Post installation assessment of CEMS

Sector specific approach

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Understand the true purpose of Real time monitoring

Must not consider just a regulatory requirement, it is actually a proven tool to ensure optimised process, adequate pollution monitoring & control and compliance.

Pioneering countries- the US, Europe have experienced the benefit and many countries are following. Future, demands for accurate, less manpower intensive and quicker solutions, going to be era of real time monitoring. **A win-win situation for all- Government, industry and public at large. Good for India.**

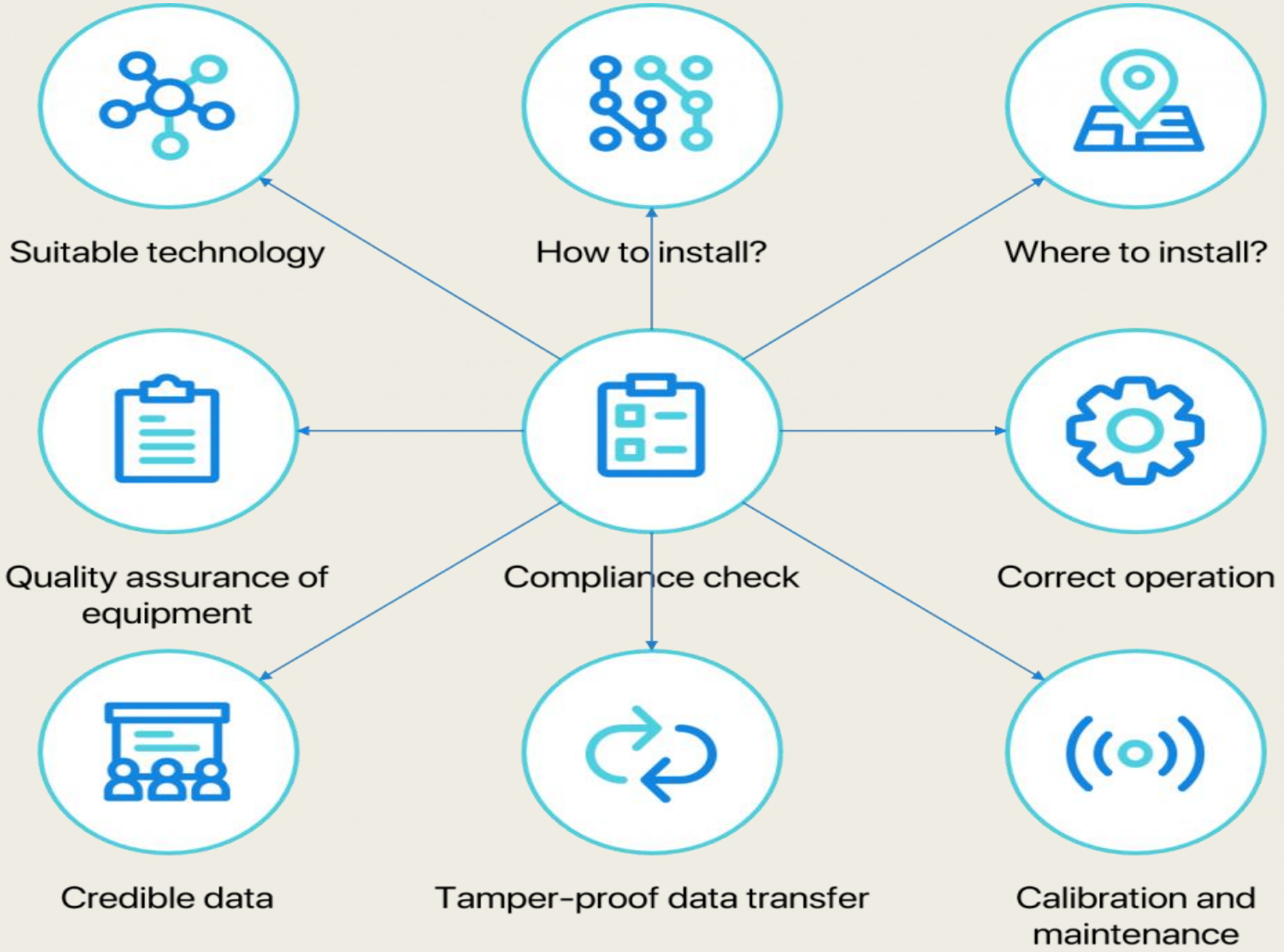
- **Industry gets-** opportunity to adopt self- monitoring, better compliance, better operational optimization, better/optimized pollution control with less human intervention, less unwanted regulatory interference.
- **Government gets-** better compliance check, better regulatory vigil with available limited resources, better quality and abundant data for policy level assessment, action plans and improvements
- **India gets-** better implementation of international commitments towards environment, better international recognition and support for sustainable development, effective environmental conservation and public health plans.

India's experience in CEMS: lessons learned

- Nearly 6 years of experience.
- Large industries have mostly installed
- Under many programmes in states, smaller RED category industries are also installing
- Initial challenges in implementation are nearly known, however only a fraction of them have been able to resolved.
- A large number of industries, mainly medium scale ones, are still unaware of the initial issues. The purpose is still limited to meet the requirement of installation and data supply.
- While moving towards data accuracy, in-depth issues are there which needs to be dealt with. Even larger industries and equipment suppliers are not aware of that. This leads to accurate data which only in-depth assessment can find.
- However, industry-focus towards environment monitoring has improved. Deputes dedicated person for CEMS handling
- Regulators are now keen on data quality
- Besides, the process of developing certification system has been started.

Implementation Challenges

Initial Implementation challenges



Wrong technology selection

MISLEADING CERTIFICATIONS

ZERTIFIKAT ■ CERTIFICATE ■ 認證證書 ■ СЕРТИФИКАТ ■ CERTIFICADO ■ CERTIFICAT

Management Service

CERTIFICATE

The Certification Body
of TÜV SÜD Management Service GmbH
certifies that

xylem

1

including the sites and scope of application
see enclosure

has established and applies
a Quality Management System.

An audit was performed, Report No. 70018126.

Proof has been furnished that the requirements according to

ISO 9001:2008

are fulfilled.

The certificate is valid from 2016-08-12 until 2017-08-11.

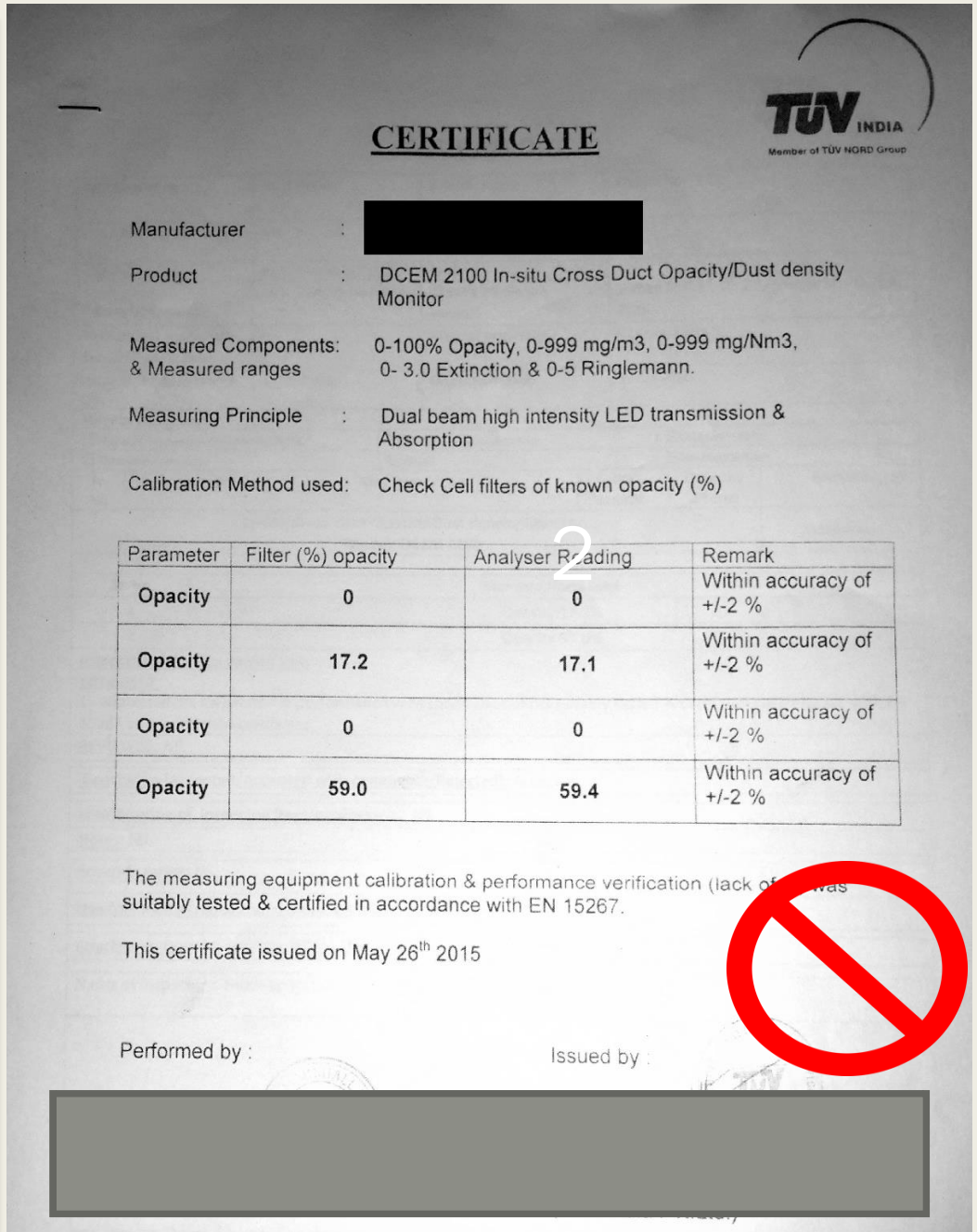
Certificate Registration No.: 12 100 17506 TMS.

