ISA Delhi Section

Setting the Standard for Automation™

CEMS IN FERTILIZERS INDUSTRIES

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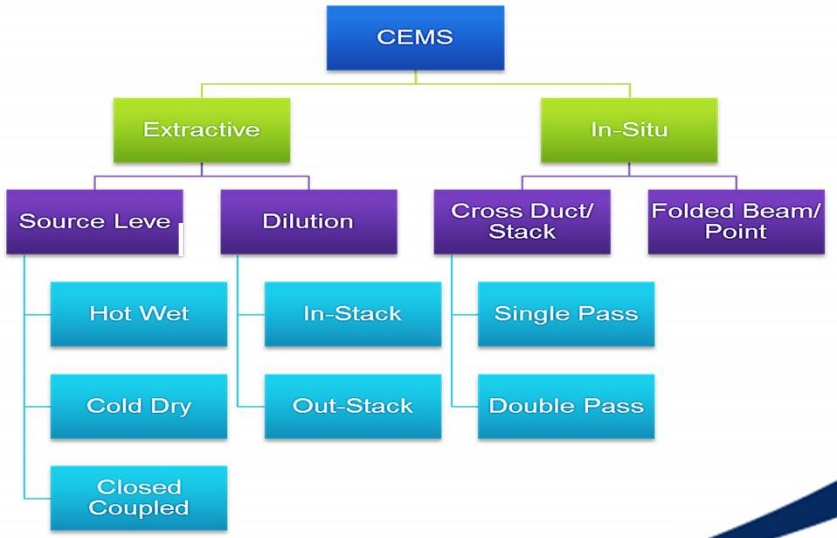
CEMS IN FERTILIZERS INDUSTRIES

In recent years, environmental issues/ concerns have grown over the contribution of pollutants emitted by the fertilizer plants such as gaseous ammonia (NH3), nitric and nitrous oxides (NOx), carbon dioxide (CO2) and hydrogen fluoride (HF) - sulfur oxides (SOx), fertilizer dust and acid mists.

The violation of the environmental norms in terms of emission of pollutants can result in strict penalties from regional and national environmental authorities including complete lockout of the processing unit.

WHAT IS CEMS ?

A continuous emission monitoring system (CEMS) is composed of equipment and instruments to draw, condition, analyze the sample and provide the permanent record of emission or process control parameters continuously at real-time basis. CEMS analyzers are installed at the stack and equivalent locations to achieve the compliance with regulation and to ensure the correctness of measured values.



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Common Pollutants and their Measuring Methods in Fertilizer Plants

S.No	Captive Plants and Fertilizer Industries	Area or Units	Parameters	Recommended Methodologies	Recommended Technologies
1	Ammonia Captive Plant (NH_3)	Primary Stack Reformer (Flue Gas)	CO_2, SO_2, NO_2, CO.	Cold Dry Extractive	NDIR
2	Nitric Acid Captive Plant (HNO_3)	Absorption Tower (Tail Gas)	NOx, N_2O, O_2, H_2O And N_2	Hot Wet Extractive	NDIR/ NDUV/ FTIR
3	Sulfuric Acid Captive Plant (H_2SO_4)	Absorption Tower (Off Gas)	NOx, SO_2, H_2SO_4 Mist & Spray and Dust Particles	In-Situ, Hot Wet Extractive	NDUV/ FTIR
4	Phosphoric Acid Captive Plant (H_3PO_4)	Grinder And Scrubbers	HF, H_3PO_4 Mists And H_2S Acid	In-Situ Hot Wet Extractive	TDLAS/ FTIR/ DOAS
5	Urea Fertilizer Plant	Prilling Tower	NH_3 and PM	In-Situ, Hot Wet Extractive	TDLAS/ NDUV/ FTIR
6	Ammonia Sulphate (Ammonia + Sulfuric)	Carbonation Tower, Filtration, Drying &Cooling	NH_3, NOx, SOx	In-Situ, Hot Wet Extractive	TDLAS/ NDUV/ DOAS/ FTIR
7	Calcium Ammonium Nitrate Fertilizer (CAN) (Ammonia + Nitrate)	Condenser, Lime Stone Grinder, Granulator	NH_3, NOx, N_2O	In-Situ, Hot Wet Extractive	TDLAS/ NDUV/ DOAS/ FTIR
8	Single Super Phosphate Fertilizer (SSP) (Phosphate + Sulfuric Acid)	De-dusting, Scrubber Curing Shed	HF, PM, SOx, and Fluorides	In-Situ Hot Wet Extractive	TDLAS/ FTIR/ DOAS
9	Diammonium Phosphate Fertilizer (DAP) (Ammonia + Phosphoric Acid)	De-dusting, Scrubber	NH_3, HF, NOx, SOx	In-Situ, Hot Wet Extractive	TDLAS/ FTIR/ DOAS
10	NPK Complex Fertilizer	De-dusting, Scrubber	NH_3, HF, NOx, SOx	In-Situ, Hot Wet Extractive	TDLAS/ FTIR/ DOAS

