ERVIA CCS PRE-FEED STUDY

Process Control & Safeguarding Philosophy- Dublin

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HOLDS	Description	Responsibility
N/A		

Glossary

Term	Definition
CCR	Central Control Room
CCS	Carbon Capture and Storage
CCGT	Combine Cycle Gas Turbine
C&E	Cause and Effect
CPF	Central Processing Facility
DCS	Distributed Control System
EDP	Emergency Depressurising
ESD	Emergency Shutdown
ESDF	Emergency Shutdown Facility
ESDV	Emergency Shutdown Valves
FEED	Front End Engineering Design
F&G	Fire & Gas
HMI	Human Machine Interface
HAZOP	Hazard and Operability
ICSS	Integrated Control and Safety System
IEC	International Electro technical Commission
I/O	Input/Output
LOPA	Layer of Protection Analysis
PFD	Process Flow Diagram
PLC	Programmable Logic Control Panel
P&ID	Piping and Instrumentation Diagram

PFP	Passive Fire Protection
RTU	Remote Terminal Unit
SIF	Safety Instrumented Function
SIL	Safety Integrity Level
SIS	Safety Instrumented System
SDV	Shutdown Valves
TSO	Tight Shut-Off
UCP	Unit Control Panel

References

1. Ervia CCS Pre-FEED Study, MDE 1234-RPS-01-DX-RP-Z-0001
2. IEC 61508- Functional Safety of Electrical / Electronic / Programmable Electronic Safety Related Systems
3. IEC 61511- Functional Safety – Safety Instrumented Systems for the Process Industry Sector
4. Communications & Control Philosophy – Dublin, MDE1234-RPS-01-DX-RP-Z-00013
5. Control System Architecture Diagram - MDE1234-BEC-03-DX-DR-E-0001

1 INTRODUCTION AND SCOPE

1.1 Project Background

Ervia is assessing how Carbon Capture and Storage (CCS), located close to large-scale CO_2 emitters can play a role in reducing Ireland's CO_2 emissions. A technical feasibility study on the potential for large-scale CCS in Ireland was completed by Ervia in 2020.

The general location of Poolbeg Power Station in Dublin was selected for a Central Processing Facility (CPF) for liquefaction, storage, and export of CO_2 overseas via a new marine jetty. The CPF will cater for CO_2 captured at 3 emitter locations (Dublin Waste to Energy (Covanta), Poolbeg Power Station and ESB Dublin Bay (Synergen) CCGT). A new CO_2 gas pipeline gathering network will transport CO_2 from the emitters to the CPF.

Ervia has appointed RPS / Bechtel to carry out a Pre-FEED study that involves a detailed assessment of the key CPF, pipeline and storage infrastructure necessary to condition, compress, transport and store liquid CO_2 at Dublin Port for subsequent loading onto ships for export. (Note: The scope of this project does not include the carbon capture facilities at each emitter).

1.2 Scope

The scope of this document is to define process control, process safeguarding and emergency shutdown philosophy for Ervia Dublin CCS project.

2 ICSS AND OVERALL SAFEGUARDING PHILOSOPHY

The basis for this philosophy is that all systems installed will be connected to a single Integrated Control and Safety System (ICSS). The ICSS shall be installed with separate DCS (Distributed Control System), SIS (Safety Instrumented System) and F&G (Fire & Gas) System. The ICSS shall control, monitor, shutdown and safeguard the plant. It is a single operating window for SIS, DCS and F&G.

The SIS system shall be SIL rated and independent from the DCS. It shall be a standalone intelligent unit with smooth interface (without lag) to the DCS system for monitoring only. The DCS enables the plant to operate safely and efficiently as per design. The intent is to avoid abnormal conditions via process control rather than initiating a Safety Instrumented Function (SIF). ESD functions are implemented via the Safety Instrumented System (SIS), which is a high integrity safety instrumented programme electronic system with functions dedicated to emergency shutdown, depressurisation and automated trips known as Safety Instrumented Functions (SIFs). Each SIF is designed and tested to meet its target SIL.

Safety Instrumented Functions (SIF) shall be developed on the basis of this philosophy and as defined on the Piping and Instrument Diagrams (P&IDs) / Cause and Effect (C&E) Diagrams.

