Continuous Gas Monitoring System (CGMS)

Description

CO_2 Capture Facility

Kårstø, Norway

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1.0 SYSTEM OVERVIEW

The purpose of the Continuous Gas Monitoring System (CGMS) is to sample, measure and analyze incoming flue gas from the Naturkraft Combined Cycle Power Plant (CCPP), absorber off-gas emissions, and the CO_2 product stream, and then calculate, record, report and archive these emissions for use by both the Safety and Automation System (SAS) and the plant management in reporting environmental compliance. The CGMS accomplishes these goals by performing the following general functions:

- Monitors, measures and records continuously during normal operation of the plant, freeing the operator to attend to normal and abnormal plant operating conditions.
- Gathers, organizes, and presents gas quality and emissions information to the Central Control Room (CCR) operator, empowering the operator to make informed operating decisions.
- Documents plant operating conditions and emissions, providing approved data collection, handling and processing tools from which plant and environmental management can demonstrate that the plant meets environmental compliance requirements to the competent Norwegian Pollution Control Authority (SFT).
- Transmits required emissions data and reports using the Data Acquisition Handling Systems (DAHS).

The Kårstø CGMS is a direct-extractive sampling system. It provides integrated sampling, analysis, monitoring, and data acquisition and storage to meet the requirements outlined in Exhibit E4.5 – General Technical Requirements, Continuous Gas Monitoring and Metering System [Ref 5.3] and applicable codes listed in Appendix E1.2 – Design Codes and Standards [Ref 5.4].

The CGMS for the CCPP incoming flue gas and each absorber off gas is located between the absorbers in the CGMS Shelter. The gas monitoring equipment for the CO_2 product is located in cabinets in a separate room in the compressor building. Conceptual layouts for CGMS equipment are provided in References 5.1 and 5.2. There is a common DAHS with operator interface in the shelter and the central control room (CCR).

Although no air permit specific to the CO_2 Capture and Compression (CCC) Plant has been issued to date, certification will be to EU regulations. The aux boiler online emissions monitoring includes typical required analysis for this type of equipment. Consequently, the CGMS described in this document is conceptual and subject to change during detailed design depending on actual permitting requirements and the final vendor selection.

2.0 DEFINITIONS AND ABBREVIATIONS

CCC	CO_2 Capture and Compression
CCR	Central Control Room
CPU	Central Processing Unit
CCPP	Combined Cycle Power Plant
CGMS	Continuous Gas Monitoring System
DAHS	Data Acquisition and Handling System
DCS	Distributed Control System
ESD	Emergency Shutdown
Ethernet/IP	Ethernet Industrial Protocol
F&G	Fire and Gas Monitoring and Alarm System
FTIR	Fourier Transform Infrared
GFC	Gas Filter Correlation
HMI	Human Machine Interface
HSE	Health, Environment and Safety
HVAC	Heating, Ventilation and Air Conditioning
IMS	Information Management System
I/O	Input / Output
IP	Internet Protocol
IR	Infrared
LAN	Local Area Network
LER	Local Equipment Room
LIR	Local Instrument Room
NDIR	Non-Dispersive Infrared
OIT	Operator Interface Terminal
OLE	Object Linking and Embedding
OPC	OLE for Process Control Standard
OS	Operator Station
PLC	Programmable Logic Controller
SAS	Safety and Automation System
TDLAS	Tunable Diode Laser Absorption Spectroscopy
UPS	Uninterruptible Power Supply
VDU	Video Display Unit
ZrO2	Zirconium Oxide

3.0 COMPONENT DESCRIPTION

The major components of the CGMS are as follows:

- CGMS Shelter
- Compressor Building Analyzer Cabinets
- Aux Boiler Analyzer Cabinets
- Sample Probes

- Sample Umbilicals
- Sampling and Conditioning System
- Analyzers and Analyzer Rack
- PLC
- System Network
- Plant Operator Station
- Data Acquisition Handling System (DAHS)

3.1 CGMS SHELTER

The CGMS for the CCPP duct flue gas and absorber off gas samples is housed in a self-contained, environmentally controlled shelter that is located at grade elevation between the absorbers. A conceptual layout is provided in the CGMS Shelter Conceptual Layout [Ref 5.1]. The analyzers, PLC, input/output signals, and calibration gas are centrally located in and attached to the CGMS Shelter.

