Fuji Electric

Continuous Emissions Monitoring System

ZPA-CEMS

$CO / CO_2 / NO_X / SO_2 / O_2$

OPERATION AND MAINTENANCE MANUAL

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Fuji Electric France S.A.S
46, Rue Georges Besse-ZI du Brézet - 63039 Clermont-Ferrand CEDEX 2 - FRANCE - Tel. +33 (0)4 73 98 26 98 - wwww.fujielectric.fr

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1 FUJI ZPA-CEMS DESCRIPTION

1.1 General presentation

The Fuji ZPA-CEMS is designed for continuous emissions monitoring and for continuous combustion control. Typical application is measurement of CO, CO_2, NOx, SO_2, and O_2 concentrations.

The Fuji ZPA-CEMS performs on-line measurements of gas concentrations in wet, and potentially dirty gas streams.

The Fuji ZPA-CEMS consists of the Fuji ZPA multigas analyzer, the Fuji ZDL05 NOx converter, and a high industrial grade state-of-the-art sampling system. It also includes the 180°C heated sampling probe and sampling line. All power connections and temperature controllers for heated line and heated probe are included.

The measuring data can be transferred from the CEMS cabinet to the plant operator DCS, with digital outputs (Modbus, not part of type-approval) or with analogue outputs 4 - 20 mA. The alarms are transferred with relay outputs, as well as through the digital outputs. System error signal indicates that the system does not operate properly and maintenance signal indicates that a service technician is at the CEMS performing a maintenance and/or repair.

Optionally, the Fuji ZPA-CEMS can be equipped with the Fuji CEM System ^{v6} DAHS (Data Acquisition and Handling System), including following modules :

- ✓ Fuji CEMS Manager ^{v6} : local cabinet Fuji PLC and 10'' touchscreen front door HMI
- ✓ Fuji CEMS Reports ^{v6} : remote HMI installed on PC in control room
- ✓ Fuji CEMS Backup ^{v6} : > 10 years data backup with triple locations savings for full data safety
- ✓ Fuji ACE Data ^{QAL3} : QAL3 manual or automatic hardware and software Fuji suite

The DAHS was also not used during the type approval tests, as out of the certification process scope.

CAUTION:
Be sure to read carefully this manual before using this system.
Improper or not correct use can damage the components of this system. This will not be considered as guarantee not even during the period of validation of the same. FUJI ELECTRIC will not be retained however liable for damages caused from system or hastened to the same for uses incorrect of the devices also at the end of the period of guarantee.

1.2 System technical specifications

This manual presents the general technical specifications of the Fuji ZPA-CEMS. More detailed technical data can be found from the individual operating manuals and data sheets of the sub-systems integrated in the ZPA-CEMS.

1.2.1 Heated Sample Probe

Here are the key technical data of the M&C standard heated sampling probe supplied with the Fuji ZPA-CEMS :

- Model type : SP2000H
- Mounting flange : DN65PN6
- Probe material : SS316
- Filter material : ceramic
- Porosity : 2 microns
- Sample temperature : maximum 600°C
- Sample pressure : atmospheric +/- 100 mbar
- Filter temperature : 180°C

The sampling probe power is supplied from the CEMS cabinet. The sampling probe temperature error is transferred to the CEMS cabinet.

1.2.2 Heated Sample Line

Here are the key technical data of the Fuji Electric standard heated sampling lines supplied with the Fuji ZPA-CEMS :

- Sample tube material : PTFE
- Sample tube temperature : 180°C

The heated sample line power is supplied from the CEMS cabinet. The sampling line temperature error is transferred to the CEMS cabinet.

1.2.3 CEMS cabinet

Here are the key technical data of the standard ZPA-CEMS cabinet :

- Dimensions (H x D x W): 1900 x 600 x 600 mm (excluding air conditioning unit)
- Materials : Painted steel + insulation
- Air conditioning : 1000W
- Front face lamps : main status lamps on cabinet front face (if no DAHS option)
  - White : system powered
  - Green : normal operation
  - Orange : maintenance or calibration
  - Red : system fault
- Front face 10'' HMI : if Fuji CEM System ^{v6} optional DAHS selected

1.2.4 General technical specifications

- Measured components : CO, CO_2, NOx, SO_2, and O_2
- Analytical technologies : NDIR, ZrO2, Paramagnetic
- Operating temperature : 5 – 40°C, non-condensing
- Operating location : clean ambient air area without vibrations
- Sample gas flow : ~ 3 l/min

1.2.5 ZPA multigas analyzer

The following part shows the key technical data of the ZPA analyzer model most frequently integrated in ZPA-CEMS emissions monitoring system.

