GASEOUS CEMS FUNDAMENTALS

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BHUBANESWAR, JULY 11TH – 13TH, 2022

INTERNATIONAL CENTRE FOR
SUSTAINABLE CARBON

CONTENT

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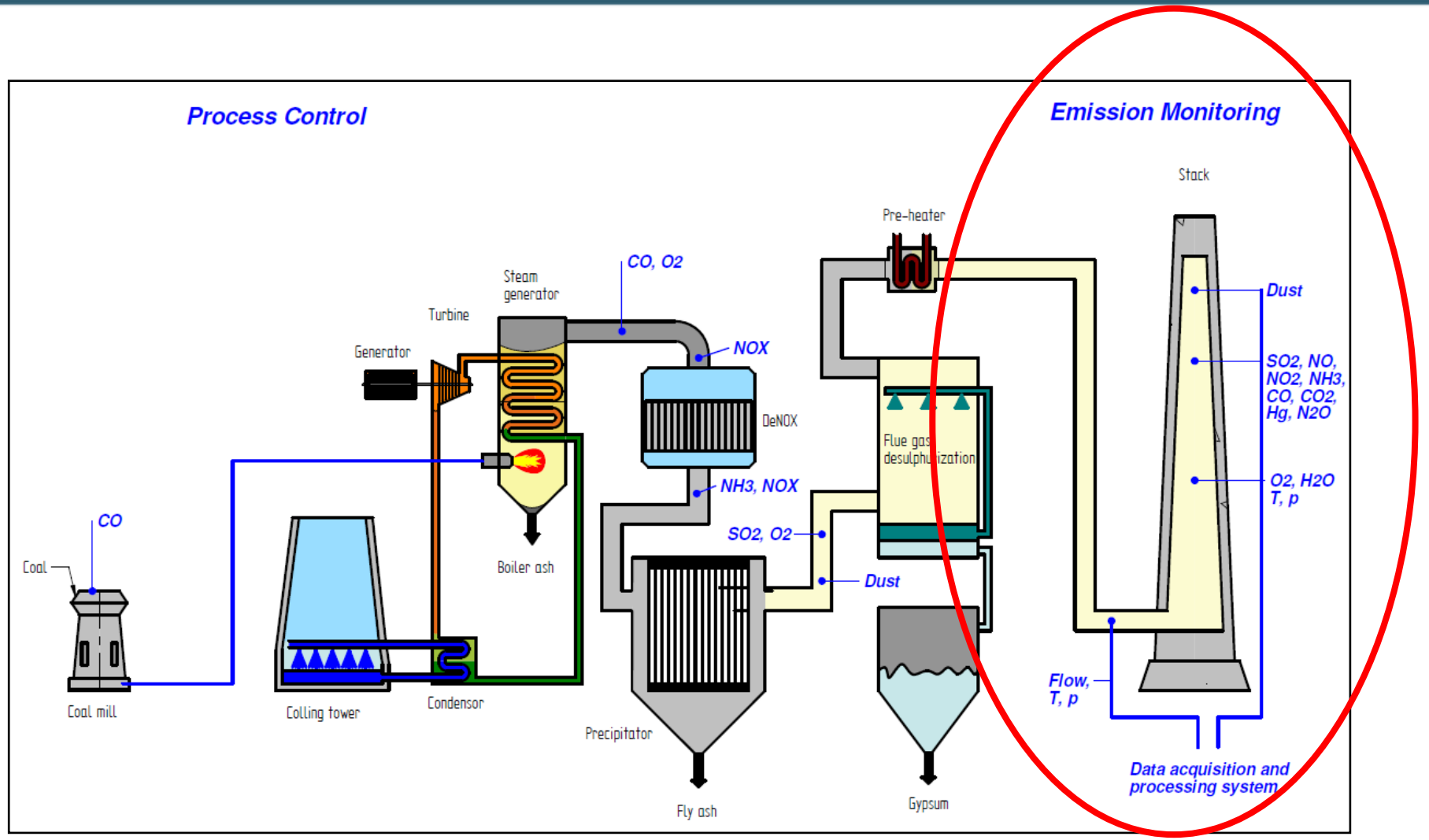
WHERE DO WE NEED TO MEASURE ?



LEGISLATIVE MONITORING

WHAT IS IT WE ARE INTERESTED IN?

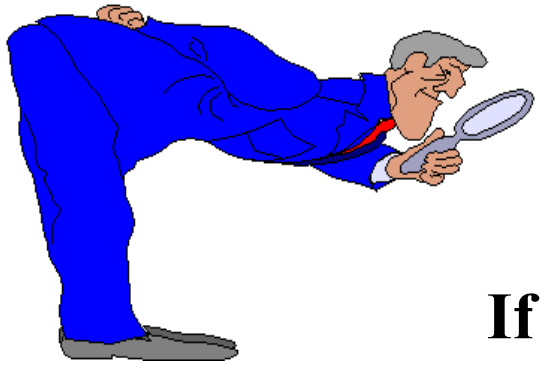
There are plenty of pollutants we can or must measure:

- Particulates:
  - Total Dust or Opacity, Heavy Metals
- Inorganic Compounds:
  - CO, CO_2, SO_2, $NO/NO_2/NO_x$, NH_3, HCl, HF, Total Hg
- Organic Compounds:
  - THC, Dioxins & Furans

- Reference Values:
  - O_2, H_2O, Temperature, Pressure, Gas Velocity / Flow

CONTENT

WHY MONITORING AT ALL??



