Concept Occupational Health Impact Assessment

CO_2 Capture Facility

Kårstø, Norway

0	20.11.2008	Issued for Comment	SBR	DA			
Rev.	Date	Reason for Revision	By	Check	App	App	

Bechtel Power Corporation

Job No. 25474

Document No.	Rev.
25474 - 000 – U0Y - 0000 – 00003	0

GASSNOVA

Project No. - Originator - Disc Code - Doc Type - Serial No.

10112936 – PB – S – HSE – 0008

Contents

1.0 INTRODUCTION

It is the intention of the Norwegian Government to develop a carbon dioxide capture and compression (CCC) project in association with an existing 420 MW gas-fired combined cycle power plant (CCPP), which is located in Kårstø, Norway.

The CCC facility will recover at least 85% of the CO2 contained in the flue gas from the CCPP and deliver liquefied CO2 to the battery limit of the facility. This is a new, proposed process plant to be located within an existing facility.

During the design cycle and through construction, commissioning and operation of the CCC facilities, working environment impact and risk assessments are to be developed that will make it possible to design out the hazards to workers in the plant areas to provide efficient, safe and healthy workplaces and reduce the need for modifications during operations.

To optimize the project design, it is necessary to consider technological solutions to prevent unacceptable working environment risks for planned tasks that are foreseeable and reasonable.

NORSOK Standard S-002 Working Environment provides a framework and guidance in the preparation of a "Concept Working Environment Impact Assessment".

This narrative should be read in conjunction with the Working Environment Area Charts (WEACs) for the CO2 Capture and Compression facilities. Reference should be made to Fichtner-Gassnova document number 10112936-PB-S-HSE-00XX "Concept Health Area Charts".

2.0 DEFINITIONS AND ABBREVIATIONS

In addition to the definitions and abbreviations provided in NORSOK S-002, the following definitions are applicable in this assessment:

Project Development is the full lifecycle of the project from concept definition through to operation, including concept selection, FEED, detailed engineering (or "engineering", construction, mechanical completion, commissioning and operation

WEIA is modified in this document to be synonymous to Occupational Health Impact Assessment

WEAC is modified in this document to be synonymous to Occupational Health Area Chart

Concept Definition/Selection/Optimization are defined as pre-FEED engineering and project development activities

During Engineering is defined as synonymous to detailed engineering activities

Construction is considered to define the construction phase of the project development cycle

3.0 SCOPE OF ASSESSMENT

Per NORSOK S-002 "Working Environment", clause 4.4.2.0-1, the plant Working Environment Impact is to be assessed during project development cycle and through construction, commissioning and operation.

NORSOK S-002, clause 4.4.2.0-1 states that a concept Working Environment Impact Assessment (WEIA) shall be performed during the concept selection phase to identify installation areas and vendor packages that need particular attention during design development and to provide input to concept selection and validation of the selected concept.

Further, it states that the concept selection phase WEIA shall be updated during concept definition and optimization/FEED, to summarize WE aspects of the selected concept as input to detailed engineering. NORSOK S-002 indicates that WEIA shall include [sections] 4.4.3 to 4.4.10 and the resulting extent of relevant analyses shall be based on qualified identification.

A concept WEIA from the concept selection phase has not been furnished to Bechtel as an input for FEED for Bechtel to update. This assessment will proceed on the assumption of such a document being unavailable. This assessment is considered a FEED level assessment as qualified by NORSOK S-002.

Fichtner-Gassnova document number 10112936-FI-B-CON-0331-06, the Contractor's Document Requirement list shows the following FEED deliverables deleted:

- Detail and General Drawings (based on 3D model);
- Occupational Health Risk Analysis (Job Hazard Analysis, Chemical Health Risk Assessment, Comparison Risk Analysis);
- Ergonomic Analyses (Task Analysis, CRIOP, Valves and Instrument Access and Operability);
- Occupational Health Design Review Report;
- Blast Load Calculations (buildings, equipment, structures);
- Explosion Simulation Report (input to DAL spec. and structural design);
- Establish the Hazardous Area Zoning Requirements for all CCC Plant equipment;

- Material Handling (cranes, hoists, etc.);
- Illumination Design Philosophy;
- Typical Graphic Display drawings;
- Alarm Management Narrative.