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Technical Selection of CEMS for Fertilizer Plants

S.No	Technology	Methodology	Principle	Gases Measured	Suitable	Limitation of Technology based on parameter
1	NDIR	Cold Dry Extractive Hot Wet Extractive In-Situ	Beer Lambert Law Filter Photometer	CO_2, SO_2, NOx, CO, etc.	Upto 4-5 gas measurements	Inability to measure HF, Cl_2, H_2S etc. Soluble gases can be lost during cooling.
2	NDUV	Hot Wet Extractive	Beer Lambert Law Filter Photometer	SO_2, NOx, NH_3, Cl_2, CS_2 etc.	Upto 2-3 gas measurements	Wet based measurement is mandatory for soluble gases like NH_3.
3	FTIR	Hot Wet Extractive	Beer Lambert Law Filter Photometer	CO, CO_2, SO_2, NOx, NH_3, N_2O, HF, HCl, Moisture etc.	Upto 5-12 gas measurements	Heated Sample Line
4	DOAS	In-Situ : Open Path Long distance/ Perimeter	Differential Optical Enhanced Absorption Spectroscopy	CO, CO_2, SO_2, NO_2,NH_3, HF, HCl, VOC etc.	More than 5 gases	Limitation in high dusty stacks and smaller dia. Stacks.
5	TDLAS	In-Situ: Path Type	Wavelength Modulation Spectroscopy	CO, CO_2, NH_3, HF, HCl, CH_4, O_2, H_2S and Moisture etc.	Cost effective for single component	Wet based measurement requires online measurement of H_2O, O_2, P T, Flow. Limitation in high dusty stacks and smaller dia. Stacks.
6	Transmissio metry	In-Situ	Light attenuation	Particulates Matters	Dry Stacks	Can't monitor particulate levels below 25 mg/m ^{3} per meter path length.