If we don’t know “what and how much”, we don’t know “how to reduce it”

Emission Monitoring documents the efficiency of Emission Control Activities

REGULATIONS

There are two major ways of regulatory approach for CEMS:

- **U.S.A.**
  - **US-EPA regulations are laid down in 40CFR60 and ASTM's**
  - **Instruments cannot get type-approval – there is no scheme like that in USA**
  - **Extensive site testing after installation is required**

- **EUROPE**
  - **European regulations are laid down in EN's as well as country-specific laws and regulations, f.e. in Germany: TA-Luft, BImSchG, and BImSchV 1 – 44**
  - **Instruments have to successfully complete type-approval ("TUEV-Test, MCERTS") = QAL 1**
  - **Extensive site testing after installation is required = QAL 2**

WHY GAS ANALYSIS

Process Monitoring

- Safe fuel
- Optimize process
- Control process
- Automate process
- Quality control
- Safety

RETURN ON INVESTMENT? YES

Emission Monitoring (CEMS)

- Environmental Regulations
- Environmental protection
- Cleaner Process
- Transparency
- Avoid fines
- CO_2 Emission Trading

RETURN ON INVESTMENT? NOT REALLY

TECHNO-COMMERCIAL REQUIREMENTS FOR GAS ANALYZER SYSTEMS

Analyzers

- Stability
- Availability
- Repeatability
- Low detection limits
- No interferences
- Low cost of maintenance

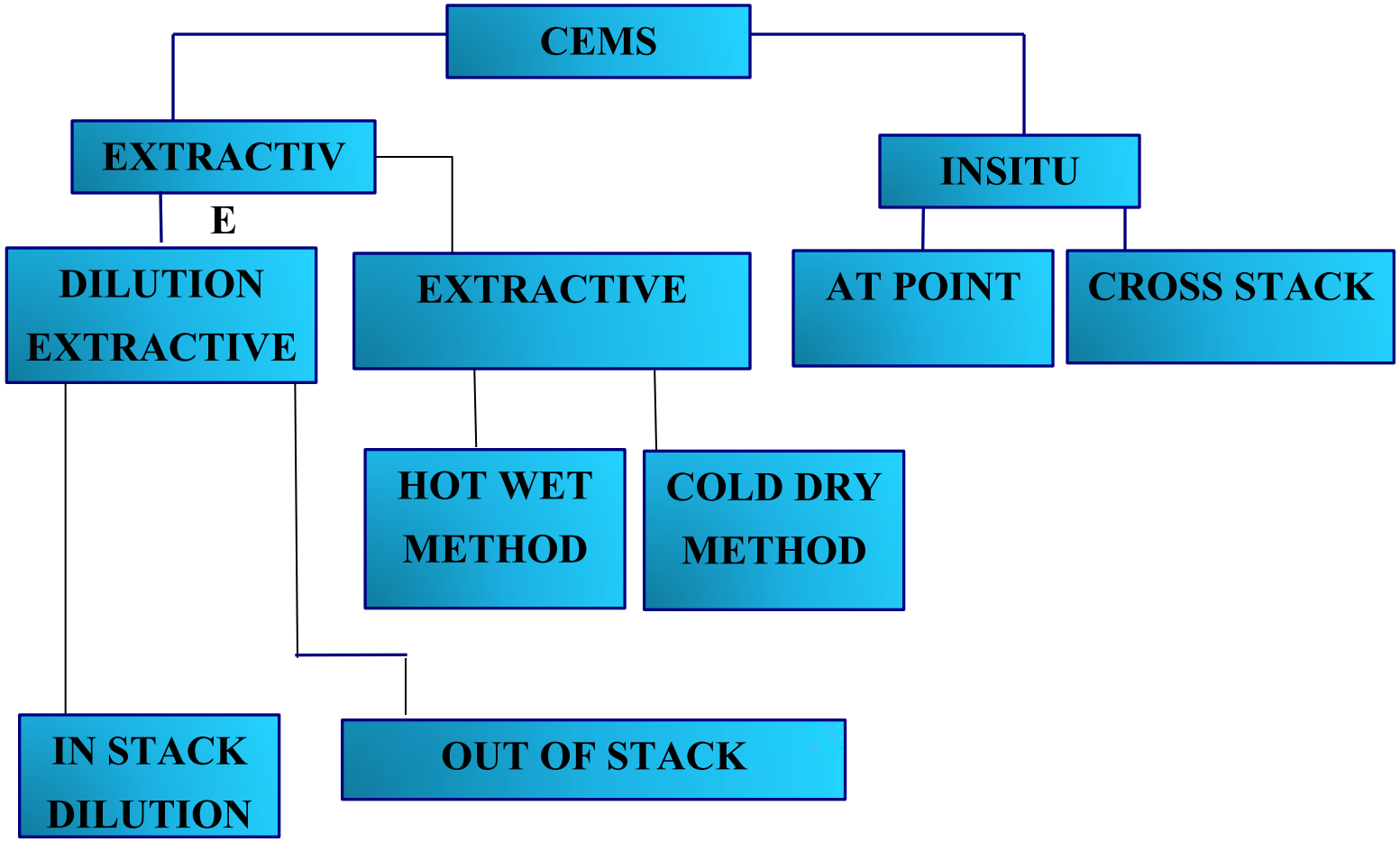
System

- Simple to install
- Low cost of installation
- Easy integration
- Long lifetime
- Accurate data availability

and what about the

SAMPLING and CONDITIONING SYSTEM ??