The CGMS Shelter will be subjected to a coastal environment with varying weather conditions including heavy fog, snow, and rain. The shelter exterior shall be 316 stainless steel with insulated walls. All outdoor instruments shall be protected from dust and water by selecting equipment with protection class IP 65 to IEC 60529 and be suitable for Zone 2, Gas Group IIA, Temperature Class T2 Hazardous Area. The shelter shall be capable of withstanding the site blast load. The preferred type of protection for electrical equipment is intrinsic safety or a flameproof enclosure.

The main support equipment located inside and around the CGMS Shelter includes:

- A cylinder rack located in a separate room within the shelter.
- Manifolds and regulators for the cylinders.
- Power transformer for the shelter power.
- Main power disconnect switch.
- Power distribution panels.
- 2 x 100% redundant HVAC system (HVAC shall have an ATEX certificate of conformity).
- Exterior and interior lighting. All interior lighting including approximately 70% fed from normal 230 VAC power and 30% supplied via 230 VAC UPS power.
- Gas, O_2 and smoke detectors.
- Blue beacon light above each door to be activated on gas detection within building.

3.2 CO_2 PRODUCT ANALYZER CABINETS

The CGMS for the CO_2 product samples is housed in a set of free standing, environmentally controlled cabinets located in a separate room inside the compressor building. A conceptual layout of the compressor building equipment room is provided in the Compressor Building Analyzer Room Conceptual Layout [Ref 5.2].

The main equipment located in the equipment room associated with the CGMS includes:

- A cylinder rack located in a separate room adjacent to the analyzer room.
- Manifolds and regulators for the cylinders.
- 2 x 100% redundant HVAC system (HVAC shall have an ATEX certificate of conformity).
- Exterior and interior lighting. All interior lighting including approximately 70% fed from normal 230 VAC power and 30% supplied via 230 VAC UPS power.
- Gas, O2 and smoke detectors.
- Blue beacon light above each door to be activated on gas detection within building.

3.3 AUX BOILER ANALYZER CABINETS

The CGMS analyzer cabinets for the aux boiler are prepackaged with the aux boiler. The analyzers will be integrated into the DAHS for reporting and control purposes.

3.4 SAMPLE PROBES

The following sample test ports and probes are provided for the gas sampling:

- One 6" sampling/testing port and sample probe in the common flue gas duct.
- Eight (8) 6" sampling/testing ports are arranged around the circumference of each absorber stack, at the CGMS testing platform. One probe is located at each stack.
- One 6" sampling/testing port and sample probe in the CO_2 dryer outlet piping.
- One 6" sampling/testing port and sample probe in the aux boiler stack.

A continuous volume of flue gas is extracted by each sample probe. Each sample probe draws a representative sample of flue gas that is transported through heated sample tubes inside an umbilical to the location of the analyzers as describe in the next section. The probe is equipped with a coarse particulate filter. Periodic automatic blowback through the probe assembly using instrument air acts to keep the filter clean between periodic replacements. In addition, there is a fine filter located in the sample conditioning system. These two filters prevent contamination and plugging of the flue gas sample lines. Calibration gas of known concentration

and mixture is transported from the associated bottle rack to the probe, and is injected into the sample probe for analyzer calibration.

3.5 SAMPLE UMBILICALS

Sample umbilicals are provided as follows:

- Duct inlet probe to CGMS Shelter.
- Absorber 1 stack probe to CGMS Shelter.
- Absorber 2 stack probe to CGMS Shelter.
- CO_2 product line probe to compressor building analyzer cabinets.
- Aux boiler stack to aux boiler analyzer cabinets.

Each sample umbilical is heated to prevent condensation within the sample line. A temperature controller is used to control the umbilical temperature.

Due to the site layout, the length of the sample umbilical for the duct inlet sample will be longer than is typical. In order to avoid potential transport issues with the ammonia in the sample, an in-situ type ammonia analyzer will most likely be incorporated during detailed design. Multiple temperature sensors and heating segments for the umbilical will also be required to ensure proper temperature is maintained along the entire length.

