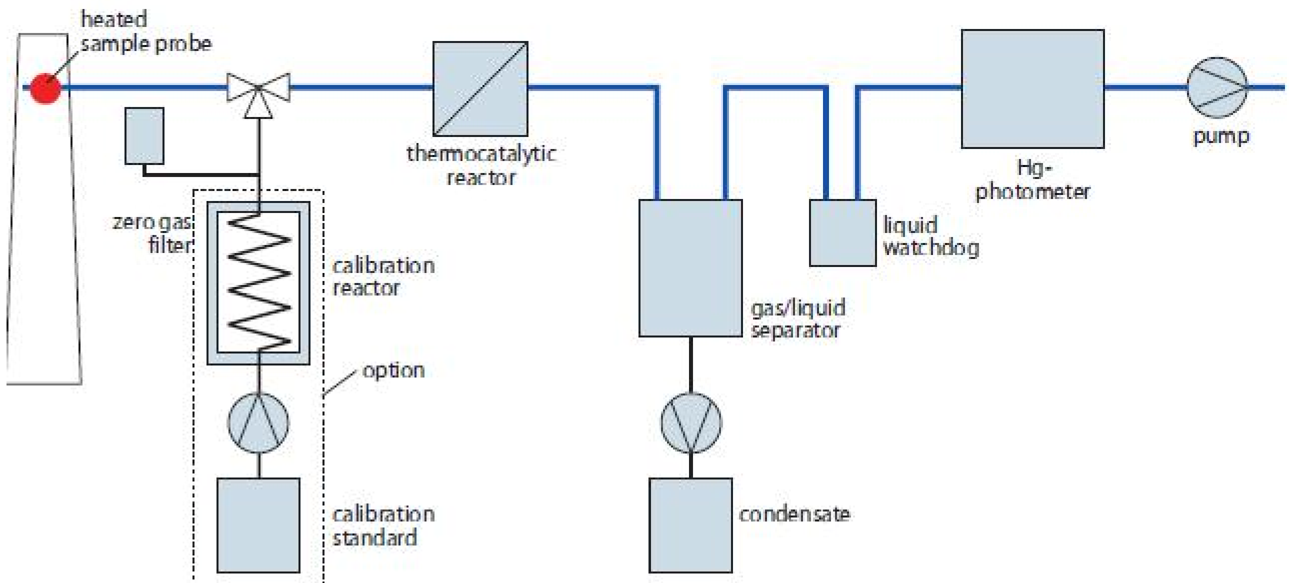


Accuracy / Validation : Optional Gas Filled Calibration Cells:

< 0.3 % Drift p.a

Mercury - Hg

Methodology	• Thermal decompsition • Reducing Vaporisation
Principles	• Atomic Absorption Spectroscopy : AAS • Atomic Absorption Fluoresence : AFS



Packaged CEMS Solutions
Custom Design to Meet Industries Needs

Emission Systems in Shelters **Free Standing Panels**

Summary...

- Guideline Document – For all Stake holders to follow / not Interpret on Convenience ~ Proven Scientific Approach
- BAT – Highlight the various technologies, where what to use
- Plant / Industry to provide correct stack data – Do right things first time
- Emissions get linked to Fuel - Accordingly the Analyser Technique
- Regulation / Compliance / Legal / Public – Certification for reliability / standardisation and is Enforceable.
- Clarity on Raw / Corrections Values – eg. Oxygen corrections
- Local Calibrtaion Facility / Lab for Linearisation in accordance to certifications
- Complementary Techniques like PEMS – Fill in Blank when system's down

Q & A
CEMS – Continuous Emission Monitoring

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