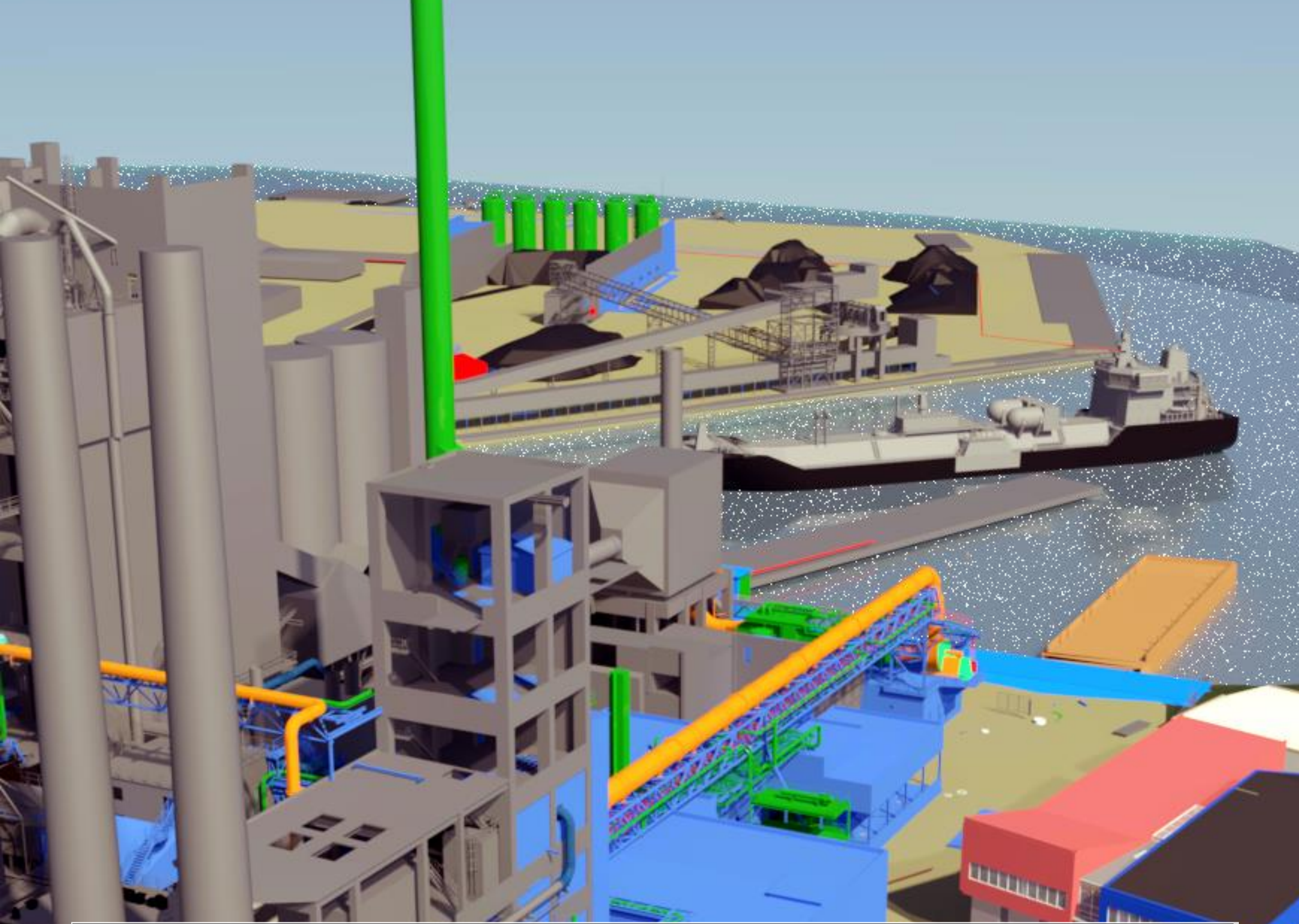

Document No.:NC04-NOCE-Z-RA-0004					Rev.: 03	Page: 1 of 14
Originator: NOCE	Tag.No.:		System No.:	Area Code:		
Classification Code: Confidential / Open						
Rev.	Issue date	Description	Made by:	Checked by:	Disc. Appr.	Proj. Appr.
01	21.02.2024	Issued for Invitation to Tender (ITT)	GJL	OMB, YDG, KAS		TG
02	23.02.2024	Issued for Invitation to Tender (ITT)	GJL			TG
03	28.02.2024	Issued for Invitation to Tender (ITT)	GJL			TG