Product Compliance Management
Munich, 2016-08-12

Page 1 of 2

TÜV SÜD Management Service GmbH • Zertifizierungsstelle • Ridlerstraße 65 • 80339 München •
www.tuev-sued.de/certificate-validity-check

TÜV®



CERTIFICATE

TÜV INDIA
Member of TÜV NORD Group

Manufacturer : [redacted]

Product : DCEM 2100 In-situ Cross Duct Opacity/Dust density Monitor

Measured Components: & Measured ranges : 0-100% Opacity, 0-999 mg/m3, 0-999 mg/Nm3, 0- 3.0 Extinction & 0-5 Ringlemann.

Measuring Principle : Dual beam high intensity LED transmission & Absorption

Calibration Method used: Check Cell filters of known opacity (%)

2

Parameter	Filter (%) opacity	Analyser Reading	Remark
Opacity	0	0	Within accuracy of +/-2 %
Opacity	17.2	17.1	Within accuracy of +/-2 %
Opacity	0	0	Within accuracy of +/-2 %
Opacity	59.0	59.4	Within accuracy of +/-2 %

The measuring equipment calibration & performance verification (lack of ... was suitably tested & certified in accordance with EN 15267.

This certificate issued on May 26th 2015

Performed by :

Issued by :

[redacted]

ZERTIFIKAT ◆ CERTIFICATE ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

Umwelt Bundes Amt

Zertifikatsnummer: 1629370-ts

TÜV SÜD Industrie Service

ZERTIFIKAT

Über Produktkonformität (QAL 1)

Zertifikatsnummer: 1629370-ts

Messeinrichtung	Mess MY47 für Temperaturmessung in Verbrennungsgasen
Gerätehersteller	Sensortherm GmbH Hauptstraße 123 65843 Sulzbach/Ts Deutschland
Prüfinstitut	TÜV SÜD Industrie Service GmbH

Hiermit wird bescheinigt, dass die AMS die Anforderungen der Normen DIN EN 15267-1: 2009, DIN EN 15267-2: 2009, DIN EN 15267-3: 2008 und DIN EN 14181: 2004 erfüllt.

TÜV SÜD

Zertifikat Nr. 1629370-ts

Eignungsbekanntgabe im Bundesanzeiger
vom 06.03.2013

Gültigkeit des Zertifikates
bis 04.03.2018

Umweltbundesamt
Dessau, den 27.03.2013

i. A. Dr. Marcel Langner

TÜV SÜD Industrie Service GmbH
Prüflaboratorium Emissionsmessung/ Kalibrierung
München, den 26.03.2013

Dr. Michael Weeber

TÜV SÜD Industrie Service GmbH · Abteilung Umweltschutz · Westendstraße 199 · 80686 München · Germany
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TÜV

sira

mCERTS
THE ENVIRONMENT AGENCY'S MONITORING CERTIFICATION SCHEME

Environment Agency

PRODUCT CONFORMITY CERTIFICATE

This is to certify that the

PCME QAL 181 Particulate Analyser
(previously LMS 181)
Including PCME QAL 181 SEN Sensor

manufactured by:

PCME Ltd
Edison Road
St Ives
Cambridgeshire
PE27 3GH
UK

has been assessed by Sira Certification Service
and for the conditions stated on this certificate complies with:

MCERTS Performance Standards for Continuous Emission Monitoring Systems, Version 3.1 dated July 2008, EN15267-3:2007,
& QAL 1 as defined in EN 14181: 2004

Certification Ranges :

Particulate Concentration	0 to 15 mg/m³ 0 to 100mg/m³

Project No:	674/0263
Certificate No:	Sira MC090162/00
Initial Certification:	17 August 2009
This Certificate Issued	17 August 2009
Renewal Date:	16 August 2014