TYPE OF CEMS TECHNIQUE



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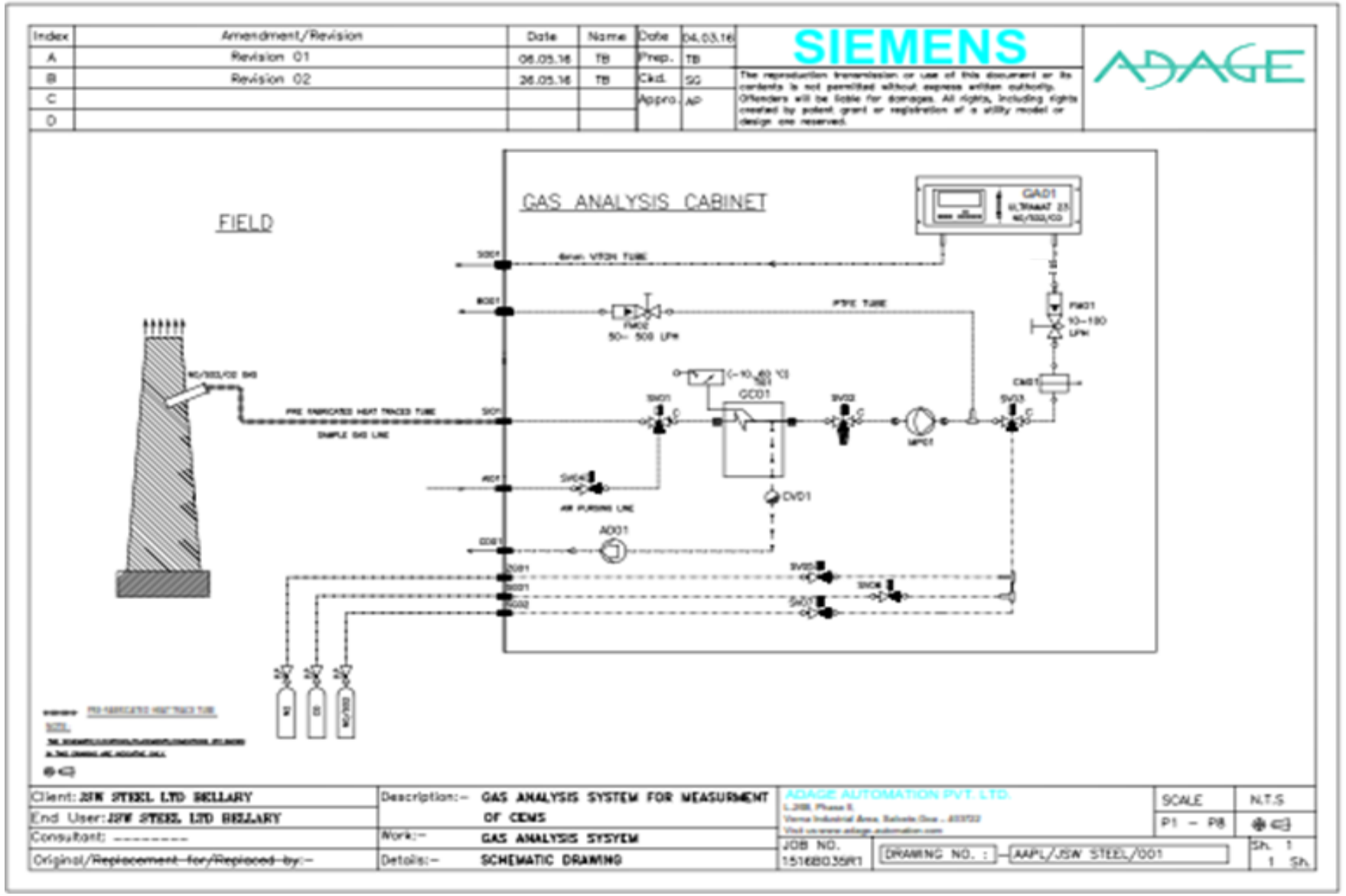
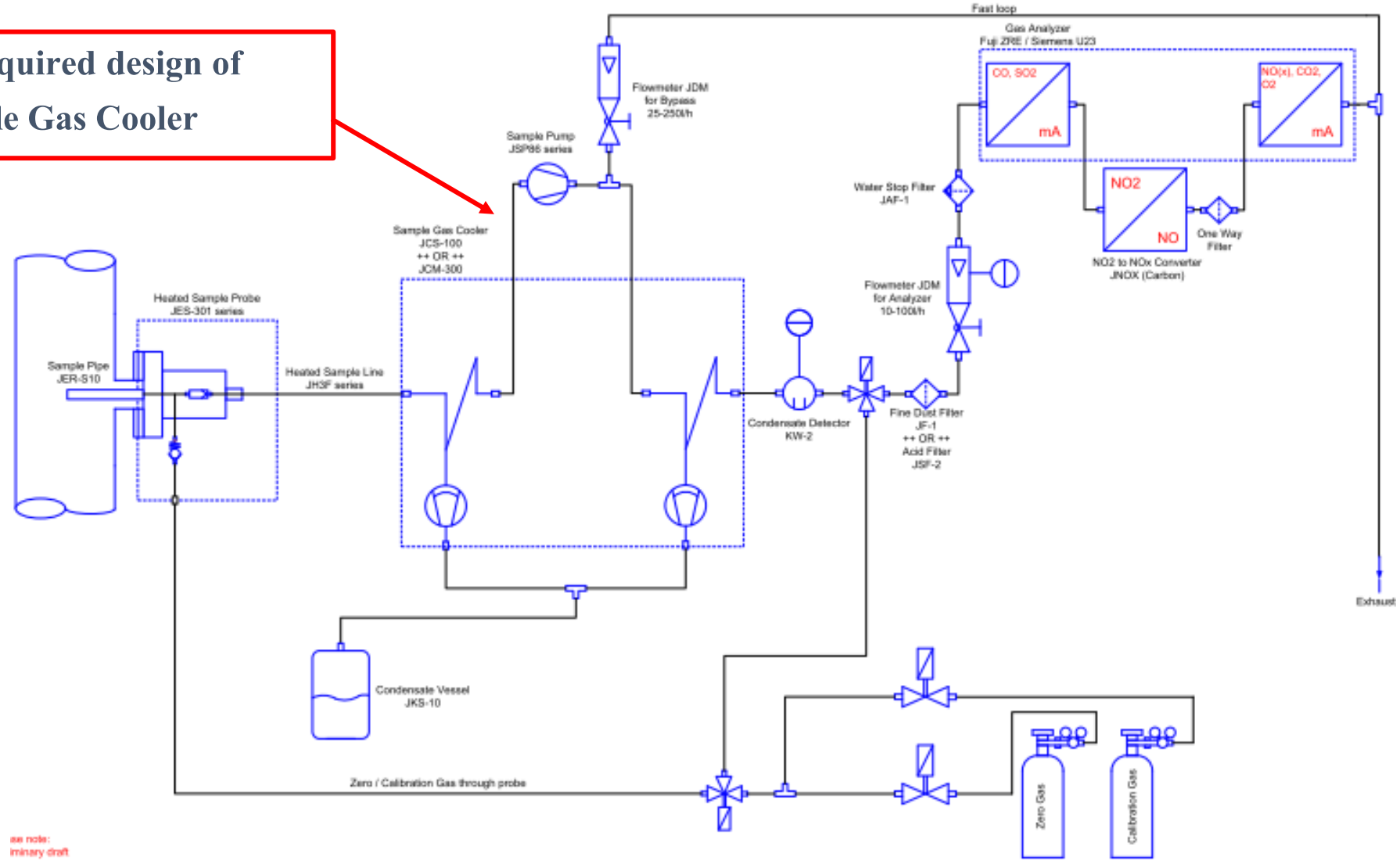
TYPICAL SHS DESIGN FOR HOT EXTRACTIVE CEMS