Brevik CCS

Technical Specification – Analyser for online measurement of impurities in CO2

Contents

Revisions to this document

Rev. no.	Revisions in chapter	Description
03	2.1	Rearranged order of bullet points
03	2.2	Refrased heading
03	2.5.1	Updated text in bullet point 4. Added bullet point 5.
02	2.2.4	Figure 3 is changed
02	2.4.1	Figure 5 is changed

1 Introduction

1.1 General, background

The background for the Norwegian CCS project Longship is the need to limit global warming through reduction of Green House Gas emissions, including CO_2. The Longship project shall through demonstration of full-scale CO_2 handling contribute to the necessary development of CO_2 handling, to reach the long-term climate targets in Norway and EU at the lowest possible cost. Demonstration of CO_2 handling shall by 2030 increase the efficiency of CO_2 capture, transportation, and storage.

The purpose of the Longship project is thereby to:

- Establish a first complete CO_2 handling chain, including CO_2 capture, transportation, and storage, in Norway.
- Facilitate technology development and learning effects, as well as experience and knowledge exchange nationally and internationally, and
- Contribute to cost reduction and increased maturity of the market for CO_2 handling nationally and internationally.

The State contributes to the realisation of the Longship project by giving the recipient(s) grants for the establishment and operation of the capture plant and storage facilities in accordance with regulations for public contributions to environmental measures.

Heidelberg Materials shall, in accordance with the agreement with the Norwegian State, establish and operate a full-scale CO_2 capture and conditioning plant integrated with the existing cement plant in Brevik, targeting the capture of 400 000 tons of CO_2 per year with the required quality for ship transportation and permanent storage below the seabed on the Norwegian continental shelf.

1.2 Project goals and objectives

The overall goal of the Longship project is that the demonstration of CO_2 capture and storage will contribute to the necessary development of CCS, so that the long-term climate goals in Norway and the EU can be achieved at the lowest possible cost. As part of this goal, the CCS Project must:

- provide knowledge that demonstrates that it is possible and safe to carry out full-scale CO_2 capture and storage,
- provide productivity gains for upcoming projects through learning and scaling effects,
- provide learning related to regulations and incentives for CCS, and
- establish market players, further develop suppliers, and provide business development.

The Heidelberg Materials part of the CCS project shall contribute to the realisation of these goals, including establishment of the CO_2 capture and conditioning facilities and the necessary modifications to the existing cement production plant at the lowest possible cost for the entire CCS chain.

1.3 The site

The carbon capture plant is in Brevik, Telemark, close to the shore of Eidangerfjorden.

Address: Setrevegen 2, Brevik, Norway.

2 PACKAGE DESCRIPTION

2.1 Overall package description

This package consists of the following equipment and services:

a) Analyser for online measurement of impurities in CO_2.
b) Documentation.
c) Necessary integration equipment, fittings, tubing, etc., for the analyser to form a complete working unit.
d) Services needed for installation, commission, testing and putting into operation.

The new analyser will be an extension to the existing sampling and analyser setup for detecting oxygen and water in the liquid CO_2. The new analyser is planned to be connected to the existing LCO_2 sampling & evaporiser system.

2.2 Analyser for online measurement of impurities in CO_2 – Category (a)

2.2.1 Introduction

The new analyser shall be a complete and freestanding unit/ cabinet suitable for installation inside a container. It shall be equipped with operator panels or local PC and with communication equipment/ modules (see section 2.4.3) for communication to CCR for monitoring and operation from both locations.

The new analyser shall have connections/ arrangement for connection of calibration gases. Calibration gas bottles for 1^{st} commissioning, testing, and putting scope of work into operation to be included.

The new analyser shall be delivered with CE marking if applicable.

2.2.2 List of impurities

The new analyser shall analyse for the following pollutants in CO_2 and within the stated levels as shown in Table 1 and Table 2.

Table 1 contains priority 1 compounds that Heidelberg expect to be found in both the liquid and the vapor CO_2 and forms the base case for the compounds and are all to be included.

