Emission Monitoring and Reporting (EMR)
Guidelines for Continuous Emissions Measurements in Holcim Cement Plants

(European Version)

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1. INTRODUCTION / GENERAL

1.1 General Situation with regard to EMR:

- With the adherence to the WBCSD Holcim has accepted to publish a corporate SD report (Including a chapter on environment) within two years from the date of adherence.
- In discussions around AFR implementation the lack of a systematic record of emission data always again is a matter of concern.
- Authorities more and more proceed to the issuing or revision of emission limit values for industries and thus also need reliable back-up data.
- Holcim's engagement for continuous (environmental) improvement, too, needs reliable emission data for adequate preparation of decisions.

To this ends, the Holcim ExCo has adopted the EMR scheme, which requires the Group plants:

A) To install and operate continuous emission monitoring (CEM) equipment for Dust, NOx, SO_2, VOC (and O_2).

B) To measure HCl, NH_3, C_6H_6 (benzene), D/F and HM emissions (at least) once per year.

C) To calibrate CEM equipment (at least) once per year.

D) To report in a standardized form once per year (01.03.xy) to HGRS-CIE.

E) To see for it that organizations entrusted with work according to points B) and C) above are capable of delivering quality work.

Note:
Points C) and E) are not directly subjects of the above cited Exco decision, but mandatory to assure a high quality level of information according to points A) and B).

1.2 Supporting Documents

In order to standardize and streamline emission measuring and reporting in the Group, to facilitate EMR implementation and generally to assure a high EMR quality level, three documents were prepared by HGRS CIE and CTS, namely:

- Emission Monitoring and Reporting Manual for European Countries
- **Guidelines for Continuous Emissions Measurements in Holcim Cement Plants (Document on hand)**
- Guidelines for Annual Discontinuous Emissions Measurements in Holcim Cement Plants

In the document on hand continuous emission measuring devices for dust, NO_x, SO_2, VOC, O_2 and other compounds are specified and declared Holcim standard.

All three documents can be found in ENVIROnet on HolSpace.

2. TECHNIQUES OF CONTINUOUS EMISSION MEASURING DEVICES

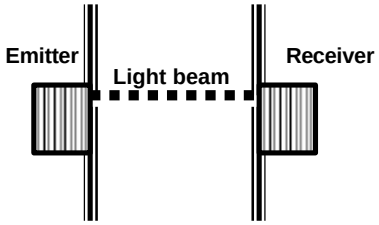
The concentration of a substance in the exhaust gas can be measured directly in the stack (in-situ) or a part of the exhaust gas can be extracted from the stack and then measured (extractive).

2.1 In-Situ Measuring Devices

The measurement is made directly in the stack and no gas is extracted.

Example: Dust can be measured using the physical principle of light absorption. The light is sent directly through the stack and the light absorption is an indication of the dust content.

FIGURE 1:
Principle of an In-Situ Measuring Device



Problems with this measuring device are very often related to calibration. A calibration gas cannot be introduced easily. Therefore special calibration facilities need to be installed.

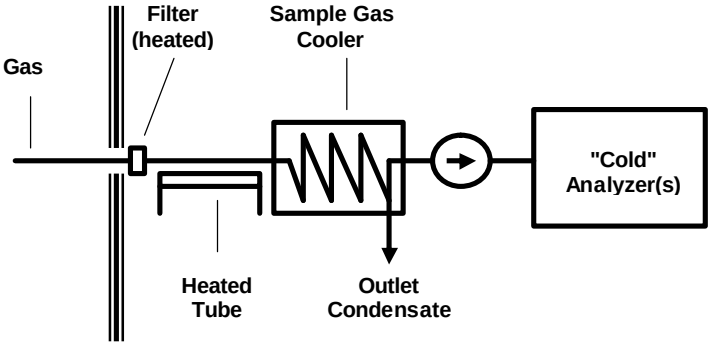
2.2 Extractive Measuring Devices

Part of the gas stream is extracted from the stack and fed to the analyzing system. The extracted gas must be cleaned and eventually dried before entering the analyzers

2.2.1 The “Cold” Extractive Measuring Device

After the extraction the sample gas stream is cooled down to approximately 4 [°C]. The water vapor condenses and is extracted through a special output system. Then the gas is fed to the analyzers.

FIGURE 2:
Example of a “Cold Extractive Measuring Device”

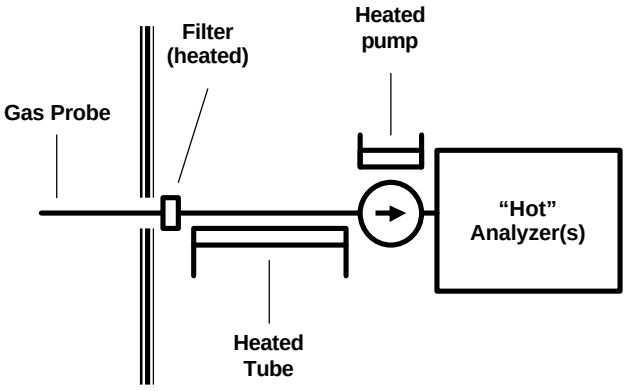


The problems of this device are related to reactions of some components with the condensate in the gas cooler. So, compounds like ammonia, sulfur, hydrogen chlorides, etc. are completely or partly “washed out” with the condensate and a measurement is not possible.