SAMPLING & CONDITIONING SYSTEM
GAS ANALYSIS (HOT EXTRACTIVE / COLD ANALYSERS)

EN required design of Sample Gas Cooler



ase note:
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KEY POINTS FOR THE SHS

- ✓ The SHS's MOC should not interfere with the sample gas components
- ✓ Back Purge or Back Flush incl. in-situ pre-filter for the sample probe should be selected based on dust concentration and total flow rate through the probe
- ✓ Position of the sample tube inlet inside the stack should be at a ***representative point*** with laminar flow
  - ✓ Vertical: i.e. ≥ 5 * stack diameter before / ≥ 2 * stack dia. after the tube inlet
  - ✓ Horizontal: between 15 and 50% of stack diameter
- ✓ There should be **NO COLDSPOT** possible between Stack Outlet (Tapping Point) and Sample Gas Cooler Inlet
- ✓ Diameter of the sample tube inside the HSL should be selected in correlation to its length and the required flowrate to minimize the sample gas travelling time
  - ✓ For long HSLs a bypass pump should be included
- ✓ Condensate outlet of the sample gas cooler should be safely discharged (highly acidic)

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CEMS DESIGN

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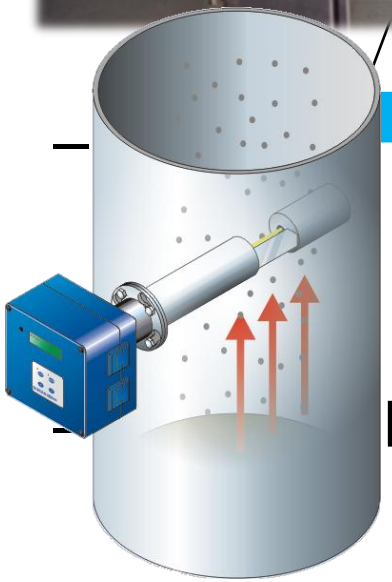
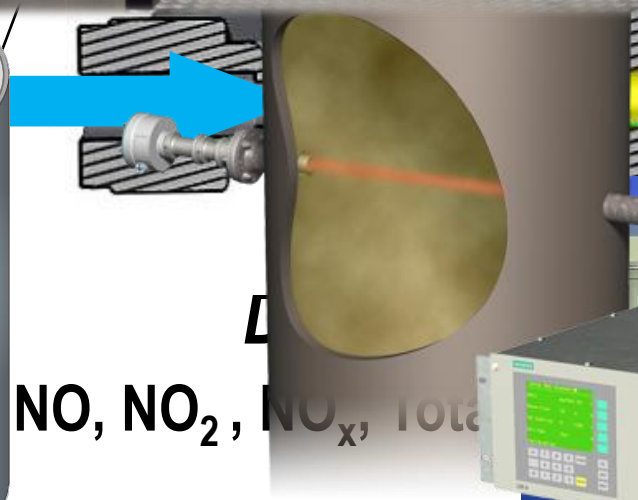