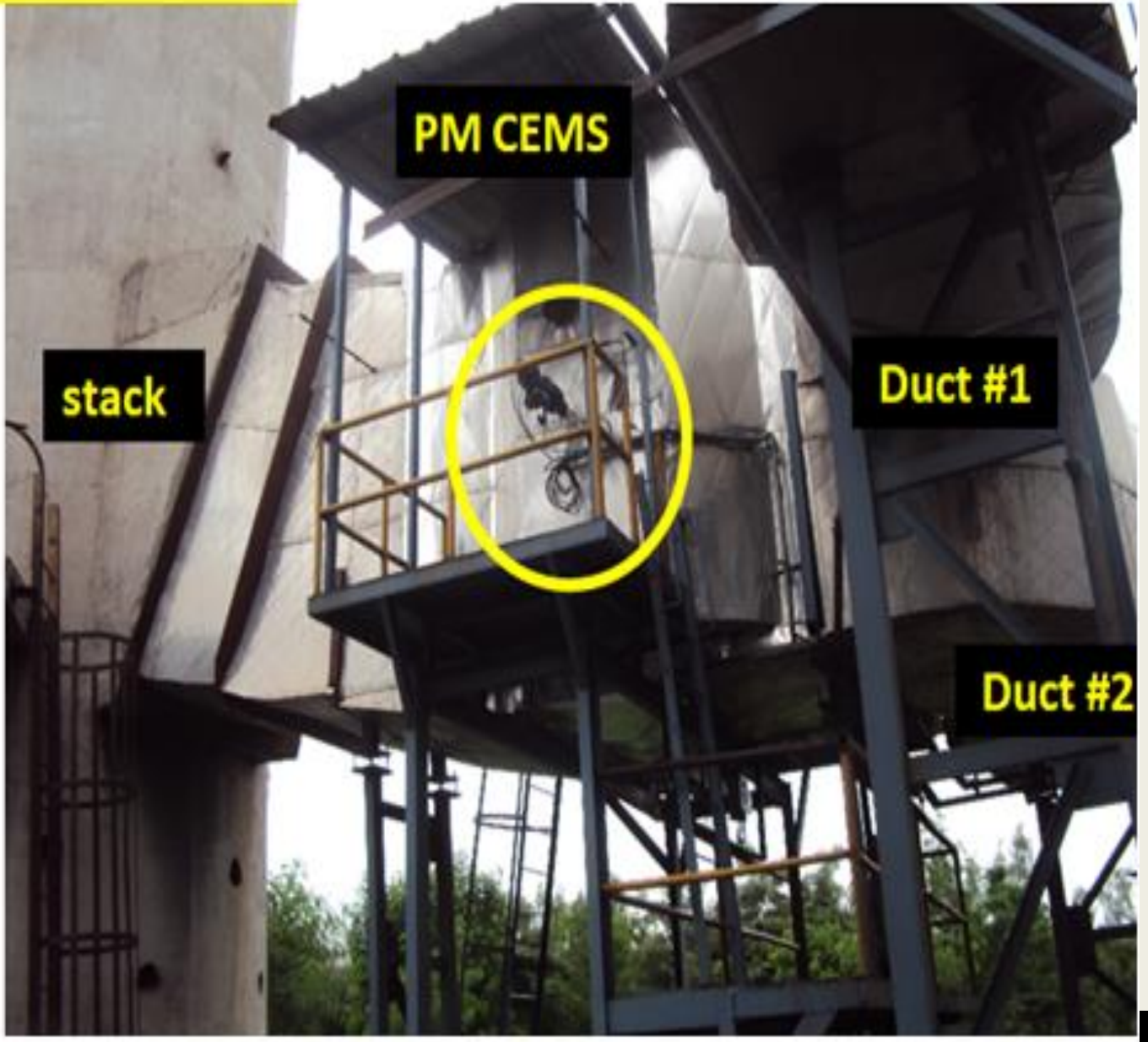
Technical Director

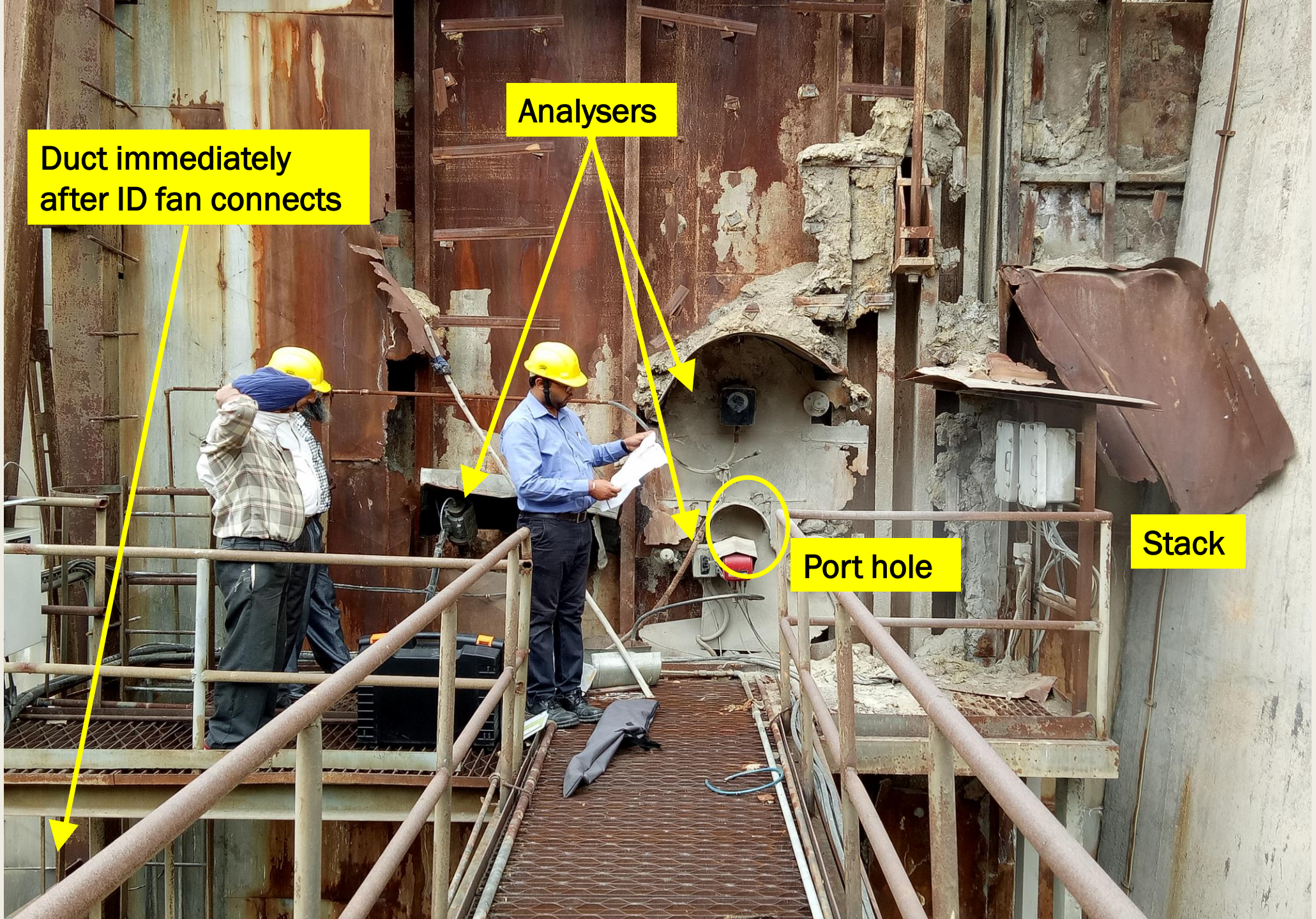
MCERTS is operated on behalf of the Environment Agency by

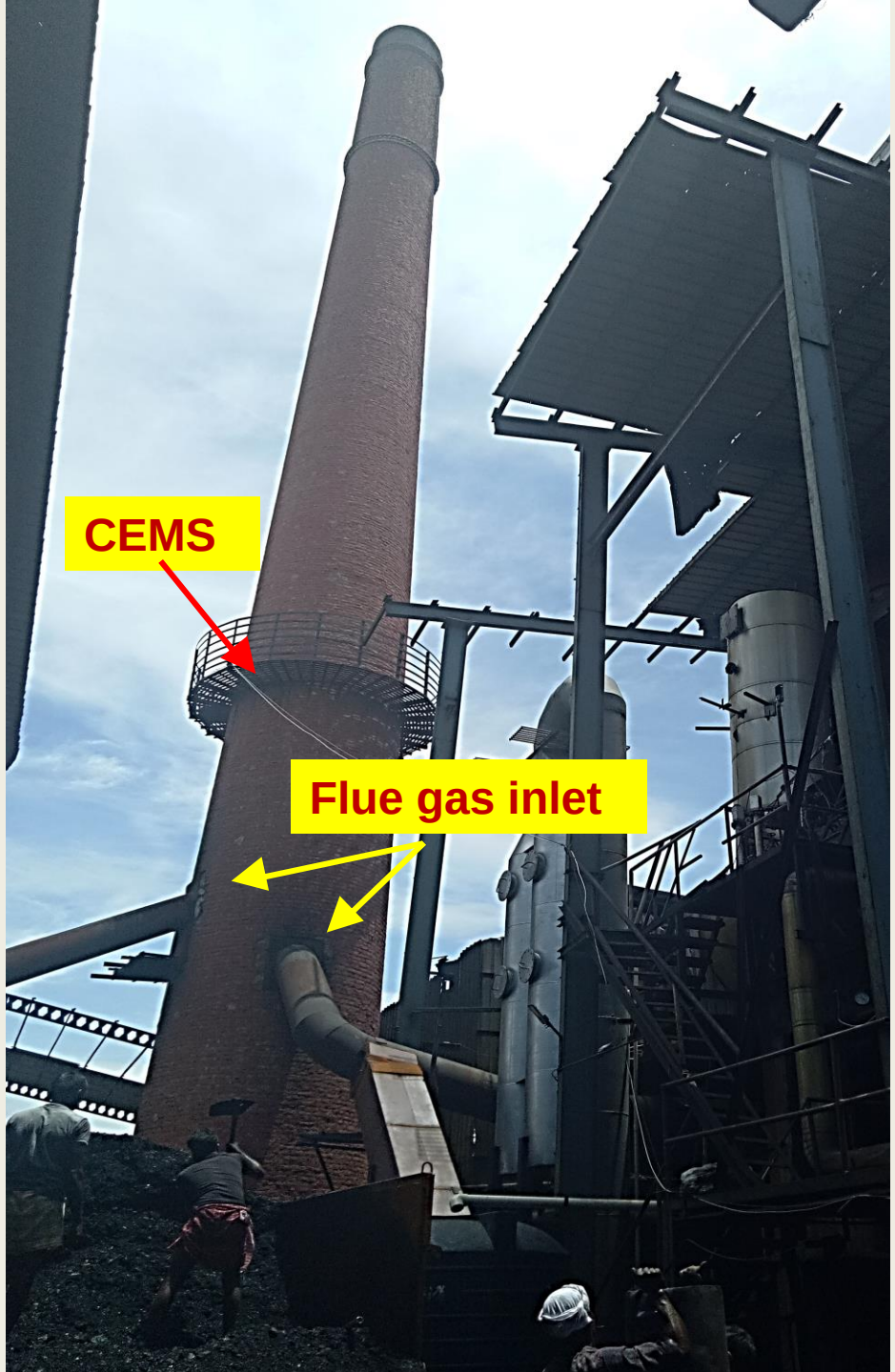
Sira Certification Service
12 Acorn Industrial Park, Crayford Road, Crayford
Dartford, Kent, UK, DA1 4AL
Tel: 01322 520500 Fax: 01322 520501

