HyNet North West

VERTEX HYDROGEN

# HyNet Hydrogen Production Plant 1 – Technical Note

## EPR RESPONSE – 10a – Availability and Reliability

### Summary

Problem Statement

BAT for reliability and availability.

Identify key equipment and systems that are critical to avoiding emissions during other than normal operating condition and explain how you have designed or will design, operate and maintain these to ensure they are reliable and available, including providing installed back-up equipment, where necessary.

### Response

Submission Provided in Environmental Permit Application

| Considerations & Guidance |
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| *Environmental impacts of equipment or systems being unavailable should be identified, with the need for redundancy, buffer storage, etc. considered.*<br>*Such impacts within the facility could include for example:*<br>• *Disruption to operation, with flaring required on shutdown and subsequent start-up.*<br>• *Requirement for venting of captured $CO_2$, for example when downstream $CO_2$ compression, $CO_2$ conditioning or export route is not available.*<br>• *Requirement for short term turndown of hydrogen production and flaring of hydrogen if the downstream export route or demand is lower than minimum feasible hydrogen production rate.*<br>• *Loss of performance of emissions abatement systems*<br>*Target availability for systems critical to environmental performance should be established, with proposed configuration supported by reliability, availability, and maintainability assessments.* |
| **HPP Status** |

| Considerations & Guidance |
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| • The HPP has a designed availability of at least 93.5% averaged over its lifetime calculated with respect to hydrogen production as a proportion of total requested hydrogen production assuming 8760 h/y operation. The availability takes account of both planned and unplanned maintenance, and includes the reliability of all utilities and services (including the electricity supply). The plant is designed so that no planned outage is greater than 30 days from hydrogen off to hydrogen on (full load to full load).<br>• The main process units will be developed in a phased approach in that there will be a separate LCH unit and $CO_2$ Removal unit built for each phase of the project. These units and their associated equipment are CAPEX intensive and therefore investment in Phase 1 to support Phase 2 would not be supported.<br>• The $CO_2$ Dehydration unit has been sized for Phase 1 only as there is no foreseen benefit in oversizing the Phase 1 package for Phase 2.<br>• A single ASU will be provided as part of Phase 1 and sized to handle the total Phase 1 flow. An additional ASU will be added during Phase 2. This arrangement is preferred for ASUs due to their high CAPEX.<br>• A single demineralizer water plant will be provided as part of Phase 1 and sized to handle the total Phase 1 flow. An additional demineralizer water plant will be added during Phase 2. This arrangement was selected as the design of demineralizer plants using RO treatment is highly modularised.<br>• A single Waste Water Treatment Plant (WWTP) will be provided as part of Phase 1 and sized to handle 100% of the process effluent flowrate from the combined Phases 1 & 2. The reasoning for this is that a significant portion of the site civils work (including drainage systems) will be completed as part of Phase 1. As such, during Phase 1, the WWTP would need to be able to handle, not only the normal process rundown from a single unit, but also the drainage water from a larger area. This means the Phase 1 WWTP would need to be able to process up to 100% of the combined Phase 1 & 2 flowrate.<br>• The ROG Compression package has been sized for Phase 1. Phase 1 will use the majority of the capacity of the dry ROG from the refinery complex. The design of the ROG compression for Phase 2 will thus be very different. For this reason no allowance has been made in the Phase 1 design for the Phase 2 ROG supply.<br>• Two NG compressors (and their associated equipment) will be provided as part of Phase 1. Each will be sized to provide 150% of the Phase 1 flowrate and will operate as duty and spare. During Phase 2 a third, identical, compressor will be added to total three compressors, each capable of supplying 50% of the combined Phase 1 & 2 flowrate (i.e. 2 operating, 1 spare). This arrangement will ensure that multiple compressors are available during all project phases to ensure redundancy.<br>• The flare will be designed with a capacity to relieve the inventory of the future arrangement of two process trains (Phase 1 & 2). A common flare header will serve Phases 1 and 2 with a low pressure and high pressure flare riser up the common stack. |
| • Raw water and electrical supply service connections have been sized for Phases 1 and 2 combined in order that the Phase 1 plant does not require shutting down for the installation of Phase 2.Where tanks are required, a single tank will be provided as part of Phase 1 and will be sized to accommodate the expansions required for Phase 2 without any modification. The reason for this is the much larger plot area required for the provision of two separate smaller tanks.<br>• For most pumps, two pumps will be provided during Phase 1, each sized to handle the entire flowrate of Phase 1 (thus operating as duty and spare). Two further pumps of the same size will be added during Phase 2.<br>• A single exchanger (heaters and coolers) will be provided as part of Phase 1 and sized to handle the total Phase 1 flow. An additional identical type exchanger will be added during Phase 2 for the Phase 2 duty. The exception to this is for the oxygen/nitrogen vaporisers which are provided as 1 x 100% of Phase 2 flow. When multiple ASUs are available there is redundancy in the supply of $O_2$/$N_2$ therefore multiple vaporisers are not needed. In addition, it is likely only one train will require starting up at a time, therefore there is no requirement to supply multiple trains simultaneously. |

