Constructability Report

CO_2 Capture Facility

Kårstø, Norway

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1.0 PURPOSE

The purpose of this document is to outline the recommended construction 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, 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 report addresses the construction methods and sequences of operations required to safely construct the CCC processing facilities.

4.0 DEFINITIONS

4.1 FREP (Forming, Rebar, Embeds, and Placement) – The sequence of operation for constructing concrete structures. The installation of concrete forms, rebar, embeds and the placement of concrete.

4.2 SPMT (Self Propelled Motorized Transporter) – A heavy haul vehicle used to transport large heavy loads.

5.0 RESPONSIBILITIES

5.1 Construction Organization.

5.1.1 The Contractor's construction organization has the responsibility for the project management of the construction site.

5.2 Owner's Organization

5.2.1 The Owner's organization has the responsibility to oversee the Contractor's construction operations.

6.0 CONSTRUCTABILITY REPORT

6.1. Construction Approach

6.1.1 Zone 1 – Stack Tie-in

The Karsto CO2 Capture and Compression Plant work scope is sub-divided into three discrete construction zones. Zone 1 scope consists of existing plant modifications and new construction work within the Naturcraft Power Plant. Also, Zone 1 encompasses the flue gas ductwork system routed over to the (2) absorber vessels. Zone 2 includes all construction activities from the absorber vessels up to the compressor building, and Zone 3 consists of the compressor building.

Working within Zone 1 will entail performing construction operations within the operating Naturcraft Power Plant, as well as, constructing adjacent to the existing plant. Consequently, the overall construction approach will require different methodologies within and adjacent to the operating plant.

The critical path for Zone 1 is located within the operating Naturcraft Power Plant at the stack tie-in. Construction of the tie-in must be completed during the designated 4 week outage window. Hence, the key factors from a constructability standpoint will be to minimize the scope of work required during the limited outage window. This will be achieved by planning and scheduling the majority of work as pre-outage construction activities.

Within the vicinity of the Naturcraft's flue gas stack, the overall construction approach can be characterized as stick built with some pre-assembly. The majority of work surrounding the stack will be planned and scheduled as pre-outage work. This approach is driven by the fact that the majority of the construction work will need to be accomplished prior to the plants scheduled outage. Furthermore, this pre-outage work will need to be accomplished while the power plant is in full operations. Thus, one objective of this constructability study was to ensure that no operations disruptions occurred during pre-outage construction. These pre-outage activities will be accomplished as detailed in following sections.

The first priority will be to identify any existing equipment adjacent to the stack that will require relocating and/or temporarily rerouting. This would also include identifying any underground utilities that may interfere with the new installations. A case in point is the potential interference between the CEMS building and the new support structure for the stack. Early in detail design a determination will need to be made as to the available options. An added concern that will have an impact on constructability is the limitation of loads on existing undergrounds. Crane selection will be influenced by load limits, as well as, access restrictions. Refer to Appendix "B" Pre-Outage Month 1.

Early within the pre-outage civil phase, localized excavations and FREP activities for stack support structure foundations, damper support foundations, and ductwork support foundations will be performed. These excavations will be evaluated for earth retaining/support systems, as well as determining what access restrictions are created for plant operations. Excavation equipment will be selected with load limits and access restrictions in mind. See Appendix "B" Pre-Outage Month 3. All surveying and site control work will use a project-specific coordinate system transposed from the existing plant monument system.

After the civil work is accomplished, structural steel erection will commence. The pre-outage phase will include erection of the stack support structure. See Appendix "B" Pre-Outage Month 4. A constructability review of the erection sequence indicates that the lower elevations of this steel may necessitate stick building. Large pre-assembled sections will be difficult to maneuver around the operating equipment on the south side. Stick building the lower elevations will help minimize any safety risks. At elevations above the existing equipment pre-assembled sections will be considered. Man lifts will be used to the maximum extent possible to minimize congestion created by scaffolding. On the north side, temporary removal of the existing stair tower will be evaluated. Refer to Appendix "B" Pre-Outage Month 2 for stair tower location. Detailed design will determine if the stair tower removal is required. After the flue gas tie-in structural framing is completed, the steel will be torqued down in preparation for the seat connection to the stack. It will be during the four week outage that the structural seat connection supports will be welded to the stack wall.

