Discharge and Emissions Data Forms

CO_2 Capture Facility

Kårstø, Norway

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1.0 INTRODUCTION

This narrative is prepared to comply with Fichtner-Gassnova query number 10112936-Q-FIPB-S-0022, dated September 24, 2008. The query requests that a description be provided before each emission and discharge data form, respectively, in order to outline the origin of the emission/discharge, the content, physical conditions and proposed treatment.

Section 2.0, below, is written in a form that the subsections (2.1, 2.2, etc.) correspond to the five (5) Emission and Discharge Data Forms furnished in Fichtner-Gassnova document 10112936-FI-B-CON-0248.

2.0 DISCHARGE AND EMISSIONS DATA FORMS INFORMATION

2.1 RELEASES INTO WATER

The discharge data form in support of "Releases into Water" from Fichtner-Gassnova document number 10112936-FI-B-CON-0248-03 is located in Attachment 1, part 1.0. This form should be referenced first and is supported with the description below.

2.1.1 Process Releases

The main release to water is the seawater cooling system. The heat exchangers in the CO2 Capture and Compression Plant employ seawater cooling.

All seawater will return to a common pit location to the Karsto site north of the battery limits of the CO2 capture plant. Reference drawing is Site Drawing 10112936-0082-GAD, rev. 05 showing as "Seawater Discharge Pit" I-21 "Underground Pipe: Seawater Discharge". No treatment beyond filtration on the inlet side is proposed.

Temperature rise across heat exchangers is 10°C and discharge to the seawater discharge pit OSBL will not exceed 21°C. No further treatment is planned beyond temperature monitoring under normal conditions. Seawater return temperature will be alarmed for high temperature to the CCR.

There are four (4) streams of Seawater Return, 502, 504, 506 & 510. The governing case is the Winter Case Reclaimer Off.

Table 2.1.1: Sea Water Discharge*

Process Simulation Case	Total Mass Flow (kg/h)	Total Volumetric Flow (m^3/h)
Normal Reclaimer On	15,011,270	15,047
Normal Reclaimer Off	14,604,446	14,640
Summer Reclaimer Off	14,866,806	14,903
Winter Reclaimer Off	15,828,568	15,867
Turndown Reclaimer Off	13,523,343	13,556

* Values obtained from Heat & Mass Balance Diagrams 25474-000-M4-CN-00001, Rev 0

Heat Exchanger Leakage potential is covered further below in section 2.5 "Preventive Measures and Contingency Plans for Abnormal Releases", including leak detection potential.

2.1.2 Water Intermittent Release Potential

The process design philosophy is to maintain an overall water balance with only net input to the process.

The incoming water will consist of potable water at up to 7 m^3/min. This water will be softened through a cation exchange unit. The effluent will consist of brine. It is proposed that this be discharged to the waste water holding tank for later sample testing and disposal to the seawater return pit.

2.1.3 Precipitation Run-off

Water run off will occur at ambient temperature and pressure conditions. All rainwater/snow melt will be routed to catch basins and onto an oil separator tank (location and capacity to be determined). Proposed treatment for separated oil is to pump out by professional contractor and remove from site for professional disposal or offsite recycling facility. Skimmed rainwater/snow melt will then be sent to the seawater discharge pit.

Sampling will be performed on this effluent to ensure it meets site requirements and then will be routed to the seawater discharge pit located to the Karsto site north of the battery limits of the CO2 capture plant. Reference drawing is Site Drawing 10112936-0082-GAD, rev. 05 showing as "Seawater Discharge Pit" I-21 "Underground Pipe: Seawater Discharge".

Precipitation design requirements will follow those defined in Fichtner-Gassnova documents 10112936-FI-B-CON-0070-03 "Exhibit E2 General CCC Plant Requirements", 10112936-FI-B-CON-0051-03 "Exhibit E0 - Design Basis" and clause 2.9 of 10112936-FI-B-CON-0241-03 "Appendix E1.1 - Meteorological Conditions".

Fire water discharges are treated as a contingency addressed below in section 2.5.

2.2 RELEASES INTO AIR

The discharge data form in support of "Releases into Air" from Fichtner-Gassnova document number 10112936-FI-B-CON-0248-03 is located in Attachment 1, part 2.0. This form should be referenced first and is supported with the description below.

2.2.1 Process Emissions

The CO2 Capture facility is designed as an abatement facility for the Naturkraft CCPP facility.

Absorber Towers (T-101/T-102) are the only major sources of airborne emissions.

The design employs Continuous Emissions Monitoring and feedback for process adjustment to optimize CO2 capture and report on emissions as required.

Internal to the absorbers, the water wash section consists of two beds of stainless steel structured packing. The water wash section serves to reduce both the ammonia and MEA content in the flue gas. In addition, the water wash section cools the flue gas to approximately 40 - 45°C to reduce the amount of water vapor leaving the tower. After passing through a final mist eliminator, the flow rate of the flue gas is measured and is then released to atmosphere. Exit velocity and composition is to be monitored in the CEMs analyzer shelter and communicated to the Control Room.