Safety Integrity Level (SIL) assessment reviews of PFDs, P&IDs and C&E diagrams, shall be performed as per IEC 61508, IEC 61511 methodology to define the SIL rating to each SIF. SIL assessment will be performed in detail engineering.

All proposed SIFs that are rated SIL 1 or above shall be implemented as a SIF in the SIS System. Any proposed SIFs rated as SIL 0 (not considered a SIF) shall be implemented in the DCS.

2.1 Emergency Shutdown Philosophy

SIS shall be provided for situations where rapid isolation of an uncontrolled release is necessary to shut-off source that could lead to toxic release, vapour cloud or feed a fire.

When an unsafe scenario occurs, the emergency shutdown procedure shall be employed. To avoid a facility wide cascade shutdown and to allow the Operations team sufficient time to deal with any potential hazard / unsafe conditions, the lowest shutdown in the hierarchy level (i.e Level 1) shall be activated first. The next shutdown level shall be activated by Operations team should the hazard develop beyond the control of the Operations team. Trip in one train / item of equipment should not shut down other facilities on higher hierarchy level. Details will be shown on C&E diagrams and P&IDs. C&E diagrams will be developed in detail engineering.

This method of operation is preferred over immediate facility wide cascaded shutdowns since it can avoid lengthy and potentially unsafe facility wide re-starts.

3 EMERGENCY SHUTDOWN SYSTEM

To reduce the impact of a hazard, the ESD shall be designed to bring the facility to a safe, predetermined shutdown condition via SIS. The SIS shall be designed to implement safe and dependable emergency shutdown of the process and utility systems and their associated equipment in order to prevent the development of a hazardous condition, which may be caused by a process upset or by an external event, such as fire or gas leakage. The operator shall generally initiate emergency shutdowns for external events, except in certain cases, specified on P&IDs / C&E diagrams, where ESD may be automatic.

The objective of ESD is to establish a safe shutdown system of process operations and equipment by detecting any abnormal or unsafe process condition, either manually or automatically isolating flammable/toxic inventories and energy based on abnormal condition or equipment conditions within the facility.

The ESD will shutdown, isolate and enable depressurisation and/or evacuation of inventory in the event of an abnormal process or equipment condition to prevent the situation escalating. Once an emergency situation is detected by the ESD system, the SIS will take the necessary action to drive the process to safe condition, by equipment or section isolation, tripping of equipment and/or depressurisation.

The ESD system shall be designed to provide remote manual (operator initiated from matrix panel) or automatic shutdown.

Control function shall be developed based on this philosophy and as detailed in the P&IDs / C&E diagrams.

Below are some abnormal conditions that would require remote manual or automatic shutdown, the conditions which would operate shutdown automatically are shown on P&ID's (others would require manual ESD initiations):

- Loss of containment
- Flammable/toxic gas release
- Fire & Explosion
- Instrument air failure
- Power failure
- Utility failure
- Process upsets
- Machinery fault
- Worsening weather

The main purposes of ESD are:

- To protect people
- To protect the installed facilities and equipment (to protect the assets)
- To protect environment
- To maintain plant availability / continuity of production
- To prevent event escalation

When a SIF has been initiated, the SIF shall act independently within the required response time to:

- Detect an abnormal or unsafe process condition and log the event.
- Automatically react to such conditions with shutdown or isolation of equipment, as appropriate.
- Enable the operator to manually initiate emergency shutdown in response to external events, such as fire and/or gas leakage, when required.
- In certain cases, as specified on the P&IDs and C&E diagrams, to automatically depressurise equipment to the vent stack.

Shutdown functions shall be limited to those required for safety, based on the upset condition detected. The final SIFs determined in detail engineering shall be limited to those identified and documented during the HAZOP/ LOPA reviews. The main production process shall not be interrupted unnecessarily. If any section of the process has to be stopped, then it shall be left in a condition that facilitates a timely restart, provided that this condition is consistent with the safety of the plant.

The actual course of action to be taken by SIF, in response to its initiator(s), shall be in accordance with the C&E diagrams / P&IDs.