2.2.2 The “Hot” Extractive Measuring Device

The gas is extracted and kept at a temperature, which does not allow condensation or chemical reactions to occur. Depending on the substances measured this temperature must kept between 140 and 200 [°C].

FIGURE 3:
Example of a “Hot Extractive Measuring Device”



3. STANDARDIZED CONTINUOUS EMISSION MEASURING DEVICES

Complete emission measuring equipment covering the EMR requirements (dust, NO, SO_2, VOC and O_2) consists of mainly three different analyzer types:

- Dust monitor (in-situ)
- Continuous emission measuring device for inorganic gases (CEM)
- Flame ionization detector for the measurement of volatile organic compounds (The FID can be integrated in the CEM but is in any case a separate device)

3.1 Dust Measuring Devices

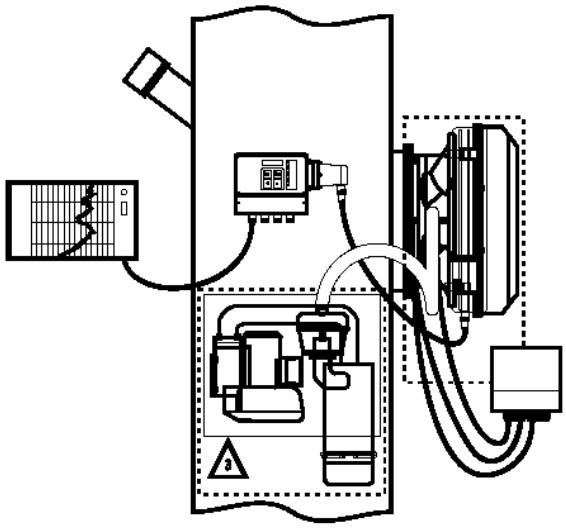
Suitable dust measuring devices are “In-Situ” monitors. The supplier of an emission measuring system mainly buys one out of the below four dust analysers and integrates the signal into the electronic part of the system.

Durag	D-R-280-10	**10 – 12’000 US-$**	– Suitable for high dust applications (> 200 [mg/m^3]) – A dust concentration below approximately 10 [mg/m^3] cannot be measured.
Durag	D-R300	**10 – 12’000 US-$**	– Measuring volume limited – Suitable for very small dust concentrations (below 1 [mg/m^3])
SICK	FW100	**6’000 US-$**	– Point measurement – Suitable for very small dust concentrations (below 1 [mg/m^3])
SICK	RM210	**10 – 12’000 US-$**	– Penetration depth is adjustable – Suitable for very small dust concentrations (below 1 [mg/m^3])

3.1.1 DURAG: D-R280-10

Supplier	DURAG Industrie Elektronik GmbH&Co KG Kollaustr. 105 D-22453 Hamburg/Germany Phone: ++49 40 55 42 18 0 Fax: ++49 40 58 41 54 Internet: www.durag.de
Type	Dust Concentration Meter D-R280-10
Measuring principle	In-Situ Two-beams alternate light method
Measuring range	10 to 250 [mg/m^3] (higher ranges possible)
Calibration	Comparison measurement, e.g. according to VDI 2066.
Gas conditions	Above dew point
AMBIENT CONDITIONS	-20 to + 50 [°C]
Configuration	
Approval	TA Luft, 13. BImSchV
Budget price	Approximately 10'000 to 12'000 US-$
Remarks	– For high dust applications (> 200 [mg/m^3]) suitable – Concentration below approximately 10 [mg/m^3] cannot be measured.

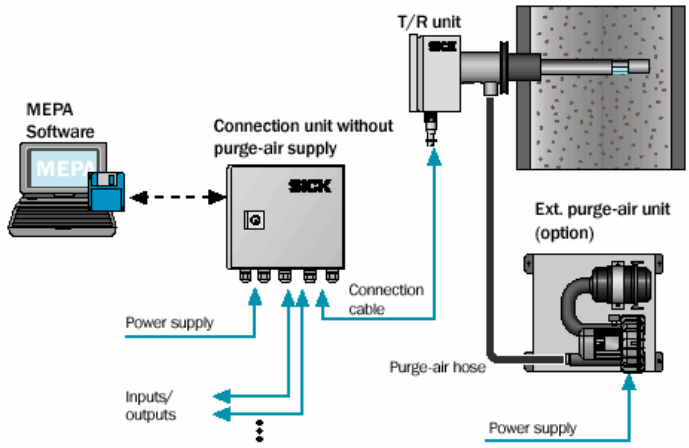
3.1.2 DURAG: D-R300

Supplier	DURAG Industrie Elektronik GmbH&Co KG Kollaustr. 105 D-22453 Hamburg/Germany Phone: ++49 40 55 42 18 0 Fax: ++49 40 58 41 54 Internet: www.durag.de
Type	Dust Concentration Meter D-R300
Measuring principle	In-situ Scattered light measurement principle
Measuring ranges	0 to 1 [mg/m³] (minimum range) 0 to 200 [mg/m³] (maximum range)
Calibration	Comparison measurement, e.g. according to VDI 2066.
Gas conditions	Temperature above dew point up to 320 [°C]
AMBIENT CONDITIONS	-20 to + 50 [°C]
Configuration	