Table 1: List of priority 1 impurities to analyse.

Impurities	Liquid Expected concentration, molppm	Vapor Expected concentration, molppm	Comments
Water, H_2O - optional	0-50	0-5	
Oxygen, O_2 - optional	0-20	0-600	Should not be affected by the organic/combustible impurity compounds. The detection limit on the liquid sample shall be given priority over the accuracy of the detection limit of the vapor.

Impurities	Liquid Expected concentration, molppm	Vapor Expected concentration, molppm	Comments
Sulphur dioxide, SO_2	0-10	0-5	
Nitrogen oxide, NO	0-10	0-100	
Nitrogen dioxide, NO_2	0-10	0-10	
Hydrogen sulphide, H_2S	0-10	0-10	
Ammonia, NH_3	0-10	0-10	
Formaldehyde, CH_2O	0-20	0-20	
Acetaldehyde, CH_3CHO	0-20	0-20	
Carbon monoxide, CO	Not expected	0-2400	
Hydrogen, H_2	0-50	0-6000	
Methane, CH_4	0-100	0-2000	
Nitrogen, N_2	0-100	0-5000	
Argon, Ar	0-100	0-3000	
Methanol, CH_3OH	0-10	0-1	
Ethanol, C_2H_5OH	0-10	0-1	
Ethylene, C_2H_4	0-5	0-5	
Ethane, C_2H_6	0-10	0-20	
Acetone	0-10	0-10	

The following requirements are valid for Table 1:

- ⇨ ***Supplier to state analysing method/ principle for all listed compounds.***
- ⇨ ***Supplier to state name and model of their recommended analyser for all listed compounds.***
- ⇨ ***Supplier to state accuracy in ppm/ % for the stated measuring ranges and detection limits for all listed compounds.***

Table 2 contains priority 2 compounds that Heidelberg do not expect to be found in either the liquid or the vapor CO_2.

Table 2: List of priority 2 impurities to analyse.

Impurities	Comments
1-propanol	
2-butanol	
1,2,4-trimethylbenzene	
Methyl acetate	
Hexanal	
Diethyl ether	

Impurities	Comments
Acetonitrile	
Mono-Ethylene Glycol (MEG)	
Tri-Ethylene Glycol (TEG)	
Benzene	
Toluene	
Ethylbenzene	
Xylene	
Hydrogen Cyanide (HCN)	
Aliphatic Hydrocarbons (C_3+)	Total amount of hydrocarbons not to exceed 1,100 ppm-mol. Individual limits for groups of HCs: C3 <1,100 ppm-mol, C4-C5 < 815 ppm-mol, C6-C7 < 75 ppm-mol, C8-C9 < 8 ppm-mol. C10+ not allowed.

The following requirements are valid for Table 2:

⇨ ***Supplier to indicate detection limit for the listed compounds, if detected with the analyser offered for the priority 1 compounds.***

2.2.3 System description

The new analyser will be connected to the existing sampling system. This connection will be inside the existing container shown in Figure 1.

In the field there are three sampling points:

1. Online measurement of impurities in LCO_2 when pumping from the process area to the LCO_2 storage tanks.
2. Online measurement of impurities in LCO_2 when pumping from the LCO_2 storage tanks to the ship during ship loading
3. Online measurement of impurities in vapor return coming from ship when loading LCO_2 to ship.

Sample point 1 and 2 are tied into pipes carrying liquid CO_2 and these are equipped with a local evaporisation cabinet (200W) providing a 100% vaporized CO_2 sample for the analyser at pressure 0-3barg, available vapor flow is max 10 Nl/min. Sample point 3 is tied into a pipe carrying CO_2 vapor. Locations for sample points and the container in which the analyser will be located are shown in Figure 1 below. The arrangement shown on Figure 1 are for information only as the connection points for the new analyser to the existing sampling system is inside the container. The whole area is safe area and no Ex. area.

⇨ ***Supplier to state required <u>flowrate</u> of fully evaporated vapor needed at analyser tie-in point, see Figure 5.***

⇨ ***Supplier to state required <u>pressure</u> and temperature range of fully evaporated vapor needed at analyser tie-in point, see Figure 5.***

However, supplier may offer, as an option, additional local evaporator cabinets of their chose and design if the existing local cabinets are not compliant with supplier requirements for CO_2 vapor flow to the new analyser. See section 2.2.4.