Safety Integrity Level (SIL) assessment reviews with LOPA shall be performed to assign a SIL rating to each SIF. The SIL assessment procedure has the primary function of ensuring acceptable protection to personnel in the event of potentially hazardous situations and the secondary function of providing protection against environmental damage or economic loss due to damaged equipment or interrupted production. The SIL rating allocated to each SIF will, to a large extent, define the initiators and final elements for that SIF and the maintenance, proof testing and documentation procedures to be adhered to.

Levels of protection will be provided to reflect the relative severity of the hazardous event. In addition to the high level ESD functions which close-down the overall facility or trains, plant protection shall also include lower level ESD functions which will shutdown particular items of equipment.

The ESD and EDP shall be executed in SIS, however the SIS will interface directly with the DCS to transfer information to the operator via the DCS HMI.

In general, shutdowns shall cause the affected systems to be blocked in and isolated from other systems, or process areas, where upset conditions have not occurred, and pressure is retained.

Depressurisation of the blocked-in systems shall be initiated manually by the operators from the EDP hand switches/push-buttons located on ESD/EDP panel in the control room. Based on the C&E diagrams / P&IDs, depressurisation of the system shall be provided based on Risk Assessment and standard practices.

Emergency depressurisation uses the same dedicated instrument logic as the SIS and operates on dedicated depressurisation valves.

In the event that depressurisation of a gas system is required on detection of a confirmed fire or accidental gas release for example, the operator can initiate the depressurisation using the individual hand-switches dedicated to each depressurisation valve. Initiation of depressurisation shall activate the associated sectionalisation by the associated ESD valves and on confirmation of the closure of the ESD valves, depressurisation will be carried out by opening of the EDP valves.

If necessary, the operator shall be prevented from depressurising a Sub-Unit or Section, if it overloads the vent stack. Alternatively, it may be necessary to use interlocks to delay initiation of depressurisation from more than one Sub-Unit/Sections. The requirement to inhibit the opening of blowdown valve shall be determined based on the finalised relief and blowdown information developed during detail engineering.

3.1 Emergency Shutdown Philosophy

ESD levels shall be categorised as below:

- Level 1 – Equipment or local shutdown
- Level 2 – Train or sub-system shutdown
- Level 3 – Facility Shutdown

Emergency Shutdown is achieved by one of the following ways:

- Level 1 – Automatically or manually
- Level 2 –Automatically or manually via pull-buttons
- Level 3 – Manual via pull-buttons

3.1.1 Level 1 – Equipment or Local Shutdown (Safety Trips)

Level 1 shutdown provides inventory containment for individual process equipment within the system and/or prevents damage to individual equipment items.

Level 1 shutdowns shall be initiated automatically by the SIS or can be initiated manually from the operator interface via DCS HMI console or ESD/EDP panel.

Level 1 shutdown can also be initiated manually in special cases, e.g. rotating machinery, toxic inventory. For Level 1 shutdown, manual initiation will be available from the DCS HMI console also. Manual Initiation from DCS console shall be followed by a confirmation message prior to activation. The shutdown of vendor packages will be from DCS and ESD and developed as per the vendor guidelines and process requirements, details will be developed during detailed engineering. For electrical drivers of large and complex rotating machinery (e.g. large pumps or compressors), the shutdown shall be implemented by the vendor supplied SIS and its shutdown logic may involve more actions than tripping only the driver, e.g. also closing ESD valves. These facilities are in addition to local normal stop controls.

In case of Inventory Isolation at equipment, if there is a rotating machinery downstream of the valve, the C&E diagrams shall ensure that the machinery is not incurring any damage during shutdown, (e.g. SIS stops pump and after a time delay closes upstream isolation ESD valve). Closing time of such ESD valves to be agreed with the rotating machine (compressor, pumps etc.) vendor.

An alarm shall be generated in the DCS and repeated in the field only for the critical package items (as recommended by the package vendors) for Level 1 shutdown.

An ESD Level 1 will not automatically lead to a higher level shutdown. In many cases an equipment shutdown will occur to prevent escalation of an abnormal event and will allow sufficient time for the operator to take mitigating action to prevent a higher level shutdown of the unit or train.

A Level 1 shutdown is initiated either by higher levels of shutdown or by equipment protective trips designed to place equipment in an operational safe condition.

Level 1 is activated manually or automatically by individual safety trips.