Each umbilical contains multiple tubes and cables, as a minimum the following tubes are included:

- Main sample transport (1)
- Spare sample tube (1)
- Calibration gas (1)
- Blowback (1)
- Electrical cables for power and heating

3.6 SAMPLING AND CONDITIONING SYSTEM

Each flue gas sample is drawn through the probe and umbilical at the sampling platform and then transported to the CGMS by a sampling and conditioning pump. The pump draws the sample into a heat exchanger, which cools it and removes sample moisture (except for samples where moisture is being analyzed) using a drain pump, and then delivers a clean and dry sample to the analyzer rack for distribution to each of the individual analyzers. Activation of the sampling pump, gas sample valve, calibration flow control valve and solenoids are controlled through the system PLC.

There are calibration gas cylinders containing gas as needed for calibration of each analyzer. Automatic calibration is performed daily from the PLC. Manual calibration can be performed through the OIT/PLC.

3.7 ANALYZERS AND ANALYZER RACK

The clean and dry flue gas sample that was distributed to the analyzer rack by the sample and conditioning system is supplied to each of the following analyzers:

Component→ Sample ↓	Amine (MEA)	Carbon Dioxide (CO2)	Carbon Monoxide (CO)	Ammonia (NH3)	Nitrogen Oxides (NOx)	Water (H20)	Oxygen (O2)	Analyzer Type
Flue Gas from CCPP	--	X	--	--	X	X	--	FTIR
	--	--	--	X	--	--	--	IR or TDLAS
	--	--	--	--	--	--	X	ZrO_2 or Paramagnetic
	--	X	--	--	--	--	--	NDIR (Note 2)
Off Gas (each Absorber)	X	X	--	X	X	X	--	FTIR
	--	--	--	--	--	--	X	ZrO_2 or Paramagnetic
	--	X	--	--	--	--	--	NDIR (Note 2)
CO_2 Product	X	X	--	--	--	X	--	FTIR
	--	--	--	--	--	X	--	IR
	--	--	--	--	--	--	X	ZrO_2 or Paramagnetic
	--	--	--	--	--	--	X	ZrO_2 or Paramagnetic
Aux Boiler	--	X	--	--	--	--	--	NDIR
	--	--	X	--	--	--	--	GFC or NDIR

Notes:

1) Sulfur dioxide (SO_2) content may potentially be analyzed in the flue and off gases. Space is reserved in the CGMS Shelter for the future addition of SO2 analyzers.

2) A separate single-gas CO_2 analyzer is provided for primary control. During calibration or downtime of the CO_2 analyzer, the FTIR signal will be used as backup.

3) The specific manufacturer would be decided during the detailed design. Potential analyzer make(s) and model(s) for each analyzer type:

Analyzer Type	Manufacturer	Model
FTIR	Thermo Scientific	70

Analyzer Type	Manufacturer	Model
NDIR	Thermo Scientific	410i
IR or TDLAS	Servomex Siemens	2500 or 2900 Ultramat 6
Paramagnetic	Thermo Scientific Siemens	60i Oxymat 6
GFC	Thermo Scientific	48i

Each analyzer includes its own power supply, sample and calibration gas distribution and measured signal input/out connections. The analyzers provide raw, uncorrected data, analyzer status, calibration, and trouble indications to the PLC for transmission to DAHS.

3.8 PROGRAMMABLE LOGIC CONTROLLER (PLC)

The CGMS is controlled by a PLC, which provides the overall system architecture for data input, output, storage and conversion. The PLC provides local storage for raw analyzer data and communicates with the DAHS for long-term storage, data collection, calculations, data correction, and reports generation. In the event of failure of the DAHS or communications between the DAHS and the PLC, the PLC will continue to operate and record raw data for a minimum of 14 days.

3.9 SYSTEM NETWORK

The PLC from the CGMS Shelter and the DAHS for each train are linked to a switch in the CCR. The data highway link between the switch and the CGMS Shelter PLC is fiber optic.

Analysis points used for control are hardwired between the CGMS PLC or the analyzer and the plant DCS. Other analysis points, general system status displays and alarms are transmitted to the DCS via the DCS interface servers.

3.10 OPERATOR INTERFACE TERMINAL (OIT)

The primary interface for technicians/engineers to the PLC is through the local CGMS operator interface terminal (OIT), a keypad and display located in the CGMS Shelter and Compressor Building Analyzer Room cabinets. This interface allows the engineer/technician to perform all of the functions of the operator station in the CCR as well as conduct maintenance, troubleshooting and programming to the CGMS. Additionally, the engineer/technician may connect to the PLC through the engineering station or through a laptop computer interface.