The exhaust from the absorbers will appear as steam. Mist eliminators at the top of the absorbers will be sized to limit droplet size of 99% of emitted droplets to under 10 µm. Up to 1% of the droplets emitted could reach up to 550 µm in size due to flooding requirements in the structured packing employed in the design of the absorbers. The absorber top vent stack exit velocity is estimated at 20 m/s (dependent on flue gas temperature).

Small amounts of MEA (< 2 ppmv) and NH3 (< 4 ppmv) are expected to exit the absorber vent stacks under normal, peak and turndown conditions. Normal and peak cases are tabulated on the Emission and Discharge Data Form "1. Releases into Air". Therefore, it is possible that a mild ammoniacal or fishy odor may be present and discernible to workers.

Emissions from the Absorber Towers (at 53.33 m above grade) are expected to contain amine decomposition products Piperazine (CAS 110-85-0), Formaldehyde (CAS 50-00-0) and Acetaldehyde (CAS 75-07-0). The concentration of each respective decomposition product listed above is expected to less than 1 ppmv each at the vent stack outlet.

Please refer to the CCC Amine Emission Abatement Study (10112936-PB-P-TDO-0011) that elaborates on the means to mitigate the airborne emissions of contaminants related to the Absorber Tower airborne effluents identified on this data form.

2.2.2 Intermittent Releases

Diesel Generator Exhaust (emergency generator testing cycle)

The emissions (composition and temperature) from the diesel engine have not been quantified or qualified at this stage of FEED studies.

It is assumed that there will be a monthly test run of the emergency diesel generator for up to 60 minutes per test cycle and an annual dummy load test run for up to 12 hours.

Total estimated planned run-time is approximately 24 hours per year. Fichtner-Gassnova document 10112936-FI-B-CON-0106 "Electrical Specification for Emergency Diesel Generator" clause 5, depicts a datasheet that is to quantify the emissions of the engine for NOx, CO and particulates, respectively, in mg/Nm³ of exhaust and fuel consumption at peak electrical output. The emissions from this equipment tag can be quantified upon submission of the information later in FEED.

General arrangements drawings for the selected generator set and container are to specify the location of the exhaust discharge point. It is expected that the discharge will occur at less than 5 m above grade. The generator container is located along the northern battery limit to the west of the main electrical switchgear building.

Laboratory Reagents

The following reagent listing is required for operation of the laboratory:

Reagents and analytical equipment used and/or stored in lab	**Safety precautions and protective facilities in handling**
Compressed gases compressed helium gas compressed argon gas	- cylinder securely clamped with cap in place when not in use - make sure the regulator is removed and caps are on when transporting gas cylinders
Cryogenic materials liquid nitrogen liquid argon	- venting in transportation - established procedures to eliminate suffocation risk
Combustible chemicals methanol acetonitrile	- must be stored in flammable storage cabinets
Inorganic acid hydrochloric acid phosphoric acid	- must be stored separately from organic acid and flammables
Organic acid acetic acid	- can be stored with flammables but separately from other acids and oxidizers - handle in fume hood
Bases sodium hydroxide	- must not be stored with acid
Other general chemicals methyl orange sodium bicarbonate sodium chloride potassium dihydrogen phosphate deuterium oxide deuterated chloroform dimethyl sulfoxide potassium bromide hexamethyl benzene CE standards, CE buffer ICP standards pH buffer conductivity standards	- check MSDS for more information about each chemical - do the chemical inventory regularly

The presence of these materials will require the installation of a fume hood for the safe ventilation of the laboratory. The HVAC design during detailed engineering will address the size and exhaust location of the fume hood. Exhaust gas potentials have not been quantified at this stage of design.

Fugitive Emissions and Cold Vents

Tank Atmospheric Vents: The main amine storage tanks (TK-101 and TK-102) are to have relief venting and will be maintained with a nitrogen blanket to prevent emissions under normal conditions. There should be no intermittent releases from these tanks during normal operation.

The Amine Sump Tank (TK-103) is to be fitted with an atmospheric vent to prevent overpressure. The vent will be routed to atmosphere to a safe location with consideration for a nitrogen blanket for odor control.

Rotating Equipment Seals

Centrifugal pumps in amine services will employ high integrity seals with an interstitial barrier fluid as a contingency against fugitive emissions. Inner seal failure is to be monitored in the Main Control Room. Toxic and combustible gas detection will be employed nearby pumps in amine service. Gas detection will be provided with area alarms and annunciation of detection to the Control Room.

The remaining centrifugal pumps are in services that are predominantly water where application of standard seals is considered a reasonable barrier against airborne emissions.