Level 1 does not affect other units or processes.

It should be noted that, the SIS integrates package units for upset conditions. On detection of fire, or gas-release, an alarm generated in the DCS/F&G System will alert the operator that a manually initiated shutdown action may be required depending on the level of gas leakage or fire coverage.

Manual shutdown initiation shall be available for all levels of shutdown. The Manual activation shall be either hardwired physical buttons in the Central Control Room (CCR) or via package PLC UCP and/or in the field.

3.1.2 Level 2 – Train or Sub System Shutdown

A Level 2 shutdown is activated to prevent the scenario that may lead to a hazardous situation to the train or Sub-Unit. Level 2 will also be activated by Level 3. Level 2 can be activated manually via pull-buttons located in CCR at matrix panel.

A Level 2 shutdown shall automatically:

- Effect isolation of the Sub-Unit at its boundaries (and isolate sections within the Sub-Unit), by the closure of the associated ESD valves. Confirmation of the ESD valve position is permissive to depressurisation.
- Initiate all Level 1 shutdowns of packages and individual items of equipment within the Sub-Unit boundaries.

A Level 2 shutdown is initiated for the following events:

- High High Level (2LIT-11024) in Refrigeration Compressor Suction KOD (V-2111) initiates Train 1 ESDP.
- High High Pressure (2PIT-11026) at Refrigeration Compressor (X-2111A/B) initiates Train 1 ESDP

- High High Temperature (2TIT-11027) at Refrigeration Compressor (X-2111A/B) discharge initiates Train 1 ESDP.
- High High Temperature (2TIT-11045) at Refrigeration Compressor Aftercooler (E-2112) discharge initiates Train 1 ESDP.

3.1.3 Level 3 – Facility Shutdown

An ESD Level 3 shutdown (ESDF) is the highest level of shutdown for the overall facility. A Level 3 shutdown can be initiated manually via pull-button, that shall be installed in the CCR. High High Pressure at PIT-01008 closes 1XV-01003 A/B and initiates ESDF.

A level 3 shutdown shall initiate the shutdown of the CPF.

A Level 3 shutdown shall automatically perform all Level 2 shutdowns, as described in Section 3.1.2, above.

3.1.4 Operating Modes

A number of different process operating modes may be involved for some process units, for example, loading, unloading, gaseous CO_2 from emitters to CPF, air drier package regeneration. During development of the C&E diagrams consideration shall be given to the potential effect of these different operating modes, which may require the SIS to activate different groups of shutdown valves when operating in different modes. To cover this situation, if it occurs, provision will be made in the CCR for selection of the appropriate ESD at different operating modes.

3.1.5 Vendor Packages

The vendor packages will be addressed on the same basis as individual process units, and as such can be shutdown by:

- Automatic internal trips,
- Automatic external process upsets that cause trips
- Automatic as part of a Level shutdown
- Automatically or manually as part of a Level 1 or Level 2 shutdown
- Manually as part of Level 3 shutdown.

3.2 Emergency Shutdown Valves (ESDVs)

Provision of Emergency Shutdown Valves (ESDVs) shall be provided in accordance with sectionalisation of the facility and as shown on P&IDs.

ESDVs are provided for isolation of equipment/plant due to activation of ESD (including loss of power, loss of air, fire or manual shutdown etc).

ESDVs shall be designed as per Project specification of Actuated On-Off valve to be developed during detailed engineering.

All ESDVs shall be fail to close. Exceptions to the fail position rules may apply for vendor packages or any other process reasons. Critical ESDVs will have air accumulator. P&IDs will cover ESDVs that need to be provided with air accumulator.

The ESDVs are to be reset manually from the field or from independent valve reset in DCS HMI operator console after all trip conditions associated with ESD valves have been normalised. Exceptions to the resetting

philosophy of the ESD valves may apply for special cases determined by the process engineer or the package vendor. Unless otherwise stated in the logic narrative or diagram, DCS interlocks will be automatically reset when all the abnormal conditions are cleared. Reset will be automatic, plant start-up will be operator initiated.