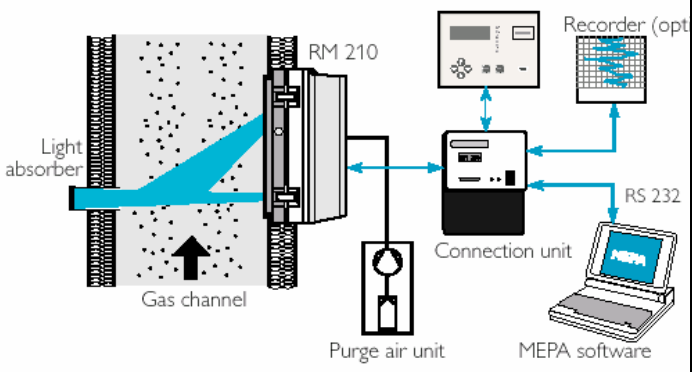
Approval	TA Luft, 13. BImSchV, 17. BimSchV (Co-incineration of waste)
BUDGET PRICE	Approximately 10’000 to 12’000 S-$
Remarks	Measured volume ranging from 80 to 280 [mm] off wall only. Eventually not representative determination of dust load in ducts where the concentration profile varies significantly over the diameter.

3.1.3 SICK: FW100

Supplier	SICK AG Environmental Monitoring Nimburger Strasse 11 D-79276 Reute/Germany Phone: ++49 7641 469 0 Fax: ++49 7641 469 11 49 Internet: www.sick.de
Type	Dust Concentration Monitor FW100 FW 101: for gas ducts with a diameter larger than 500 [mm]. FW 102: for gas ducts with a diameter larger than 200 [mm]
Measuring PRINCIPLE	In-situ Scattered light measurement principle (forward scattering). Suitable for measuring of very small particle concentrations.
Measuring ranges	0 to 5 [mg/m^3] (minimum range) 0 to 200 [mg/m^3] (maximum range)
Calibration	Comparison measurement, e.g. according to VDI 2066.

Gas conditions	Standard version: 0 to 220 [°C] High temperature version: 0 to 400 [°C] Version with external purge air: -50 [mbar] to +70 [mbar] Version with instrument air: -50 [mbar] to 1 [bar]
Ambient conditions	-20 to + 50 [°C] for transmitter/receiver unit -20 to + 50 [°C] intake-air temperature for fan
Configuration	
Approval	TA Luft, 13. BImSchV, 17. BimSchV (Co-incineration of waste)
Budget price	Approximately 6000 US-$
Remarks	The dust concentration is measured in a small area of the duct only. If the concentration profile varies significantly over the duct diameter, the instrument should not be used.

3.1.4 SICK: RM210

Supplier	SICK AG Environmental Monitoring Nimburger Strasse 11 D-79276 Reute/Germany Phone: ++49 7641 469 0 Fax: ++49 7641 469 11 49 Internet: www.sick.de
Type	Dust Concentration Monitor RM210
Measuring principle	In-situ Scattered light measurement principle (forward scattering). Suitable for measuring of very small particle concentrations.
Measuring ranges	0 to 0.5 [mg/m^3] (minimum range) 0 to 200 [mg/m^3] (maximum range) Measurement ranges switching effected automatically
Calibration	Comparison measurement, e.g. according to VDI 2066.
Gas conditions	Temperature above dew point up to 500 [°C]
Ambient conditions	-20 to + 50 [°C] -20 to + 65 [°C] and 50 [%] relative moisture (storage)
Configuration	

Approval	TA Luft, 13. BImSchV, 17. BimSchV (Co-incineration of waste)
Budget price	Approximately 10’000 to 12’000 US-$
Remarks	High penetration and detection depths up to 1700 [mm] due to adjustable transmitter and receiver segments Representative determination of dust load in ducts where the concentration profile varies significantly over the diameter.

3.2 Continuous Emission Measuring Devices (CEM) for Inorganic Gases

The CEM must be able to measure the compounds NO, SO_2, CO and O_2 and can be easily extended to NO_2, HCl, NH_3 and other gases. The FID can be integrated in the system.

FTIR-Analyzers (Fourier Transformed Infrared Spectroscopy)

- "Extractive hot" with FTIR analyzer
- ABB, Advanced Cemas-FTIR (former Hartmann&Braun)
- Compounds: CO, NO, SO_2, HCl, NH_3, H_2O, O_2
- Budget price: 72'000 - 81'000 US-$ (without FID)
- Integration of flame ionization detector possible

Differential Optical Absorption Spectrometroscopy

- In-Situ
- Technology similar to FTIR but absorption in exhaust gas duct
- Opsis, AR600/AR650/O2000
- Compounds: CO, NO, SO_2, HCl, NH_3, H_2O, O_2
- Budget price: 150'000 US-$
- Further selectable compounds: CO_2 (5'500 US-$), H_2O (5'500 US-$), HCl (5'500 US-$), HF (5'500 US-$), NH_3 (5'500 US-$), C_6H_6 (8'500 US-$)
- VOC can only be measured by a separate FID line
- Rather small service organization
- Wide extension possibilities

"Extractive Hot" with IR-Technology

- "Extractive hot" with IR analyzer
- SICK, MCS100 HW
- Development of the former Bodenseewerk/Perkin Elmer
- Compounds: CO, NO, SO_2, H_2O, CO_2, HCl, O_2
- Budged price: 76'000 US-$ (without FID)
- Integration of flame ionization detector possible

