Operating and Maintenance Philosophy

CO_2 Capture Facility

Kårstø, Norway

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PAGE 1 of 9

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Contents

Operation and Maintenance Philosophy

1.0 PURPOSE

The purpose of this document is to outline the recommended operational philosophy and recommended plant maintenance philosophy.

2.0 DESCRIPTION

The Karsto CCC Project is located adjacent to the Karsto gas terminal and the combined cycle power plant (CCPP) owned and operated by Naturkraft AS. The CCC plant is owned by Gassnova SF. The CCC project's technology is based on the use of amine for the bulk removal of CO_2 from a flue gas stream by liquid chemical absorbents. The amine plant mainly consists of flue gas ducting and blowers, direct contact coolers, absorption columns, a stripper column, reboilers, reclaimer, and CO_2 compression and drying, along with other equipment such as pumps, filters, and heat exchangers.

3.0 SCOPE

This document describes the operational and maintenance philosophy for the plant.

4.0 DEFINITIONS

SOP's	Standard Operating Procedure (Prepared by Owner)
DCS	Distributed Control System
CCR	Central Control Room
CRO	Control Room Operator
OEM	Original Equipment Manufacturer
Off-line	Plant equipment which has been shut down, isolated, and de-energized
Standby	Plant equipment which is not running, but is lined up for service and may start at any time
Ready for Service	Equipment which may, after trip, shut down, or offline condition, be safely placed back into operation after having been verified by line of sight
System	Group of equipment, which combined, generally performs process function

5.0 RESPONSIBILITIES

5.1 Startup Organization.

5.1.1 The Contractor's Startup organization (Startup) has the responsibility to receive turnover of systems from Contractor's construction organization, until all systems have been turned over to Startup. Startup then commissions and places systems into service, conducts required plant operational tests, and maintains care custody and control of the systems until plant operation has been achieved and systems are turned over to the Owner's organization.

5.2 Owner's Organization

5.2.1 The Owner's organization has the responsibility to receive turnover of systems from Contractor's startup organization, until all systems have been turned over to the Owner. The Owner's operation and maintenance group will then operate the plant according to plant design specifications.

5.2.2 During the period of commissioning and startup, the Owner's operators shall support the Contractor's startup organization by operating equipment and systems, as well as performing minor or routine maintenance activities. During this period, the Contractor's startup team will provide direction with regard to these activities.

5.2.3 Once equipment and systems have been turned over to the Owner, plant operators shall operate the equipment in accordance with provided guidelines, instructions, and supplier information as available to the operator.

5.2.4 The plant engineer will provide assistance in interpreting supplier information, specifications, operating procedures, additional instructions to the operators where deficiencies in such are found, as well technical guidance in resolution of identified problems. The plant engineer will also provide guidance with respect to process details such as required chemicals, solvent conditions, as well as information on handling of various chemicals and materials involved.

5.2.5 It shall be the Onwer's organization responsibility to prepare standard operating procedures (SOP's) for the operating plant. It is envisioned that the plant engineer will produce and maintain such documents.

6.0 OPERATION PHILOSOPHY

6.1 Plant Operation and Control

6.1.1 All controls for the carbon capture plant system shall be accessible through the plant distributed control system (DCS) workstations located in the central control room (CCR). The control system shall be designed to include automatic control with interlock functions to minimize operator actions. The operator shall also be capable of manually performing startup, operation and shutdown functions, with sufficient interlocks to prevent unsafe operation. Abnormal or unsafe operating conditions

shall initiate appropriate alarms, with subsequent plant shutdown. Restart shall be by operator initiation.

6.1.2 Operation of the plant will be controlled from the main plant control room with the following key operator required actions:

a. System line up and verification of equipment "ready for service" prior to system start

b. Line up of "off-line" equipment

c. Verification of manual valve (non-actuated) positions

d. Verification of tank and vessel levels via sight glass or level gauge

e. Operator initiation of plant start after trip or from standby condition

f. Operator initiation of plant shutdown for standby (other than permissive/interlock condition)

6.1.3 The Control Room Operator (CRO) shall be responsible overall operation of the plant from the central control room. CRO duty station will normally be at the main control console in the CCR. The operator mechanics will assist with verification of system line up and equipment condition verification as required and directed by the CRO.

6.1.4 Operator mechanics shall be responsible for operation of the physical plant equipment, including system line-ups (verification of valve positions for operation), verifying readiness of equipment, placing local control equipment in and out of service, as well as taking direction from the control room operator for placement of large equipment and systems in and out of service.

6.1.5 Refer to document 25474 - 000 - J0Y - JD – 00001, Rev 0[10112936 – PB – I – PAL – 0001], "Control Philosophy," for details on process description and control philosophy.