3.11 OPERATOR STATION

The operator station located in the CCR presents CGMS information to the operator by displaying dynamic process graphics. Process graphics are simplified pictorial representations of the process and are designed to collect and display important information about the emissions, analyzers, and environmental compliance of the plant. The operator station also organizes and presents emissions alarms to the

operator. The operator can acknowledge selected alarms and input background or cause/effect data into the system. A single printer is provided for printing regular and on-demand reports.

The operator station also includes password-protected software necessary to modify and edit the commands used by the operator station.

3.12 HMI / ENGINEERING STATION

The HMI / Engineering Station located in the CGMS Shelter is used to interface with the FTIR analyzers along with local operator station and engineering functions.

The engineering station also includes password-protected software necessary to modify and edit the commands used by the engineering station and PLC.

3.13 DATA ACQUISITION HANDLING SYSTEM (DAHS)

Each DAHS collects the raw data from the respective unit's PLC for calculation, correction, reports generation, and storage.

The DAHS resides in the PC-based Operator Station located in the CCR and includes Operator Station software necessary to allow personnel to sort, configure and print miscellaneous reports. It also includes software necessary to configure historical archiving and storage of CGMS reports and data. Those points selected for historical archival will be stored in RAM and periodically saved to permanent storage.

All measured values shall be transmitted to an industrial evaluation computer with dedicated software and VDU installed in the CCR. The emission data shall be calculated, converted, printed out and stored as required per site requirements.

Selected data related to the CO_2 product shall be sent to the Transport and Storage System Control Center (TCC). All flow measurements and field variables used for fiscal calculations or comparison with fiscal figures shall be calibrated with documentation by an accredited laboratory to international/national standards.

All process values to be measured and analyzed, status signals, and alarms will be transmitted to the Safety and Automation System (SAS) for processing and evaluation in the CCR. Additionally, critical alarms will be connected the Emergency Shut Down (ESD) and Fire & Gas (F&G) systems.

4.0 SUPPORT SYSTEMS

4.1 400 VAC

The 400-Volt power distribution system is used to power the CGMS Shelter by providing 400 VAC, 3-Phase power feed from the Essential MCC to the CGMS shelter for internal power and distribution. The CGMS shelter has its own 400 VAC 3-Phase to 230 VAC step-down transformer with disconnect switch to provide power to umbilical and probe heating, HVAC, lighting, and feed to the CGMS Shelter 230 VAC distribution panel.

4.2 230 VAC

The CGMS Shelter power and distribution panel distributes the power from step-down transformers to its own distribution panel for 230 VAC that is used within the shelter for HVAC, heated sample lines, sample conditioning, lighting, and utility outlets.

4.3 UNINTERRUPTABLE POWER SUPPLY (UPS)

The DAHS located in the main control room is powered from the Plant UPS.

The following equipment in each CGMS shelter is powered from the Plant 230 VAC UPS to prevent data loss and provide for normal system shutdown:

- 24 VDC Power Supplies
- Fiber Optic Converters
- PLC
- All Analyzers
- HMI / Engineering Station

4.4 INSTRUMENT AIR SUPPLY

Instrument air is supplied to each CGMS analyzer area (CGMS Shelter, Compressor building analyzer room, and aux boiler) from the Plant Instrument Air (PA) System. A self-contained instrument air clean up system at each location uses filters with purge air dryer to maintain the quality of instrument air used by the CGMS. This clean, dry instrument air is distributed for purging, blowback and instrument calibration.

5.0 REFERENCES

5.1 CGMS Shelter Conceptual Layout

25474-000-J0-4410-00001 / 10112936-PB-I-DRW-0006

5.2 Compressor Building Analyzer Room Conceptual Layout

25474-000-J0-4010-00001 / 10112936-PB-I-DRW-0005

5.3 Exhibit E4.5 – General Technical Requirements, Continuous Gas Monitoring and Metering System

10112936-FI-B-CON-0095, Revision 02

5.4 Appendix E1.2 – Design Codes and Standards

10112936-FI-B-CON-0242, Revision 06