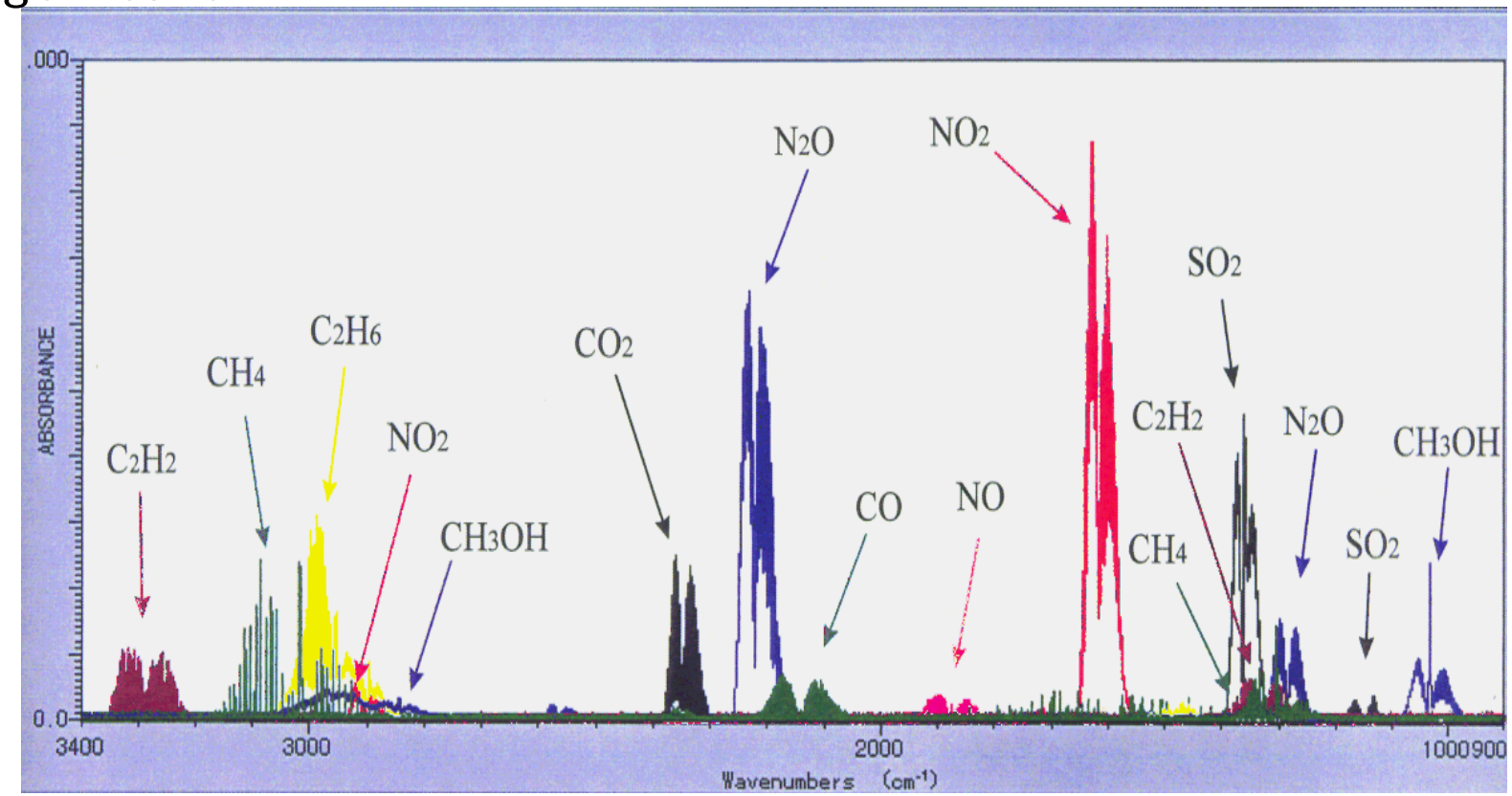


D

NO, NO_2 , NO_x, Tota

INFRARED TECHNOLOGY

Many gaseous pollutants show absorption band(s) in the infrared wavelength band



FURTHER GAS MONITORING TECHNOLOGIES

- UV-Absorption is used for a number of pollutants like NO and NO_2
- Chemiluminescence is used for NO, NO_2, NO_x
- FTIR Spectrometry is used as Multicomponent Analyzer
- Tunable Diode Laser Absorption Spectroscopy (TDLAS) is used as Single- or Multicomponent Analyzer – most modern technology
- Flame Ionization Detector (FID) is used for Total Hydrocarbons (THC) and Non-Methane Hydrocarbons (NMHC)
- Gas Chromatography with e.g. FID, PID, FPD is used for individual Hydrocarbons
- UV-Photometry, CVAFS, or CVAAS, together with sample preparation, are used for Total Mercury
- ZrO_2 probes are used for O_2

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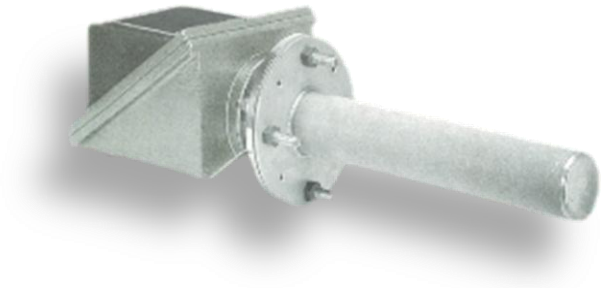
OVERVIEW OF INSITU CEMS

CEMS:
(Analyzer Used:
IR/UV Based)

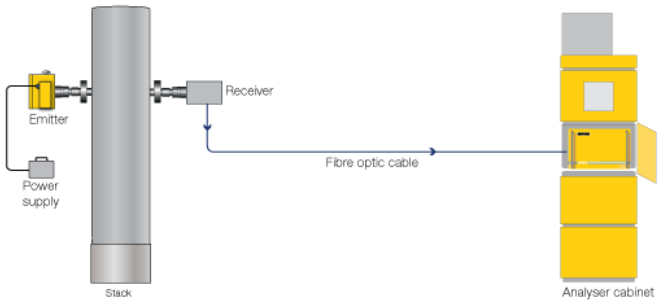
POINT SYSTEM



$SO_2/NO_x/CO/CO_2/O_2$

CEMS:
(Analyzer Used:
DOAS)

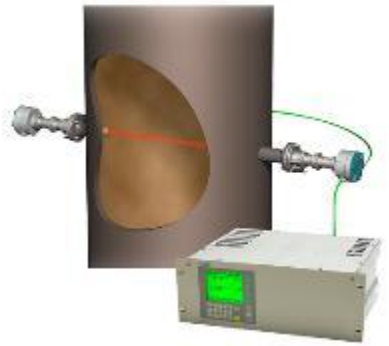
PATH SYSTEM



$SO_2/NO_x/CO/CO_2/NH_3$

CEMS:
(Analyzer Used:
TDLS)