NORSOK S-002 stipulates that the Working Environment Impact Assessment shall include the elements outlined in clauses 4.4.3 through 4.4.10 inclusive and the resulting extent of analyses shall be based on qualified identification.

With some documentary requirements deleted from the original FEED package requirements, the assessment that follows will be qualified where available information is limited or where deletions from the FEED deliverables limit assessment, as required.

Working Environment Area Charts (WEACs) have been prepared for specific work areas (FEED Stage) to address reasonable and foreseeable working environments (WE). The form depicted in NORSOK S-002, Annex E, "Working Environment Area Chart" was used to document the WE review.

The impact assessment that follows below intends to address the following potential problem areas:

- Accidents and musculoskeletal injuries when handling heavy materials;
- Important issues regarding arrangements of permanent access and transportation routes, lay down areas, and material handling of equipment > 1000 kg (heavy equipment) or where routine handling of items may exceed 25 kg in mass;
- Exposure to cold stress/wind chill in open and semi-open areas. This assessment will use data from Fichtner-Gassnova document number 10112936-FI-B-CON-0240-03, Appendix E1.1 "Meteorological Conditions";
- Storage and handling of hazardous substances, including an initial framework for Chemical Health Risk Assessment for use in detailed engineering;
- Storage of bulky equipment and materials, (e.g. containers, scaffolding);
- Noise and vibration-emitting equipment and areas with noisy activities adjacent to quiet areas. The basis of this assessment will the Noise and Vibration Assessment (Fichtner-Gassnova document number 10112936-PB-S-HSE-0012);
- Solitary work in permanently manned areas.

In the assessment that follows, there are instances where Working Environment Area Charts (WEACs) are referenced to access additional information or detail specific to a working environment. This information is available in "Occupational Health Area Charts" (Fichtner-Gassnova document number 10112936-PB-S-HSE-0007).

4.0 WORKING ENVIRONMENT ASSESSMENT

4.1 JOB HAZARD/RISK OF OCCUPATIONAL INJURIES & ERGONOMICS/PREVENTION OF MUSCULOSKELETAL STRAINS AND INJURIES

Sections 4.1.1 and 4.1.2 below provide general exposure assessment for risks to Musculoskeletal and Repetitive Strain Injuries (MSIs/RSIs). Detailed information for each Working Environment in the CCC Plant can be found in Attachment 1.

4.1.1 JOB HAZARD/RISK OF OCCUPATIONAL INJURIES

As outlined in section 3.0 above, Job Hazards Analyses have been deleted from FEED scope for completion.

The Occupational Health Area Charts in Fichtner-Gassnova document 10112936-PB-S-HSE-0007 (i.e. Working Environment Area Charts) provide baseline exposure information for potential worker injury by Working Area. The charts include relevant information by area in relation to the following types of injury exposures:

- tasks associated with:
  - unit operation;
  - equipment and installation repair/maintenance;
  - material handling;
  - waste handling/housekeeping activities;
  - personnel traffic/walking
- risks of severe injury or fatality due to:
  - moving parts of machinery (Technical Appliances);
  - trapping/entanglement (Technical Appliances);
  - falling to a lower level (elevated work – platforms, piperacks);
  - sliding/stumbling/collision (walkways, vehicle movement);
  - ejected materials (pressure failure);
  - fire/explosion;
  - energized equipment exposures (not taken to zero energy state by lock-out/tag out deficiencies)
  - toxic/corrosive chemicals (preliminary Chemical Risk information)
  - asphyxiation/confined spaces

The preparation of WEACs resulted in twenty-nine (29) identified working environments for the CCC Plant. Where evaluation of the respective working

environments has highlighted a need for formal Job Hazards Analysis, this is documented on the WEAC for that work area. Elements for consideration in JHA studies and preparation during detailed may apply the information on the WEACs to facilitate and expedite JHA documentation.

In accordance with NORSOK S-002, section 4.4.3.0-1, during detailed engineering, the risk of occupational injuries must be further analyzed and compared to the risk acceptance criteria in the WE program.

4.1.2 ERGONOMICS/PREVENTION OF MUSCULOSKELETAL STRAINS AND INJURIES

As outlined in section 3.0 above, formal Ergonomics Analyses have been deleted from FEED scope for completion.