Equipment in CO2 services will adhere to all design codes and requirements for such services to prevent a loss of containment. The equipment will be segregated to the CO2 Compressor Building, where CO2 gas detection will be provided with area alarms and annunciation of detection to the Control Room.

2.3 WASTE

The discharge data form in support of "Waste" from Fichtner-Gassnova document number 10112936-FI-B-CON-0248-03 is located in Attachment 1, part 3.0. This form should be referenced first and is supported with the description below.

2.3.1 Amine Degradation/Process Drains

The Kårstø CO2 Capture and Compression (CCC) plant is specifically designed to capture CO2 emissions from the Naturkraft CCPP facilities nearby. Therefore, the CCC facilities are the abatement plant for Naturkraft CCPP.

Liquid amine and process streams at any concentration will not be discharged untreated to any sewer or bodies of water as regular or intermittent waste streams.

The CO2 Capture and Compression plant is designed to optimize usage of MEA solvent degradation to minimize reclaimer residue formation. Under normal operating mode, process water, steam and intercooler condensate and stripper reflux purge liquid will be returned to the process via TK-104 supply to pumps P-109A/B to maintain a water balance.

It is expected that shutdown procedure will route all process streams to Tank TK-103 (Lean Amine) for temporary sequestering to prevent waste. Upon restart, this material can be returned to the circulating process streams without generating any waste.

There may be an infrequent requirement to dispose of sump material accumulation. As required, waste material can be pumped via P-112A/B for disposal to external facilities via tank truck. See table 2.3.1 below for risk assessment and labeling requirements of this possible effluent. Quantification of liquid waste has not been defined in modeling at this point in the FEED.

The waste composition includes the typical amine decomposition products Oxalic Acid, Acetic Acid, Formic Acid and Thiovanic Acid.

The table below depicts the outcome of Health Risk Assessment per NORSOK S-002 methodology to determine an overall worker exposure risk for handling this material.

Table 2.3.1: Potential Process Effluent Risk Assessment

Component	EU Symbol	Adjusted Risk Phrase	Risk Reduction based on Concentration (wt%)[Note 1]
Water [H2O]	--	n.a.	n.a.
Monoethanolamine (MEA) [C2H7NO / H2NCH2CH2OH]	Xn C	R20/21/22 R34	>25%
Sulfur Dioxide [SO2]	Xi	R36/37/38	<< 5%
Nitric Oxide [NO]	T C	R23/R24/R25 R34	Note 2
Nitrogen Dioxide [NO2]	Xn	R20	<< 0.5%
Ammonia [NH3]	Xi	R35	<< 5%
Carbon Dioxide [CO2]	None	None	N/A
Oxalic Acid [C2H2O4/(COOH)2]	Xi	R36/38	<< 25% [Note 4]
Acetic Acid [C2H4O2/CH3COOH]	Xi	R36	N/A [Note 4]
Formic Acid [HCOOH]	Xi	R36/38	<< 10% [Note 4]
Thiovanic Acid [C2H4O2S / HSCH2COOH] – "Thioglycolic Acid"	Xn	R20/21/22	<< 2% [Note 4]

Notes:
1. Concentration thresholds from Norwegian "Stofflisten" database for Risk phrase reductions to mitigate risk based on concentration threshold
2. Circulating concentration less than 4 ppm under normal case.
3. Maximum MEA concentration in process streams that could be routed to drain is 37.6 wt.% under normal case.
4. Maximum concentration in process streams will not exceed 0.01 wt% under normal case.

Process liquids drained to the sump will also have process water. Please refer to the Heat & Mass Balance Diagrams 25474-000-M4-CN-00001, Rev 0.

The sump liquid composition, though variable, can be assumed to be degraded amine waste. As requested in client document 10112936-FI-B-CON-0140-05, section 4.2.5, the waste product should be labeled as follows:

- T: Toxic
- C: Corrosive
- Xn: Harmful (Sensitizing)
- Xi: Irritant

- R-Phrases: R23/24/25 - R20/21/22 - R34 - R36/37/38
- S-Phrases: S9-S22-S23-S24/25-S26-S27-S28-S36/37/39-S45-S61

This initial labeling shall be validated by laboratory analysis of samples from the operating sump. All precautions and PPE required by S-phrases shall be used to mitigate risk.

A localized disamenity to workers should be considered from the potential vent emissions. Nitrogen blanketing will be considered to prevent the worker exposure. A localized disamenity to workers should be considered when removing waste from the sump by tanker truck. All precautions and PPE required by S-phrases shall be used to mitigate risk.

All requirements of Fichtner-Gassnova document 10112936 – FI-B-CON-0070-03 "General CCC Plant Requirements", clause 2.6.5 "Hazardous Waste" will be followed.