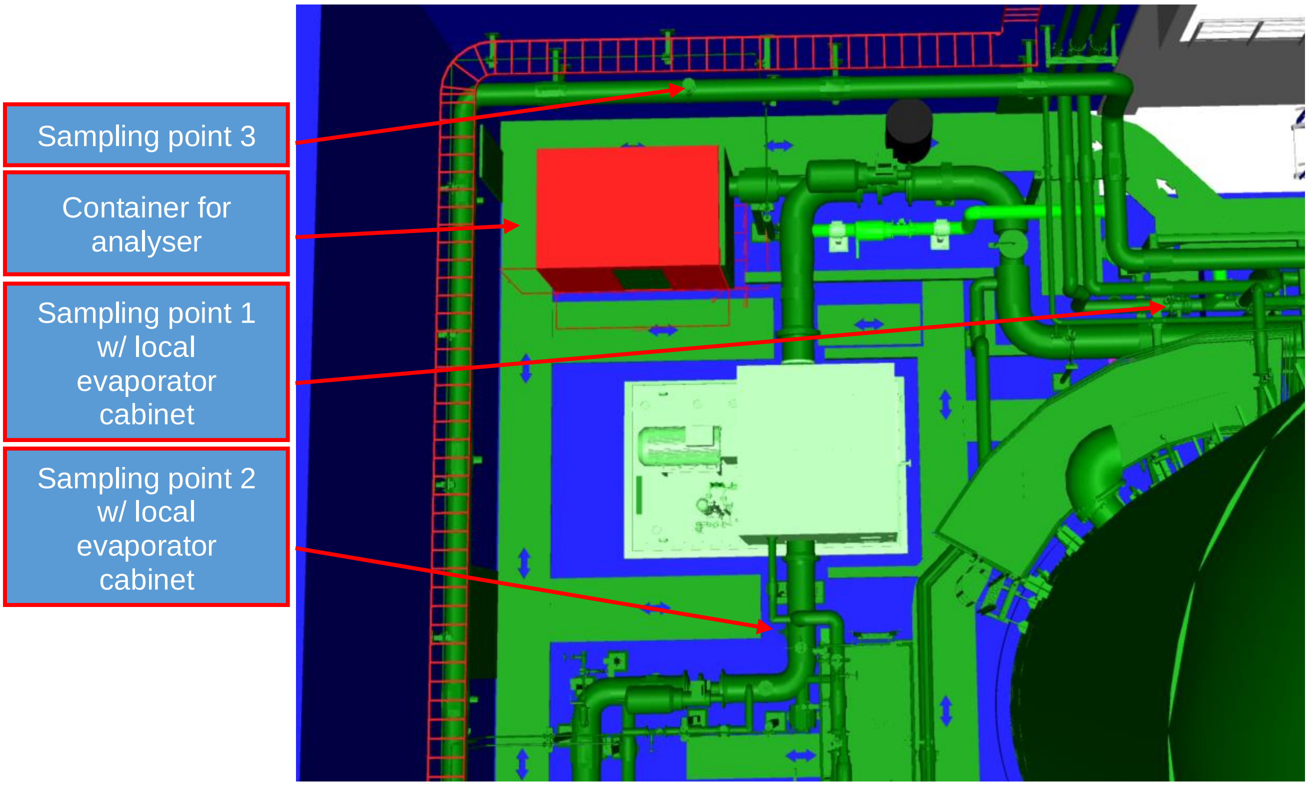

Figure 1 - Sampling and analyser locations

The extraction of the samples from all the tie-in points and through the evaporator cabinets are continuous, but when reaching the analyser cabinets, the given CO_2 stream is either analysed or vented to atmosphere as described in the following and shown in Figure 2 below.

<u>Online measurement of impurities when pumping LCO_2 from the process area to the LCO_2 storage tanks.</u>
This is done continuously when LCO_2 is pumped to the storage tanks when there is no loading of ship. During loading of ship, the analyser will prioritize analysing on the LCO_2 going to ship, but a sample from this sampling point is analysed for a short period at given intervals.