The plant design shall accommodate NORSOK S-002 Annexes B and C for equipment access. The 3D model reviews during detailed engineering milestones will review arrangements for compliance with all regulations, codes and standards. Additional access, equipment and lifting hardware may be required.

The assessment that follows qualifies areas of concern by work environment and/or tasks that present an increased risk of Musculoskeletal Strains and Injuries (MSIs) to workers. The principles outlined in NORSOK S-002, clause 5.2 are used for hazard identification and qualification.

Detailed working environment assessment information is provided in Attachment 1. The following general Ergonomics and Injury Risks may apply to various working environments in the CCC Plant:

Slips, trips and falls:

Outdoor CCC Plant access roads are designed with worker walkways for transit within the process unit area and between buildings. This is considered to be a seasonal risk from low to low-moderate and highly dependent on weather for exposure to MSI's.

Snow clearing efforts are further defined in section 4.8 below. Priority should be given to clearing for emergency services access for personnel safety and egress.

Building layout, clearances and walkway spacing are not fully defined at FEED stage documents. ISO and NORSOK standards requirements must be met regarding material selections (e.g. flooring), illumination and spacing and sizing for corridors and walkways within buildings. Indoor MSI exposure from personnel movement is considered low.

Slipping Hazards due to oil spills under normal operating conditions is considered a credible scenario surrounding all pumps applying fixed bearing lubrication systems. The major sources of spills are identified:

- Flue gas blowers
- CO2 Compressor stages
- CO2 Sendout pumps

Where routine tours to these areas identify a developing problem, collection of the oil using absorbents is appropriate. Standard practice should be to trace the source of the leak and correct the problem immediately. Where the condition is deemed minor, the problem should be monitored and addressed during the next scheduled maintenance cycle unless the problem progresses to an unmanageable extent.

Access and clearances for performance of tasks:

All sample points are to be placed at easily accessible points, ideally at grade or from an elevated platform accessible by ladder. Sampling will use "grab sample" type sample bombs. Sample bomb installation and valve operation, while repetitive, poses no greater than a low exposure to MSI/RSI injuries.

Exposure to MSI's from climbing platform access stairs or ladders is considered low to moderate. Proper design of corrugated steel stair treads and platforms and handrail placement mitigates the stair risks.

Ladders must adhere to ISO and NORSOK design requirements. Fall arrest equipment may be required in certain circumstances. In such instances, specialized training and equipment will be required.

Location of work functions (displays, control actuators, manual valves, etc.)

Manual valves (intended for routine operation), valve actuators and field instrument displays and controls (including hand switch operators) are to be placed at easily accessible points, ideally at grade or from an elevated platform.

Large valves should be provided with pneumatic or motorized actuators or manual reduction gear operators to mitigate MSI/RSI injury risk.

Exposure to MSI's from climbing platform access stairs or ladders is considered low to moderate.

View conditions / Identification of additional task lighting or working limitations;

General area illumination requirements are identified on the respective WEACs for each working environment.

Specific work task may require the use of task lighting to improve worker safety conditions. These are identified on specific WEACs for environment limit requirements for illumination, including additional task lighting and specific requirements.

Repetitive movements that expose workers to Repetitive Strain Injuries (RSIs)

Under normal operations, the plant runs automatically, with no planned process or compression plant operations that present credible risk to RSIs.

During maintenance or repairs, work planning should consider worker rotation of tasks to reduce the potential for strains. The major areas of concern for the CCC Plant relate to RSIs for hands, wrists, elbows, knees/ankles and lower back.

Activities that require consideration are:

- Implementation of lock-out/tag-out during entry into a facility shutdown/scheduled maintenance where a systematic isolation effort is necessary;
- Bolting/Unbolting activities (e.g. manway opening, blanking/blinding);
- Manual material handling in central stores (shelf storage of parts);
- Ladder usage in central stores area (part shelves access);
- Laboratory Activities (manual agitation work);
- Office Work (computer workstation);
- Machine Shop hand tool/small power tool usage;
- Instrumentation/Electrical Shop fine detail work.

Manual handling

Small parts (e.g. fasteners, o-rings, gauges, etc.) will most likely be stored in shelving units in a controlled are of the main stores. This is considered a low risk of MSI.