6.2 Modes Of Operation

6.2.1 The following describe the steps taken for varios modes of plant operation:

First Startup

1. Operators to verify manual valve and equipment line-up.
2. Charge Amine Storage tank w/ MEA
3. Establish recirculation flow through the lean and rich amine flow paths
4. Establish sea water cooling flow through cooling system

5. With amine loops recirculating, begin to add MEA to bring concentration up to specification level.

6. If CCPP plant is not already operating, request plant a plant start to establish steam supply to CCC plant.

7. Allow amine solution to build temperature. Once amine is at temperature in the stripper section, initiate start of the ID fans and begin to close damper in CCPP plant stack. Initiate flue gas temperature control.

8. Allow CO2 transfer process to approach equilibrium – monitor CO2 flow to reject valve to absorber stack outlet.

9. As CO2 builds up, start CO2 compressor.

10. Initiate transfer of CO2 to the CO2 compressor suction drum (feed to compressor). Valve PV609B closes, PV690A opens.

11. Initiate CO2 sendout pumps once CO2 liquid level is established in the CO2 surge tank.

12. Balance and tune control loops to stabilize levels, flows, and total amount of CO2 stripped.

Startup After Short Downtime (hot start where CCPP plant is already running)

1. Establish recirculation flow through the lean and rich amine flow paths

2. Establish sea water cooling flow through cooling system

3. Initiate start of the ID fans and begin to close damper in CCPP plant stack.

4. Allow CO2 transfer process to approach equilibrium – monitor CO2 flow to reject valve to absorber stack outlet. Initiate flue gas temperature control.

5. As CO2 builds up, start CO2 compressor.

6. Initiate transfer of CO2 to the CO2 compressor suction drum (feed to compressor). Valve PV609B closes, PV690A opens.

7. Initiate CO2 sendout pumps once CO2 liquid level is established in the CO2 surge tank.

Startup After Longer Time (cold start where CCPP plant is already running, but shut down condition has crossed shift change)

1. Operators to verify manual valve and equipment line-up. Open dampers as necessary.

2. Transfer amine from the lean amine storage tank to fill absorber column sumps (if they have been emptied to lean amine tank).

3. Establish recirculation flow through the lean and rich amine flow paths

4. Establish sea water cooling flow through cooling system

5. Allow amine solution to build temperature. Once amine is at temperature in the stripper section, initiate start of the ID fans and begin to close damper in CCPP plant stack. Initiate flue gas temperature control.

6. Allow CO2 transfer process to approach equilibrium – monitor CO2 flow to reject valve to absorber stack outlet.

7. As CO2 builds up, start CO2 compressor.

8. Initiate transfer of CO2 to the CO2 compressor suction drum (feed to compressor). Valve PV609B closes, PV690A opens.

9. Initiate CO2 sendout pumps once CO2 liquid level is established in the CO2 surge tank.

Shutdown (planned shut down, short duration < 24 hrs, following shut down of CCPP plant) Applies to 6 hr and 24 hr CCPP plant shutdown scenarios.

1. Open damper in CCPP plant, and shutdown ID fans and spray water temperature control.

2. Initiate shutdown of the CO2 sendout and pumps and CO2 compressor. Vent valves on knockout and feed drums remain closed. Vent valve on reflux drum opens.

3. Initiate shutdown of steam to amine loop.

4. Allow amine to recirculate for approximately 1 hour to allow CO2 to off gas and minimize pockets at restart.

5. Initiate shutdown of amine loop flow.

6. Initiate shutdown of sea water cooling.

7. Close ID fan suction isolation dampers (manually from control panel).

For planned shutdown > 24 hrs, transfer absorber sump amine to the lean amine storage tank to minimize O2 degradation.

For restart, follow start after longer time [shut down]

7.0 MAINTENANCE

7.1 Operator Mechanics

7.1.1 In addition to operation duties described above and in the Plant Operating Staff Concept, the operator mechanics duties shall also include the following;

1. Maintain equipment maintenance logs
2. Collection of equipment operating data – pressure/temps/service hours/vibration spectra, etc.
3. Routine maintenance activity with regard to plant equipment such as:
    i. Lubricant maintenance (lubricant change/replenishment)
    ii. Repair of minor leaks
    iii. Small pump repair/seal/coupling replacement
    iv. Cleaning of strainers
    v. Changing of gaskets
    vi. Minor valve maintenance/seal replacements
    vii. General housekeeping

7.2 Plant Engineer

7.2.1 In addition to the duties described in Plant Operating Staff Concept, the plant engineer shall also perform the following:

1. Routine maintenance of instruments and electrical components, performing cleaning, calibration, etc.
2. Scheduling of contract maintenance for those activities plant personnel are not qualified or equipped to perform.
3. Scheduling and planning for major maintenance during planned outages

7.3 Plant Maintenance Categories

7.3.1 Maintenance described here includes planned maintenance. Unplanned maintenance and forced outages are outside the scope of this document. Unplanned maintenance and forced outages must be dealt with in a case-by-case basis.

7.3.2 In general, planned maintenance will be scheduled in accordance with Original Equipment Manufacturer (OEM) recommendations. These recommendations shall be transferred from the supplier documentation to the Maintenance List. It shall be the responsibility of the Plant Engineer to maintain and update the list with requirements as deemed appropriate by experience gained during operation.