This certificate may only be reproduced in its entirety and without change

Wrong installation



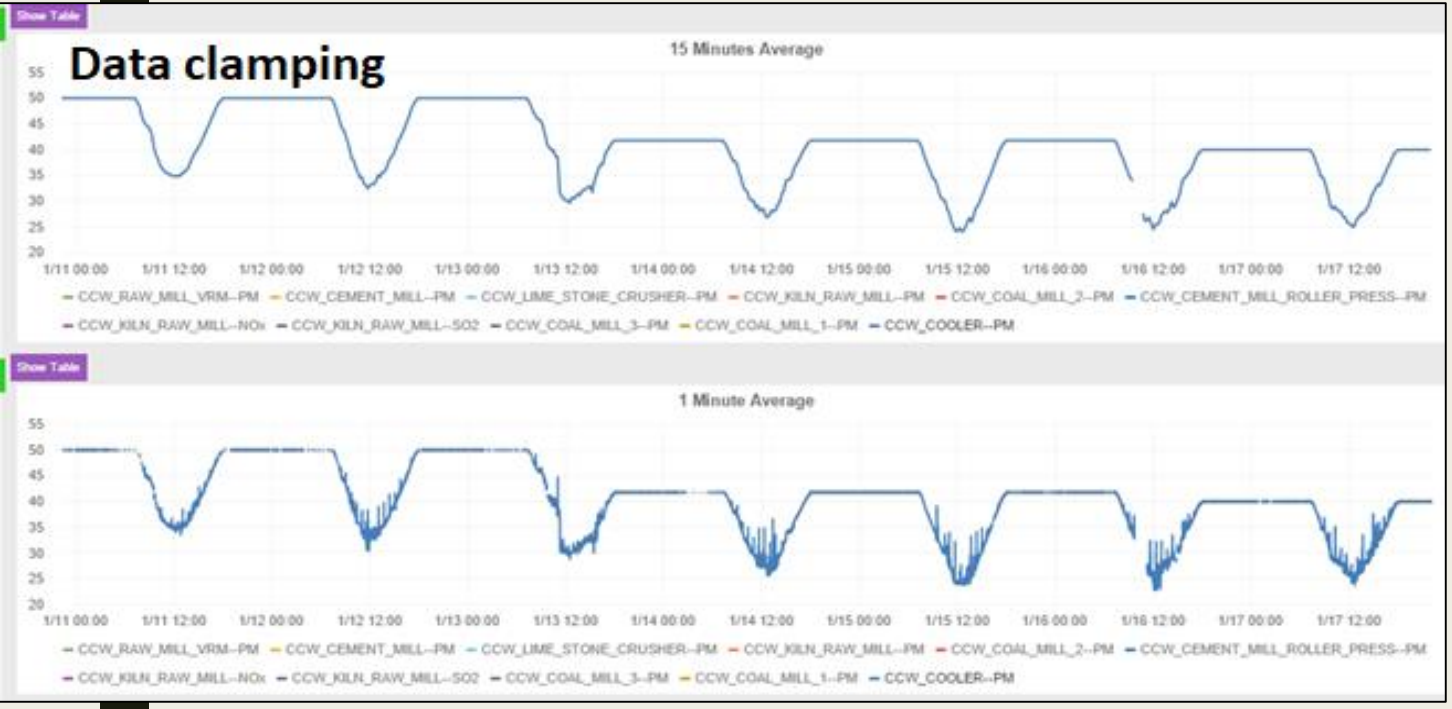

Duct immediately after ID fan connects
Analysers
Port hole
Stack



CEMS cabinet with no AC, Fan, Light

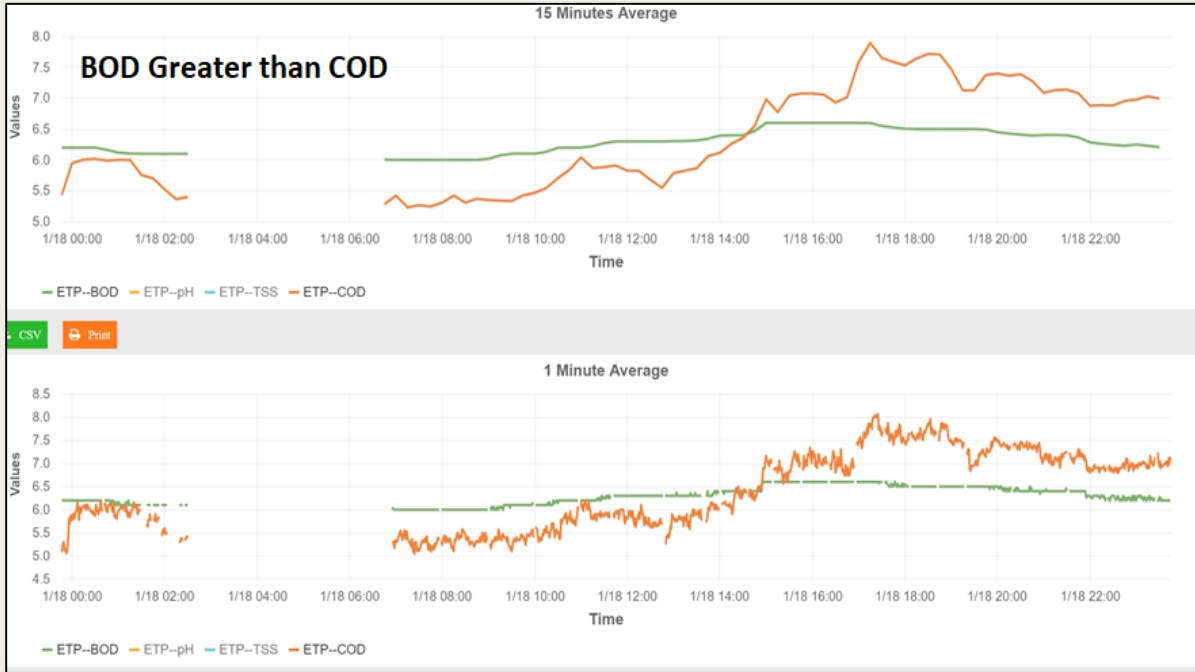
Cheat- No monitor installed

Cheat Data generator

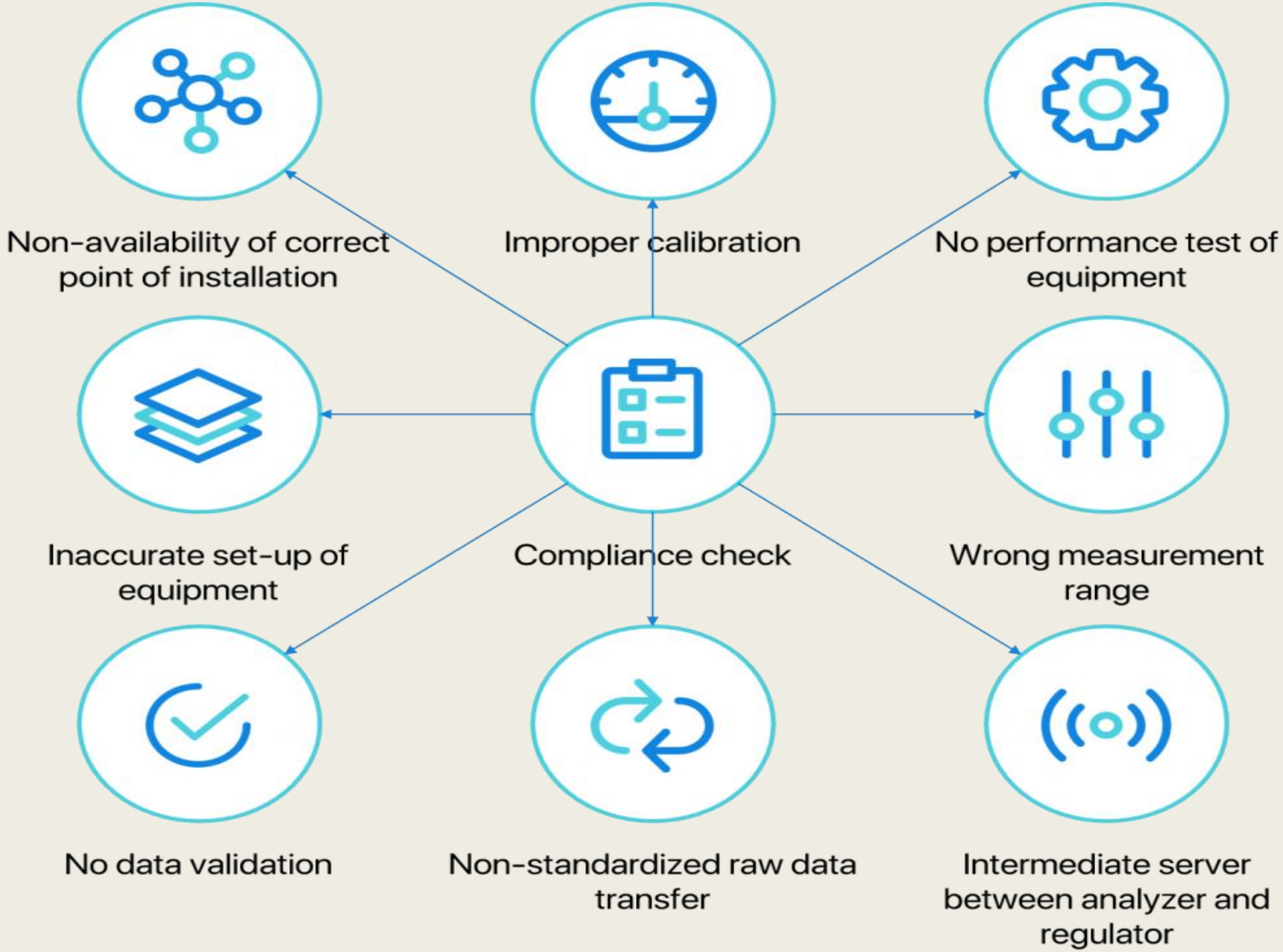


Data tampering

Simulated



Challenges now



Roadmap for implementation

Roadmap

Self -regulation regime

Compliance check system

Regular operation & maintenance

Capacity building

Tamperproof data transfer system

Correct installation
Right location/position/ platform

Capacity building

Capacity building

Right equipment selection

Quality assured-
Certified/ Performance checked

Inspection/ Assessment

Self assessment/inspection – Important

Expert audit/assessment and inhouse audit/assessment

- To assess the status of implementation
- To identify the issues in installation
- To understand the issues related to operation and maintenance
- To understand the data acquisition, processing and quality
- Assessment to drive towards corrective measures
- Action plan for future
- Training of employees

Self assessment/inspection – Basic requirement

keep in mind the objective or purpose of the Assessment/inspection.
Basic preparation is must.

Required to have prior knowledge of CEMS before visiting the facility.

- **About plant-** operation, pollution issues and control practices
- **Regulatory requirement for plant-** CEMS requirement, parameters, performance history, manual monitoring data
- **CEMS installed-** CEMS technology, components, working principle, suitability, limitations.
- **Installation guidelines-** Correct installation requirement
- **Data handling-** Data acquisition and transfer system, standardization
- **Calibration and Maintenance requirements-** calibration, zero and span drift and other maintenance

Components of CEMS Audit/Assessment

Audit must include infrastructure where and how CEMS has been installed. CEMS is not only the analyser. It includes all the equipment from sampling to DAHS

- **PM CEMS-** Light source and receiver, probe/sensor, sampler and sample line, air blower
- **Gaseous CEMS-** Sampler, heated/non-heated sampling line, sample conditioning system, analyzer, flue gas temperature monitors, flow meter, pressure monitor
- **Data Acquisition System (DAS)-** Iot/Data logger, Analog to digital converter (in case analyser produce analog signal), LAN/GPRS/internet connection, server software, data standardization mechanism, server installed at facility
- **Infrastructure for CEMS installation-** stack/duct, approach, shelter etc.