Parts up to 25 kg may be manually handled by workers and/or moved into the field manually for maintenance activities (e.g. small motor, electrical or instrumentation parts). This is considered a low to moderate risk of MSI based on correct lifting technique and the provision of adequate equipment (e.g. trolleys or hand carts) to safely move such hardware between the storage/laydown area and the installation/usage location.

Filter cartridges and carbon filter replacement activities are considered a moderate exposure to MSIs, as filter cartridges could easily exceed 100 kg in mass and covers to

access filter elements or carbon beds will be bulky. Consideration in the design for lifting hardware that can be moved into position as a worker aid for filter/media replacement can mitigate this risk. This exposure is present once every six months.

Sedentary work

Sedentary standing or sitting work can lead to muscle fatigue and strains. The following areas present an increased (low to moderate) risk of worker injury due to such working environments:

- Work in laboratory area where technicians are anticipated to perform tasks where considerable concentration and fine detail work is required.

  Task and ergonomic studies in detailed engineering should be completed. Use of specialized furniture should be considered to assist workers in maintaining efficient seated positions.

- Work in offices; administrative and supervisory staff could be sitting for extended periods with computer usage. These are considered lighter work duties, but present the low to moderate potential for RSIs and muscle strain/eye strain.

  Ergonomic evaluations should focus on selection of ergonomic workstation design to increase worker comfort. Workflow should promote regular informal breaks that permit workers to relax and consider performing stretching to reduce muscle stiffness or strains and eye strain.

- Control Room Technicians are considered a Critical Safety element in the safe operation of the CCC Plant. Maintaining a comfortable working environment that promotes a relaxed seating position, reduced eye strain and provisions to maintain visual contact with control system displays while seated or standing are of critical importance for evaluation during detailed engineering.

  Workstation design must comply with all codes and standards for display (VDU) selection and information content and presentation, refresh rates and annunciation. Workstation design must accommodate two (2) control room operators to maintain full

  Task and ergonomic studies in detailed engineering should mandate the coordination and timing of work to permit regular formal breaks that permit workers to relax and consider performing stretching to reduce muscle stiffness or strains and eye strain. Use of specialized furniture should be considered to assist workers in maintaining efficient seated positions.

- Main shop, electrical/instrumentation shop work with moderate to high detail work presents a moderate exposure to back/neck strain, eye strain.

  Task and ergonomic studies in detailed engineering should focus on the coordination and timing of work to permit regular formal breaks that permit

workers to relax and consider performing stretching to reduce muscle stiffness or strains and eye strain. Use of specialized furniture should be considered to assist workers in maintaining efficient seated positions.

Main stores material handling equipment

The CCC Plant is design with a full stores area located in the Control/Shop/Stores Building. The full building layout had not been completed at the time of assessment.

Based on the types of equipment present in the CCC Plant, spare parts on hand will likely include electric motors of various sizes, pipe section, instrumentation and electrical parts, pump parts (e.g. casings and impellers) that would exceed 25 kg in mass. As well, a wide variety of smaller supporting parts for the facility (e.g. belts, couplings, fasteners, studs, etc.) are expected.

Warehouse operations are expected to include the use of lift trucks and small cranes to facilitate movement of larger equipment. However, there will likely be the use of ladders and/or stairs to provide rack and shelf access to parts and components. Manual picking will likely occur.

There exists MSI potential from lifting (both due to mass approaching 25 kg and poor lifting technique), stretching/reaching (due to less than optimal storage layout), slips/trips/falls (ladder work, floor maintenance/housekeeping) and back injury. These will require examination that is more careful during detailed engineering.

Commissioning/Shutdown Activities

Bulk storage of equipment, following construction, should only occur during annual maintenance or a full plant turnaround event. At this time, bulk material handling involving both manual pick and place and the use of equipment is anticipated.

To mitigate the risk of MSIs to personnel at this time, as part of pre-planning to a shutdown and turnaround, a training refresher should be completed for each worker involved in the shutdown and particular attention paid to material handling techniques, site rules regarding worker activities and roles and responsibilities.