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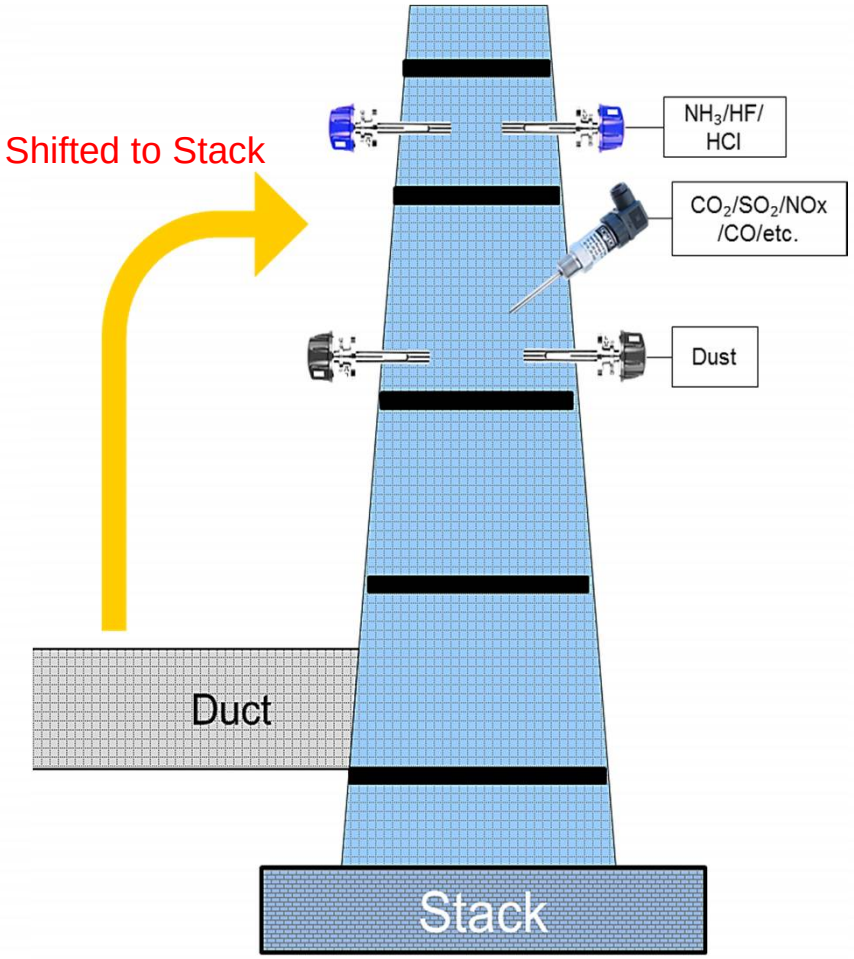
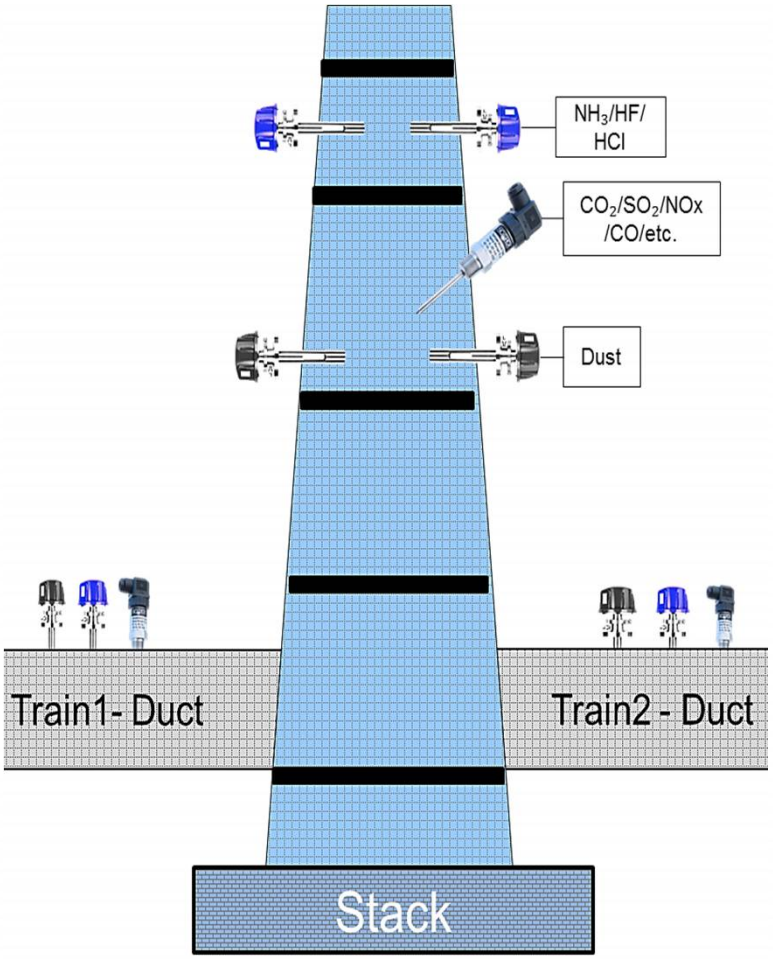
Case Study – Common CEMS Analyzer for Combined Duct



Case1



Case2

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Non-Dispersive Infrared/ Ultra Violet (NDIR/UV)

1. Non-Dispersive Infrared (NDIR):-

✓ **NDIR** is a direct method for continuous monitoring of multiple gases suitable upto **4-5 gas** without any dilutions.

Advantage:

- Popular for **low level SO2/ NOx;**
- Avoid background interference from moisture;
- Less **chances of failure;**
- Consumes less **calibration gas**;
- Probe installation at **lower height.**

Limitation:

- Time consuming installation;
- Inability to Measure soluble gases;
- Required heated sample line.

CEMS:

Analyzer used : IR/UV Based Extractive system

CO_2/SO_2/NOx/CO/etc.

2. Non-Dispersive Ultraviolet (NDUV):-

✓ **NDUV** is a direct method for continuous monitoring of multiple gases suitable upto **2-3 gas** measurements without any dilutions.