| Conformance with BAT: | ✓ |
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<u>Analysis of Key Equipment and Systems Critical to Avoid Emissions</u>

The interpretation of "*key equipment and systems that are critical to avoiding emissions during other than normal operating condition"* is that the requirement refers to emergency systems designed to protect the environment from not normal operation of the Hydrogen Production Plant (HPP).

The following table includes the identification of critical equipment and systems required during not normal operation. i.e. what systems are required to operate and, if required, shut down the HPP in case of emergency.

| Key Equipment and Systems That Are Critical to Avoiding Emissions During Other Than Normal Operating Condition | Design, Operate and Maintain These to Ensure They Are Reliable And Available | Providing Installed Back-Up Equipment |
|---|---|---|
| **Control Systems** required to ensure the plant control responses to not normal operation to protect the environment. | <u>Design</u><br>The HPP plant is operated and controlled by an Integrated Control and Safety System, consisting of DCS for process control, with an independent Safety Instrumented System (SIS) performing automated shutdown and Emergency Shutdown (ESD) functions. The overall system architecture is shown by drawing ICSS Architecture (5194812-000-48DG03-4-0001-01).<br>The integrated control and safety system comprise of the following as specified in the Specification for the DCS, 5194812-000-48EG-4-0011:<br>• Main plant Distributed Control System (DCS);<br>• Safeguarding system or Safety instrumented System (SIS);<br>• Fire & Gas safeguarding system (F&G control system);<br>• Equipment packages control system.<br><u>System Availability</u><br>The supplier shall ensure that the DCS shall be cost effectively designed to achieve an availability of 99.99% with an assumed Mean Time to Repair (MTTR) of 8.0 hours or less. The Mean Time between Failure (MTBF) of the system shall be submitted as part of the design documentation.<br><u>Redundancy</u><br>In order to meet the required system availability, redundancy and / or fault tolerant technology shall be incorporated.<br>The following equipment shall be redundant:<br>• Communication Networks and Servers;<br>• Control Processors;<br>• Power Supplies;<br>• Input / output modules for control functions, interlocks, sequences and digital output modules;<br>• Serial links with other systems such as ESD, F&G, MMS, etc.<br>The following equipment shall be mutually backed-up on a unit / plant basis:<br>• Graphics;<br>• Operational Keyboard function Switch Configuration;<br>• System Database.<br>DCS shall be designed so that, on failure of the primary unit, automatic changeover to the other unit shall take place (in addition the units shall be supplied with the facility for manual changeover). It shall be possible to replace any failed units without disrupting the control of the process. | The following equipment shall be redundant:<br>Communication Networks and Servers;<br>Control Processors;<br>Power Supplies;<br>Input / output modules for control functions, interlocks, sequences and digital output modules;<br>Serial links with other systems such as ESD, F&G, MMS, etc.<br><br>Diverse / redundant fibre-optic and hard wire routes from HPP to the control room. |
| **Fire and Gas (F&G) System** detecting fire or gas release in order to safely shut down the HPP. | The main objectives for the F&G detection system are to:<br>• Provide reliable protection of plant personnel, the environment and process equipment from fire, potential explosion and environmental Release;<br>• Provide protection for equipment and minimize production losses;<br>• Interface with plant integrated control and safety system to provide operators with overview of F&G detection system via control system operator workstations;<br>• Interface with the existing Essar site F&G detection system. | See above for Control System to which the F&G System is connected. |