4.2 ERGONOMICS/HUMAN FACTORS IN WORK SYSTEMS

4.2.1 Human Factors Assessment

NORSOK S-002 defines the assessment requirements for Human Factors during FEED stage evaluation. It states that analyses shall be performed to ensure that the design complies with main objectives and philosophies, and minimizes the potential for human error in work systems that control safety-critical activities on the installation, and to enhance the system's capacity for recovery from incorrect actions.

Consistent with NORSOK S-002 guidance for evaluation during FEED, the working environment assessment activity is to include :

- A functional analysis and allocation describing functions to be performed, defining system performance requirements, and allocating manual and/or automatic functions.
- A task analysis defining tasks based on allocated functions, and defining requirements (time, cognitive demands, etc.) for operator tasks, including information needed and the interface devices necessary to handle these tasks.

Fichtner-Gassnova document number 10112936-FI-B-CON-0331-06, the Contractor's Document Requirement list shows the following FEED deliverables deleted:

- Ergonomic Analyses (Task Analysis, CRIOP, Valves and Instrument Access and Operability);
- Typical Graphic Display drawings;
- Alarm Management Narrative.

4.2.2 Function Allocation/System Performance Requirements

An assessment of allocated functions for operators in the Control Room (CCR) is provided below. The functions described below are conceptual and subject to change during detailed design depending on the Distributed Control System, Emergency Shutdown System and Fire and Gas Detection systems selected.

The Human Machine Interface (HMI) must include a main operator interface in the CCR, supplemented by a Critical Action Panel (CAP) to ensure manual operability of critical safety functions. The HMI in the CCR must ensure operator situational awareness of process conditions and drive appropriate actions during upset conditions or emergencies.

NORSOK I-002 recommends using Petroleum Safety Authority YA711 for the design of alarm systems. The fundamental principle regarding the HMI in the CCR is that every alarm must be accepted to ensure the operator has read and understood the alarm message.

The allocation of functions cannot result in the overload of the operator or create an expectation of response time that is not feasible or achievable. NORSOK I-002 specifies the following performance requirements for system time response must be met (based on a 1 second cycle time):

Operator command	2 sec. for acknowledgement of alarms on the operator station (measured from operator action until acknowledgement is observed on the operator VDU).
Operator command	2 sec. from command to field action (measured from operator action until output card/channel has reached new state).
Closed loop control	Max. 2 sec. from input to output action, i.e. from input signal/ IO module to output signal/ IO module (measured at I/O card terminals). For special control functions, shorter cycle time may be necessary in order to fulfill function requirements.
Alarm display text	2 sec. from alarm limit is reached.
Picture update	Max. 2 sec. to complete picture on call up for picture containing 100 variables (dynamic objects).
Picture dynamic update	Max. 2 sec. for dynamic objects on picture to show input state/value (measured from input signal I/O card terminals until dynamic point shows same state/value).
ESD initiation from F&G	Max. 4 sec. from confirmed F&G detection to activation of ESD outputs (measured from F&G input signal is in alarm state until ESD outputs are activated).

The overall system architecture is depicted in the "SAS Architecture Diagram", drawing number 25474-000-JD-JD-00001 / 10112936-PB-I-DRW-0001, Revision 0.

4.2.3 Function Allocation/System Functions

The general requirement of the HMI interface in the CCR is to maintain the attending operators with the following safety systems and/or functions:

- Process safety systems and Process Shutdown (PSD);
- Emergency Shutdown System (ESD);
- Fire and Gas detection systems;
- Ignition Source Control (e.g. low voltage system lockout on confirmed 2ooN combustible gas detection);
- Heating, Ventilation and Air Conditioning Systems performance and interlocking;

- Public Address, alarm and emergency communications networks;
- Emergency power and lighting grid;
- Fire fighting systems;
- Closed Circuit TV systems for unit visual monitoring.

The DCS provides direct detailed control of the CO2 Kårstø facility. This is accomplished by:

- Direct manual control of system prime movers such as pumps and blowers,
- Direct manual control of system final control elements such as control valves and on/off valves,
- Direct monitoring of system instrumentation such as pressure transmitters, flow measurements, and temperature elements,
- System alarm annunciation,
- Protective interlock logic, and
- Automatic control of most final control elements and system prime movers.

Manual control is provided for most final control elements to allow the operator to take direct control of an upset condition. Manual control is also useful for troubleshooting, startup, and shutdown purposes. Interlock logic prevents the operator from creating an undesirable operating condition that could endanger personnel safety or cause equipment damage.