Overview of CEMS installations

To start with some visual observation can cover overview of CEMS installation in the plant	
Need of CEMS installation	• Number of units in plant • Parameters to monitor- unit wise • Number of installation done • Installation incomplete/ to be done • Reason of incomplete installation, plan of action
Stack or duct installation	• Installation carried in stack • Installation carried in duct • Manual monitoring point?- duct or stack? • Reason for installation in duct?
Working/non-working units	• CEMS working in working units? • Is CEMS working and data available in non-working units?
CEMS installation maintenance	• Is CEMS protected from weather conditions? • CEMS in shelter (if extractive) ? • Gas cylinders (if applicable) are available and properly connected? • Remote calibration system available
Data handling	• Analog or direct digital data transfer • Direct data transfer or server/PC in-between • Visual dust emission comparison to PM CEMS data

Assess- Location of installation

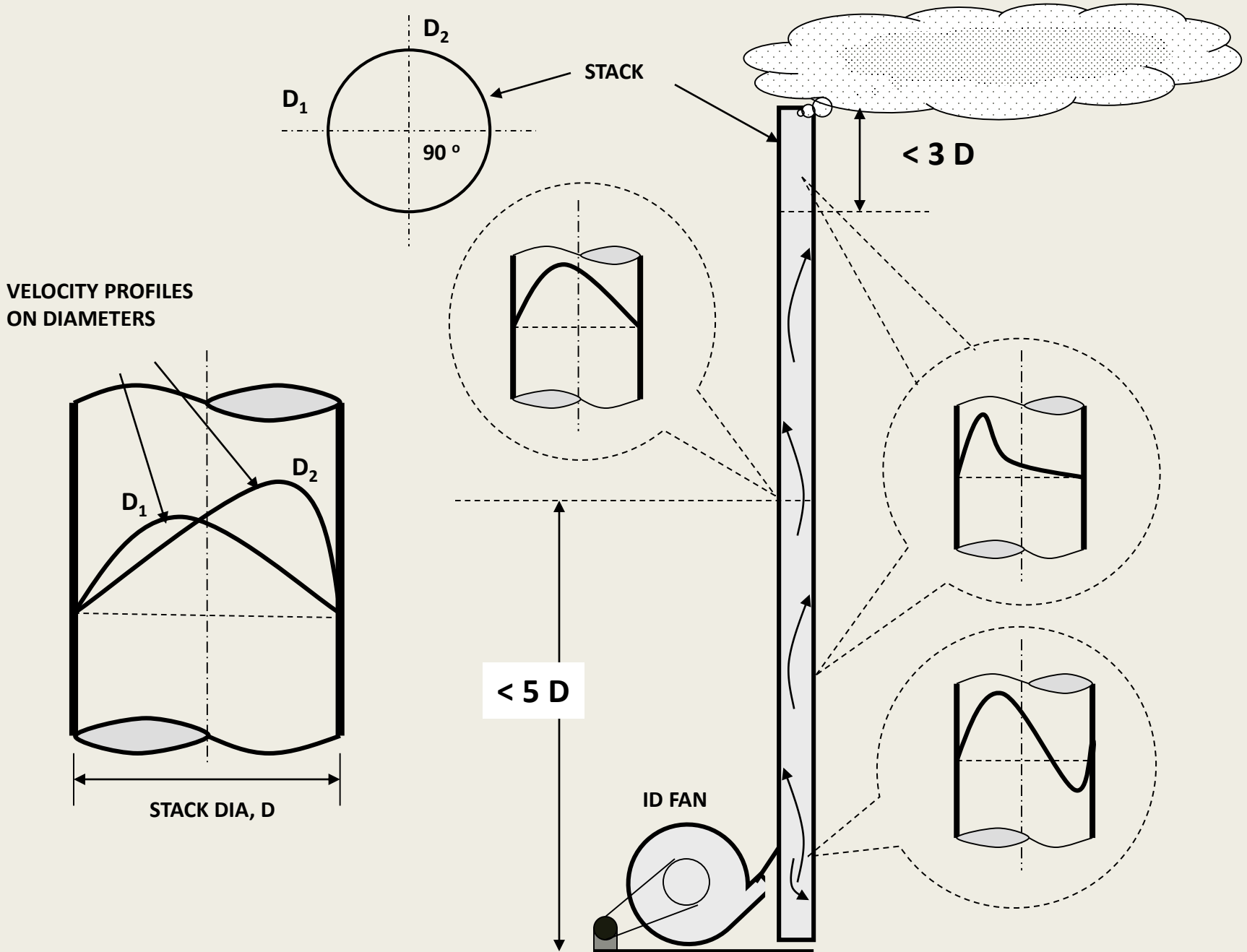
PM CEMS installation location must ensure stabilised and un-interrupted flow to get representative sampling.	
If installation in stack	• Stack material, height, diameter (at last disturbance point in upstream and downstream) • Height of the point of manual monitoring and CEMS • Does manual and CEMS installation fit in 8D/2D formula? • If fits in 4D/4D formula, during calibration requires 12 samples instead of 9. • If not, whether stratification study carried? • CEMS at-least 500mm below manual monitoring? • Other analysers/monitors should be in proper position, not affecting each other. • PM CEMS installation in Horizontal plane • Gaseous CEMS, protruding downwards facing the direction of flow
If installed in duct	• Standalone duct or combined duct? • If a combined duct (two or more ducts joining)- ➢ Each duct has separate installation ? ➢ Installation is in common duct? • Shape of duct, duct diameter/equivalent diameter • Does installation fit in 8D/2D or 4D/4D? • If not, whether stratification study carried?
Platform and approach	• Is the platform approachable for regular maintenance? • Is the platform safe?- Width, Guardrail, Safe ladder etc. CPCB guideline: “stack monitoring – material and methodology for isokinetic sampling http://www.cpcb.nic.in/newitems/15.pdf

Key mounting infrastructure, utilities, safety

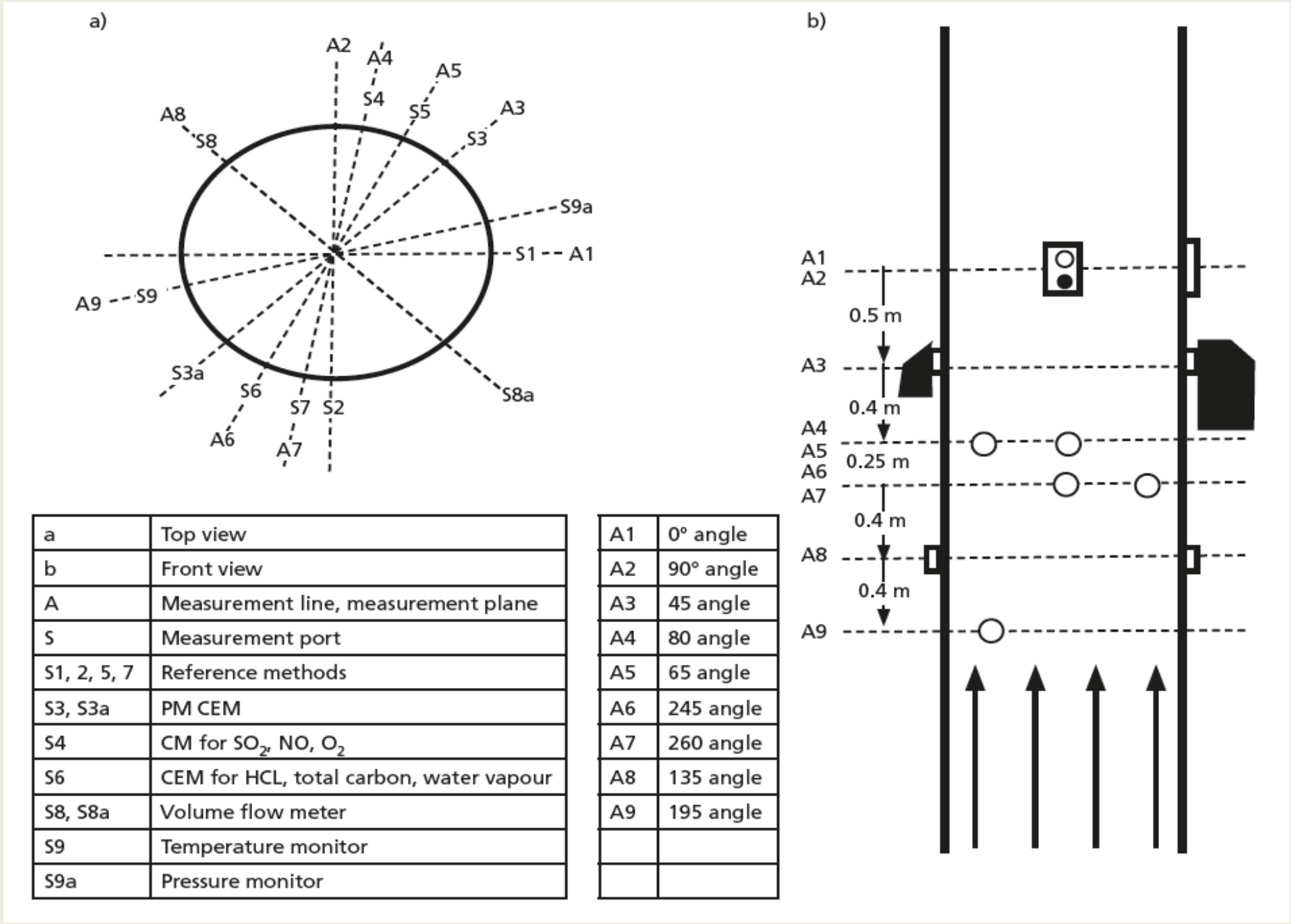
- Strong platform with safe approach/ladders/stair.
- If mounting location is >45mtr then proper staircase/ elevator
- Monkey ladder not preferred for height > 30 mts. from the ground.
- For vertical ladder: caged, every 10-12 mtrs- a landing platform
- Strong, maintained ladder, continued through platform to some distance above for safe landing.
- Platform railing at least reach 1.2 mtr in height
- Min. platform width: metallic stacks- 800mm, concrete stack- 1000mm.
- All the cables, instrument air tubings - properly laid & clamped
- Uninterrupted, properly earthed power supply, Lightning arrestor wire line
- Proper and quality Instrument air connection as per demand