3.2.1 ABB, Advanced Cemas-FTIR (former Hartmann&Braun)

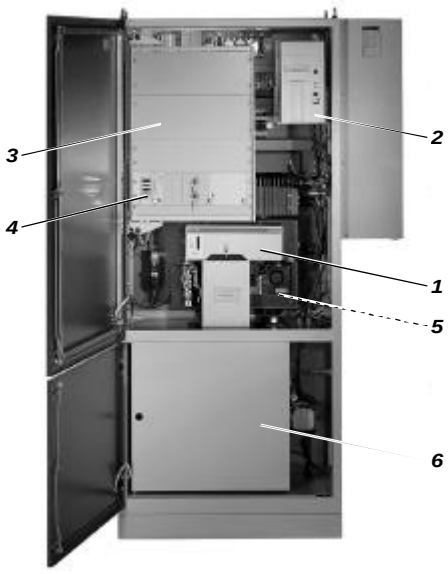
Supplier	ABB Automation Products GmbH (former Hartmann&Braun) Analysentechnik Stierstädter Strasse 5 D-60488 Frankfurt am Main/Germany Phone: ++49 (0)69 79 30-0 Fax: ++49 (0)69 79 30-45 66 Internet: www.abb.de/automation
Type	Advanced Cemas-FTIR “Hot extraction” with FTIR-technology (Fast Fourier Transformed Infrared Analyzer)
Gas Extraction	Gas probe type 40 Max. temperature: 500 [°C] Pressure: 0.8 to 1.05 [bar] Filter, heated, 180 [°C] Heated tube, 180 [m], length: 10 [m]
Gas preparation	Fine filter Gas flow module with pump, flow controller

Compound	**Analyzer**	**Measuring Range**		**17. BimSchV**
		Minimum	**Maximum**	
CO	FTIR	0 - 75 [mg/m^3]	0 - 2500 [mg/m^3]	0 - 75 [mg/m^3] 0 - 300 [mg/m^3]
NO	FTIR	0 - 200 [mg/m^3]	0 - 2000 [mg/m^3]	0 - 200 [mg/m^3] 0 - 390 [mg/m^3]
SO_2	FTIR	0 - 75 [mg/m^3]	0 - 1500 [mg/m^3]	0 - 75 [mg/m^3] 0 - 300 [mg/m^3]
HCl	FTIR	0 - 15 mg/m^3]	0 - 325 [mg/m^3]	0 - 15 [mg/m^3] 0 - 90 [mg/m^3]
NH_3	FTIR	0 - 15 [mg/m^3]	0 - 230 [mg/m^3]	0 - 15 [mg/m^3]
H_2O	FTIR	0 - 10 [vol%]	0 - 40 [vol%]	0 - 40 [vol%]
O_2	Electrochem. Sensor	0 - 10 [vol%]	0 - 25 [vol%]	0 - 10 [vol%] 0 - 25 [vol%]

VOC	Multi-FID 14	0 - 10 [mg/m^3] (as C)	0 - 200 [mg/m^3] (as C)	0 - 15 [mg/m^3] (as C)
CO_2 (Option)	FTIR	0 - [vol%]	0 - 30 [vol%]	0 - 20 [vol%]
HF (Option)	FTIR	0 - 10 [mg/m^3]	0 -1800 [mg/m^3]	

Calibration	Daily self-control with zero gas Calibration with gases every 6 months VOC with calibration gases, more frequently
Ambient condition	5 to +40 [°C], short-time: +50 [°C] The measuring device should be protected against heat radiation, dust

Configuration



1: FTIR-Spectrometer
2: Computer
3: Control and analog outputs
4: Temperature controller
5: O_2 Analyzer
6: Gas flow module (heated)

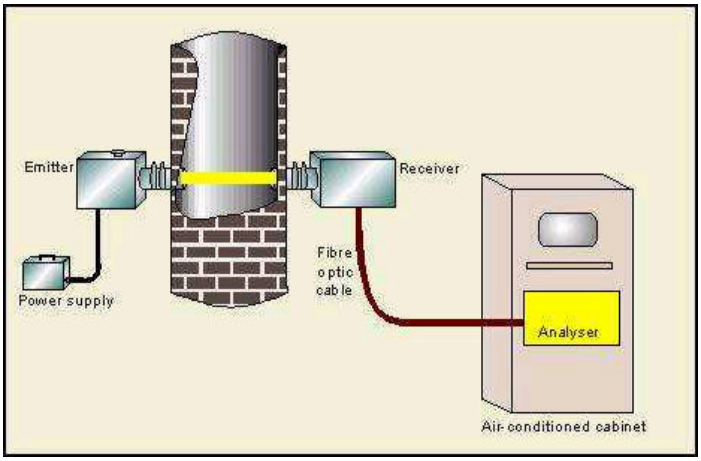
Budged Price	Included steel sheet analysis cabinet with air conditioning Included is the VOC-measurement (Multi-FID 14) Between 72'000 and 81'000 US-$
Remarks	The dust signal can be integrated. Usually ABB works together with DURAG