Advantage:

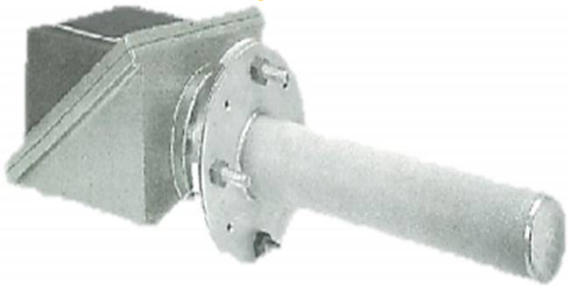
- Measures **both NO and NO_2**;
- Popular in **harsh applications**;
- Lower Interferences;
- Available for **soluble gases like NH_3.**

Limitation:

- Cannot measure other gaseous pollutants like **CO, CO_2, HCl, HF etc.**

CEMS:

Analyzer used : IR/UV sed Point system



SO_2 /NOx/CO/CO_2/O_2

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Fourier Transform Infrared (FTIR)
&
Differential Optical Absorption Spectroscopy (DOAS)

3. Fourier Transform Infrared (FTIR):

✓ FTIR is a direct method for continuous monitoring of multiple gases suitable upto **5-15** gases using **high-end spectroscopy** technique.

Advantage:

- Preferred for very **low concentration** of soluble gases.
- Uses Hot Wet extractive technique for **complex stack** gas matrix with high moisture and soluble gases;
- Additional modules **O2 and VOC** can be also integrated into the online measurement.

Limitation:

- **Highly** expensive.

4. Differential Optical Absorption Spectroscopy (DOAS):-

✓ DOAS is a Non-contact method for continuous monitoring of multiple gases preferably more than **5 gases** using **optical measurement path** that can operate across the stack.

Advantage:

- Suitable for **Trace** measurements;
- No **sampling** and very **less maintence** is required;
- Preferable in **harsh** applications.
- Multiple **stack measurements**.

Limitation:

- **High** initial cost;
- Limitation in **high dust and moisture** application;
- No **online** and **remote** calibration is available;
- Limitation in Optical Fiber cable and **Calibration challenges** at site.

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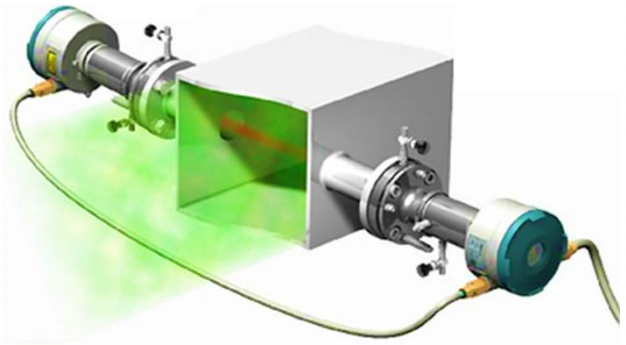
CEMS:

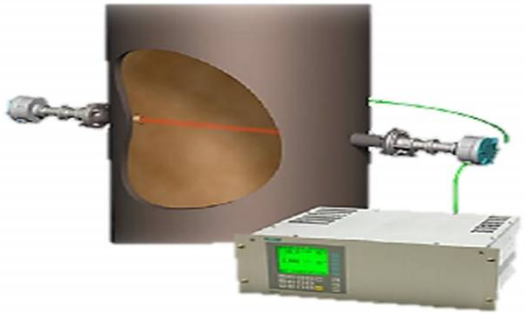
Analyzer used : TDLA/ DOAS
Path system (Cross Duct)



DOAS- SO_2 /NOx/CO/CO_2/NH_3
TDLS- NH_3/HCL/HF/CO/CO_2

CEMS:

Analyzer used : TDLA/ DOAS
Path system (Across Stack)



DOAS- SO_2 /NOx/CO/CO_2/NH_3
TDLS- NH_3/HCL/HF/CO/CO_2

5. Tunable Diode Laser Absorption Spectrometry (TDLAS)

5. Tunable Diode Laser Absorption Spectrometry (TDLAS):-

✓ TDLAS is an indirect method for continuous monitoring of **NH3, HF and HCl** using optical measurement path that can operate across the stack.

Advantage:

- Capable of measuring a **no. of near infrared** absorbing;
- Capable of measuring the sample under **difficult condition**.
- Integrated across **path length**;
- **Cost effective** solution for single measurement.