ZPA multigas analyzer

Fuji Electric ZPA is a multigas analyzer able to measure the concentration of up to 5 different components. The models used in the ZPA-CEMS can perform continuously and simultaneously up to the five following components concentration measurements: CO, CO_2, NOx, SO_2, and O_2.

The below table presents the typical measurement ranges adjusted for the ZPA-CEMS emissions monitoring system :

Component	Measurement method	Typical Range	Other Range 1	Other Range 2
CO	NDIR	0-200 ppm	0-500 ppm	0-2000 ppm
CO_2	NDIR	0-20 Vol.-%	-	-
NOx	NDIR	0-200 ppm	0-500 ppm	0-2000 ppm
SO_2	NDIR	0-200 ppm	0-500 ppm	0-2000 ppm
O_2	ZrO2[(1)] / PMG[(2)]	0-25 Vol.-%	0-10 Vol.-%	-

Different range adjustments and combinations are possible.

[(1)] *ZrO2 :* *Oxygen concentration measured with Fuji Electric proprietary zirconium oxide method In such case, the sensor is located in parallel or downstream the ZPA analyzer enclosure, ref. ZFK-7 (See ZPA datasheet)*

[(2)] *PMG :* *Oxygen concentration measured with paramagnetic method In such case, the sensor is located inside the ZPA analyzer enclosure*

The ZPA multigas analyzer can measure the concentration of up to 5 components. These are maximum 4 components concentration measured with NDIR (Non Dispersive InfraRed) method, plus eventually the oxygen concentration measurement.

Inside one ZPA analyzer, the components concentrations are measured with NDIR method on maximum two Optical Benches, and each Optical Bench can measure the concentration of up to 2 components.

The below table presents, depending on components combination selected, and the technology chosen for the oxygen concentration measurement, the repartition of the diverse measurements on each Optical Bench.

name			combination	Optical benches *	
w/o O2	with O2z	with O2p		bench 1	bench 2
	ZPA-Yz	ZPA-Yp	O2		
ZPA-B	ZPA-Bz	ZPA-Bp	CO	CO	
ZPA-Z	ZPA-Zz	ZPA-Zp	CO+SO2	CO+SO2	
ZPA-P	ZPA-Pz	ZPA-Pp	NO	NO	
ZPA-F	ZPA-Fz	ZPA-Fp	NO+SO2	NO	SO2
ZPA-D	ZPA-Dz	ZPA-Dp	CO2	CO2	
ZPA-G	ZPA-Gz	ZPA-Gp	CO+NO	CO	NO
ZPA-J	ZPA-Jz	ZPA-Jp	CO+CO2	CO+CO2	
ZPA-N	ZPA-Nz	ZPA-Np	CO+NO+SO2	CO+SO2	NO
ZPA-W	ZPA-Wz	ZPA-Wp	CO+NO+CO2	CO+CO2	NO
ZPA-Q	ZPA-Qz	ZPA-Qp	CO+NO+SO2+CO2	CO+SO2	NO+CO2