3.2.2 OPSIS AR/600/650/O2000

Supplier	OPSIS AB Box 244 SE-244 02 Furulund / Sweden Phone: ++46 (0)46 72 25 00 Fax: ++46 (0)46 72 25 01 Internet: www.opsis.se
Type	"OPSIS extended module in-situ" In-situ measuring devices for NO, NO_2, SO_2, CO, CO_2, H_2O, HCl, HF and O_2
Measuring principle	In-situ NO, NO_2, SO_2, CO, etc. Differential optical absorption spectroscopy O_2: ZrO_2 method

Compound	**Analyzer**	**Measuring range (recommended for a 2 [m] stack) DL --> detection limit**	**17. BimSchV 1 [m] measuring length**
NO	AR 600	0 - 1000 [mg/m³]	0 - 150 [mg/m³]
NO_2	AR 600	0 - 20 [mg/m³] (DL: 0.5 [mg/m³])	0 - 20 [mg/m³]
SO_2	AR 600	0 - 800 [mg/m³]	0 - 80 [mg/m³]
CO	AR 650	0 - 1000 [mg/m³]	0 - 150 [mg/m³]
CO_2 (selectable)	AR 650	0 - 25 [vol%]	
H_2O (selectable)	AR 650	12 - 18 [vol%]	0 - 30 [vol%]
HCl (selectable)	AR 650	0 - 10 [mg/m³] (DL: 0.5 [mg/m³])	0 - 15 [mg/m³]
HF (selectable)	AR 650	0 - 5 [mg/m³] (DL: 0.2 [mg/m³])	

NH_3 (selectable)	AR 600	0 - 40 [mg/m^3] (DL: 1 [mg/m^3])	0 - 10 [mg/m^3]
C_6H_6 (Benzene)	AR 600	0 - 5 [mg/m^3] (DL: 0.5 [mg/m^3])	
O_2	O2000 (ZrO_2-Probe)	0 - 25 [vol%]	
VOC	M&A Thermo FID	0 - 100 [mgC/m^3]	???

VOC Integration	• For the VOC measurement a separate hot extraction line with a flame ionization detector must be installed • VOC measurement directly with OPSIS analyzer is not possible! • Opsis works together with the FID supllier Mess- und Analysentechnik, Leverkusen • The direct coupled version from M&A is not recommended
Calibration	Opsis: calibration with gases every 6 month
Gas conditions	
Ambient conditions	Spectrometer: +15 to +25 [°C] Receiver and emitter: -40 to +50 [°C]
Configuration	 Figure without VOC-analyzer

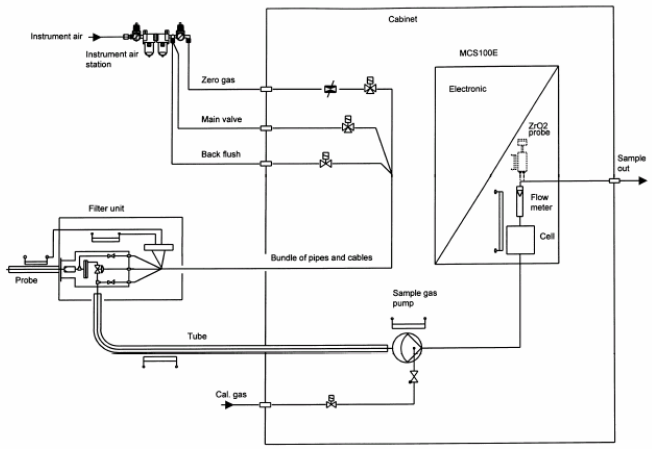
BUDGET PRICE	Prices without cabinet Basic set (NO, NO_2, SO_2, CO, O_2): 150'000 US-$ Selectable compounds: CO_2: 5'500 US-$ H_2O: 5'500 US-$ HCl: 5'500 US-$ HF: 5'500 US-$ C_6H_6 : 8'500 US-$ VOC: 24'000 US-$
Remarks	Rather small service system

3.2.3 SICK MCS 100 HW

Supplier	SICK AG Environmental Monitoring Nimburger Strasse 11 D-79276 Reute/Germany Phone: ++49 7641 469 0 Fax: ++49 7641 469 11 49 Internet: www.sick.de
Type	"SICK Extended Module Extractive Hot" "Extractive hot" with NIR-/IR-photometer ZrO_2-Probe integrated in analyzing system
Gas extraction and preparation	Gas probe tube, not heated, steal 1.4539 Coarse (20 [µm], max. 400 [°C]) and fine filter (2 [µm], max. 220 [°C]), high-grade steel 1.4404 Heated tube, tube 6/8 [mm] PTFE, interchangeable

Compound	**Analyzer**	**Measuring Range**	**17. BimSchV**
NO	MCS 100 HW KHK-75	0 - 2000 [mg/m³]	0 - 200 [mg/m³]
SO_2	MCS 100 HW KHK-75	0 - 1500 [mg/m³]	0 - 500 [mg/m³] (only TA Luft)
CO	MCS 100 HW KHK-75	0 - 2000 [mg/m³]	0 - 100 [mg/m³]
H_2O	MCS 100 HW KHK-75	0 - 25 [vol%]	0 - 40 [vol%]
CO_2	MCS 100 HW KHK-75	0 - 30 [vol%]	0 - 25 [vol%]
HCl	MCS 100 HW KHK-75	0 - 50 [mg/m³]	0 - 15 [mg/m³]

O_2	PEOX100 (ZrO_2-Probe)	0 to 25 [Vol%]	???
VOC			

Calibration	With calibration gases
Gas conditions	Maximum gas temperature: 400 [°C]
Ambient conditions	+5 to +45 [°C]
Configuration	 Figure without dust- and VOC-Analyzer
Budget price	Price without container Price: 76'000 US-$ (Price without FID)
Remarks	"Extended Module" with two measuring cells

3.3 Flame Ionization Detector (FID)

The sum of the emitted organic carbon (volatile organic compounds) cannot be measured with any principle of light absorption (FTIR, DOAS, IR). Therefore a completely different measuring principle must be used and this means that the CEMs must be coupled with such an analyzing system. In this chapter the correct integration of VOC analyzers into existing and new measuring stations is described.