Control valves in general shall not be used for ESD service. In certain cases, to meet SIL verification, control valves may be used for ESD service with written approval from the OWNER. In case of an SIS trip, any control valve that is used for ESD service shall be put into the safe position by means of a solenoid valve that is wired to the SIS and is independent of the DCS system. At the same time the DCS logic shall put the controller, that drives those control valves, into manual and force the output to the corresponding safe trip position. For DCS controlled valves that are located on the same line as an ESD valve, on ESD actuation, the DCS logic shall be initiated to put the controller into manual mode and force its output to the corresponding safe trip position. On restart of the process, the operator will give output to the controller to gradually open/close the control valve prior to being put back to automatic control.

The ESD and EDP valves shall have open and closed limit switches wired to the SIS for the ones which are being used as permissive to ESD logics. e.g. confirmation that the isolation ESD valve is closed prior to opening the EDP valve for depressurisation.

The ESD/EDP valve limit switches shall be used to generate discrepancy alarms transmitted to DCS that will alert the DCS operator when an SIS command is opening (closing) the ESD/EDP valve, but the status of the valve open (closed) limit switch is not confirmed.

3.3 Emergency Depressurisation Functionality

3.3.1 Individual depressurisation valve

Each depressurisation valve shall have EDP hand-switches (selector type) located at DCS HMI console and the ESD/EDP panel. Both set of EDP hand-switches shall be connected to the SIS. The detailed philosophy on the operation of these hand-switches, including permissive to open, overrides of the permissive, additional push-buttons, shall be determined in detailed engineering.

Emergency depressurisation valves do not require logic resets. The ability to close these valves manually from the local or the individual EDP hand-switch in CCR or individual valve reset switches in DCS (in case multiple EDP valves are operated as part of one EDP logic) should always be available, in order to prevent depletion of the complete gas inventory during depressurisation.

All EDP valves shall be usually fail to open, unless operational or environmental requirements or other constraints suggest otherwise. All EDP valves shall be provided with volume bottle (air accumulators) to avoid inadvertent simultaneous opening of all EDPs in case of air failure.

3.4 Fire and Gas System

The purpose of the Fire & Gas System (F&G) system is to detect fire or gas hazards to provide early warning to personnel for taking appropriate action to avoid event escalation. The Fire & Gas detection system for this facility will mainly be for leaks of asphyxiant CO_2 or toxic ammonia. Smoke detectors will be provided inside buildings.

The F&G systems shall be SIL rated and independent from DCS and SIS. It should be a stand-alone PLC based system with interfaces to both ESD (for trips) and DCS (for status).

On confirmed detection of fire or gas, the system shall automatically generate a plant general alarm.

The facility shall be divided into fire areas (or zones). Inputs from F&G system may be used to determine the sequence for sequential blowdown.

3.5 Emergency Shutdown System Reset

ESD systems should not be designed to auto-reset, i.e. the outputs remain in the trip state until a reset command is given. Reset should be manual after all relevant permissives are cleared. If a field reset is required, a DCS reset should also be required prior to enabling the field reset.

Process permissives do not allow for a process sequence to start (e.g. start-up, depressurisation, purging) unless the permissives are satisfied. They usually involve valve limit switches. For instance, the suction valve confirmed open limit switch allows the pump to start or a limit switch that confirms the ESD valve is closed allows the depressurisation to begin.

The logic for any of the permissive conditions related to the SIF resides in the SIS. Process permissives do not initiate trips but inhibit operator actions when they are not met.

Start-up overrides shall be implemented as documented on the C & E diagrams.

Maintenance overrides are not allocated to process permissives. Maintenance overrides shall be provided on input elements to enable testing and maintenance of I/O without interrupting the process.

4 PROCESS CONTROL AND SAFEGUARDING

This section provides the process control narrative and shutdown philosophy for CPF. The equipment tag numbers throughout this process control narrative and safeguarding are indicative for one liquefaction train (Train 1). Train 2, 3, 4 and 5 control narrative and shutdown philosophy are analogous to Train 1.

4.1 Refrigeration/Liquefaction

4.1.1 Process Control

- Gaseous CO_2 from pipeline from emitters is let down across pressure control valve (2PV-01007) in the CPF.
- Total flowrate is measured using flow transmitter (2FIT-01006) and is equally split across three liquefaction trains. Pressure measured in the pipeline using pressure transmitter (2PIT-01006) upstream of 2PV-01007 provides an input to flow control valve (2FV-11006) to increase or decrease the flowrate depending upon the flow rate from the emitters.
- Liquid CO_2 temperature downstream of chiller (E-2111) is controlled by varying the refrigerant flowrate to chiller using expansion valve (2TV-11011).