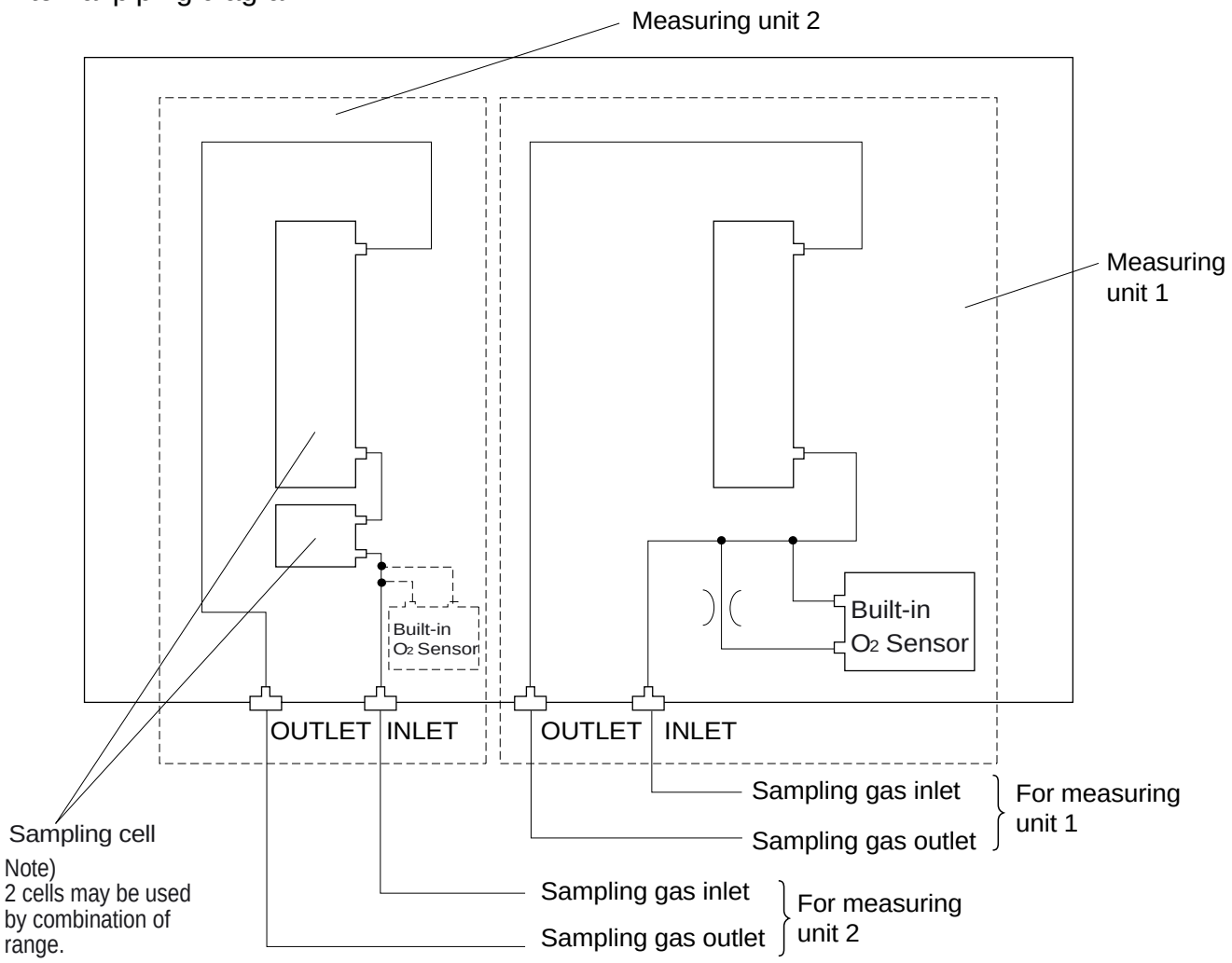
* Position of O2 measurement :

O2z : zirconia technology -> always measured with ZFK7 in parallel with ZPA

O2p : paramagnetic -> always the first measured component in the ZPA

The drawing below represents a basic composition of a ZPA multigas analyzer equipped with two optical benches.

Internal piping diagram



Flow scheme example

1.2.6 ZDL05 NOx converter

Here are the key technical data of the Fuji Electric ZDL05 NOx Converter :

ZDL05 NOx Converter

- Dimensions (H x D x W): 212 x 130 x 148 mm (excluding air conditioning unit)
- Mounting : wall mounted, indoor
- Temperature : 220°C
- Catalyst replacement : Once every 6 months (O_2=5 Vol.%, NO_2=10 ppm, flow rate=0,5 l/min)
- Conversion efficiency : > 95%

1.2.7 Sample gas conditioning system

Between the sampling point and the inlet of the ZPA multigas analyzer, the sample need to be transported and treated so that the chemical components concentration measurements are representative, and so that the ZPA analyzer itself is not damaged by a dirty, corrosive or wet sample.

The following main sampling components are integrated in the ZPA-CEMS sample conditioning system :