3.3.1 Principle of Operation of VOC Analyzers

The Flame Ionization Detection (FID) method is used to determine the presence of volatile organic compounds (or total hydrocarbon) concentrations in a gaseous sample:

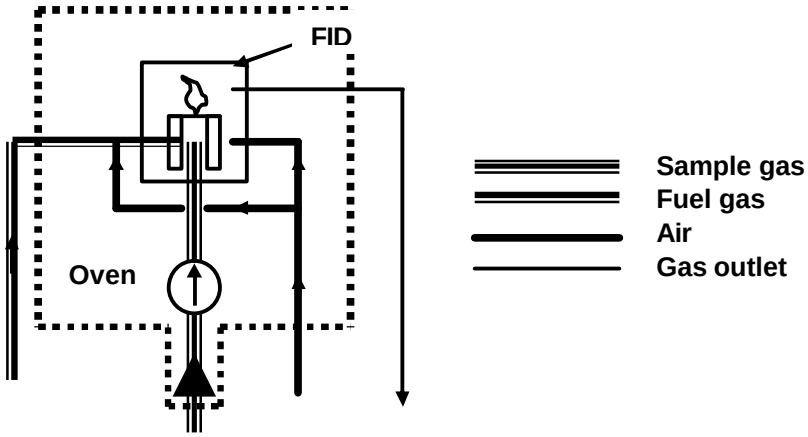


FIGURE 4: FID: Measuring Principle

Burning hydrocarbon-free hydrogen in hydrocarbon-free air produces negligible number of ions. Once a sample containing hydrocarbons is introduced into the flame a very complex ionization process is started. This process creates a large number of ions. A high polarizing voltage, producing an electrostatic field, is applied between the two electrodes around the burner nozzle. Now negative ions migrate to the collector electrode and positive ions migrate to the high voltage electrode. The so generated ionization current between the two electrodes is directly proportional to the concentration of volatile organic compounds in the sample that is burned by the flame.

3.3.2 Connection of the Analyser

The gas sample must be extracted from the chimney and kept “hot” until the sample enters the FID analyzer. From experience it is known that organic compounds with high evaporation temperatures can be present in the exhaust gas of a cement plant. If these compounds enter the flame ionization analyzer with too low temperatures

the compounds condense in the internal fine filter, in the internal capillary system, etc. and block the analyzer.

Therefore it is recommended

- to keep the gas temperature inside the flame ionization detector at a temperature of at least 180 [°C], if possible at 200 [°C].
- to kept the gas temperature in the extraction system above the maximum gas temperature in the chimney, but at least at 150 [°C].

3.3.2.1 FID with a Separate Extraction Line

If the FID cannot be integrated into an extraction line, e.g. in connection with in-situ measuring devices (Opsis), the gas must be extracted through a separate extraction line and fed to the FID analyzer. The volume stream should be sucked through the analyzer by an integrated pump inside the analyzer. The gas temperature inside the whole line and the analyzer should be kept at least at 180 [°C].

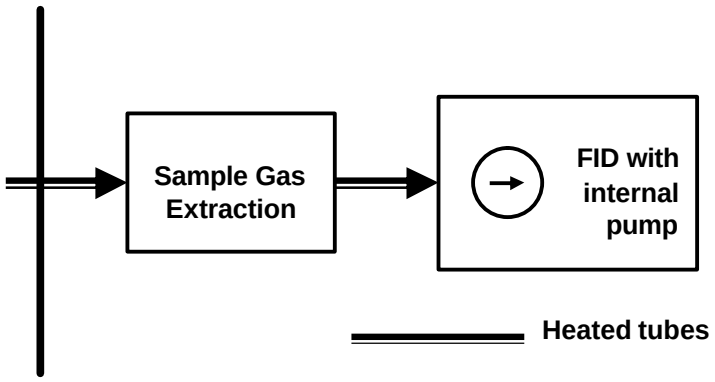


FIGURE 5: FID with Separate Extraction Line

3.3.2.2 Integration of the FID into an Extractive CEM System

3.3.2.2.1 Integration of the FID Analyzer into an Extractive System with “Cold Analyzers”

Sometimes, the plant has an extractive measuring system with “cold” analyzers, and the flame ionization detector should be integrated into the emission cabinet.

In this case the gas can be extracted directly from the hot line. It is important, that the gas remains “hot”, i.e. the sample gas temperature should not drop below 150 [°C] around the connection point. The problem of such an arrangement is in any case the gas flow. It must be checked that the volume stream for the cold analyzers, respectively for the flame ionization detector, is large enough and additionally it must

be checked that the flame ionization detector is not subject to any pressure fluctuation in the measuring system.