<u>Online measurement of impurities when loading LCO_2 to ship.</u>
This is done almost continuously when LCO_2 is pumped to ship. At given intervals, the common analyser will alternate to analyse for a short period on LCO_2 coming from the sample point on the line feeding the storage tanks. In addition, the common analyser will alternate to analyse on CO_2 vapor coming ashore from ship at a given interval.

<u>Online measurement of impurities in vapor return when loading LCO_2 to ship.</u>
This is done as a spot check at given intervals only. The common analyser will alternate at given intervals to analyse on CO_2 vapor coming ashore from ship.

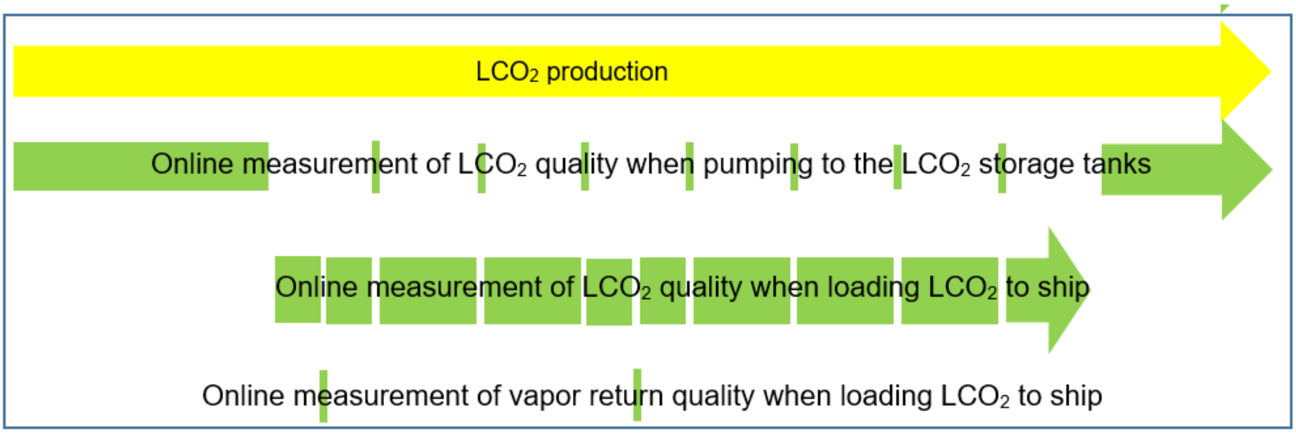

Figure 2: Principle for analysing on CO_2 from the various sampling points.

The ship is scheduled to arrive for loading every fourth day giving a total cycle time of 96 hours. During these 96 hours there will be a continuous production of LCO_2 in the process area, which is pumped, also during loading of ship, to the storage tanks and being sampled from sampling point 1. Sampling from sampling point 2 and 3 is only during loading of ship.

Timing for sampling from the various sampling points are shown in Table 3 below.

Table 3: Timing for sampling from the various sampling points

Sample point	Sampling frequency during normal operation (~88h duration)	Sampling frequency during loading (~8h duration)
1. CO_2 from process to tanks	Continuously	Once every hour
2. CO_2 from tanks to ship	None	Continuously during all remaining time
3. Vapor return from ship	None	Once every second hour, for as long as needed to get a stable reading.

This existing arrangement for alternating between the sampling points will also be used for the new analyser.

⇨ ***Supplier to state response time (time to get a stable reading) for the analyser when changing from one sample point to the next, where the actual composition may be different.***

2.2.4 Local evaporator cabinets

The existing two local evaporator cabinets are located close to the tie-in points and are designed to evaporate the liquid sample 100% thus providing a representative vapor sample to the analyser.

Figure 3 below shows the arrangement for one of the local cabinets and how it is hooked up to the process pipe for liquid CO_2 and connected to the existing analyser inside the container. See Figure 5 for details for the tie-in point.