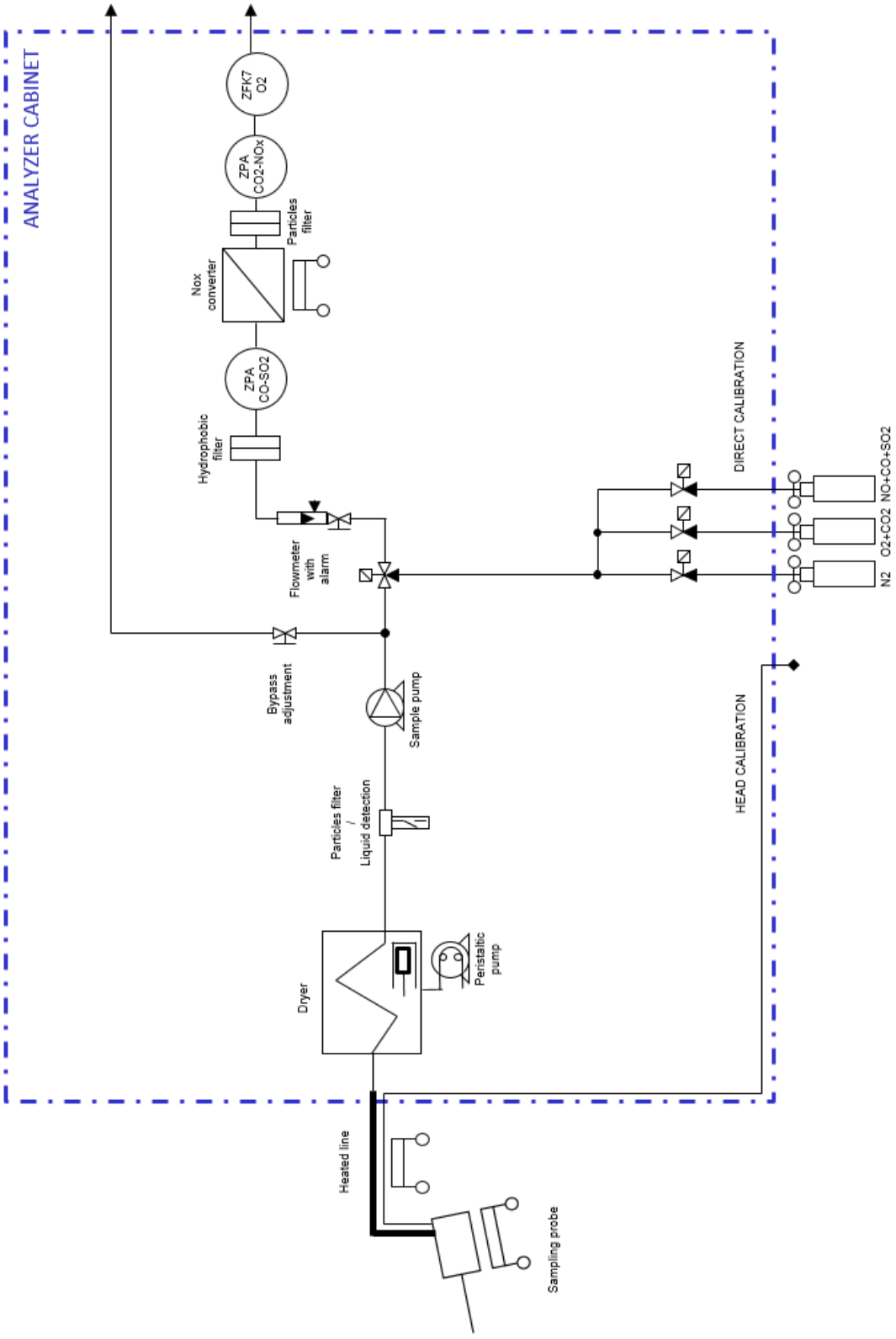
- ✓ 180°C M&C type heated filtering sample probe
  Temperature controlled by Fuji temperature controller on front face of cabinet, or if option selected by Fuji PLC and HMI with Fuji CEMS Manager [v6]
- ✓ 180°C Fuji Electric heated PTFE sample line
  An additional PTFE tube is optionally added for head (sample probe) calibrations
- ✓ 5°C M&C ECM Type fast compressor cooler dryer with peristaltic pump condensate removal
- ✓ Particle filter with condensate alarm
- ✓ Sample pump
- ✓ Bypass with bypass flow adjustment valve
- ✓ Calibration valves system (calibration gas cylinders supplied as options)
- ✓ Analyzer inlet sample flowmeter with flow adjustment valve and low flow alarm
- ✓ Hydrophobic “Water Stop” filter

Technical specifications and/or instruction manual of each of these sampling components are supplied together with this ZPA-CEMS operation and maintenance manual.

The ZPA-CEMS typical fluid diagram including above listed components is shown lower in this manual section.