Refer: CPCB's Emission Regulation Part III (COINDS/20/1984-85)

Stabilized Flow – Why 8D/2D or 4D/4D or 5D/5D



Understand the Mounting position



a	Top view
b	Front view
A	Measurement line, measurement plane
S	Measurement port
S1, 2, 5, 7	Reference methods
S3, S3a	PM CEM
S4	CM for SO_2, NO, O_2
S6	CEM for HCL, total carbon, water vapour
S8, S8a	Volume flow meter
S9	Temperature monitor
S9a	Pressure monitor

A1	0° angle
A2	90° angle
A3	45 angle
A4	80 angle
A5	65 angle
A6	245 angle
A7	260 angle
A8	135 angle
A9	195 angle

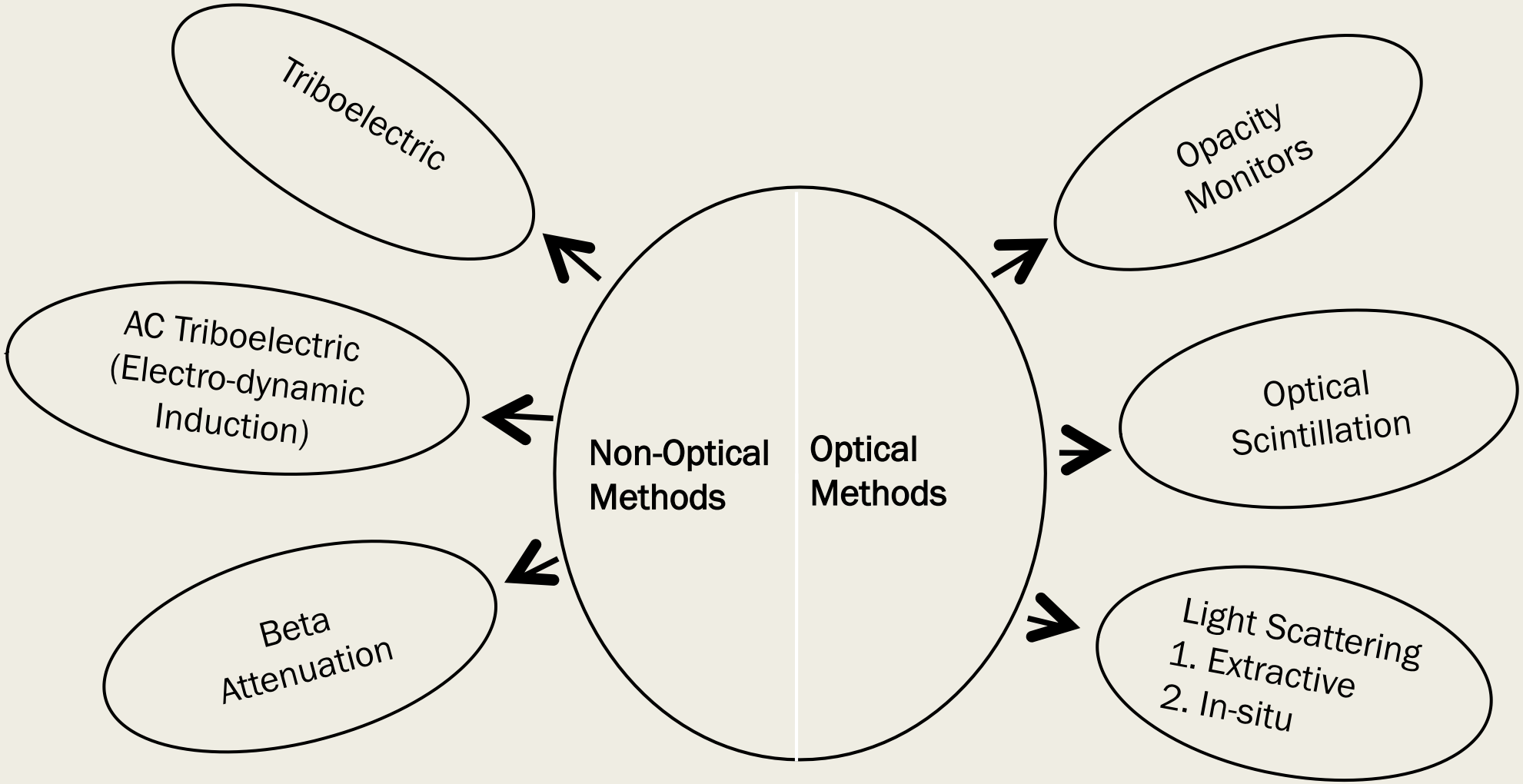
Asses PM CEMS installation

Right equipment selection- Refer “CEMS guidelines”

- **Technology fits as per the guidelines ?**
  - Suitable with installed pollution control equipment?
  - Suitable with pollution concentration?
  - Measuring range- 2.5-3 times of limit?
  - Suitable with moisture condition?
  - Suitable with diameter of stack (reached to centre of stack)?
  - Suitable with vibration level (if cross duct, specially in duct installation)?
  - O2 monitor installed?
  - Temperature, moisture, pressure monitor installed?
  - Performance specification ±2%, performance accuracy ±10% of reference measurement

- **Quality assured?**
  - Certified under MCERTS, TUV?
  - If not certified, performance test carried during installation?
  - Certificate available?
  - Certificate of calibration or performance check carried during installation available? Required for setting dust factor?

Methods for PM CEMS



Asses PM CEMS installation

Measurement Technology		Stack Diameter (m)	Concentration mg/m³		APC device	Min. certification. range	Dry	Humid	Wet	Velocity Dependant
			Min	Max						
Probe Electrification	Electrodynamic	0.1 -3 (6m with multiple probes)	< 0.1	250	Bag, Cyclone, Drier,	0 to7.5mg/m3 (QAL1 to EN-15267-3)	√	√	x	Not in 8 - 18m/s range
	AC Tribo	0.1 - 3	< 1	250	Bag, Cyclone	0 - 15mg/m3	√	x	x	Yes
	Tribo	0.1-3	< 1	250	Bag, Cyclone	qualitative bag leak	√	x	x	Yes
Transmissometry	Dynamic Opacity / Scintillation	0.5 - 10	10 10 (5m stack) 25 (2m stack)	1000	Cyclone, ESP, None	0- 150mg/m3	√	x	x	No
	Opacity/ Extinction	1 - 15	10 (at 5m) 50 (at 1m)	1000	Bag, Cyclone, ESP, None	0- 50mg/m3	√	x	x	No
		0.5-12	< 30	1000	ESP, None	None	√	x	x	No
In-situ Light Scatter	Scattered Light (Fwd)	1 - 3	< 0.1	300	Bag, ESP, None	0-15mg/m3	√	x	x	No
	Scattered Light (Back)	2 - 10	<0.5	500	Bag , ESP, None	0-7.5mg/m3	√	x	x	No
Extractive light scatter		0.5 - 10	0.1	100	Wet collector (wet FGD)		√	√	√	N/A
Extractive Beta		0.5 -10	0.5	< 150	Wet collector (wet FGD)		√	√	√	N/A

Asses Gaseous CEMS installation

Right equipment selection- Refer “CEMS guidelines”

- **Technology fits as per the guidelines ?**
  - In-situ or extractive?
  - If extractive what is gas conditioning and transport architecture (Hot-wet, Cold –dry, Hot?
  - Check heated line, termination, functioning?
  - Measuring range- 2.5-3 times of limit?
  - Suitable with moisture condition?
  - O2/CO2 monitor installed?
  - Temperature, moisture, pressure monitor installed?
  - For extractive type- Temperature, gas flow rate measurement?
  - For extractive- Shelter condition?
  - Zero/Span/Linearity specification ±1%, performance accuracy ±10% of reference measurement
  - Gas cylinders (zero, span)- valid calibration certificate, not expired, connected?
  - Gas cylinder concentration 80% of measuring range?

- **Quality assured?**
  - Certified under MCERTS, TUV?
  - If not certified, performance test carried during installation?
  - Certificate available?
  - Certificate of calibration or performance check carried during installation available?