4.1.2 Safeguarding

- ESDF- Initiation of ESDF closes 2XV-01003 A/B and Train 1, 2, 3, 4 and 5 ESDP.
- ESDP1 - Initiation of Train 1 ESDP closes 2XV-11001, 2XV-11013 & 2TV-11011, and trip Refrigeration Compressors (X-2111A/B).
- ESD-01-001 - High D/P (2PDIT-01005) inhibits opening of 2XV-01003 A/B.
- ESD-01-002 - High High Pressure at PIT-01008 closes 2XV-01003 A/B and initiates ESDF.
- ESD-11-001 - High D/P (2PDIT-11002) inhibits opening of 2XV-11001.
- ESD-11-002 - High High Temperature (2TIT-11012) at CO_2 chiller (E-2111) outlet closes 2XV-11001 & 2XV-11013.
- ESD-11-003 - High High Level (2LIT-11024) in refrigeration compressor suction KOD (V-2111) initiate ESDP1 (TRAIN 1 ESDP).
- ESD-11-004 - High High Pressure (2PIT-11026) at refrigeration compressor (X-2111A/B) initiate ESDP1 (TRAIN 1 ESDP).
- ESD-11-005 - High High Temperature (2TIT-11027) at refrigeration compressor (X-2111A/B) discharge initiate ESDP1 (TRAIN 1 ESDP).
- ESD-11-006 - High High Temperature (2TIT-11045) at refrigeration compressor aftercooler (E-2112) discharge initiate ESDP1 (TRAIN 1 ESDP).
- ESD-11-007 - Low pressure at 2PIT-11015 closes or inhibits opening 2XV-11004 and 2HV-11016.
- ESD-11-008 - Low Low Liquid level at 2LIT-11040 stops refrigerant storage drum pump (P-2301).
- ESD-11-009 -High High Liquid level at 2LIT-11040 stops refrigerant storage drum pump (P-2301) and closes 2HV-11046.

4.2 Refrigeration Storage System

4.2.1 Process Control

- Anhydrous ammonia is stored in the Refrigerant Storage Drum (V-2301). Anhydrous ammonia is off-loaded from a truck to the Refrigerant Storage Drum (V-2301) using on-truck pumps. The Refrigerant Storage Drum Pump (P-2301, 1 x 100% Intermittent) transfers ammonia from the Refrigerant Storage Drum to receiver (V-2112) using hand control valve (2HV-11046). The receiver (V-2112) can be de-inventoried using Refrigerant Storage Drum Pump (P-2301) using hand control valve 2HV-3014.
- Anhydrous ammonia is stored at ambient temperature in the Refrigerant Storage Drum (V-2301). As such, the vessel is designed to handle the change in vapour pressure associated with the change in ambient temperature. However, excess pressure generated in the Refrigerant Storage Drum (V-2301) due to heat ingress or during truck unloading may be vented to the vent stack via pressure control valve (2PV-03004).

4.2.2 Safeguarding

- ESDF – Initiation of ESDF trips P-2301 and closes 2XV-03015.
- ESD-03-001 - High High Pressure (2PIT-03011) closes 2XV-03010 and 2XV-03001.
- ESD-03-002 - High High Liquid Level (2LIT-03002) closes 2XV-03010 & 2XV-03001 and trips P-2301.
- ESD-03-003 - Low Low Liquid Level (2LIT-03002) trips P-2301.

