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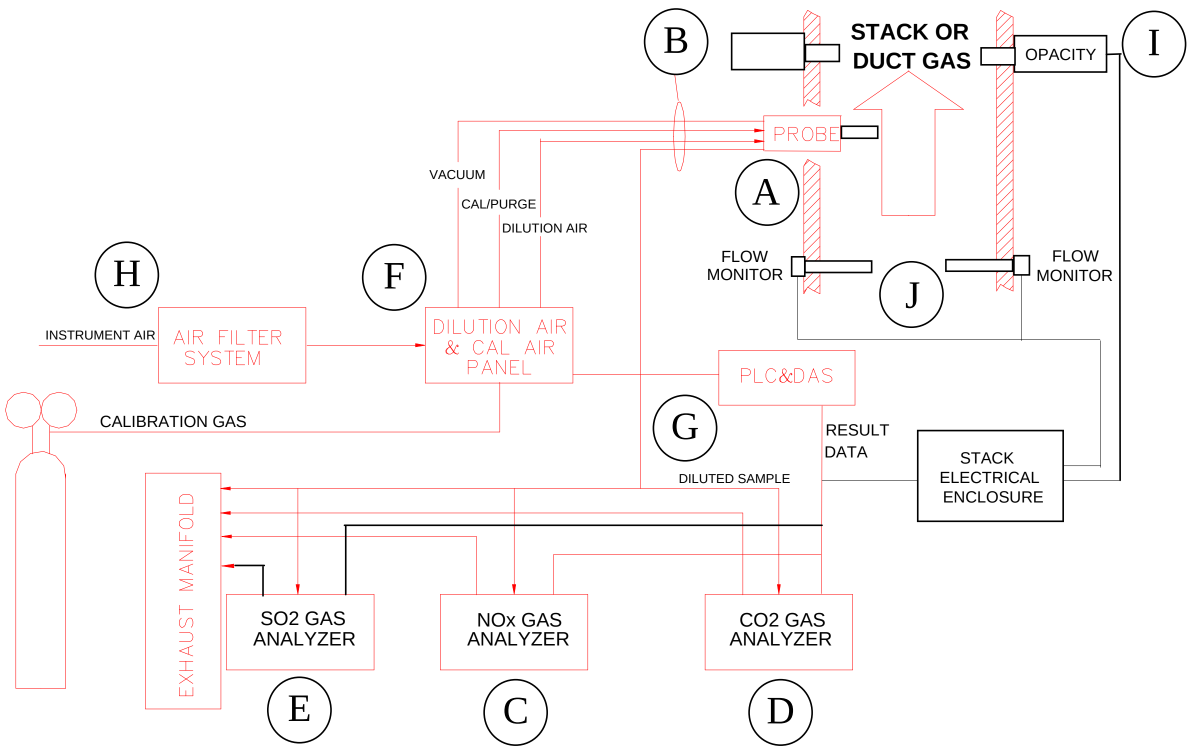
Dilution CEMS – Overview

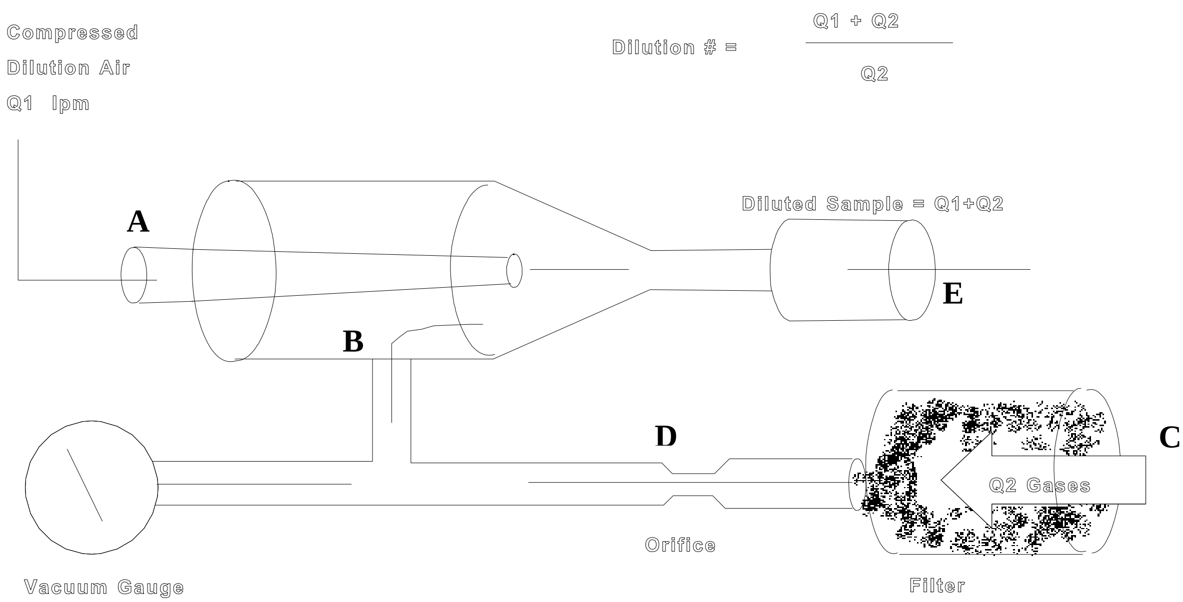
The dilution system was the most popular CEMS installed through the 80's and 90's. Many dilution systems are still sold today where high pollutant levels are present. The majority of the systems in the field today are dilution type. In a dilution system, clean compressed air (H) is sent up to a probe in the stack (A) where it is mixed with the stack gases and brought back down for monitoring (G). The stack gases are "diluted" with the compressed air in ratios ranging from 25:1 to 200:1.