Waste from Amine Reclaimer (X-102)

During normal process operations, the amine reclaimer will not be in operation. Modeling for the composition breakdown of the sludge and duration of reclaimer operation was not available at the time of preparation of this document and its accompanying Emissions and Discharge Data Form ("3. Waste"). When the reclaimer is in operation, it is expected to produce up to 170 kg/h of "reclaimer sludge". The sludge composition is based on current research in the field of CO2 capture and is tabulated below. Table notes include the research reference for possible sludge contaminants.

The table also includes the worker and environmental risk factors based on chemical information from the Norwegian Labor Inspection Authority requirements annotated in "Guidance on administrative standards for pollution in the work atmosphere."

Table 2.3.2: Reclaimer (X-102) Waste Breakdown with Worker Health Risk Factors

Component	EU Symbol	Risk Phrase	Concentration Threshold (wt%)
Ammonia [NH3] – [CAS 7664-41-7]	Xi	R35	< 5%
Soda Ash [Na2CO3] – [CAS 497-19-8]	Xi	R36	N/A
Acetic Acid [C2H4O2/CH3COOH] – [CAS 64-19-7]	Xi	R36/38	< 10%
Monoethanolamine (MEA) [C2H7NO / H2NCH2CH2OH] – [CAS 141-43-5]	Xi	R36/37/38	< 10%
N-acetylethanolamine [C4H9NO2] – [CAS 142-26-7]	Xi	R36/37/38 R41	N/A
N-glycylglycine [C4H8N2O3] – [CAS 556-50-3]	Xi	R36	N/A
N-(hydroxyethyl)-succinimide [C6H9NO3] – [CAS 18190-44-8]	Xi	R36/37/38	N/A
N-(2-hydroxyethyl)-lactamide [C5H11NO3] – [CAS 5422-34-4]	No Info	No Info	No Info
1-(2-hydroxyethyl)-2-imidazolidinone [C5H10N2O2] – [CAS 3699-54-5]	Xi	R36/37/38 R41	N/A
N,N-diacetylethanolamine [C6H11NO3] – [CAS 71510-95-7]	No Info	No Info	No Info
Propionic acid [C3H6O2] – [CAS 79-09-4]	C	R34	<25%
N-butyric acid [C4H8O2] – [CAS 107-92-6]	C	R34	N/A
2,6-dimethyl-4-pyridinamine [C7H10N2] – [CAS 3512-80-9]	No Info	No Info	No Info

Component	EU Symbol	Risk Phrase	Concentration Threshold (wt%)
2-imidazolecarboxaldehyde [C4H4N2O] – [CAS 10111-08-7]	Xi	R36/37/38	N/A
1-methyl-2-imidazolecarboxaldehyde [C5H6N2O] – [CAS 13750-81-7]	Xi	R36/37/38	N/A
2-oxazolidone [C3H5NO2] – [CAS 497-25-6]	Xn	R22 R36 R43	N/A

Notes: From Norwegian "Stofflisten" database for Risk phrase reductions to mitigate risk based on concentration threshold

EU Symbol and Risk Phrases sourced from MSDS listings of Sigma-Aldrich Norway AS and modified as permissible under Norwegian Stofflisten based on CAS number lookup

Chemical listing depicted in the table above based on source: "B.R. Strazisar, C.M. White, Degradation of Monoethanolamine Use in Carbon Dioxide Capture from Flue Gas of a Coal-fired Electric Generating Station, (National Energy Technology Laboratory Clean Air Technology Division, undated)."

As requested in client document 10112936-FI-B-CON-0140, rev. 05, section 4.2.5, this degraded amine waste solids product should be labeled as follows:

- C: Corrosive
- Xn: Harmful (Sensitizing)
- Xi: Irritant

- R-Phrases: R34 - R22-R36/37/38-R43
- S-Phrases: S9-S16-S22-S23-S26-S36/37/39-S45-S61

A localized disamenity potential to workers and the environment is considered when removing waste from the reclaimer by tanker truck. Nitrogen blanketing is proposed to minimize the worker exposure. All precautions and PPE required by S-phrases shall be used to mitigate risk. During detailed engineering, a specialized procedure shall be developed for the pumpout operations. The use of a specialized coupling type and drip trays are proposed to minimize the possible disamenity. All requirements of Fichtner-Gassnova document 10112936 – FI-B-CON-0070-03 "General CCC Plant Requirements", clause 2.6.5 "Hazardous Waste" will be followed.

The reclaimer waste will vary due to the expected variability of the degradation products, heating value and full physical properties of the mixture cannot be quantified at the FEED stage. It is assumed that the sludge will contain approximately 20%soda ash to neutralize the acidic degradation (acetic acid) products. It is assumed that an additional 10-20% water will be required to flush the reclaimer to remove all residues during the pumping out process to tanker truck.