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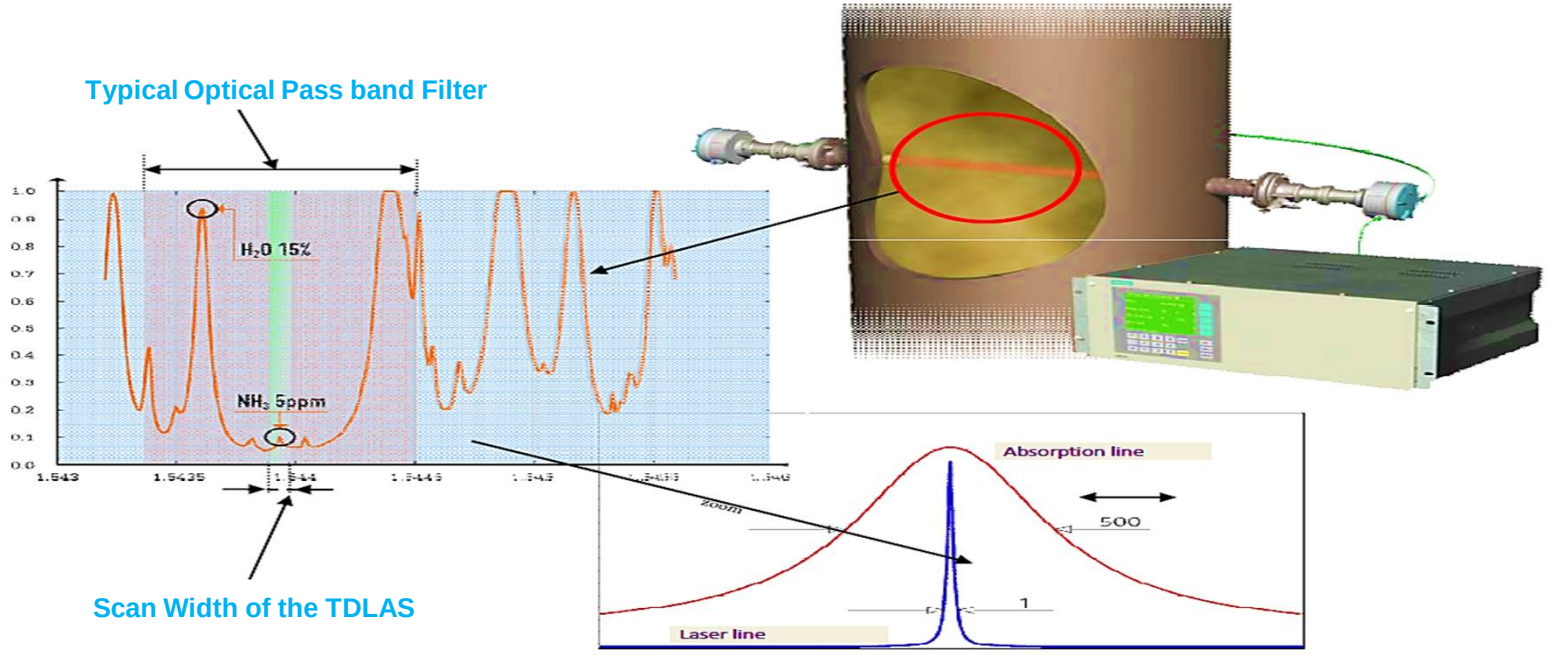
Limitation:

- Deformation of ducting can lead to **misalignment**;
- Initial installation for the **mounting flange** is required;
- **Very expensive** for multi-gas measurement