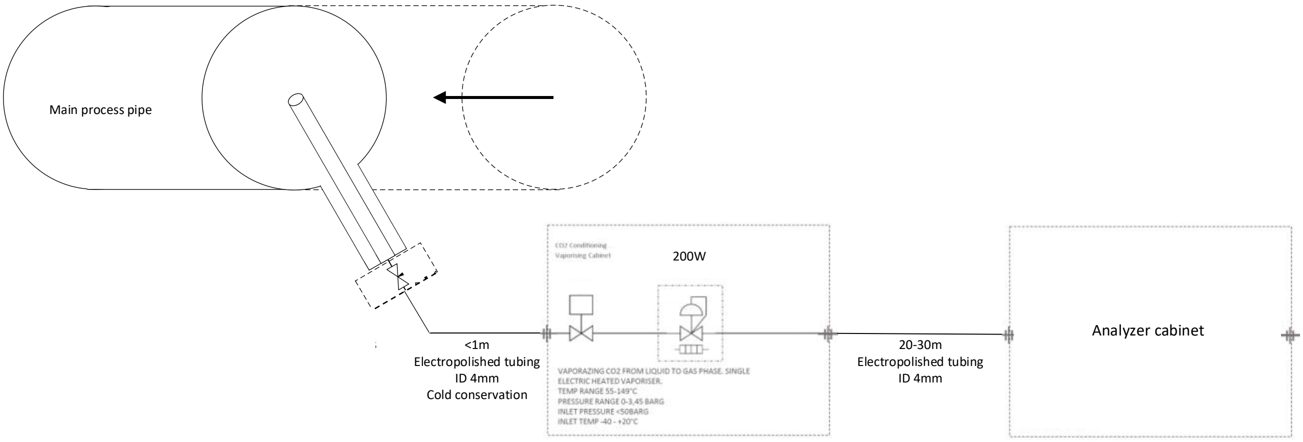

Figure 3: Local evaporator cabinets – arrangement

⇨ ***Supplier to offer, as an option, additional local evaporator cabinets of their chose and design if the existing local cabinets are not compliant with supplier requirements for CO_2 vapor flow to the new analyser.***

Tie-in point for such optional local evaporator cabinets will be downstream the *Monoflanged DBB needle valve* in series shown on Figure 3 above. If such optional local evaporator cabinets are offered, the existing and new systems will operate in parallel and only share the existing tie-in points to the process piping.

2.2.5 Container for installation of the new analyser.

This is an existing container in which the existing analyser is already installed.
Dimensions: L=3350 mm, W=2250mm, internal height=2290mm. Door, free opening=810x1935mm. The container is equipped with internal heater 1000W and overpressure ventilation with filters. Window and workbench along the shorter wall. Internal lightning arrangement in ceiling. See Figure 4 below.

⇨ ***Supplier to state additional requirements, if any, for the atmosphere e.g., temperature range inside the container.***

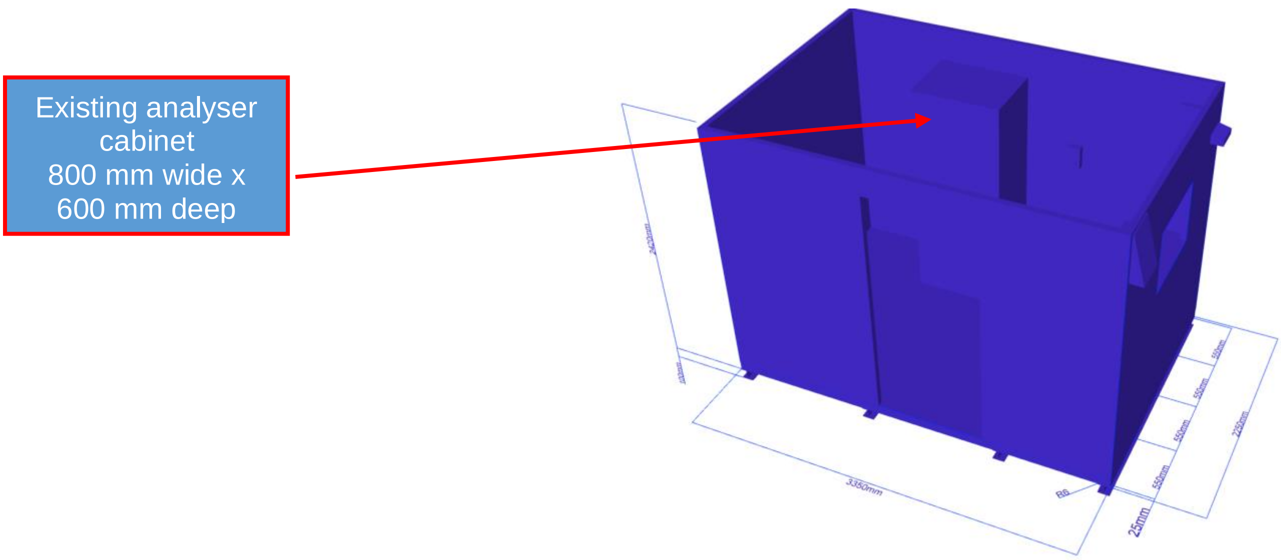

Figure 4: Container for installing the analyser.