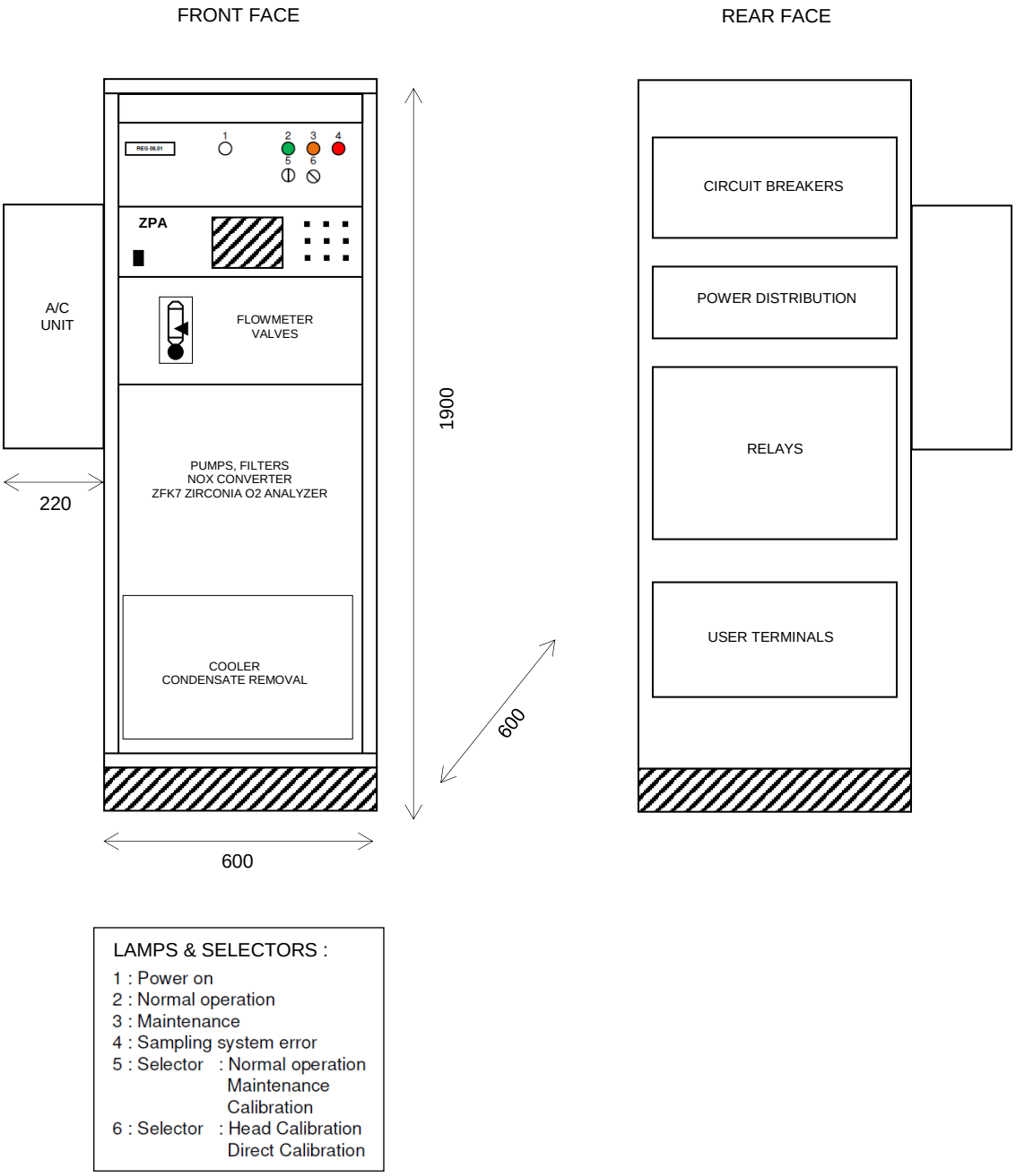
1.3 Fuji ZPA-CEMS typical layouts

1.3.1 Flow Diagram



ZPA-CEMS typical flow diagram

1.3.2 Cabinet layouts



ZPA-CEMS typical layout

1.4 Inputs / outputs / communication signals

Depending on the options selected in the ZPA-CEMS, several types of signal inputs and outputs can be available. The system drawings supplied with the ZPA-CEMS show exactly which natures and types of these signals are available. These can be part of following types.

1.4.1 Analog inputs

If required, the ZPA-CEMS can be equipped with additional analog inputs for external signals integration in the optional Fuji CEMS Manager ^{V6}. Such as dust monitor, or flue gas flow rate measurement, etc…

1.4.2 Analog outputs

In case the ZPA-CEMS is not equipped with the optional Fuji CEMS Manager ^{V6}, raw concentration measurement values can be output with analog outputs, such as standard 4-20mA signals. This concerns all components measured with the ZPA multigas analyzer, but also eventually external measurements. For instance :

From ZPA multigas analyzer :

- ✓ CO concentration
- ✓ CO2 concentration
- ✓ NOx concentration
- ✓ SO2 concentration
- ✓ O2 concentration

From external monitors :

- ✓ NH3 concentration
- ✓ Flue gas flow rate
- ✓ Flue gas pressure
- ✓ Flue gas temperature
- ✓ Dusts concentration

1.4.3 Digital inputs

If required, the ZPA-CEMS can be equipped with digital inputs.