Automatic logic is used to execute routine corrective action on the system prime movers and final control elements, freeing the operator to focus on the overall plant condition.

The DCS and PSD systems are located on a common network. These systems are connected to the ESD and F&G systems. The ESD and F&G interface capabilities are outlined below.

The DCS is connected to external systems such as the CCPP, Kårstø Gas Plant, and Storage facilities. These interfaces allow for selected alarms and status signals to be communicated between the CCC plant control room and the other control rooms at the Kårstø facility.

The DCS is also connected to the plant network. This interface allows viewing of plant status and retrieval of historical data by authorized external users.

The PSD shuts down equipment in case of an abnormal operating condition. The PSD functions are initiated automatically if any monitored parameter exceeds the allowed value. Dedicated sensors and outputs are used for initiating a process shutdown.

The PSD system status is shown and alarms are annunciated at the DCS operator stations in the control room.

The ESD provides emergency shutdown of equipment in case of major spill, fire, etc. The operator manually initiates emergency shutdown via pushbutton in the control room or via the DCS operator station. If the ESD system is activated, manual reset is required prior to restarting the unit.

The ESD system status is shown and alarms are annunciated at the DCS operator stations in the control room

The two Operator Stations are located on a console in the control room. Text occurring on the operators Video Display Units (VDUs) related to normal operations will be in Norwegian. The Operator Stations present plant information to the operator by displaying dynamic process graphics. Process graphics are pictorial representations of the process.

Operator Stations are designed to collect and efficiently display important information about The CCC Plant processes. They also allow the operator to select a particular process system or component with the mouse for control. Extensive use of pop-up graphic windows allow the operator to select equipment operation states.

4.2.4 Automatic Functions

The purpose of the Safety and Automation System (SAS), a DCS based system, is to automatically control and monitor plant equipment and processes in a safe and efficient manner. The DCS accomplishes these goals by performing the following general functions:

- Enforces protective logic for individual devices, providing safe and orderly shut down of abnormally operating equipment.
- Supervises and controls normal operation of individual devices, freeing the operator to attend to abnormal operating conditions.
- Gathers, organizes, and presents dynamic plant process information to the control room operator, empowering the operator to make informed operating decisions.
- Records data continuously for analysis, troubleshooting, and diagnostics.
- Directs operator commands to the proper individual device, allowing the operator to manipulate the process intuitively.

- Accommodates changes to its architecture and programming, facilitating plant improvements.
- Documents plant operating information, providing data from which plant engineering can make informed improvement decisions.

There are additional functions that are communicated to the HMI for operator information.

The Plant Historian receives and records selected input, output, and calculated values from the data highway. This data can be organized into configurable reports, and dumped to the printers. Data is readily available for trending purposes from any operator station.

A video monitoring system (CCTV) is provided for monitoring relevant areas of the CCC Plant. The CCTV is connected to the DCS and its displays are available to the operator as part of the human machine interface and shown as windows within the large display unit or on the operator stations.

The PSD system automatically shuts down discrete equipment, a system, or the CCC Plant, in a safe and controlled manner, in the event of abnormal operating conditions, which could cause permanent damage to the plant, endanger human safety or exceed operating limits to the detriment of plant life.

The F&G is largely an alarm system, but it is also able to take certain actions other than activating remote or local area alarms devices, like shutting off HVAC systems on gas detection, etc. in case of fire or gas and spill detection

4.2.5 Manual Functions

The provision of a Control Room Critical Action Panel (CAP) ensures manual operability of critical safety functions.

An Auxiliary Panel, containing emergency trip pushbuttons for the ESD, is located in the custom console next the operator station. ESD functionality is triggered manually by the operator based on information available through the HMI.

Two more panels (Critical Action Panels) are provided for status display, manual activation and reset of the ESD and F&G systems. The action panels are mounted in the CCR next to the large screen display.

A Large Screen Display unit is mounted in the CCR for additional supervision and monitoring of the process as a supplement to the operation stations.

The ESD system will essentially actuate the appropriate PSD sequence(s) plus de-energize necessary electrical equipment and depressurize the unit (e.g. CO_2

compression system) in a safe manner. The ESD functions are manually initiated by the operator, usually as the result of a fire, major spill, combustible gas detection, etc.