Methods for Gaseous CEMS

Optical methods

> Simple Non- Dispersive Infrared (NDIR)

> Luft Detector NDIR

> Photoacoustic Detector

> Gas Filter Correlation (GFC) NDIR

> Differential Optical Absorption Spectroscopy (DOAS)

> Fourier Transform Infrared Spectroscopy (FTIR)

> Non Dispersive Ultraviolet (NDUV)

> Chemiluminescence Analysers

> Flame Photometric

> Derivative Spectroscopy

Non- optical methods

Electrochemical cells <

Conductivity Analyser <

Flame Ionisation Detector (FID) <

Photo Ionisation Detector (PID) <

Gas Chromatography <

Mass Spectrometry <

Ion-Mobility Spectrometry <

High Temperature Electrochemical Cells <

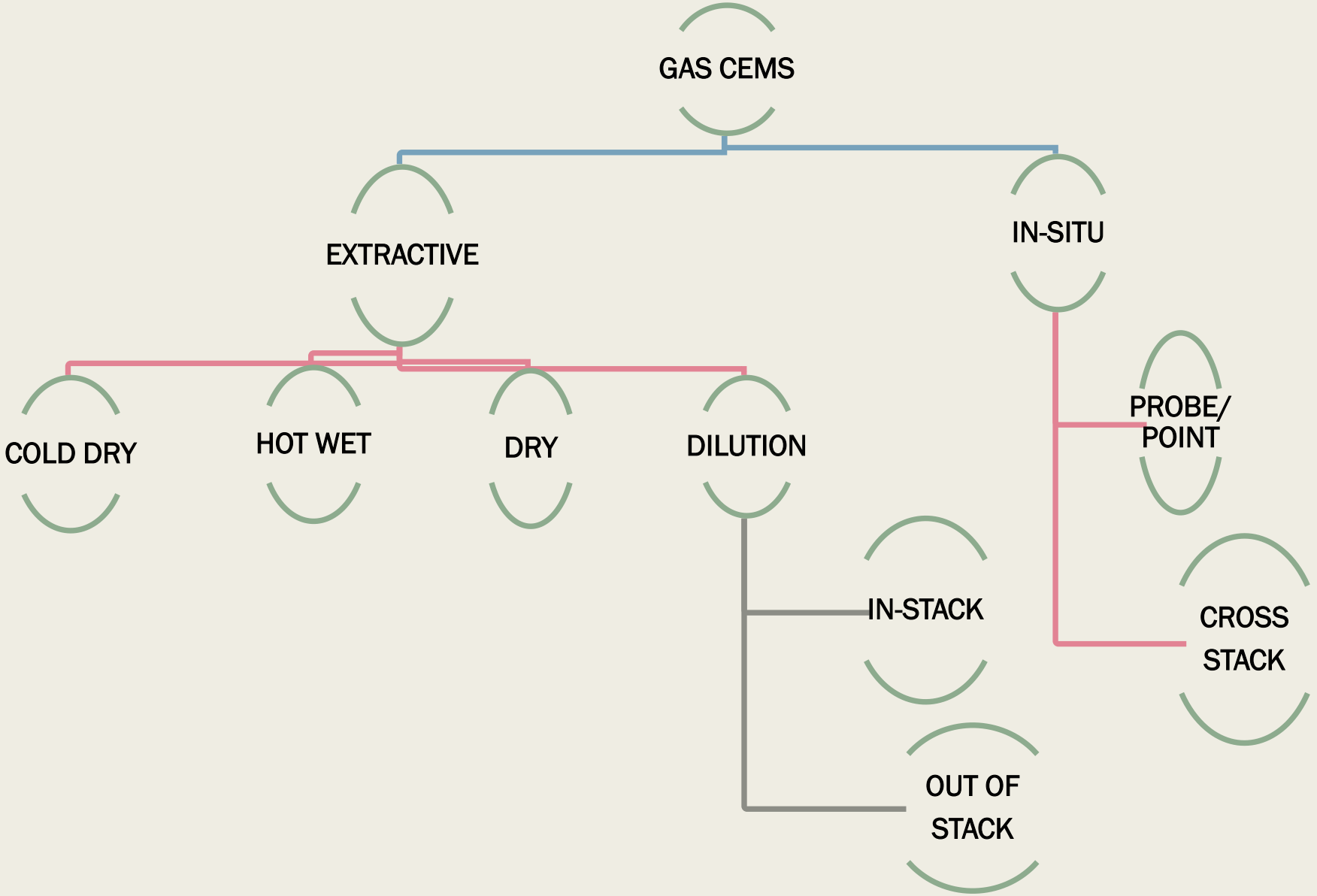
Paramagnetic Analysers (Thermomagnetic, Differenetial Pressure, Automatic null Balance) <

Potentiometric Analysis <

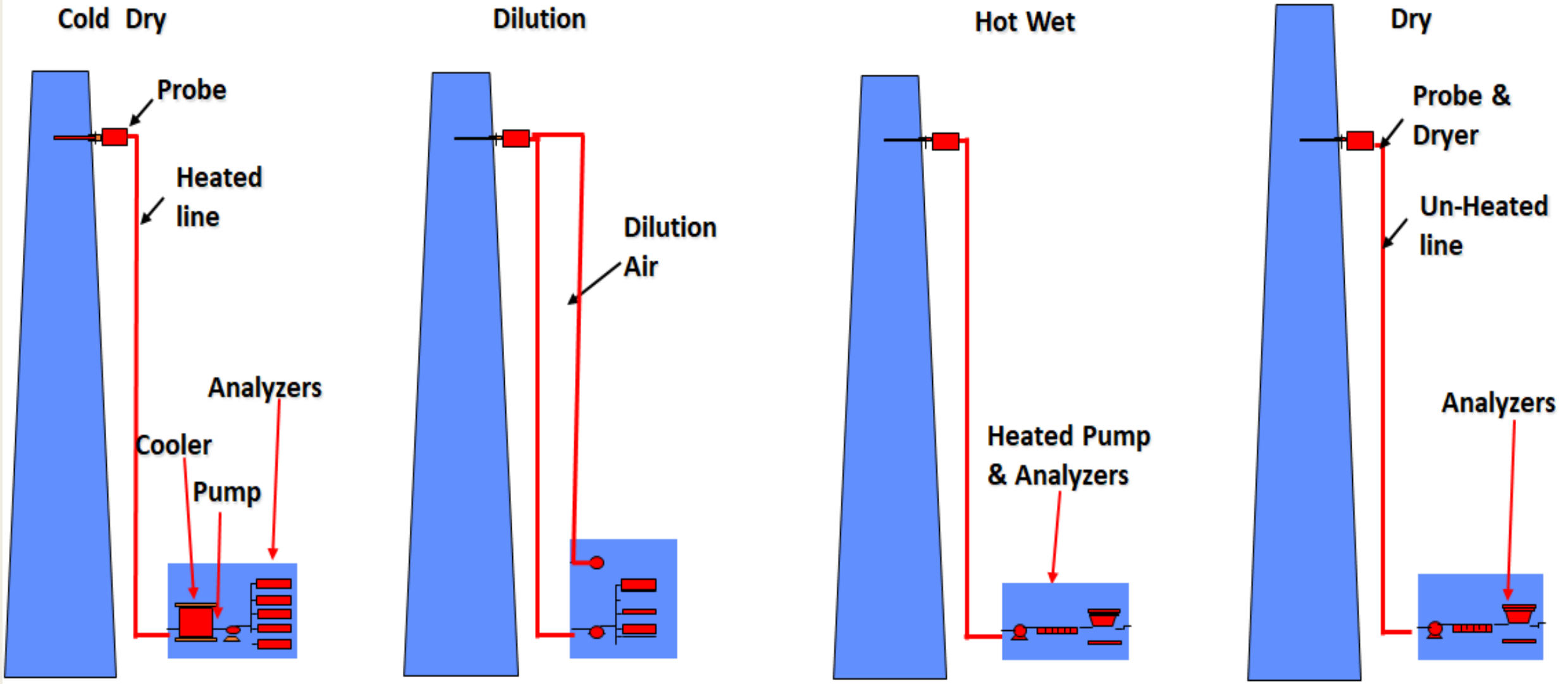
Electrochemical Fuel Cells <

Zirconium Oxide (ZrO_2) <

Gaseous CEMS technology



CEMS Types - Extractive



CEMS calibration and Maintenance

Calibration

- By NABL/EPA accredited lab?
- Full Calibration carried during installation? How many points/load (number of readings)?
  - PM CEMS- Full calibration is not only comparison on manual and CEMS value. Not only one point?
  - Gaseous CEMS- Includes functioning, drift, linearity, detection limit, output, operating temp etc.
- Calibration certificate (showing the entire process and calculation) available?
- Calibration frequency, post installation?
- Any repair/replacement? If any major repair/lamp replacement, calibration carried or not?
- When was lamp changed last time? If yes, calibration carried?
- When last calibration carried? Record available?
- PM CEMS- Any dust factor change? Reason? Prior permission from regulator?
- Gaseous CEMS- using zero and various span gas concentration cylinder/cuvette?
- O2 consecutive deviation >10%, recalibration