1.4.4 Digital outputs

Depending on the options selected, the ZPA-CEMS is equipped with possible different digital outputs, such as for instance :

- ✓ Normal operation
- ✓ Maintenance
- ✓ Calibration
- ✓ Calibration error
- ✓ Analyzer error
- ✓ Sample conditioning system error
- ✓ Air conditioning error

1.4.5 Bus communications

The ZPA-CEMS can be optionally equipped with a communication system in order to be linked to the plant DCS for instance. This is the case when the optional Fuji CEM System ^{v6} DAHS is selected. In such case the standard protocol is Modbus IP over Ethernet. However other communication mode like Profibus can also be selected as an option.

2 INSTALLATION

2.1 Unpacking

At receipt of the system check the package and possible fault or damage and report to the manufacturer if any.
Place the system in a clean, dry and free vibration location; pay attention to the paint and the cabinet. Then proceed to the installation of the system.

2.2 Assembling

2.2.1 Mechanical assembling

The cabinet will be placed on a plain surface of concrete in a dry place and protected from the weather. The calibration gas cylinders will be placed and safely fixed vertically near the cabinet.

2.2.2 Electrical connections

The electric connectors are located at the rear panel of the cabinet.
Following electrical connections must be made with reference to the electrical drawings supplied with the ZPA-CEMS.

- ✓ Connect the general cabinet Power Supply
- ✓ Connect the sample probe Power Supply and its temperature alarm
- ✓ Connect the heated line Power Supply and its temperature sensor

- ✓ Connect if required the measurement signals analog outputs
- ✓ Connect if required the system alarms and status digital outputs

- ✓ Connect if required any digital or analog inputs

- ✓ Connect if required the Modbus communication cable

2.2.3 Fluid connections

- ✓ Install the sample probe to the sample probe flange

The flange of the sample probe is a DN65 PN6 type. Be sure that the process flange is compatible and use an adapted gasket. The probe has to be installed with an angle of 10° with the horizontal in a way to return condensates and dusts in the stack or duct.
The sample tube which is installed in the stack, must reach the first third of the stack diameter. If it is too long, cut the tube accordingly.

- ✓ Connect the heated line inlet to the sample probe outlet

- ✓ Connect the heated line outlet to the cabinet

The calibration gas inlet for head calibration can be connected to the cabinet using the additional PTFE tube. Inside the cabinet, connect the PTFE sample gas tube to the inlet of cooler heat exchanger. The second PTFE tube (head calibration is available if manual head calibration selected, or can be connected to the proper gas connector if automatic head calibration option is selected).

- ✓ Connect the calibration gas inlets

- ✓ Connect the vent outlets : gas / condensate

Make sure that the exhaust gas are sent to a ventilated area. The condensates should be properly collected and further treated according to local environmental laws, and being careful as this can be acid, so dangerous liquid.

CAUTION : the sample gas could be toxic.

CAUTION : the condensates could be acid.

3 START UP

3.1 Power up

- ✓ Check the Power Supply quality before connecting to the power input on the ZPA-CEMS terminal.
- ✓ Close all circuit breakers inside the cabinet.
- ✓ Switch on the analyzer power with the ON/OFF button on the left side of its front panel.
- ✓ Check that all instruments are switched ON. Otherwise switch ON the relative single instruments.

3.2 Fluid settings

3.2.1 Sample flow adjustment

- ✓ Adjust the analyzer inlet sample flow rate to approximately 0.5 l/min.

3.2.2 Leak tests

- ✓ Perform a sample gas leak test.
  - When the system is in normal operation (MEAS. mode), at the heated probe side, disconnect the PTFE inlet tube of the heated line and close the tube with a plug.
  - Check that the cabinet analyzer sample gas flowmeter shows 0 l/min.

- ✓ Perform a calibration gas leak test.
  - When the system is in normal operation (MEAS. mode), open the gas cylinders main valves.
  - On the pressure reducers, set the pressure to 1 bar.
  - Close the cylinders main valves and wait 5 minutes.
  - If the pressure remained the same, there is no calibration gas leak.

4 CALIBRATION

The terminology here use the word “calibration” which actually means “adjustment”. It should not be mixed with “comparison with reference method”.

The ZPA multigas analyzer is based on NDIR technology for CO, CO_2, NOx and SO_2 concentrations measurements, and on either zirconia or paramagnetic methods for the measurement of O_2 concentration. With a different frequency depending on the methods used and on several external parameters such as ambient temperature stability, vibrations, and also atmospheric pressure changes, calibrations should be done.