2.3 Documentation – Category (b)

2.3.1 Scope

The complete scope of work shall be delivered with all necessary documentation covering but not limited to:

1. General description
2. General arrangement drawing including weights,
3. Installation and hook-up to sampling system,
4. Commissioning, testing, calibration and putting into operation,
5. Normal operation,
6. Utility requirements and consumptions,
7. Maintenance, periodic and repairs, by operators if relevant,
8. Periodic calibration of analyser by operators if relevant,
9. Description, type, and concentrations, of required calibration gases,
10. Description of required/ recommended periodic maintenance, calibration, etc. by supplier,
11. Consumables and expected frequency of replacement if relevant,
12. EU declaration of conformity if applicable.
13. Contact information of closest representative to site in Norway, and typical response time for troubleshooting,
14. Describe possibilities to add components to the lists in Table 1 and Table 2 in the future and whether that requires re-calibration or software update.

Suppliers' standard documentation is acceptable if it covers the above.

2.4 Necessary integration equipment – Category (c)

2.4.1 Process connection

Process connection for the new analyser is inside the container. It will be one single line connected to the existing alternating/ change over system between the sampling points described in section 2.2.3 and shown in Figure 2.

The new analyser shall be connected to the existing tubing in a way that secure full simultaneous operation of both the existing and the new analyser. Final arrangement to be agreed between Heidelberg M and supplier. Process connections and proposed tie-in point for new analyser is shown in Figure 5. below.