The expected heating value of the sludge will be in the range of 20-25 MJ/kg, as the byproducts listed in table 2.3.2 are degraded MEA reactions. It will be necessary to test sludge products for heating value using calorimetry apparatus following commissioning to identify heating value from reclaimer waste samples.

Spent Mechanical Filter Cartridges

The following equipment tags will generate filter cartridge wastes:

- F-8605 Carbon Filter (F-101) after-filter (cartridge)
- MF-106 Carbon Filter (F-101) pre-filter (cartridge)
- F-102A/B Filter Medium (cartridge)
- F-105A/B Filter Medium (stainless steel basket)
- X-101A/B/C Filter Medium (cartridge)

Due to the potential presence of monoethanolamine in circulating process streams, it is proposed that all filter cartridge media must be handled as hazardous waste. To reduce quantities, the proposed filter media can be compacted by unit workers during maintenance into closed containers for removal from site by contractor.

The filter media are candidates for incineration and potential recycling through burning in a high temperature kiln for energy from waste. The residual ash is proposed to be landfilled.

It is proposed that for F-105A/B filter baskets that a professional contractor be retained for changeout of basket filter media for in-situ chemical cleaning within a closed, portable system and subsequent effluent disposal offsite.

The drain for these filters will be routed to closed drain system to prevent release of MEA and circulating process chemicals along with any washdown before filter basket removal to reduce worker exposure.

Spent Carbon Filter Waste (F-101)

It is proposed that spent carbon media undergo sample testing for consideration of reactivation by offsite contractor and returned to site for reuse in F-101 filter. The removed material would be placed in sealed containers and sent to a facility for regeneration.

CCC Plant Sewage

In accordance with Ficthner-Gassnova Exhibit E9 Battery Limits (document number 10112936-FI-B-CON-0070-03), a sewage collection system and underground piping network shall be provided within the facilities for the CCC Plant. Sewage treatment with all corresponding plant facilities and equipment will be handled by others

outside the CCC Plant. The sewage of the CCC Plant will be delivered to the dedicated tie-in at the battery limit.

Laboratory Waste

The waste generated in an amine CO2 plant analysis lab is mainly liquid. These liquids include amine samples, titration solution, HPLC and CE waste (mainly mobile phase). This waste should be disposed of properly through a qualified disposal company and per local regulation.

The following steps should be followed through the disposal procedure in lab:

- Waste must be properly labeled with the compounds, CAS number and concentration listed
- Separate organic and aqueous wastes
- Cap waste bottles. Ensure filling doesn't cause spills
- Use waste containers no larger than 5 litre capacity
- Rinse empty containers with the proper solvent or detergent solution three times and remove or deface the container label before discarding per proper procedures

General CCC Plant Waste (Office Wastes, Recycling Program)

It is anticipated that general office wastes, worker area wastes and shop/stores wastes that are generated will be handled using recycling and disposal methods consistent with the Kårstø Site Wide waste handling program, Fichtner-Gassnova document WR1839 – "Avfallsplan Kårstø Gassprosesseringsanlegg – Waste handling procedure for the Kårstø gas processing plant" (Appendix E1.2).

2.4 NOISE

The discharge data form in support of "Noise" from Fichtner-Gassnova document number 10112936-FI-B-CON-0248-03 is located in Attachment 1, part 4.0. This form should be referenced first and is supported with the description below.

2.4.1 Noise Emissions

Flue gas blowers, CO2 compressors, building ventilation systems and the seawater pumps are the primary noise generators associated with the CCC Plant. The tie-in to the HRSG of the existing Naturkraft CCPP facility contributes noise from the outlet of the HRSG, which originates from the combustion turbine. The transmitted acoustic energy from the HRSG is combined with the in-duct noise generated by the flue gas blowers. The noise from the flue gas blowers and outlet noise from the HRSG are transmitted through the flue gas duct work, absorber shells and the stack exit of the absorbers.

The casing radiated noise from the flue gas blowers will be mitigated with acoustic lagging for personnel protection and each blower is housed in a building designed to meet the overall far-field noise requirement per Query 10112936-Q-PBFI-B-0009. The flue gas blower building's ventilation system will be designed with low-noise fans and silencers or acoustic louvers.

The flue gas duct-work radiated acoustic energy is mitigated by the flue gas duct wall and an acoustic lagging system.

The radiated acoustic energy from the absorber shell is mitigated by the absorber shell and acoustic insulation. Silencers at the absorber stack exits mitigate the in-duct transmitted noise from the HRSG outlet and flue gas blowers.

CO2 compressor radiated noise is mitigated by acoustic lagging for personnel protection and are housed in a building designed to meet the overall far-field noise requirement per Query 10112936-Q-PBFI-B-0009. The compressor building's ventilation system will be designed with low-noise fans and silencers or acoustic louvers.

Sizing of pumps and seal air fans are still pending, so the requirement for specific noise mitigation has not been quantified yet. Some of these pumps are likely not "major" noise contributors, but are included in Attachment 1.