The ZPA-CEMS is equipped with automatic zero calibration system, and optionally also with automatic span calibration system.

During type-approval / certification the system was set with an automatic zero calibration using dry and pure air (synthetic air) every 24 h for CO, CO_2, NOx and SO_2, with a duration of 4 minutes.

ZPA multigas analyzer calibration procedures are described in detail in the ZPA analyzer instruction manual. So before performing calibration, the ZPA multigas analyzer instruction manual must be read and understood. In addition, this ZPA-CEMS manual explains the general way to perform these calibrations.

The ZPA-CEMS can be calibrated with calibration gases flowing in two different paths : either directly injected in the cabinet (“direct calibration”), downstream the sample pump, or injected upstream the heated line (“head calibration”), at the sample probe level, so that the span gas flows exactly the same way as the sample gas. This second method is the most representative one, but shows the disadvantage of consuming much more calibration gas.

In any case, this manual describes the calibration methods using the standard ZPA-CEMS configuration, i.e. without the optional Fuji CEM System^{v6} and Fuji touch screen global interface. In case this option would be supplied with the ZPA-CEMS, then the Fuji CEM System^{v6} procedures should be followed from the dedicated instruction manual, and always first referring to the ZPA multigas analyzer instruction manual.

Before performing any calibration, make sure that the required gas cylinders are connected to the respective calibration gas inlets as per drawings supplied with the ZPA-CEMS, through adapted pressure reducers. And that the reducers are correctly adjusted. Leak tests must also have been performed as described earlier in this manual section.

4.1 ZPA-CEMS Direct calibration

The ZPA-CEMS allows to perform either manual or automatic calibrations. The tests gas can be offered either through the whole sampling system (i.e. from the dedicated “calibration inlet” of the heated sampling probe) : the procedure is then called “head calibration” or offered “directly” upstream the ZPA multigas analyzer inlet : the procedure is then called “direct calibration”.

This chapter describes how to perform the direct calibration.

4.1.1 Flowing gases for direct calibration

Before performing the direct calibration, turn the front face switches to respectively “CAL” and “DIRECT” positions. The flow rate of the calibration gases has to be the same as the sample flow rate (about 0.5l/min). It can be checked on the analyzer inlet sample flow meter on front face of the ZPA-CEMS cabinet.

4.1.2 Performing direct zero calibration

Flow zero calibration gas, wait a few minutes until a constant value is read, and proceed for ZERO calibration (see ZPA Operation Manual: zero calibration).
It is possible to calibrate all the gas components simultaneously.
Zero gas should be nitrogen (N2) or dry and pure air.

Automatic zero calibrations can be set for standard ZPA-CEMS.

4.1.3 Performing direct span calibration

Flow span calibration gas, wait a few minutes until a constant value is read, and proceed for SPAN calibration (see ZPA Operation Manual: zero calibration).
Repeat this operation for the span calibration of the other gas components.

Automatic span calibrations can be set for ZPA-CEMS equipped with the relevant option.

At the end of the calibration procedure, turn the front face relevant switch to the analysis position ("NORM").

4.2 ZPA-CEMS Head calibration

As described in paragraphs beforehand, the ZPA-CEMS is also equipped with a system which allows to offer the test gases through the whole sampling system. This is designed, in compliance with the EN14181/EN15267 standards, in order to check and eventually adjust the analytical system in the most representative way as the test gas is treated exactly the same way as the sample gas in this case.

This is also the way the ZPA-CEMS was frequently evaluated during all different phases of the type-approval process.

4.2.1 Flowing gases for head calibration

Before performing the head calibration, turn the front face switches to respectively “CAL” and “HEAD”.
The calibration gases should then be lead to the sample probe either directly to the probe using an additional external PTFE tube, or through the optional additional PTFE tube inside the Fuji heated sample line.

The calibration gas flow rate should then be set around 4 l/min.

4.2.2 Performing direct zero and span calibrations

Use the same procedure as for direct calibration.

This calibration method is generally used to check the whole system and the leaks in the pneumatic circuit.
The reference gas is directly introduced at the sampling probe.

If the flow rate is too low, increase the pressure at cylinder pressure reducer. The pump pulls the gas and it is necessary to saturate the sampling probe.

At the end of the calibration, stop flowing the calibration gas, turn the switch to “NORM” position and the other to “DIRECT” positon.

CAUTION :
When the pressure of the gas cylinder is lower than 10 bars, it must be replaced.