4.3 Storage and Ship Loading

4.3.1 Process Control

- The liquid CO_2 is sent from chiller (E-2111) to CO_2 Sphere (V-2201 A/B/C) on back pressure control using 2PV-02002A/B/C. During start-up, a small slip stream on flow control using 2FV-02003A/B/C enters the CO_2 spheres from the run-down header using spray nozzles to cool the spheres with a gradual temperature change.
- Each CO_2 Export Pump (P-2201 A/B) is furnished with a flow control valve (2FV-02012) on the pump discharge. CO_2 Export pump is also furnished with a minimum flow bypass valve (2FV-02006) to maintain the pump minimum flowrate. CO_2 Export Pump flow set point is manually set.
- The cooldown line flow set by 2FV-02043 is returned back to the CO_2 Sphere (V-2201 A/B/C).
- Pressure controller (2PV-02004A/B/C) on the blanketing gas from the CO_2 pipeline maintains the pressure of the CO_2 spheres (V-2201 A/B/C). An overpressure vent valve (2PV-02013A/B/C), operating on a separate controller, vents gaseous CO_2 to the atmosphere to mitigate high pressure control excursions.
- The boil off gases from CO_2 spheres (V-2201 A/B/C) and the ship loading system are sent to boil off gas compressor package (X-2201 A/B) on pressure control using 2PT-02025. The boil of gases are compressed and recycled to CO_2 gas pipeline at the inlet of the CPF.

4.3.2 Safeguarding

- ESDF- Initiation of ESDF closes 2XV-02005/02015/02016A/B/C,2XV-02026A/B,2XV-02029A/B and trips X-2201A/B, P-2201A/B, and initiate ESDL
- ESDL - Jetty transfer arm movement outside preset limits or manual initiation will initiate shutdown of loading/unloading operation and close jetty side XV. Upon verification of closure of PERC will release the loading arm.

- ESD-02-001 A/B/C - Low Low Liquid Level (2LIT-02017A/B/C) closes 2XV-02005A/B/C and trips P-2201A/B.
- ESD-02-002 A/B/C - Low Low Temperature (2TIT-02018A/B/C) closes 2XV-02005A/B/C, 2XV-02016A/B/C, 2XV-02063A/B/C, 2XV-02021A/B/C & trips P-2201A/B, and X-2201A/B.
- ESD-02-003 A/B/C - High High Pressure (2PIT-02019A/B/C) closes 2XV-02020A/B/C, and 2XV-02015A/B/C.
- ESD-02-004 A/B/C - Low Low Pressure (2PIT-02019A/B/C) closes 2XV-02005A/B/C, 2XV-02016A/B/C, 2XV-02063A/B/C, 2XV-02068A/B/C, 2HV-02069A/B/C, 2XV-02021A/B/C & trips P-2201A/B, and X-2201A/B.
- ESD-02-005 A/B - High High Pressure (2PIT-02033 A/B) closes 2XV-02026A/B, 2XV-02029A/B and trips X-2201A/B.
- ESD-02-006 A/B - High High Temperature (2TIT-02034 A/B) closes 2XV-02026A/B, 2XV-02029A/B and trips X-2201A/B.
- ESD-02-007 A/B/C - High High Level (2LIT-02017A/B/C) closes 2XV-02020A/B/C.

4.4 Instrument Air

4.4.1 Process Control

The instrument air header pressure is controlled by a pressure control valve. Low pressure at the air supply header will automatically start standby air compressor and drier package. Air compressor and drier package (X-2901 A/B) configuration is 2 x 100%.

4.5 Nitrogen

4.5.1 Process Control

The primary source of gaseous nitrogen will be provided via gaseous nitrogen cylinders from third party. The nitrogen header pressure is controlled by a pressure control valve.

4.6 Storm Water

4.6.1 Process Control

Storm water will be collected in storm water retention sump which has a hydrocarbon interceptor. Any contamination of surface water will be captured in the hydrocarbon interceptor for off-site disposal at an authorised disposal facility. The clean storm water will be discharged to storm water discharge location using storm water retention sump pump. High level in storm water sump will start the pump and low level will stop the pump.

4.7 Utility, Potable and Fire Water

4.7.1 Process Control

Utility, potable and fire water will be supplied from the local mains supply based on level control on the respective tanks.

Two firewater jockey pumps (P-2801 A/B) will maintain the required pressure in the fire water ring. One pump will be kept on auto mode which will start/stop based on fire water header pressure. The other pump will be on

standby mode. In case jockey pump fails to maintain the required pressure in fire water ring main, electric driven water pump (P-2802) to start. In case, electric driven fire water pump fails to start or required pressure does not built up, diesel driven fire water pump (X-2801) to start.