Diluting the sample helps overcome some important sample handling issues involved with monitoring "wet" stack gas. Along with the stack gas, the sample moisture content is also diluted – greatly reducing condensation from the sample. Lower cost freeze protected sample line can replace expensive heated sample line in cases where high moisture content, low dilution ratios and very cold conditions exist.

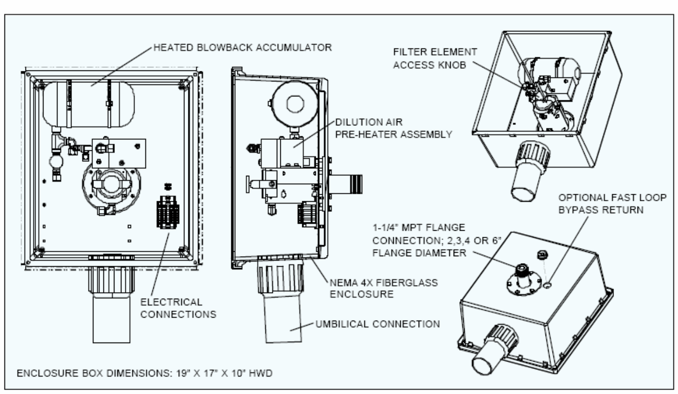
The sample is transported at a low flow rate (about 5 lpm). This minimizes particulate fouling and premature filter loading in the Dilution CEM system. The smaller drawn sample is also easier on the probe and allows for less corrosion. Dilution systems by nature are also easier on all the system components due to the much lower pollutant levels they're exposed to.

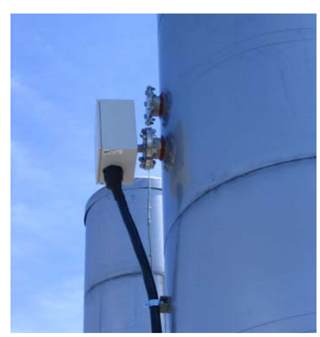
The heart of the system is the dilution orifice in the probe. In simple terms it acts as an eductor. Compressed air flows in (A) and creates a low-pressure vacuum (B) that draws air from the stack (C), through an orifice (D), and into the sample line (E).