PATH SYSTEM

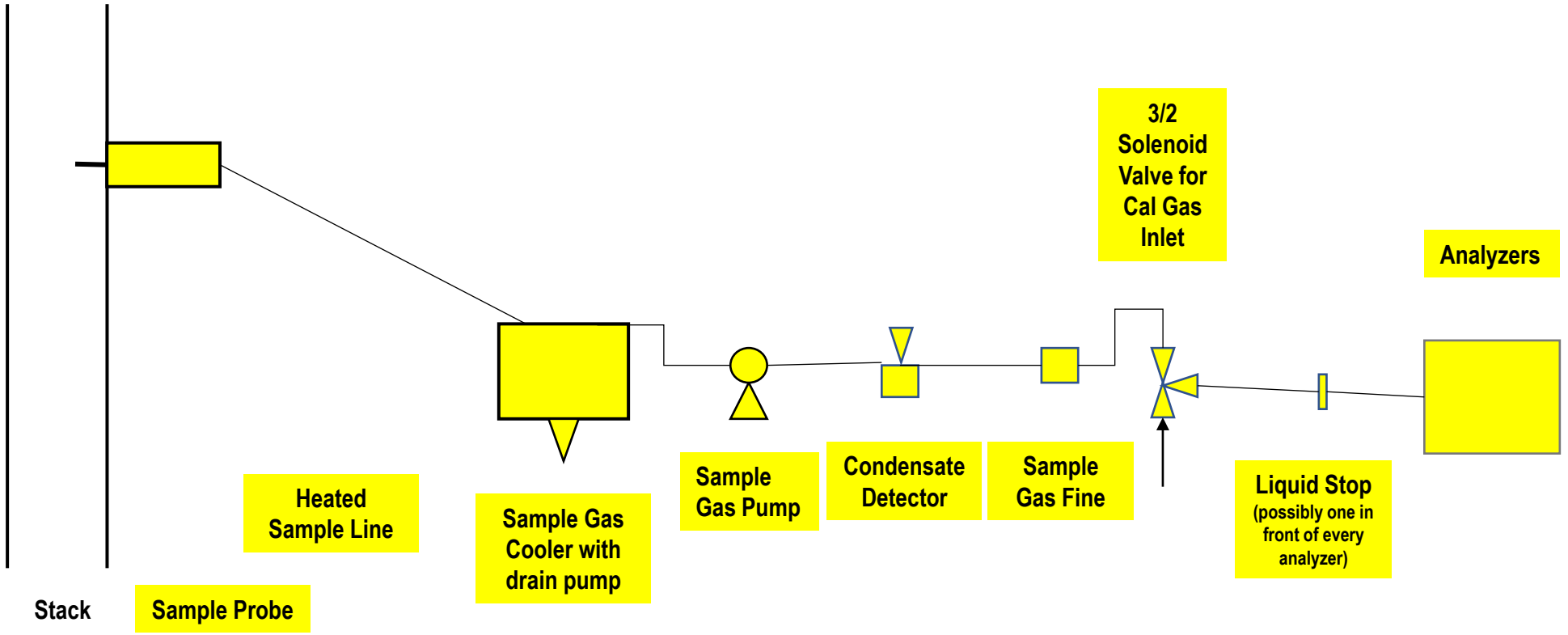


$NH_3/HCl/HF/CO/CO_2$

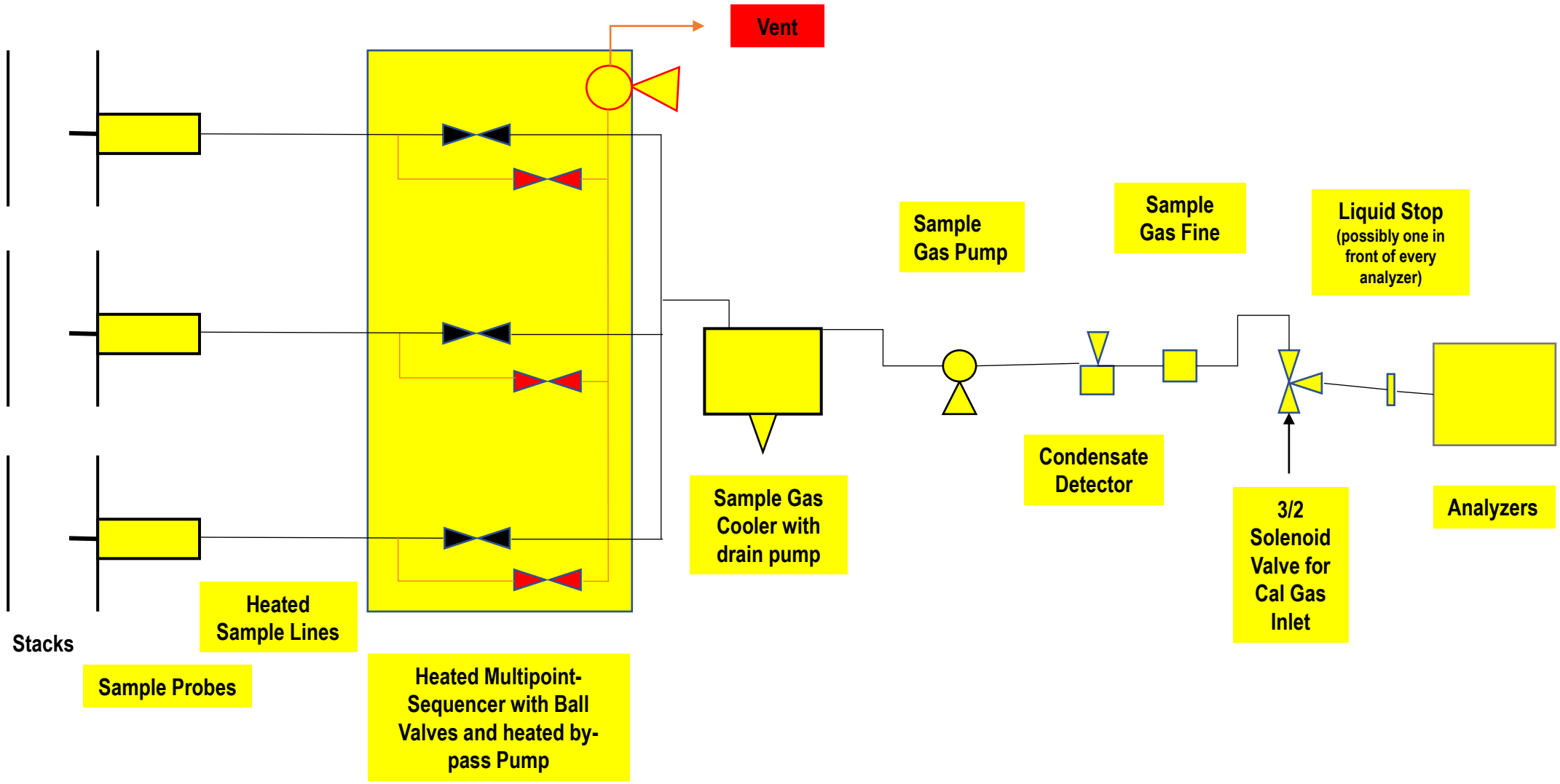
ADVANTAGE / DIS-ADVANTAGE
IN-SITU

- No sample transport – gases / dust are analysed in their stack environment
  - No SHS required, no secondary interferences by f.e. sample gas cooler wash-out
- Typically Multicomponent Analysers – reduction on space and accessories
  - Easier on maintenance
- Unknown / Unexpected interferences possible – difficult to consider during calibration