In-Situ Single Line Absorption Spectroscopy



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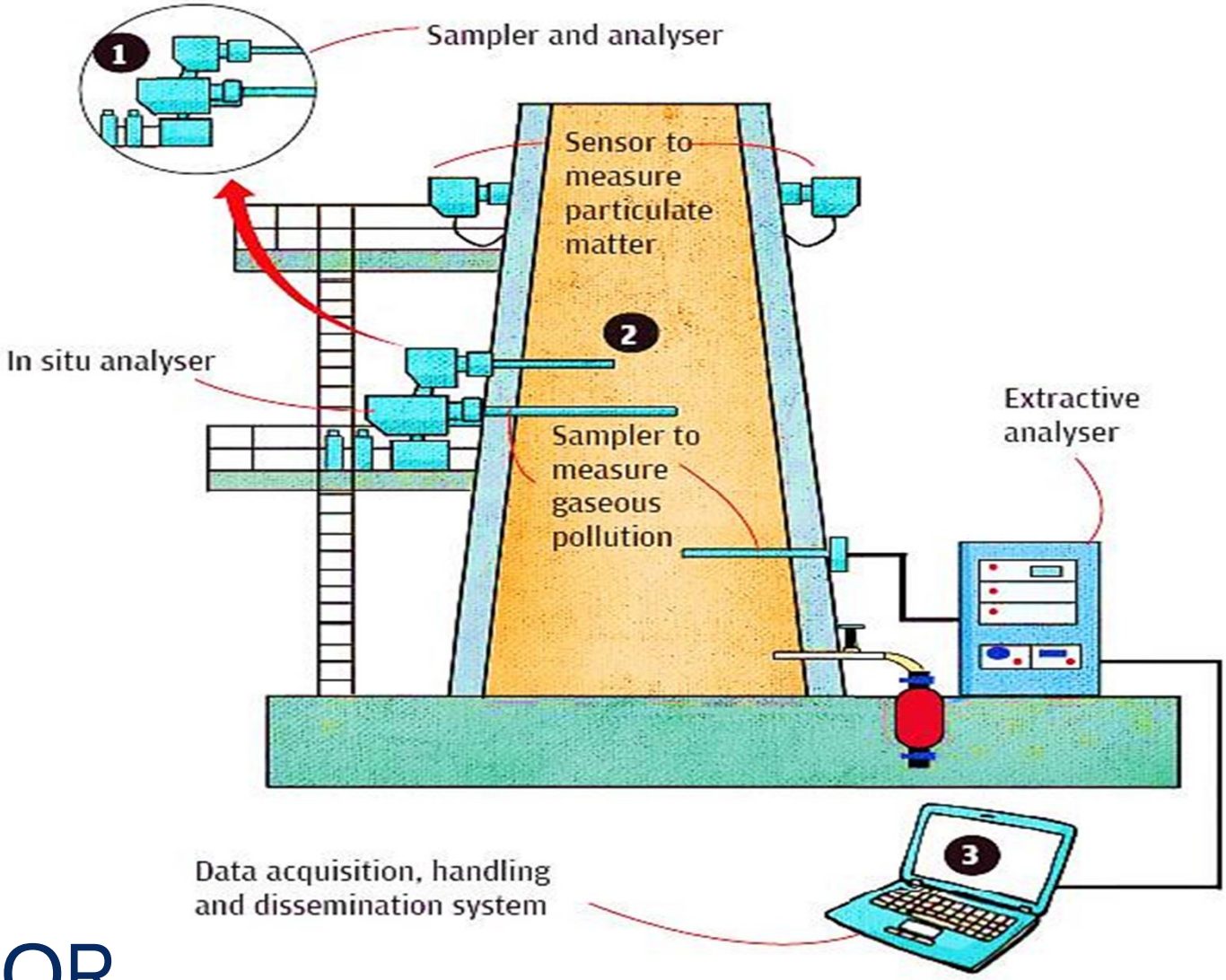
CEMS Analyzer Interconnection Drawing