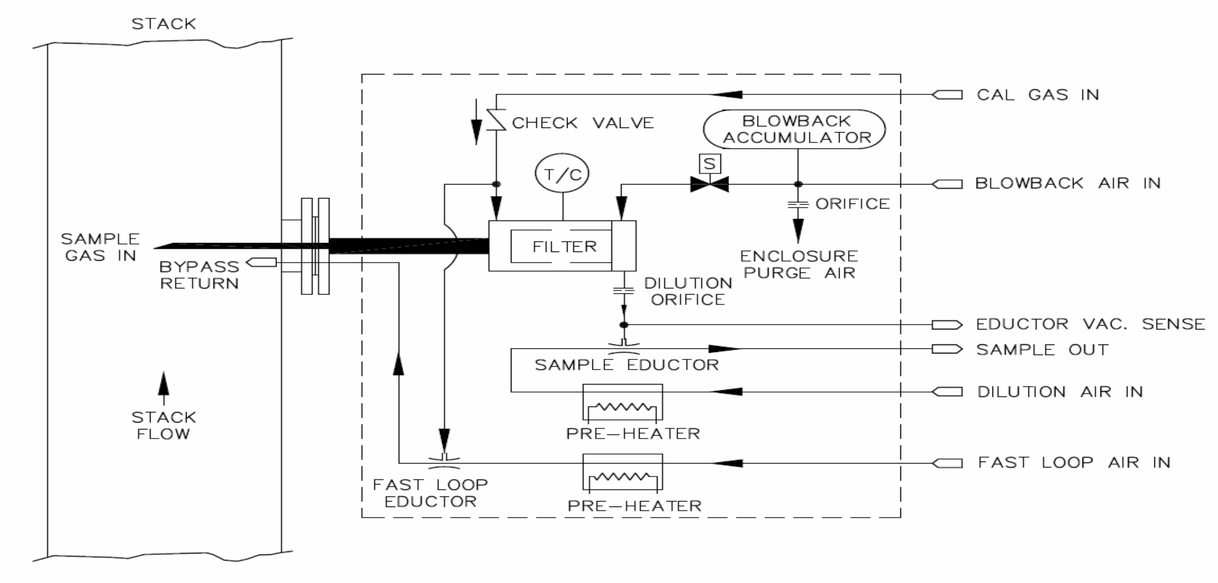


The orifice is designed to make the sample flow achieve "sonic" speed (referred to as the sonic orifice). Once sonic speed is achieved, the expected dilution ratio is reached and no further control of the sample flow is needed. The sonic orifice is sized for a specific dilution ratio. A vacuum gauge is added to the circuit to verify that the sonic condition exists – as long as it does, the resulting dilution ratio matches the expected value. To change dilution ratios, a different size orifice is installed.

Today's dilution probes contain all the components in an easy to access out-of-stack design.



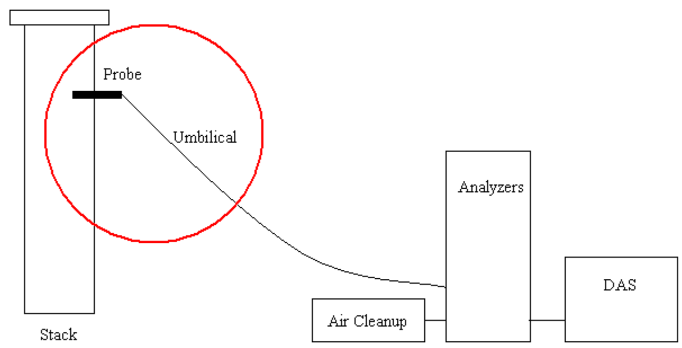




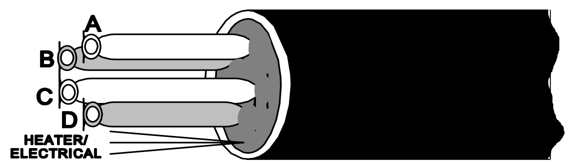
The elements of the probe include:

Filter:	For particulate and dust. Replacement of the filter is typically done at quarterly maintenance intervals.
Sample Eductor/Orifice:	Described above
Heaters:	These help to prevent condensation of acid gases in the probe and to reduce drift due to temperature changes. Typically kept at only 20-50°F above stack gas temperature.
Sample Out:	Where the diluted sample stream is carried out of the probe to the analyzer (through the umbilical)
Cal. Gas:	Where calibration gas is carried into the probe for cal checks. The EPA requires that it enter the front end of the system and travel through the entire probe.
Purge/Blowback Line:	Clean air floods the probe and creates a positive pressure that helps to “blow” out and purge the filter. Doing this at regular intervals via software control in the DAS allows the probe to stay clean and functional. An accumulator tank is used to “charge” the purge system for a more powerful blast when energized.
Eductor/Vac Sense:	Used to monitor the vacuum through the dilution orifice to make sure it’s maintaining sonic conditions.
Dilution Air:	This is the clean instrument grade air that is used to dilute the sample.
Fast Loop Eductor:	Used as an option to increase response time of a dilution system.

An “Umbilical” is used to carry the sample stream down to the analyzers – it also provides electrical connections between probe and rack components.

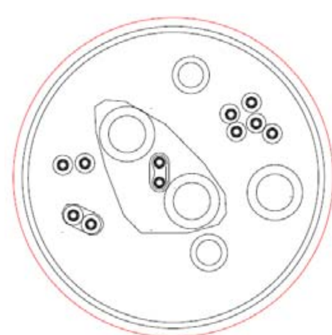


In a dilution system this is typically comprised of 4-5 lines wrapped in insulation and a protective sheath roughly 1-1/2” in diameter.



The five lines used with an out-of-stack probe are:

- Diluted sample line – 3/8” Teflon
- Dilution Air – 3/8” Poly
- Purge Air – 3/8” Poly
- Cal Gas – 1/4” Teflon
- Vacuum Line (verifies “sonic” condition) – 1/4” poly



A heater wire for the probe also runs through the umbilical. Heating the umbilical allows for protection from condensation at very low outdoor temperatures. A self-regulating system is used which keeps the entire length at approximately 140°F at all times.

To be used as dilution air, instrument grade air needs to be further scrubbed and dried. This is accomplished with an air-clean up system (polishing system) located near the analyzers.