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<tr><th>Key Equipment and Systems That Are Critical to Avoiding Emissions During Other Than Normal Operating Condition</th><th>Design, Operate and Maintain These to Ensure They Are Reliable And Available</th><th>Providing Installed Back-Up Equipment</th></tr>
<tr><td></td><td>A complete and fully operational F&G detection system with all necessary proprietary and application software shall be provided.<br><br>The Fire and Gas detection system is to provide as a minimum the following:<br>• Detection of fire and flammable / process gases;<br>• Provide plant operations and personnel with warning if fire or gas is detected and relay fire or gas warning from other ESSAR operated plants;<br>• Continuously monitor all areas where either the presence of a fire hazard may exist, or an accumulation of flammable or process gases may occur;<br>• Alert personnel at the ESSAR control room and ESSAR fire station of presence, location and nature of the fire, gas leak or emergency;<br>• Provide automatic and operator-initiated activation of fixed fire protection systems, i.e. fire water monitors; fusible plug and deluge spray enclosure protection where applicable;<br>• Reduce the risk to personnel by implementing executive actions to turn on protection equipment and/or initiate shutdown events of process equipment.<br>The Fire & Gas detectors to be used are:<br>• Fire (Flame) detectors; UV/IR detectors with integral CCTV;<br>• Flammable gas detectors (for hydrocarbon gas, H2 and O2);<br>• Process gas detectors (for CO2 and N2 gas detectors only semiconductor type shall be used, electromechanical cell type shall not be used);<br>• Smoke detectors (including high sensibility smoke detectors);<br>• Heat detectors;<br>• Gas leak detectors.<br>The type selection and specification of flame, gas, smoke, and heat detectors, manual call points, beacons and sounders shall follow the requirements of the Fire Gas Detection System Specification 5194812-000-48EG-4-0003<br>Types of alarms from different systems shall be clearly defined. Alarm positions and the direction in which they will annunciate shall also be determined. Distinction shall be made between process alarms and F&G alarms.<br>The F&G detection system is integrated within and is part of the plant integrated control and safety system.</td><td></td></tr>
<tr><td>Electrical systems required to power the plant</td><td>The electrical distribution system is supplied at 33kV from a new substation.<br>The site main switchboard is 33kV and consists of two bus-bar sections A & B, two incomer circuit breakers (one per bus section), a bus-tie circuit breaker and four outgoing circuit breakers (two per bus-bar section).<br>The outgoing circuit breakers on bus A supply transformer 1011A and ASU 1 and the outgoing circuit breakers on bus B supply transformer 1011B and future ASU 2.<br>Transformers 1011A & B step down the 33kV to 11kV and supply the 11kV distribution switchboard 1011. Switchboard 1011 consists of two bus-bar sections A & B, two incomer circuit breakers (one per bus section), a bus-tie circuit breaker and thirteen outgoing circuit breakers (seven on bus A and six on bus B). The transformers supply each section respectively via the incomer circuit breaker.<br>Each 11kV transformer is rated to supply 100% of the distribution network demand.<br>The bus-bars sections are rated to provide full power to the distribution network from either section of the switchboard and thus providing 100%</td><td>The power connection to the HPP is a dual 100% redundancy supply via cables connecting to the site main switchboard. Each connection can provide the full site power requirement.<br>Each 11kV transfer is rated for 100% demand (i.e. installed spare). 100% redundancy philosophy is continued through the network for the transformers and switchboards through 3.3kV and 400V distribution.<br>Emergency Generator to provide power to safely shut</td></tr>
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| Key Equipment and Systems That Are Critical to Avoiding Emissions During Other Than Normal Operating Condition | Design, Operate and Maintain These to Ensure They Are Reliable And Available | Providing Installed Back-Up Equipment |
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| | redundancy for the distribution network. Switching is achieved via the bus-tie circuit breakers.<br>In the event of a transformer or switchboard section failure, the network can deliver full power throughout the network by switching out the faulty section.<br>To maintain the redundancy philosophy and distribution network integrity the cables supplying the A & B switchboard sections or transformer for each section have separated routes to avoid both supplies being lost simultaneously from any single occurrence.<br>The 11kV switchboards in turn supply the 3.3 kV and 400V switchboards via stepdown transformers.<br>Emergency power is supplied via switchboard 2011 at 11kV, which distributes emergency power to the substations by radial circuits connected to a local 11kV to 400V stepdown transformer, which provides power to a local emergency switchboard.<br>Emergency switchboard 2011 is supplied from the 11kV switchboard 1011 section B and is connected on normal operation. In the event of power loss, the emergency switchboard has a backup emergency generator connected which will automatically start to supply full normal operating load requirements.<br>Vital equipment for safety and essential control are supplied from the emergency switchboards. During switching functions such as the loss of power and emergency generating starting UPS systems provide no-break supplies. The UPS systems are rated to provide sufficient power and duration to affect a safe emergency shutdown of the entire system(s).<br>There remain some scenarios where a utility or subsystem may have to shut down due to it being a single system with no redundancy. These can be catered for with a secondary and will be reviewed during detailed design. | down the facility on loss of external power supply.<br>Uninterruptable Power Supply, with battery back up, to provide power to essential power consumers (e.g. control system) follow loss of external power in order to safely shutdown the plant |
| **Instrument Air** required to provide motive force to operate control and blow down valves to operate and shut down HPP | Instrument air is produced by the Air Separation Unit (ASU) from the Main Air Compressor.<br>• Instrument air receiver operating at 9 to 10 bara – supply pressures to users to be 9 bara.<br>• On low pressure in the instrument air header (PT-0003):<br>    ○ Shutdown valve in plant air supply (XZV-0001) will close to safeguard essential instrument air supplies.<br>    ○ Emergency Instrument Air Compressor shall start.<br>• On Low Low pressure (PZT-0004) Plant shutdown (ESD-1) should be initiated. | Emergency Instrument Air Compressor provided to supply air on loss of ASU supplies.<br>Instrument Air Receiver 10-AAB-V-001 contains an inventory of air for the activation of valves in an emergency.<br>Valves that are important for process safety and plant shutdown are designed to fail in a safe position (e.g. fail open, fail closed) on loss of control or instrument air. The valve positions are considered in design safety reviews such as Hazard and Operation (HAZOP) Studies. |
| **Flare** to safely combust flammable / explosive gas inventory in case of emergency | The flare will be designed with a capacity to relieve the inventory of the future arrangement of two process trains (Phase 1 & 2). A common flare header will serve Phases 1 and 2 with a low pressure and high pressure flare riser up the common stack.<br><u>Overall Flare</u><br>The blowdown system is designed as per the project Flare, Vent and Blowdown Philosophy, 5194812-000-49EC-4-0003.<br>Blowdown valves are provided within the hydrogen export metering system, natural gas import system, and $CO_2$ capture unit, in order to depressurise the system during an emergency scenario. Each blowdown valve shall | Propane Bottle Skid - the ignition panel will include a propane back-up skid. The ignition panel shall also have the facility to automatically transfer from main to a bottled propane gas supply on loss of pilot gas.<br>Multiple ignition modules, pilots and ignitors to ensure |