5 ALARMS

The ZPA-CEMS is equipped with a set of alarms in order to guarantee :

- ✓ The system security itself
- ✓ The measurements accuracy and reliability

5.1 Security alarms

The ZPA-CEMS, including the whole sample conditioning system is protected by a set of alarms. These are :

- ✓ Heated sample probe temperature alarm
- ✓ Heated sample line temperature alarm
- ✓ Sample gas cooler temperature alarm
- ✓ Condensates detection downstream the sample gas cooler

In case one of these alarms is activated, the red lamp is ON, the relevant digital output is activated, and the sample pump is stopped.
When these temperatures are in the required range, there is no alarm shown (red lamp is not powered) and the sample pump can run.

For each of the temperature alarms, switch the system to maintenance mode “MAIN”, check the correct power of each individual item, and if correctly powered, repair or replace the faulty item.

In case of liquid alarm (condensates detection downstream the sample gas cooler heat exchanger), switch to maintenance mode “MAIN”, check the sample gas cooler and eventual presence of condensate downstream the cooler. Clean, dry and/or replace defective parts.

5.2 Function alarms

The following alarms are also reported, both on digital outputs and front face red lamp :

- ✓ ZPA analyzer fault
- ✓ Low sample flow
- ✓ Air conditioning unit alarm

In case of ZPA analyzer fault, the detailed error message can be read on the ZPA display. Turn the front face switch to maintenance mode “MAIN”, check, adjust and/or repair the analyzer, according to instructions in the ZPA analyzer manual.

In case of low sample flow alarm, switch to maintenance mode “MAIN”, check the sample pump, the filters and the pneumatic circuit for clogging or leaks.

Note: the LOW SAMPLE FLOW ALARM has to be adjusted around 0,2 l/min (below the 0,3 l/min minimum sample flow rate of the ZPA multigas analyzer).

In case of air conditioning unit alarm, an error message will be displayed on the A/C unit display. Switch the ZPA-CEMS to maintenance mode “MAIN”, and proceed to the A/C unit troubleshooting according to the A/C unit user manual. Repair or replace the defective parts.

When the system is set to MAINTENANCE MODE (middle position “MAIN”), the maintenance status signal is output on relevant DIGITAL OUTPUT terminal block.

After repair, the front face switch should be set to NORMAL OPERATION (left position “NORM”).

6 MAINTENANCE

The system is composed with components witch request a periodical maintenance. Preventive maintenance required is described below.

In addition with the guide lines of this manual, the user must also read and understand the instruction manual of each component of the system.

Before any action on the system, turn the switch Maintenance position. This information is output on the digital outputs terminal.

The main parts of the system are: the sample probe, the sample conditioning system and the analyzer.

6.1 Heated sample probe maintenance

Inside the heated probe, there is a specific filter. This has to be cleaned or replaced more or less frequently depending on the nature of the flue gas, and if the ZPA-CEMS is equipped or not with the automatic backflush system.

CAUTION : The probe is very hot: 180°C
!!!! DON'T TOUCH DIRECTLY, BUT WEAR HEAT PROTECTION GLOVES!!!!

Please refer to the specific instruction manual of the M&C sampling probe.

6.2 Sample conditioning system maintenance

The sample conditioning system includes several components to be checked every 6th month.
Replace the NOx converter catalyst.
Check and replace if necessary the tubing of the peristaltic pump.
Clean the filter on the air-conditioning unit.
Check the internal dust filter housing and change the filter cartridge if it is dirty or colored.
Check all pneumatic circuit and clean it with dry air if traces of humidity are visible, then check the sample gas cooler.
In case the sample gas cooler shows an alarm or there is any dirt or humidity visible in the heat exchanger, please refer to the specific instruction manual of the M&C sampling probe.

6.3 ZPA multigas analyzer maintenance

If there is an error message on the display, identify the fault with the instruction manual, correct it or contact the service office of FUJI ELECTRIC.
The only necessary preventive operation to be performed on the ZPA multigas analyzer is the periodical calibration (see the ZPA analyzer Instruction Manual).
Typical settings of the ZPA-CEMS calibration is :

- ✓ Automatic zero calibration : 1 per day
- ✓ Manual span calibration : 1 per month

The whole system should in any case be operated in compliance with the local standards. For instance, QAL3 compliant maintenance and zero & span checks should also be performed in Europe according to EN14181 standard.

Fuji Electric

Innovating Energy Technology

Fuji Electric France S.A.S

46, Rue Georges Besse-ZI du Brézet - 63039 Clermont-Ferrand CEDEX 2 - FRANCE - Tel. +33 (0)4 73 98 26 98 - wwww.fujielectric.fr