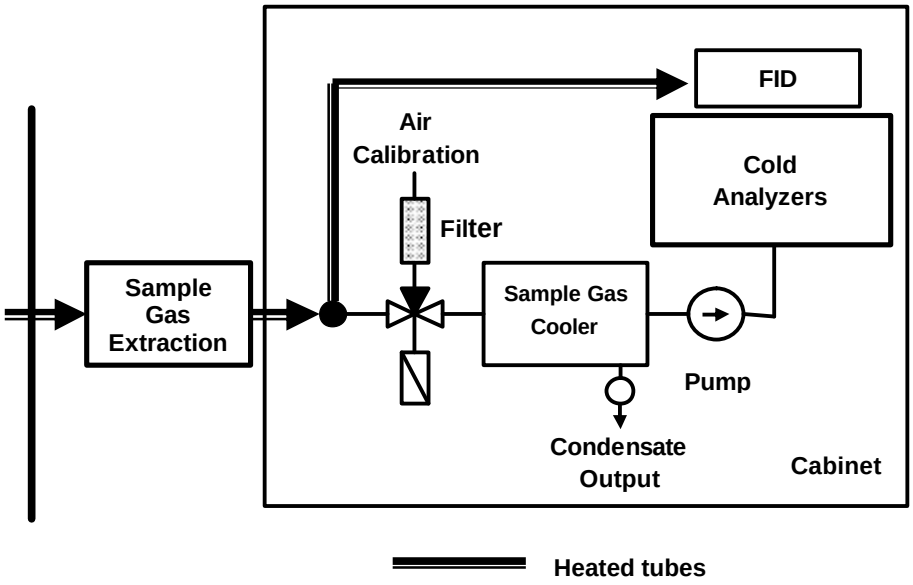


FIGURE 6: FID Integration into "Cold" Extraction System

An alternative solution is the distribution of the gases in a separate box with a “hot” pump. This solution has the advantage that a constant gas stream can be fed two the two gas analyzing systems.

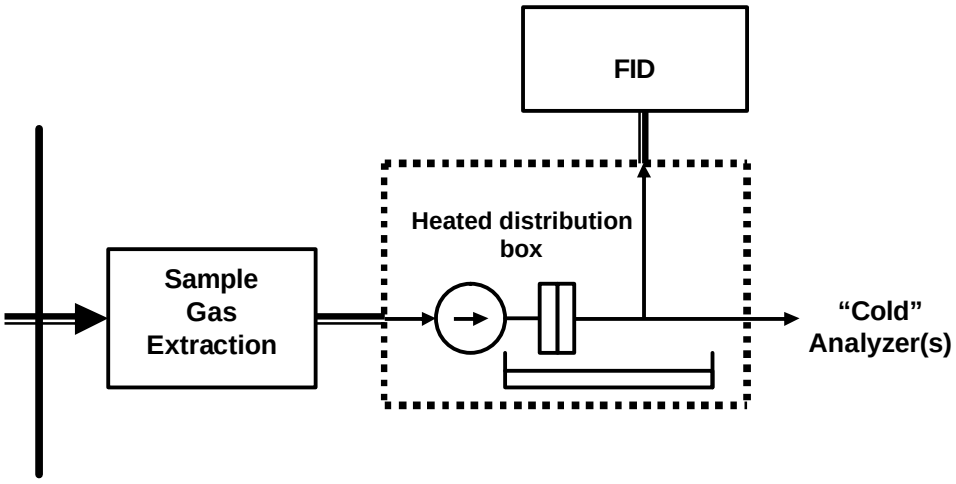


FIGURE 7: FID Integration into "Cold" Extraction System

3.3.2.2.2 Integration of the FID Analyzer into an Extractive System with “Hot Analyzers”

In systems with “hot” analyzers, the distribution of the gas is usually made in a heated box. Therefore the connection of a flame ionization detector should not be a problem. In any case, it must be only checked that the delivered volume of the pump is enough.