Design and specification for noise emissions of equipment will follow the requirements in Fichtner-Gassnova documents "Exhibit E8.1 – HSE Requirements" , "NORSOK Standard S-002 -Working Environment, dated 08.2004" and "Exhibit E0 – Design Basis".

2.4.2 Intermittent Noise Emissions

The emergency diesel generator and the auxiliary boiler are both operated on an intermittent basis and will be designed to meet the overall plant far-field noise level of 40dBA.

2.5 PREVENTIVE MEASURES AND CONTINGENCY PLANS FOR ABNORMAL RELEASE

The discharge data form in support of "Preventive Measures and Contingency Plans" from Fichtner-Gassnova document number 10112936-FI-B-CON-0248-03 is located in Attachment 1, part 5.0. This form should be referenced first and is supported with the description below.

Contingency planning shall be developed and refined during detailed engineering based on overall risk evaluation anticipated during detailed engineering and further at each project stage. All contingency planning requires coordination with the main facilities owners. Descriptions of proposed FEED stage contingency planning and preventive measures are included below.

Environmental Impact Assessment (by Gassnova retained consultant) is pending; due date 12.31.2008. Contingency plans for operation and response shall be validated during detailed engineering risk assessments and studies and revised as necessary by the EPC contractor.

2.5.1 Amine Sump (TK-103) as Destination/Pumpout Contingency

All equipment drains that could contain amine during normal operation (e.g. spared equipment maintenance) are to be routed to the amine sump (TK-103). Liquid from the amine sump is arranged to be potentially returned to process (after sampling to ensure there are no contaminants) for re-use.

If sampling indicates that the sump contents are unsuitable for re-use, the sump liquid can be sent to battery limits for shipment to a suitable disposal at professional offsite facility as hazardous waste.

2.5.2 Amine Abatement as Contingency

Please refer to the Amine Abatement Study (document number 10112936-PB-P-TDO-0011) that will be prepared during FEED.

2.5.3 Water Balance as Preventive Measure

The process design and simulation seeks to maintain an overall plant water balance to prevent unplanned discharge of effluent during normal, turndown and upset operation of short duration. Tank TK-104 is available to act as a short-term buffer to allow the plant to maintain water balance with no net discharge under these conditions.

2.5.4 Sample Point Potential Release

The following minimum sample points were identified in the "Process Description" (Fichtner-Gassnova document 10112936 – PB – P – TED – 0002)

- Main flue gas duct from CCPP plant – to control the CO2 recovery rate: instrumentation for sampling will be a closed system with instrumentation reporting to the CEMs building.
- Absorber off gas to atmosphere - to control the CO2 recovery rate and for air permit reporting requirements – this system is open to atmosphere – emission rates are shown in section 2.2 above: instrumentation for sampling will be closed to atmosphere with instrumentation reporting to the CEMs building.
- Lean amine to the absorbers – to ensure that the amine concentration and quality is maintained in the system: the plan is to use a closed sampling loop with any effluent routed to the closed drain system.
- Rich amine exiting absorber – to ensure proper solvent performance and that all CO2 is removed prior to shutdown: the plan is to use a closed sampling loop with any effluent routed to the closed drain system.
- The compressor inlet – to ensure the CO2 entering the compressor will be compatible with compressor requirements – the plan is to use a closed sampling loop with any effluent routed back to process.
- Stripper overhead condenser liquid – to check contaminants recycling to the surge water tank: the plan is to use a closed sampling loop with any effluent routed to the closed drain system.
- The CO2 product stream - to ensure the product specifications are being met – the plan is to use a closed sampling loop with any effluent routed back to process.
- Sea water inlet and outlet headers – to ensure discharge quality specifications are met – this is planned to be a closed system with online monitoring of the supply and return streams as a safeguard against an exchanger leak or introduction of contaminant from the open drain system into the seawater return pit (e.g. oil, amine).
- Closed cooling water – to ensure no contaminants in the system – this is planned to be a closed system with online monitoring of the return stream as a safeguard against an exchanger leak.
- Steam condensate return lines – to ensure condensate return quality meets CCPP requirements – this is planned as a potentially open system for product sampling, with chemical analysis performed in laboratory facilities in the CCC Plant.
- Process makeup water – to ensure no contaminants are introduced to the CCC – this is planned as a potentially open system for product sampling, with chemical analysis performed in laboratory facilities in the CCC Plant.
- Amine storage tanks (concentrated and 35%) – to confirm correct amine concentration and check for contaminants – this is planned as a potentially open system for product sampling, with chemical analysis performed in laboratory facilities in the CCC Plant. Additional PPE will be required for worker safeguarding in accordance with the MSDS for MEA.