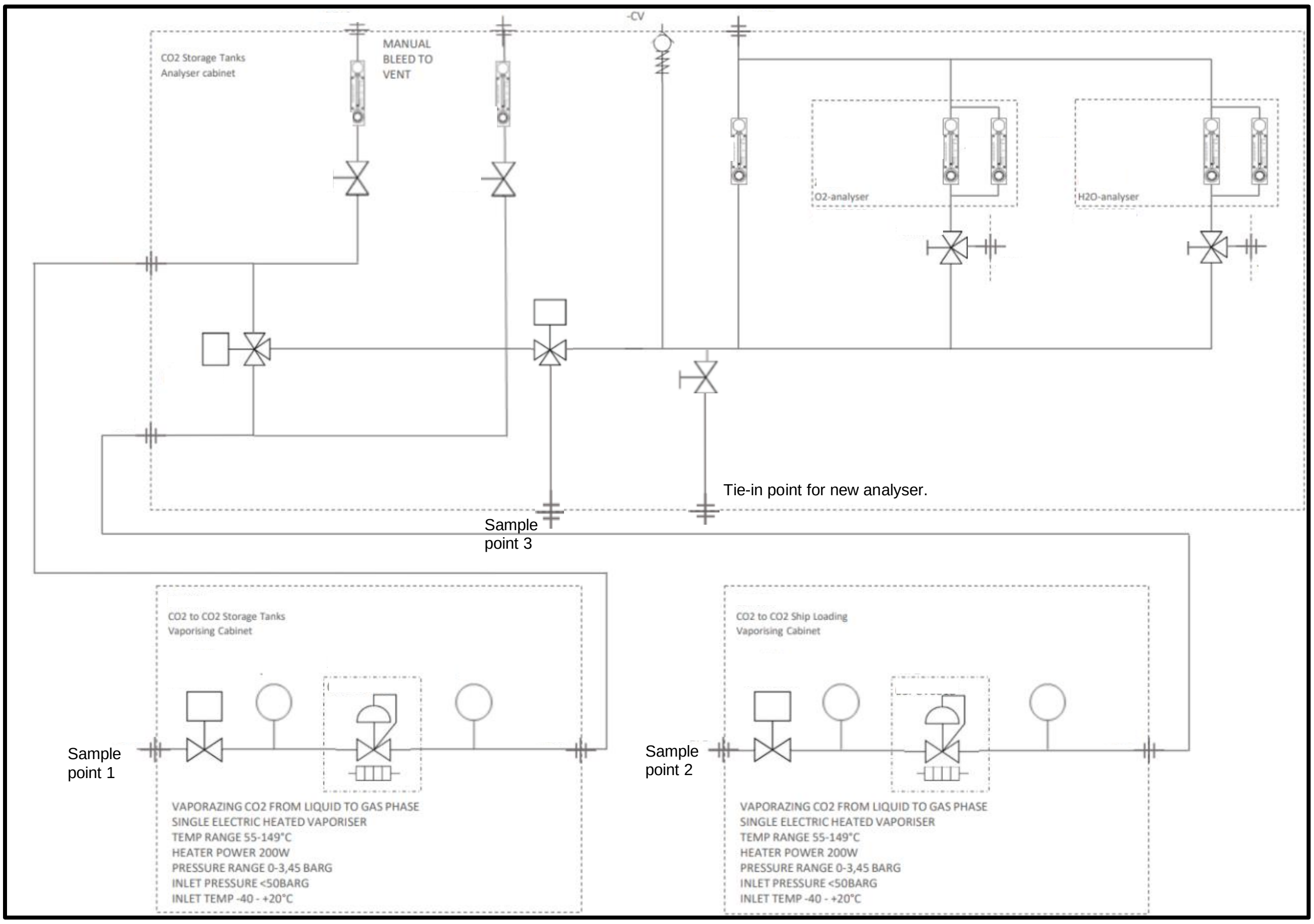

Figure 5: Process connection and proposed tie-in point for new analyser

⇨ ***Supplier to include tubing inside the container, electropolished or equal, from existing tie-in point as shown in Figure 5 to the new analyser.***

2.4.2 Power supply

The container is equipped with an electrical power supply with local cabinet inside the container in accordance with IT – grid system. The new analyser shall be compatible with this system and in general follow NEK 400.

See attachments for further information.

⇨ ***Supplier to include dedicated UPS, if required, for own scope of supply.***

⇨ ***Supplier to specify power consumption.***

2.4.3 Automation connection

See attachment *Elektro spesifikasjon for innkjøp av elektrisk utstyr*.

2.4.4 Instrument Air

Instrument air may be supplied to the new analyser if needed. Instrument air specification as follows:

Supply pressure in local air receivers/ pressure accumulators:

- Min : 6 barg
- (Instrument air consumers must be designed to operate on 4.5 barg.)
- Normal: 7-7,5 barg
- Max : 8 barg

Quality, ISO-norm 8573-1:2010:

- Particles: Class 3, size < 5 µm, rest dust content 5 mg/m3,
- Water/ dew point: Class 2, dew point ≤ - 40 °C,
- Oil: Class 3, Rest oil concentration < 1 mg/m3 (oil free compressor)

⇨ ***Supplier must specify instrument air pressure/ volume flow requirements if applicable.***

⇨ ***Supplier must specify additional requirements, if any, in addition to the above stated pressure and quality grade.***

2.4.5 Other utilities

⇨ ***Supplier must specify other utility requirements, if any.***

2.5 Services – Category (d)

2.5.1 Scope

All necessary services needed for the following to be included based on supplier's recommendations.

1. Installation of cabinet inside container and hook up to existing tubing inside the container,
2. Training of operators,
3. Commissioning, testing, and putting scope of work into operation.
4. Periodic maintenance and calibration for the first four years of operation.
5. Remote connection for e.g. remote diagnostics of analyser performance.

⇨ ***Supplier shall describe their scope of work for the above service elements divided into the following two categories:***

I. Services that are required and included as standard to secure the functionality of the analyser.
II. Services that are recommended but not required.

3 Abbreviations and definitions

Abbreviation	Definition
CCR	Centralised Control Room
Ex	Explosive atmosphere
HM	Heidelberg Materials
UPS	Uninterruptible Power Supply

4 Attachments

Title
Principle drawing – IT voltage system
Elektro spesifikasjon for innkjøp av elektrisk utstyr