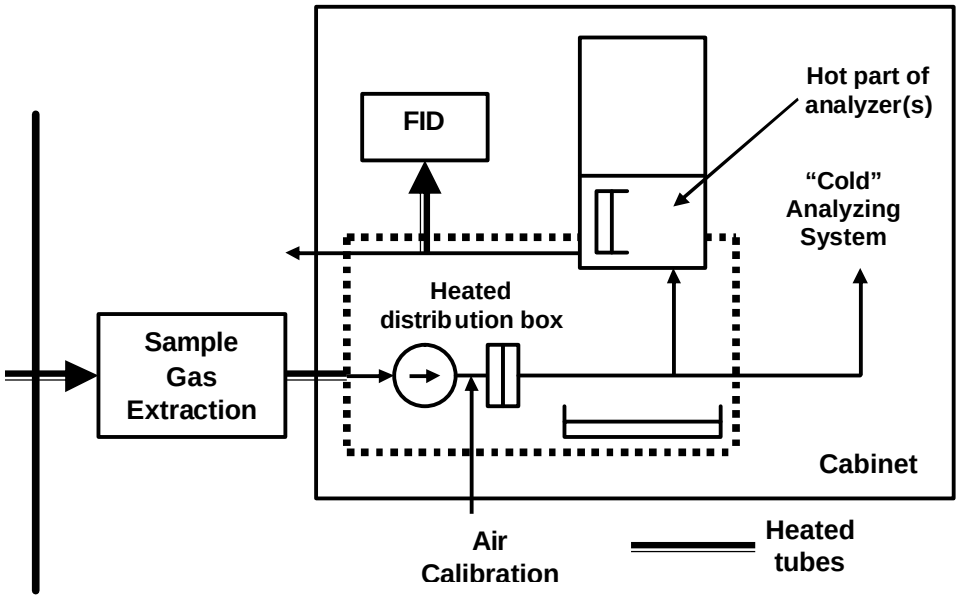


FIGURE 8: FID Integration into "Hot" Extraction System

3.3.3 Recommended FID Analyzers

In the following table some acceptable flame ionization detectors are mentioned. All these analyzers are proven by a German institute (e.g. TÜV) and are recommended from the German authorities to measure the organic emissions as total carbon.

Supplier	Type
Bernath Atomic	BA 3002
J.U.M.	VE 7 3-300A 3-400 (“wall model”)
TESTA	FID123, FID 1230 Modul
Siemens	FIDAMAT 5E
ABB Hartmann+Braun	FID-14

4. INVESTMENT COST ESTIMATES

	1000 US$
• Dust measurement only	10 – 12
• Module including - Module with compounds NO, SO_2, CO, O_2, H_2O, VOC - Extension to HCl, NH_3 and others	80 – 180
• Measuring cabin (climatized, power and pressurized air supply	10 – 20
• Annual cost for service contract	3 – 5
• Annual cost for maintenance by plant personnel	3 – 5
• TIS software for emission data handling and reports generation	20 – 30

5. STANDARD PURCHASE AND SUPPLY CONTRACT

In the purchase and supply contract the client (cement company) has to exactly define (specify) all essential details of the emission measuring system implementation. This includes:

5.1 Supplier coordinates

- Exact name and address of the equipment supplier
- Exact name and address of the engineering services supplier (if different from the equipment supplier)

5.2 Detailed scope of work

- for the equipment supplier
- for the engineering services supplier

5.3 Technical specifications

Technical specification of all parts of the system with technical descriptions, article numbers, etc.
Examples:

- Protection Box S40, 05002, in stainless steel design, insulated, IP 54
- Sample Gas Line, PTFE 6x4/1 [mm], flexible, heated type, 220 [V], 50 [Hz], length: 5 [m]

5.4 Exact description of all analyzers

Exact description of all analyzers with the following definition:

- Name of the analyser
- Measuring components with the measuring ranges
- Linear deviation
- Zero-point drift
- Sensitivity drift
- Detection limit
- Calibration
- Example:
  - Analyzer: Advanced Optima, type URAS 14
  - Measuring components
    - CO: 0 to 2000 [ppm] (IR-method)
    - O_2: 0 to 10 / 0 to 25 [%] (electro-chemical)
  - Linear deviation: ≤ 1% of span
  - Zero-point drift: ≤ 1% of span per week
  - Sensitivity drift: ≤ 1% of measured value per week
  - Detection limit: ≤ 0.5% of span
  - Calibration: Automatic with built-in calibration cells

5.5 Operational data of the analyzing system

Examples:

- The characteristic temperatures at the measuring point shall not exceed 180 [°C]
- The allowed ambient temperature shall be between -10 and +35 [°C]

5.6 Project documentation

The supplier shall prepare all studies and documents required for the implementation of the measuring system/device. This includes:

- The description of engineering services.
- The documentation for the erection work.
- The supervision of the installation work.
- The documentation for operation and maintenance of the measuring system.
- Training of the clients operation and maintenance team during the erection or during another time period.
- Spare parts list

5.7 Definition of guarantees

- Warrantee period for the equipment shall be 24 months and shall start at the acceptance or another date.
- The supplier guarantees the function and quality of the equipment, namely for a good workmanship and quality of the material used, compliance with the specifications, trouble-free functioning, etc.

6. STANDARD MAINTENANCE AND SERVICE CONTRACT

6.1 Scope of maintenance

The supplier is obliged to perform a regular maintenance work covering the entire emission-measuring device. This includes:

- Definition of the measuring device
- Definition of the work to be performed
- Maintenance plan (Includes all points required for a trouble-free operation
- Definition of the maintenance intervals
- The maintenance has to be done in the plant where the measuring device is installed
- The date of the maintenance must be arranged with the plant in advance

6.2 Repairs

- The supplier is obliged to repair all part of the whole emission-measuring device
- The repair must start at least 24/48/64 hours after the repair request of the plant

6.3 Duties of the supplier

- The personnel of the supplier must be trained and must have enough knowledge to carry out the maintenance and repair work.
- All work is reported in a maintenance or service report.
- The supplier informs about possible improvements of the measuring device.

6.4 Duties of the plant

- Guaranty of free access to the emission-measuring device
- During maintenance and repair works the person of the plant, who is responsible for the device, must coach the personnel of the supplier.
- The provision of spare- and consumer material has to be arranged between plant and supplier.

6.5 Guaranty

- The supplier gives a material guaranty for all changed parts except consumer materials.

6.6 Damage compensation

- Damage compensation only in the range of the material guaranty
- No claim of follow-up costs

6.7 Costs

- Spare part --> price-list
- Working hours
- Expenses