- Measurement is on wet basis, more complex to report dry-basis values (humidity measurement required)
- If a key component fails, the whole Multicomponent Analyzer is down
- Sensitivity is dependent on the available pathlength (stack diameter)
- Analyzer unit is installed up on the stack – all maintenance and service has to be done there
- Challenging or impossible for Hazardous Areas

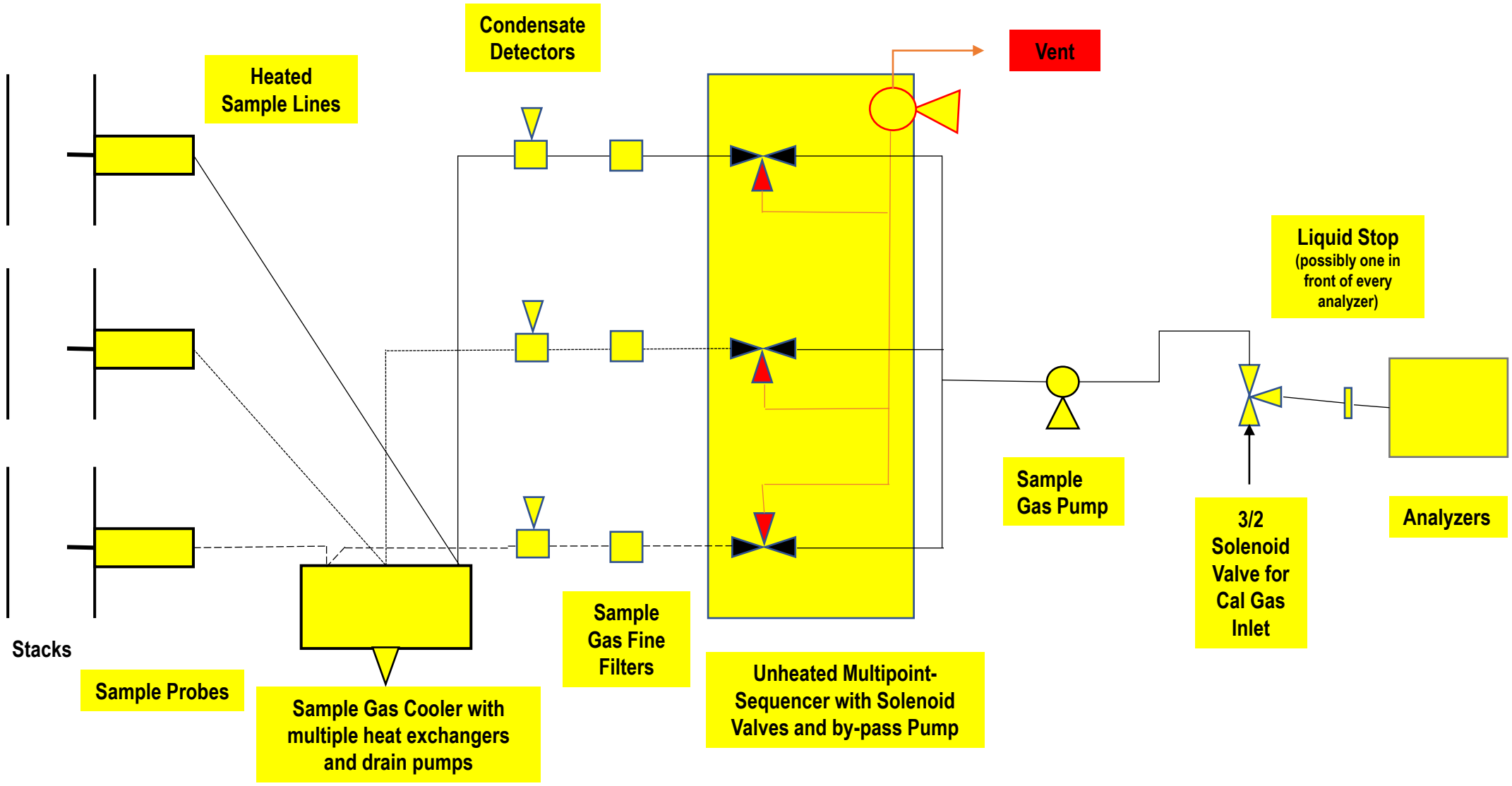
SAMPLE CONDITIONING SYSTEM FOR SINGLE STREAM