The plant instrument air is first sent through a clean-up system like the one below before being sent up and mixed with the sample gas stream in the stack.

The air goes through the following stages:

1. Coalescing filter for moisture and particulates
2. Purafil filter which scrubs out SO_2 and NOx
3. Carulite filter which scrubs out CO
4. Heatless drying system to remove as much moisture as possible. The dryer unit typically reduce the moisture level from -40 to -80F.
5. Moisture indicator for breakthrough indication.

The Analyzers:

Different analyzers are used depending on the type of gases being monitored. This is because each gas is best measured with a unique methodology – i.e. Chemiluminesence for NOx, pulsed fluorescence for SO_2, zirconia for O_2, etc. The different technologies insure the lowest concentration measurement for each gas can be attained.

A number of analyzers are available to measure a variety of gases including: SO_2, NO_X, CO, and CO_2. The analyzers are mounted in a rack and normally housed in an enclosure for protection from high or low ambient temperatures and severe weather:

NEMA 1 racks: these are used when the analyzer cabinet will reside in a control room type environment where the temperature and humidity are constantly controlled (typically 68-70°F).

NEMA 12 Cabinets: these are typically used indoors, in areas where the temperature is not constantly controlled (i.e. turbine deck). They have built in HVAC units to keep the inside of the cabinet at a constant temperature.

Walk-in Enclosures/Shelters: utilized for outdoor placement of the CEMS equipment. They have their own HVAC for temperature control, and allow maintenance people to work on the units out of the weather.

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A calibration gas system is required to perform the daily and quarterly calibrations required by Federal EPA regulations. The system is completely automated and introduces the correct cal gas at appointed times and durations using solenoids that are part of a complete sample/cal control panel. This panel is found in the CEMS rack and is controlled by a PLC.

Beside the analyzers and sample/cal control panel, the analyzer cabinet also holds a heater controller and a PLC.

- Heater controller
- Sample/Cal control panel
- PLC with Operator Interface Terminal
- Analyzer
- Analyzer

Data Acquisition System:

Last but not least is the DAS. The DAS performs many functions:

- Controls the CEMS calibration check and purge cycles
- Monitors the system for trouble (sample conditioning system failure, monitor faults, etc.)
- Outputs alarms in the event of system faults or emission exceedances
- Collects and stores the data
- Generates reports for EPA

The DAS is made up of two parts – the PLC and the PC.

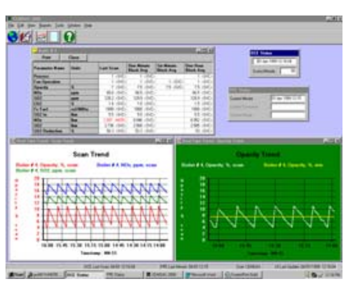
The PLC is used as the main controller and interface between the CEMS and the DAS computer. It is usually located in the analyzer cabinet. It is comprised of analog inputs and outputs and digital inputs and outputs. Some examples:

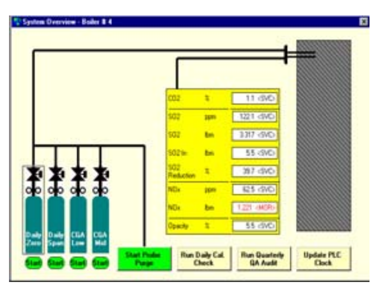
- Analog Inputs: the analyzer signals, fuel flow signals, process signals, etc.
- Analog Outputs: retransmission of analyzer signals (gas values) to a plant PLC (can also be accomplished via an Ethernet connection)
- Digital Inputs: process signals (ID fan on/off for example), alarm contacts from sample conditioner, analyzers, etc.
- Digital Outputs: alarm contact to plant PLC (can also be accomplished via an Ethernet connection), calibration solenoid enabling, purge solenoid enabling, etc.

DAS Computer:

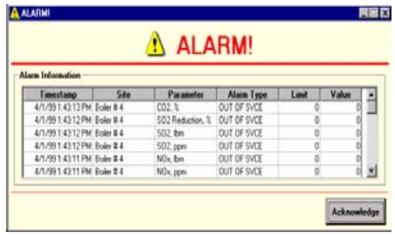
The DAS computer is connected directly to the PLC and receives all the information for storage, calculations and reporting. The DAS computer can sometimes be found in a CEMS shelter next to the analyzer cabinet, but often it is located remotely in a control room.

The DAS computer maintains and displays the status of the CEMS for an operator:





It alerts the user of alarm conditions:



and allows for reports to be generated (both manually and automatically) from the stored data:

Dilution systems save money by using less calibration gas – this is a big savings over time. They also save money in maintenance time. No moving parts or electrical utilities on or in the stack mean less stack maintenance time.

A dilution system is truly the system of choice where it can be used, and that’s typically where higher levels of pollutants are monitored.