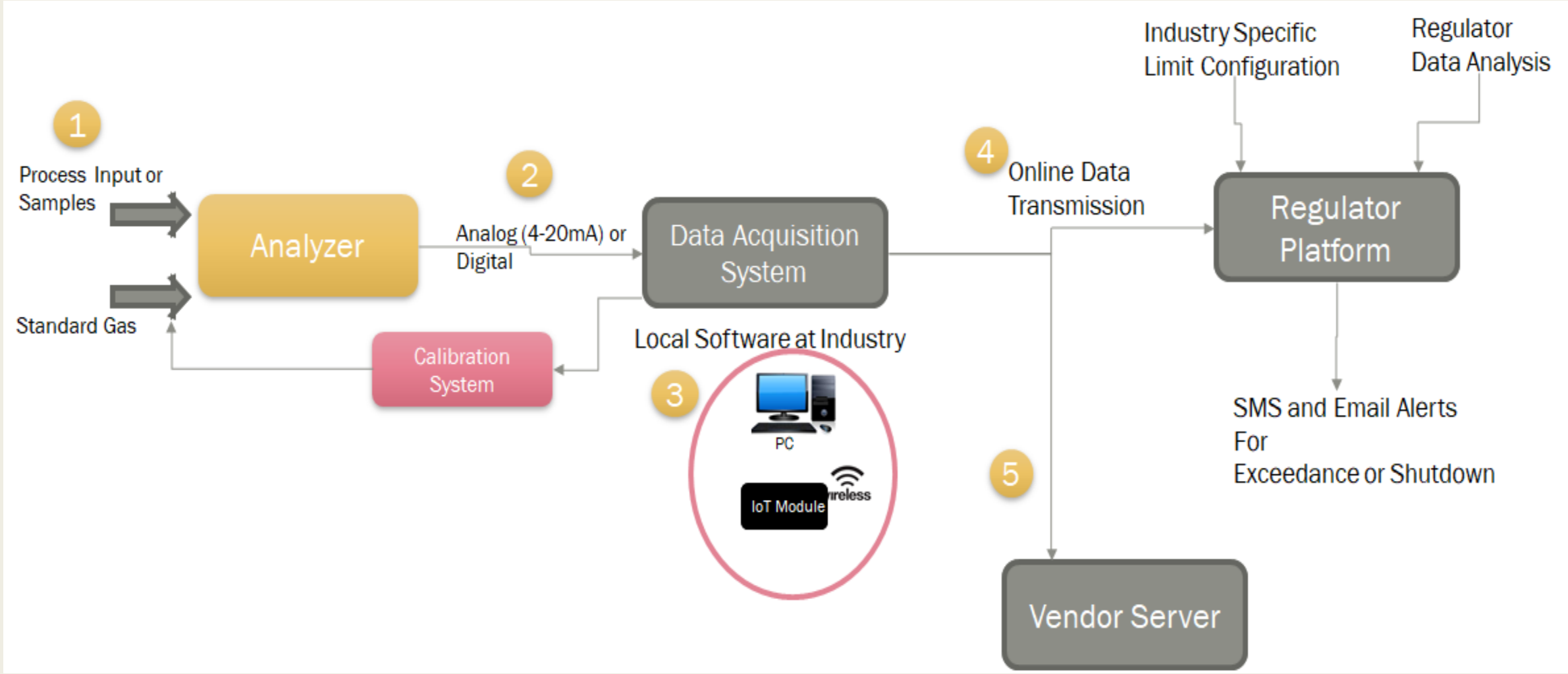
Drift check and Data comparison

- Frequency of drift check?- Zero, Span
- Timing for one cycle of zero and span?
- Post drift any correction done? How much was the drift when correction done?
- Frequency of data comparison from SRM- fortnightly, replicate?
- Any deviation above ±10% ? If so, was it recalibrated?

Online data reporting system

Important requirement-

- ✓ **Direct data transmission-** both to central and state regulator, no chance of manipulation
- ✓ **Remote calibration for Gaseous CEMS-** regulator can trigger remote calibration of gaseous CEMS



Data Acquisition and Handling

- **DAS architecture , compare the real installation on the spots**
  - Direct transmission to CPCB/SPCB?
  - Any PC/server in-between?
  - Any other foreign object/cheating device between analyser and data transmitter (IoT/Data logger)?
- **Data standardization**
  - Unit of output of analyser- ppm or mg/m3? Is same data is sent as mg/Nm3?
  - How data conversion process takes place- from mg/m3 to mg/Nm3 (temperature, moisture, pressure correction)
  - How NOx (NO+ NO2) is monitored?
  - How O2/CO2 correction happens?
- **Data check**
  - Data availability of 85%
  - Any shut down analyser showing data?
  - Calibration, zero/span process, reflects in data records?
  - Unrealistically low data- if PM, compare with visible emission, technology feasibility, fuel quality and APC efficiency.
  - Unrealistically low data- if SO2, compare with S concentration in fuel and APC, if NOx compare with fuel type and combustion technology, APC?
  - Stagnant data/clamped data/scientifically absurd data- review the analyser and range fixed?

Standardization of data

$$C_{dry}\ [ppm] = C_{wet}\ [ppm] \times \frac{1}{1 - [\%H_2O]/100}$$

Conversion from Wet to Dry

$$C_{dry}\ [mg/m3] = \frac{ppm \times MW}{22.4} = f$$

Conversion from ppm to mg/m3

PV= nRT

P (Pressure) x V (Volume)= n (amount) x R (constant) x T (Temperature)

N= PV/RT

Temperature and Pressure correction

$$C_{dry}\ [mg/Nm^3] \text{ @ Reference O2} = \frac{21\% - 10\%}{21\% - \text{Measured O2}}$$

Oxygen correction

Example of standardization of data – SO2

Example: SO_2 = 120 [ppm, wet]; Moisture content = 15% wet

$$SO_{2dry}\,[ppm] = 120 \times \frac{1}{1 - [15/100]} = 141\ [ppm/dry]$$

Conversion from Wet to Dry

$$SO2_{dry}\,[mg/m^3] = \frac{141 \times 64.07}{22.4} = 403.3 mg/m3\ dry$$

Conversion from ppm to mg/m3

If Stack Temp. 150°C and Stack Pressure 740mmHg

$$SO2_{dry}\,[mg/Nm^3] = \frac{423 \times 760}{298 \times 740} \times 403.3 = 587.9\ mg/Nm3\ dry$$

Temperature and Pressure correction

If O2 = 8.8%

$$SO2_{dry}\,[mg/Nm^3] \text{ @ Reference } O_2 = \frac{21\% - 10\%}{21\% - 8.8} = 0.902$$

Oxygen correction

$$SO2_{dry}\,[mg/Nm^3] \text{ @ } 10\%\ O_2 = 0.902 \times 587.9 = 530\ mg/Nm^3{}_{dry} \text{ @ } 10\%\ O_2$$

Standardization- NOx Conversion

Reporting Value should be NOx as NO2

NOx Conversion formula

Total NOx = NO x 1.53 + NO2 (if NO2 is measured)
Total NOx = NO x 1.53 + (NO x 5%) (If only NO is measured)

NOx Conversion - Example

NO =**400ppm[ppm, dry] and NO2 = 20ppm**

$$\text{NO to NO2 [ppm, dry]} = 400 \times \frac{46}{30} = 613\text{ppm, dry}$$

NOx_{dry} [ppm] = 613 + 20 = 633ppm, dry

Conversion from ppm to mg/Nm3

Component	Molar Mass M [kg/kmol]	Conversion Factor f
SO2	64.07	2.86
NO as NO2	46.01	2.05
NO2	46.01	2.05
CO	28.01	1.25
HCl	35.40	1.58
HF	20.01	0.89
NH3	17.03	0.76
VOC	12.01 36.03	0.54 1.61

Checklist

CEMS audit checklist

- Check stack height As per Consent (m) / Actual (m)
- Check distance of CEM installed from the point of disturbance from the downstream (m).
- Check distance of CEM installed from the point of disturbance from the upstream (m).
- What is the height of gravimetric sampling port (m)? Does it meet 8D/2D criteria?
- Is there any stratification study done if it is not meeting 8D / 2D criteria?
- Is Manual sampling port at-least 500mm above the PM-CEMS port?
- Is heated sample line having cold spots? Sampling line in analyser shows water droplets?
- If Cross duct analyser is installed, check if the stack or duct vibration is very high which can affect the reading.
- Was analyser calibrated during installation?
- Is it a certified analyser? Is certificate available? Check.
- Is O2/CO2 correction done for measurement? Calculate.
- Is Pressure & Temperature correction carried? Calculate
- Is the Remote calibration facility available? Check if zero and span gas cylinders are connected, if so?
- Is it calibration cylinder available with valid calibration certificate and required concentration (80% of FSR).
- What is the technology of the PM analyser? Is it as per the guidelines?

CEMS audit checklist

- What is the technology of Gaseous analysers? Is it as per the guidelines?
- What is the Range of Analyser? It should be 2.5 to 3 times of Emission Limit Value.
- For extractive CEMS, what is the Gas flow rate? Temperature?
- What is the dust factor and whether is it calibrated during installation? Is calibration certificate available and showing correct estimation.
- What is the calibration frequency?
- What is zero drift check frequency?
- What is span drift check frequency?
- When was the PM CEMS calibration factor changed last time? Was it permitted by SPCB?
- What is data transmission frequency?
- Is there any intermediate PC/server between analyser and data transmission to CPCB/SPCB? There should not be any. Data should be directly transmitted to the regulator.
- Is there maintenance log book for the instruments?
- Is there any check of lamp after the installation and what will be the life time of lamp?
- Do you see any analyser in shutdown and data still coming? Notice that.
- Do you see emission from stack visible and PM data unrealistically low? Notice that.
- Ask for S content in the fuel, notice if the SO2 emission is unrealistically low and enquire.
- Check the data and notice if the data is stagnant, clipped from the top, availability is low, and changing during calibration period.

Thank you

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