Consistent with Gassnova document 10112936FI-B-CON-0070-03, rev. 3, section 2.6.9.2 appropriate use of safe vent location via permanent piping or the use of connection to the closed or open drain system, will be considered.

2.5.5 Fire Event Drainage to Open Drain Contingency

At the present FEED stage of design, the full firewater flow requirements and fire areas have not been defined. Further study of such a dimensioning event is required and shall be studied during detailed engineering to address possible leakage sources and impact on the main open drain and sewer system of the Kårstø Site.

2.5.6 Outages at treatment plant (i.e. CO2 Capture Plant)

Under conditions where the CO_2 plant is unavailable, a guillotine damper at the main CCPP stack will close and isolate the CCC plant. The CCPP plant is anticipated to continue in operation using the CCPP stack and discharge directly to atmosphere until the CCC plant returns to service. Refer also to sections 2.5.14 and 2.5.15 for contingencies to minimize outage duration.

2.5.7 Standby and Idle Modes of Operation Contingency

While not energy efficient, the amine and CO2 compression systems can be placed on circulation for a period of time before shutdown and system rundown is necessary.

If the unit is expected to be idle for sometime, the system should be shut down according to procedures and the entire system be drained and purged.

2.5.8 Shutdown Contingency

Controlled shut down of the system is handled by slowly re-directing CCPP flue gas to the stack from the CCC facility. The amine inventory should be processed in the stripper to ensure that it is lean. Process equipment is shut down as it is warranted and safe to do so. The amine inventory should be transferred from the absorbers to the lean amine solvent storage tank (TK-102) so as to avoid oxygen contamination.

2.5.9 Pump Seal Failure

The following are pumps in services with toxic and/or potentially combustible process streams:

- P-101A/B/C – Rich Amine Pump
- P-105A/B – Lean Amine Pump
- P-110A/B – Fresh Amine Metering Pump
- P-111A/B – Lean Amine Solvent Fill Pump

- P-112A/B – Amine Waste Sump Pump

The listed pumps (other than P-110A/B) will employ high integrity seals with an interstitial barrier fluid (Nitrogen) as a contingency against fugitive emissions. Inner seal failure is to be monitored in the Main Control Room.

The operator in the Main Control Room will receive inner seal failure alarm as a first stage to intervene. Pumps are in redundant services in some cases and switchover can occur without loss of plant function. In other cases, turndown or shutdown may be instituted. This will require further evaluation during detailed engineering.

Pump P-110A/B is proposed to be a diaphragm style metering pump. This pump style is selected commonly for potentially toxic and flammable/combustible liquid service. The risk of seal leaks or fugitive emissions is eliminated from this style of pump.

In the case of catastrophic seal failure or pump leak, toxic and combustible gas detection will be deployed throughout the unit including alarming with low and high alarms and IR flame detection for rich and lean amine pumps. This is the contingency for a toxic or combustible gas release or a flaming event.

These alarms annunciate audibly and visually (see Fire and Gas Detection location diagram) and in the Main Control Room for the operator to intervene. Pumps are in redundant services in some cases and switchover can occur without loss of plant function. In other cases, turndown or shutdown may be instituted. This will require further evaluation during detailed engineering.

The facilities will employ remotely operable safety shutoff valves (operable by local hand switch and Main Control Room operator) that can positively isolate the hold up volumes of the Absorber Towers and Stripper to minimize the extent of a leak in the event of catastrophic pump seal failure connected to the bottoms of each respective vessel. These valves will be shown on P&IDs and reviewed during the HazOp study to occur later in FEED.

The remaining pumps are in services that are predominantly water where application of standard seals is considered a reasonable barrier against emissions.

2.5.10 Storage tanks – Containment and Overfilling/overflow

Storage tanks in lean or rich amine service will be provided with nitrogen blanketing as primary vapor containment and odor control. The lean and concentrated storage tanks are located in a bunded area for secondary containment

Underground sumps (TK-103 and the waste water holding tank will be provided with level instrumentation to prevent overfilling with alarms to the main control room. Secondary containment for both underground storage vessels will be provided.

2.5.11 Leaks to cooling water pipelines

All piping will follow the requirements of Fichtner-Gassnova document 10112936-FI-B-CON-0080-03 "Exhibit E3.1 Mechanical Fabrication" for material selections to combat corrosion and premature failure. Where surface protection is required for piping, the requirements of Fichtner-Gassnova document 10112936-FI-B-CON-0081 will be followed.

2.5.12 Sea Water Exchanger Leak

Sea water inlet and outlet headers will be monitored – to ensure discharge quality specifications are met – this is planned to be a closed system with online monitoring of the supply and return streams as a safeguard against an exchanger leak or introduction of contaminant from the open drain system into the seawater return pit (e.g. oil, amine). Plant operations can decide to shutdown to trace the leakage to an exchanger that could be causing the leak (e.g. E-101, E-102, E-104, and E-111) to effect repairs.