Along with the stack support structure, the guillotine duct dampers are critical pre-outage installations. The dual dampers will isolate the upstream ductwork from any flue gas once the stack tie-in is completed. These isolation dampers will permit construction activities to continue within the ductwork once the outage is completed.

The pre-outage phase will consist of erecting several steel tower structures. This will include main tower structures for the ductwork pony bride adjacent to the dampers. The pony bridge will support the ductwork over the Naturcraft control/maintenance facility. The west end of this ductwork will connect to the guillotine dampers on the upstream side. It is recommended that connecting this ductwork to the dampers be completed prior to starting the stack tie-in. This will permit a testing period to ensure that the dampers are leak tight. See Appendix "B" Pre-Outage Month 5.

Two steel bridges (deck truss type) will carry the ductwork that transverse 45 degrees onto the site and along the fence line. One deck truss bridge will share the tower support with the pony bridge. As detail design commences engineering and construction will assess the potential for maximum modularization. One option under consideration is to set each steel bridge first, and then install the ductwork. Construction will coordinate with the Naturcraft operations group to address the safety hazards and constructability challenges associated with erecting over top of the existing Naturcraft facility. A detailed rigging execution plan will be prepared for each of these scopes of work. Refer to Appendix "B" Pre-Outage Month 8.

Since Zone 1 comprises the ductwork and fans up to the absorber vessels. Once the 45 degree deck truss bridge and ductwork are set, the remaining ductwork is considered within the fence boundary of the site. Since this scope of work is within the site boundaries, it is not considered essential pre-outage work.

As soon as all pre-outage construction activities are completed, the focus will shift to preparation for the outage scope of work. The outage activities will take place within a 24 hour / 7day per week schedule in the following sequence.

Following the shut down of the Naturcraft power plant, the seat connection supports for the flu gas tie-in structure will be installed and welded to the exterior stack wall. Once completed the new structure will support the upper stack loads. This will permit breaching of the east side of the stack wall.

At this point, cutting for the new gas path holes will commence. Templates will be used to mark the locations of the gas path holes (approximately 80), and the holes will be flame cut. A rigging plan will be prepared to safely remove the cut sections down to grade. In parallel with the cutting operation, welding of a new frame for the ductwork transition piece will commence. The frame will be a welded connection to the stack and a bolted connection to the ductwork. In parallel with the cutting operation, welding of the new frame for the ductwork transition piece will commence.

As soon as the frame has been welded, the new transition piece will be rigged into position between the stack frame and the guillotine dampers. The transition piece will be connected via bolts to the stack frame, and temporarily supported until the last section of duct is installed. Once the last section of duct is installed, and all testing completed then the outage scope is considered complete. The guillotine dampers will serve as the isolation point between the operating power plant and the CO2 plant construction. See Appendix "B" Outage.

6.1.2 Zone 2 – Amine Plant

In parallel with the pre-outage work taking place within Zone 1 the construction of Zone 2 (Amine Plant) will commence. The boundary of Zone 2 starts at the absorber towers and incorporates all site equipment except the Compressor Building.

Immediately at mobilization all deep excavations will begin within Zone 2. Excavating for the major tower foundations, sea water pipe, storm water pipe, sump pits (amine and waste water), and electrical trenches will be the primary focus. The size and depth of each will require rock blasting operations. Blasting will commence within the first 2 months after mobilizing, and all blasting will be reviewed with Gassnova and Naturcraft operations. Detailed blasting procedures will be prepared and coordinated with operations. Appendix "A" Month 1 & 2 provides a visual representation of the blasting operations.

In parallel with rock blasting activities, the layout of underground utilities will commence. The fire water piping will be located above the rock layer and excavation for the fire water loop will be scheduled around blasting operations. Construction personnel will be evacuated from the site prior to any explosive detonation activities. Once blasting has been completed the installation of sea water piping will begin. The pipe will be installed starting from the absorber towers and finishing at the sea water cooling pumps. A study will determine if the pipe can be wrapped at grade and lowered into the trenches in sections. All testing will be performed prior to backfilling. Refer to Appendix "A" Month 3 for underground pipe installation details.

As sea water pipe backfilling progresses away from the absorber towers, then the major civil activities in Zone 2 will commence. This includes the installation of the north side electrical cable trench systems. These trenches will be designed for HS-20 loading at road crossings and the trenches are candidates for pre-casting.