4.2.6 Additional Functionality to Plant Engineer

The EWS performs all of the functions of the operator station. In addition, it allows the engineer to edit the master configuration residing on the engineer station and load it into the controllers. The EWS also can edit the master process graphic configurations, residing on the engineer stations and download it to each operator station. The engineer also accesses the IMS server, domain controller, and interface servers via the EWS.

4.3 HAZARDOUS CHEMICALS

4.3.1 Chemical Impact Assessment Details

NORSOK S-002 provides guidance for the assessment activities related to worker exposure to hazardous chemicals over the project development. Assessments are expected to increase in detail as the project progresses.

Per NORSOK S-002, activities defined for assessment during concept definition and optimization/FEED are:

- Identification of major chemical emitting sources;
- Possible enclosure of sources is evaluated,
- Potential for localization of high emitting sources in relation to permanently manned work areas is performed,
- The need for storage areas is defined.

During detailed engineering. Clauses 4.4.6.0-10 through 4.4.6.0-17 further define chemical hazards assessment activities that shall be undertaken.

During construction/commissioning, NORSOK S-002, clause 4.4.6.0-18 further defines chemical hazards assessment activities that shall be undertaken.

An initial suggested framework for Chemical Health Risk Assessment (CHRA) is provided in Attachment 1 for input to the formal CHRA during detailed engineering. This includes a detailed listing of chemicals that are present in the process plant portions of the CCC Plant. The chemical listing provides a detailed breakdown of the Occupational Exposure Limits mandated by Norwegian law under the "Merkeforskriften" chemical listings, as well as risk reductions allowable per the Norwegian chemical database "Stofflisten".

4.3.2 Identification of Major Chemical Emitting Sources

Normal Sources

Absorber Towers:

The Absorber Towers (MV-101/MV-102) are the only source of emissions normally open to atmosphere that present a credible worker exposure on an ongoing basis. The exhaust stacks from the absorber towers will emit a vapour stream that will appear as steam venting. The exhaust composition has been modeled as:

Table 4.3.2.1: Absorber Tower Effluent to Atmosphere

Component	Concentration (ppmv)
Oxygen	131,744
Nitrogen	769,164
Water Vapour	84,533
Carbon Dioxide	5,753
Sulphur Dioxide	0.1
MEA	2.94
Argon	8,794
NO	3.25
NO2	0.53
NH3	4.1

Based on the concentrations of CO2, and NOx compounds, the worker platforms at the tops of the absorber towers should be treated as a restricted space. Additional PPE requirements will be required if the platforms must be accessed while the unit is in operation.

Once dilution into the atmosphere occurs, worker exposure at lower platform levels and at grade within the CCC Plant and OSBL should not exceed the DLI 361 regulatory requirements of 1/3 of the OEL for CO2 and NOx.

Main Laboratory:

Will involve routine work by trained technicians will require the use of various reagents, chemicals, gases and cryogens. The possible listing and precautions that should be applied are shown in table 4.3.2.1:

Table 4.3.2.1: Laboratory Reagents

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

Technicians should follow all precautions tabulated above and work under mechanically ventilated conditions as required to minimize exposure. All required PPE for body and eye protection must be observed. Under such conditions, exposure should not exceed the DLI 361 requirements if all precautions are followed.

Abnormal Sources

Under normal plant operation, the emission sources listed below will be closed to atmosphere or present no credible worker exposure. However, under a leakage case or

loss of containment, occupational chemical exposure could occur that requires a response. The considered worker exposure dangers are toxic flue gases (CO2, NOx predominantly), MEA and its degradation byproducts, CO2 in gaseous and liquid forms, amine wastes.

Pump Seals:

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

- MP-101A/B - Rich Amine Pump
- MP-105A/B - Lean Amine Pump
- MP-106A/B - Flash Drum Pump
- MP-108A/B - CO2 Product Sendout Pump
- MP-110A/B - Fresh Amine Metering Pump
- MP-111A/B - Lean Amine Solvent Fill Pump
- MP-112A/B - Amine Waste Sump Pump
- MP-124A/B -- Rich Amine 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 Control Room.

The operator in the 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 a 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.