Exchangers in seawater service will be fabricated of titanium as a further mitigation against pressure failure.

2.5.13 Loss to soil from drainage network

All piping will follow the requirements of Fichtner-Gassnova document 10112936-FI-B-CON-0080-03 "Exhibit E3.1 Mechanical Fabrication" for material selections to combat corrosion and premature failure. Where surface protection is required for piping, the requirements of Fichtner-Gassnova document 10112936-FI-B-CON-0081 will be followed.

Per Fichtner-Gassnova document number 10112936-FI-B-CON-0080-03, underground metallic piping will be avoided in the design, except when use of a non-metallic material is impractical (e.g. temperature considerations). Such pipes shall be located in ducts/trenches with access for inspection and maintenance, and shall be subject to Company approval.

Buried piping shall be located below frost level. Buried piping shall be protected against overhead traffic or occasional, heavy loads. External loads due to back fill etc. shall also be designed for.

Underground drainpipes shall generally be provided with access pits at major changes of direction and at branches. In addition access pits shall be provided as required for flushing and cleaning

All buried piping shall be physically marked by the use of identification posts or cover slabs at appropriate intervals. The distance between underground pipes and cables and foundations shall allow for slopes of 1:1.5 from the lower corner of the

foundation down to the pipe or cable unless the pipes or cables are placed in ducts or culverts.

2.5.14 Gas leaks

The facilities will employ Toxic and Combustible Gas detectors to protect specific hazards, with consideration for detection (where required) for CO2, SO2, NH3, Oxygen Deficiency and Combustible Gas. These will be alarmed to the Control Room with audible and visual area alarms for outside workers and for buildings where a gas leak could expose workers or the nearby environment. Reference to the Cause and Effects charts (issued later) will show the detector action logics.

2.5.15 Oil Filled Transformers

The main transformer area will be designed in accordance with Fichtner-Gassnova document number 10112936-FI-B-CON-0120 to prevent oil contamination of surrounding ground.

Oil-filled transformers shall be supported on reinforced concrete foundations.

Provision shall be made for the catchment of oil spillage.. Owner is expected to provide appropriate measures to prevent pollution of the environment by ejected oil or other polluted water in case of fire in transformer area.

The foundation supporting the transformers shall incorporate transformer rails (when applicable) for ease of transportation and placement Transformers shall be fixed to the foundations with anchor bolts. Each transformer foundation shall be provided with slope and raised borders, enclosing an oil pit in which the oil content of the transformer can be carried in the event of an oil leak. Above the oil pit a min. 20 cm thick gravel layer on a steel grating shall be provided. The oil pits shall drain into a central oil collecting pit with integrated oil separator. The oil collecting pit shall be sized to hold the oil capacity of the largest transformer.

Attachment 1

Emissions and Discharge Data Forms

1. Planned Releases into Water

	Process Waste Water	Source	Seawater Cooling Return Header
		Discharge Point	"I-21 "Seawater Discharge Pit"

		Current	Proposed			Now	Proposed
	Discharge Depth	n.a.	Pit OSBL		pH	n.a.	No change
	Effluent Flow (m^3/h)	n.a.	15,867				

	Plans for an effluent treatment plant for the waste water?	Yes, description enclosed (SEE BELOW)	X		No	

Components	**Amount (kg) per 24 h**			**Concentration (mg/l)**		
	Now	**Proposed**		**Now**	**Proposed**	
	Mean	**Mean**	**Maximum**	**Mean**	**Mean**	**Maximum**
Sea Water (21°C)	n.a.	3.54 E+08	3.80 E+08	n.a.	n.a.	n.a.
	n.a.			n.a.		
	n.a.			n.a.		
	n.a.			n.a.		
	n.a.			n.a.		
	n.a.			n.a.		
	n.a.			n.a.		
	n.a.			n.a.		
	n.a.			n.a.		
	n.a.			n.a.		

Averaging period for mean amounts and concentrations	See "comments" below
Averaging period for maximum rates and concentrations	See "comments" below

	Will there be any intermittent releases?	Yes, description enclosed	X		No	
	Have ecotoxicity tests been run? *	Yes, description enclosed			No	X
	Have chemical analyses been made? *	Yes, documentation enclosed			No	X
	Have further measures to reduce the amounts and effects of releases been evaluated?	Yes, description enclosed	X		No	

Comments:

Data source system Heat and Material Balance (Document No. 10112936-PB-P-HMB-0001 / 25474-000-M4-CN-00001) is the basis of tabulation of effluent emission from the seawater cooling network and is based on continuous effluent from this network under normal and maximum case conditions.

* See description enclosed for details on intermittent releases and ecotoxicity data. Detailed information is supplied in Material Safety Data Sheets in Attachment 2 of Fichtner-Gassnova document number 10112936 – PB – S – HSE – 0004.