FREP (Forming, Rebar, Embeds, and Placement) activities for the Absorber #1 foundation will begin at this time. See Appendix "A" Month 4. Delivery of the absorber and stripper towers will be on critical path. Therefore, the preparation of the foundations will be key milestone activities. Utilizing pre-assembled rebar cages, pre-assembled forms and anchor bolt templates will help accelerate these activities. FREP for Absorber #2 and the Stripper foundations will follow immediately after.

Additionally, the civil phase will include FREP activities for the electrical building/transformers, and flue gas blower foundations. Completion of the building is requisite in order to begin cable pulling. Refer to Appendix "A" Month 6.

In this phase, the FREP activities for the south pipe rack footers will begin. These footers will be designed to permit a SPMT (Self Propelled Motorized Transporter) to deliver a modularized pipe rack section between the footers, and permit setting of the rack columns directly over the anchor bolts. The modularized rack temporary bracing will be designed to permit unrestricted removal of the SPMT after setting the rack. See Appendix "A" Month 7.

Once the absorbers, stripper and flue gas blower #1 foundations are complete, the FREP activities will shift to foundation work for the flue gas blower #2, amine storage tank/sump pits, compressor building, control building, east-west pipe rack footers, and area slabs around the stripper. In parallel, erection of the structural steel for the electrical building commences, and FREP activities for the west ductwork bridge supports will be started. This sequence provides sufficient area and crane travel space to erect and position the heavy lift crane for setting absorber#2 tower and flue gas blower #2. Refer to Appendix "A" Month 8.

Delivery of the absorbers and stripper towers will be via heavy shipping vessel to Gassnova's Jetty#1. The towers will be off-loaded using the ships heavy lift cranes, and set on the SPMT for transport via the module transport road. Once on site, the towers will be positioned at the heavy lift staging areas. Each tower will be evaluated to determine the extent of ground pre-assembly that can be performed. Installation of tower access platforms/ladders and riser piping will be candidates for ground assembly. The degree of assembly will depend on the crane plans. Detailed crane rigging plans will be performed as design matures.

The sequence of heavy lifts will occur as follows:

1. Absorber #2
2. Stripper
3. Flue Gas Blower #2

4. Truss Bridge and Ductwork for the 45 Degree Transverse Section.

5. Absorber #1

6. Flue Gas Blower #1

7. South Ductwork Bridge to Flue Gas Blower #2

8. East Ductwork Bridge between Flue Gas Blower #1 and #2

9. North Ductwork Bridge to Flue Gas Blower #1

Once absorber#2 and flue gas blower#2 are set, then the truss bridge and ductwork attached to blower#2 can be installed. This would be followed by setting the west truss bridge. These bridges and ductwork will be lifted and set as modularized sections. At this point, the crane would be relocated to the north side of absorber#1. See Appendix "A" Month 9 and 10.

Absorber#1 would be delivered to the heavy lift staging area, and final ground assembly would be completed. Using a heavy lift crane and tailing crane the tower will be set on absorber#1 foundation. Setting of the flue gas blower#1 would follow. The final heavy lift in this area will be the bridge and ductwork which connects to blower#1. This will permit the mechanical/electrical phases to start on the west end. Refer to Appendix "A" Month 10.

Upon completion of the heavy lifts, the pipe rack modules will be transported from temporary storage to the site. The South Pipe Rack will be sequenced from a west to east direction. The Middle Pipe Rack will be sequenced from a north to south direction, and the East Pipe Rack will be sequenced from a west to east direction. These pipe rack modules will be delivered and installed with the SPMT. One exception will be the platform frame surrounding the stripper. This frame will require stick building. The frame supports the reboilers, reclaimer, overhead condenser, and reflux drum. The equipment will be inserted onto the platform frame during steel erection. Following steel erection the installation of large bore piping and electrical will start. See Appendix "A" Month 11 and the Pipe Rack Sequence drawing.

When all civil work is completed within the amine storage area the lean amine storage tank erection begins. Wall sections will be used to minimize field welding activities. The amine storage tank will be fabricated off-site and installed as a single unit. The pumps for the waste water and amine sumps will be erected and piping and electrical tie-ins made.