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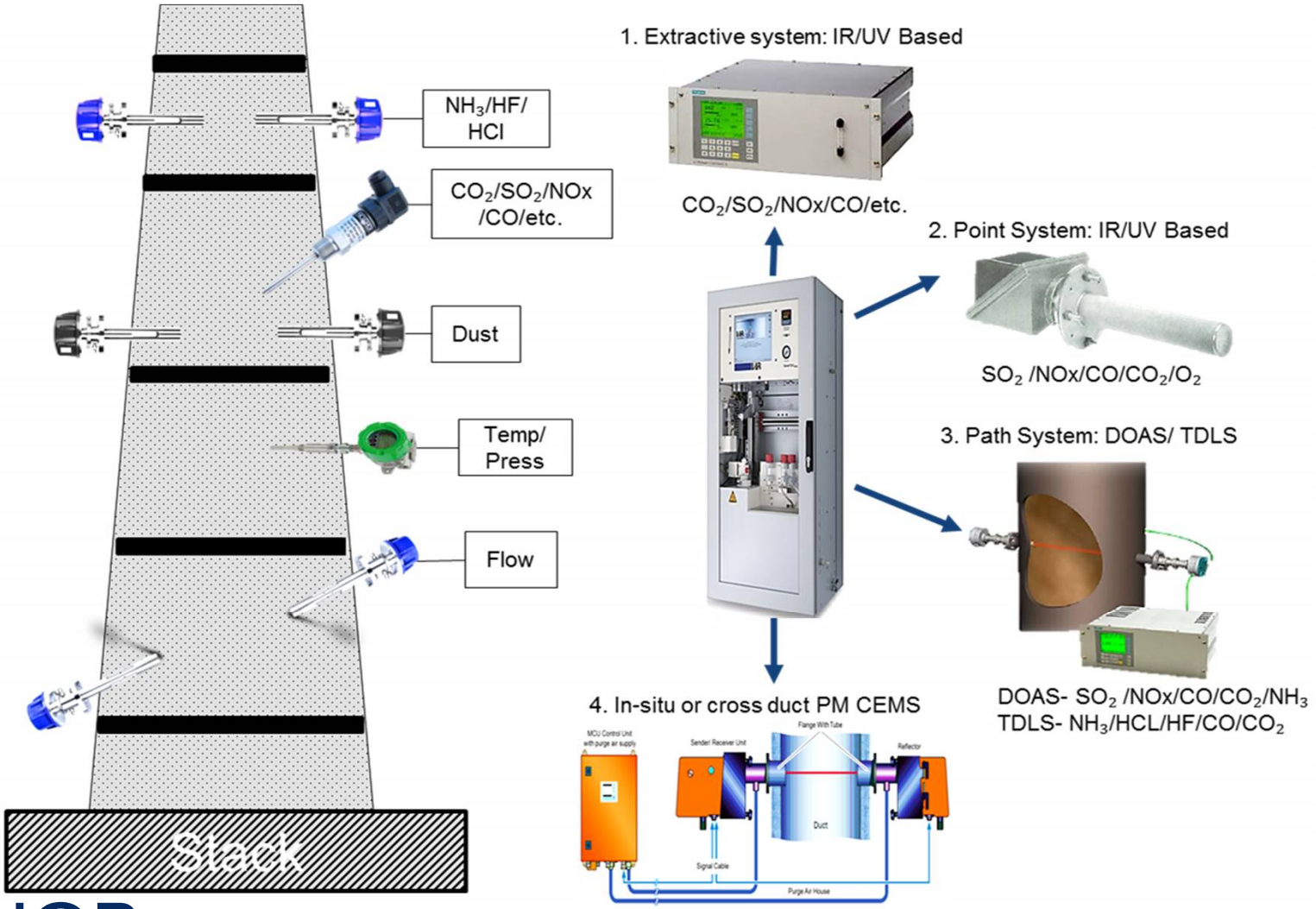
CEMS Analyzer Interconnection Drawing



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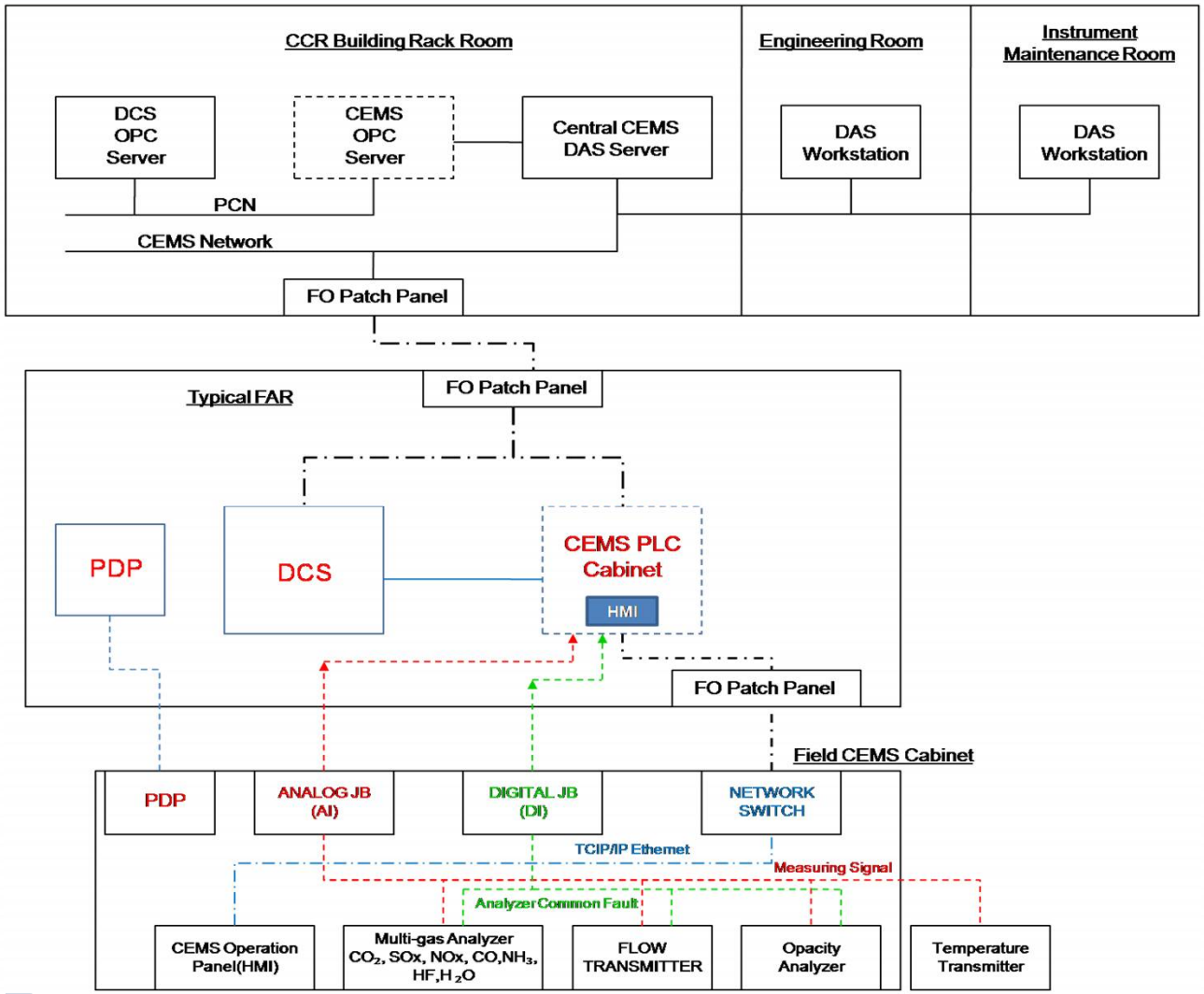
Overall Network Architecture Of CEMS