SAMPLE CONDITIONING SYSTEM FOR THREE STREAMS, VERSION 1



SAMPLE CONDITIONING SYSTEM FOR THREE STREAMS, VERSION 2

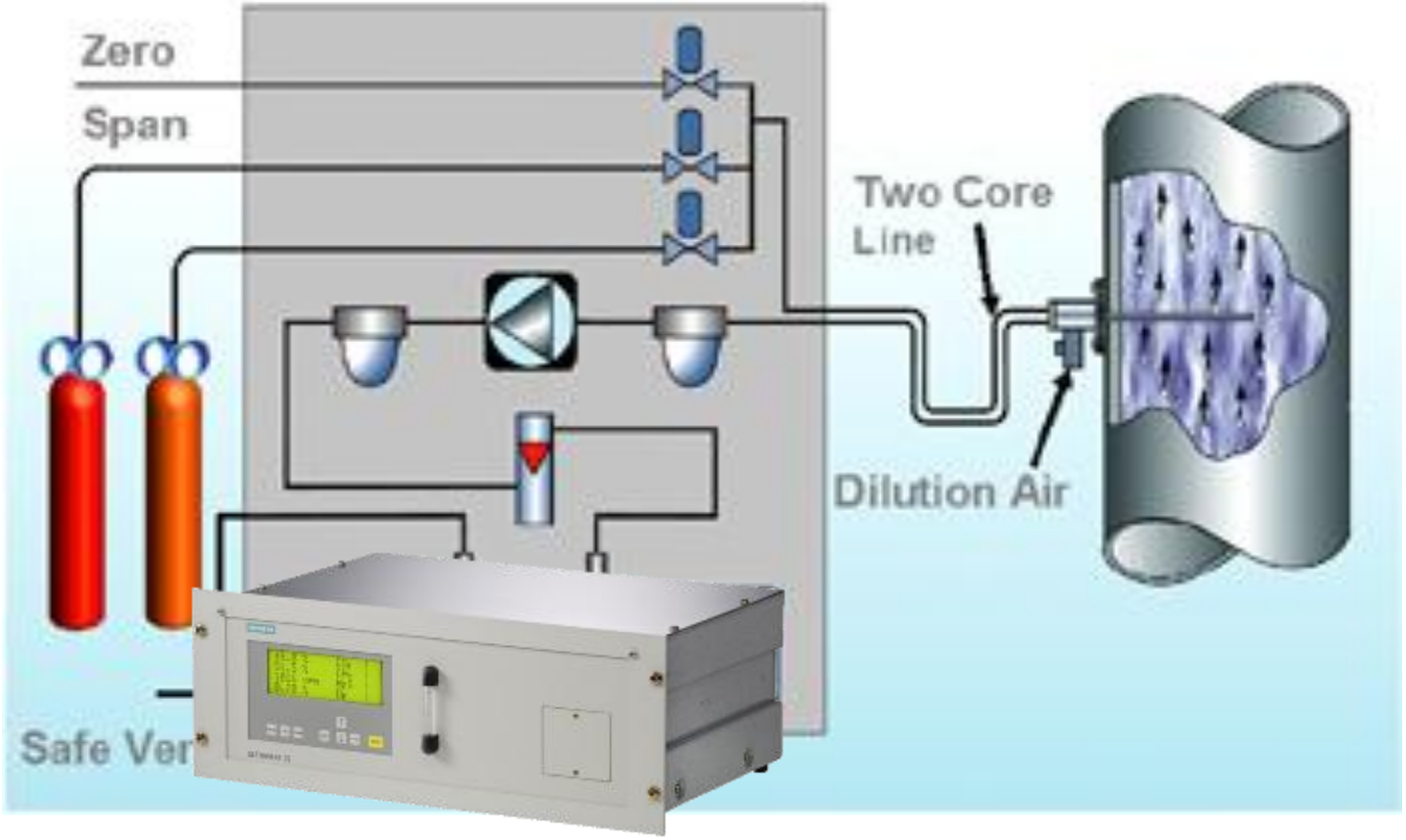


CONVENTIONAL EXTRACTIVE with 2-WAY CALIBRATION

ADVANTAGE / DIS-ADVANTAGE
CONVENTIONAL EXTRACTIVE

- Relatively simple way of calibrating the entire CEMS
- Individual analysers: typically no common breakdown possible; Multicomponent Analysers: reduced requirement on space and accessories
- Service & Maintenance to be done in the instrument shelter for analysers, at the tapping point for the SHS
- Measurement and calibration on dry basis
- Requirement of A/C instrument shelter
- Service & Maintenance to be done at the tapping point for the SHS
- With Sample Gas Chillers: probability of loss of components; with High Temperature Systems: probability for higher maintenance and service
- Accuracy of measurement strongly depending on quality of sample handling / sample transport / sample conditioning
- *SAMPLE HANDLING SYSTEM VERY OFTEN NOT PROFESSIONALLY DESIGNED!*

MEASUREMENT BASED ON DILUTION TECHNIQUE



ADVANTAGE / DIS-ADVANTAGE
DILUTION EXTRACTIVE

- Relatively simple way of calibrating the entire CEMS
- Dilution reduces interferences from inappropriate sample handling
- No wash-out of water-soluble components (SO_2, NO_2, etc.)
- With in-situ dilution units: No expensive heated sample lines required
- With individual analysers: typically no common breakdown possible
- Analyser maintenance in the instrument shelter
- Requirement of A/C instrument shelter
- Service & Maintenance to be done at the tapping point for the in-situ dilution unit
- Ambient Air Analysers with lower LDL required = typically more expensive
- Accuracy of measurement depending on stability of dilution; Critical Orifices are sensitive to inlet-pressure changes
- Measurement is on wet basis, more complex to report dry-basis values (additional humidity measurement required)
  - Calibration on dry basis

THANK YOU

Credits for providing information for this presentation goes to the following companies:

JCT Analysentechnik

SINTROL Measuring Matters

ADAGE

OPSIS

EMERSON.

DURAG GROUP

INTERNATIONAL CENTRE FOR
SUSTAINABLE CARBON

THANK YOU FOR LISTENING

ANY QUESTIONS?

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