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Overall Network Architecture Of CEMS

Typical overall system block diagram of CEMS consists of following modules:

1. **CEMS Field Cabinet:** It consists of analyzers (such as **multi-gas analyzer, flow & temp. transmitter, PM, Opacity** etc.), CEMS operation panel (HMI), Analog & Digital **Junction Boxes**, Power distribution panel (**PDP**), and **network switch**. CEMS field cabinet shall be provided with large enough **reinforced window** in the door so that the analyzer can be seen without opening local cabinet door. It contains PDP with power supply connections. Network switches are used to convert the **TCP/IP Ethernet** to optical signal send via **fiber optical cable** (FOC) to CEMS PLC. **Analyzer measuring (AI) signal** and **common fault alarm signal (DI)** send separately to the CEMS PLC cabinet thru field junction boxes.

2. **Local Equipment or Field Auxiliary Room (LER/ FAR):** It consists of **CEMS PLC cabinet, PDP, DCS and FO patch panel.** The system will ensure the intermediate **data storage** of the raw input values at minute intervals from analyzers and eventual flow/temperature and pressure. CEMS results **(i.e. NOx and O_2)** used for DCS purpose. Analyzer stream components used for control shall be redundant **MODBUS TCP** to the DCS.

3. **Central Control and Administration:** It consists of CCR building rack room, engineer room and Instrument maintenance room. CCR building rack room consists of DCS **OPC serves** (S), CEMS **OPC Server**, Central CEMS DAS server and **FO patch panel**. Integration of CEMS analyzer is required in the centralized server based CEMS **Data acquisition System** (DAS) located in CCR. The DAS shall be provided with an uninterrupted **power supply (UPS)** for a minimum of **30 min.** backup for **uninterrupted** operation in case of power failure.

4. **Data Acquisition System (DAS):** The DAS plays a critical role in reading hourly averages of pollutants emitted and also produces the data to the government inspector to certify that the industry is working within the specify norms. The DAS can also be connected to the plant DCS system/ central DAS for conversion of **wet basis to dry basis** measurement as well as consolidating all the CEMS analyzers data by **Management Information System (MIS)** in a centrally located server for overall report management, though the connectivity requirement might vary from client to client. The tamper proof (encrypted format) data shall be transferred directly from the analyzer to the server at regional and national pollution control board via central CEMS DAS. The system shall record all the monitored values and transfer 30 min. average value to **Data Acquisition & Handling System** (DAHS).

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Thank You

Welcome your Suggestions !!!

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