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| | discharge to the flare system. A blowdown valve is also provided as part of the CO2 Export System; however, this valve is vented to atmosphere due to its high composition of CO2.<br>Depressuring valves are also located within the JM process area (LCH Plant).<br><u>Flare Location</u><br>The flare is currently located on plot (located in the North West corner). This allows for a complete design meeting BEIS requirements.<br>The flare has a single stack with 2 separate risers.<br>The ground space in this area of the plot allows for the calculated 46m exclusion zone for a 60m high flare. The exclusion zone and flare height are to be confirmed in future phases of the project: there are residual design activities associated with the flare (please refer to section 22.1.2 of this report).<br><u>Hydrogen Export Blowdown</u><br>A single blowdown valve, 10-200-AAD-BDV-0002, is provided as part of the hydrogen export system which blowdowns the inventory between the Product Hydrogen Cooler, E-123, and the shutdown valves located on each export pipeline. Piping in this blowdown section is sized for Phase 2 and hence, AAD-BDV-0002, should also be sized for Phase 2.<br><u>Natural Gas System Blowdown</u><br>Five blowdown sections have been identified within the natural gas system. Each section shall be provided with a blowdown valve. Blowdown valves are provided at the following locations:<br>• Section 1: 10-200-AAF-BDV-0003 – Natural Gas Metering<br>• Section 2A/2B: 10-200-AAF-BDV-0006/0007 – Natural Gas Suction KO Pots, 10-AAF-V-002A/B<br>• Section 3A/3B: 10-200-AAF-BDV-0004/0005 – Natural Gas Compressor, 10-AAF-C-001A/B, discharge<br>• Section 4: 10-200-AAF-BDV-0009 – Natural Gas Supply<br>• Section 5: 10-200-AAF-BDV-0008 – Natural Gas Let-down<br>In Phase 1, two compression trains will be provided, and a third compression train shall be added in Phase 2. Each compression train will be capable of depressurisation from independent blowdown valves and identical blowdown sections for each train are indicated as A, B, C e.g., Section 2A, 2B.<br><u>$CO_2$ Capture Unit Blowdown</u><br>A single blowdown valve, 10-200-FAA-BDV-0001, is provided as part of the $CO_2$ Capture Unit to blowdown the $CO_2$ Absorber, 10-FAA-V-114, and surrounding inventory.<br><u>Equipment</u><br>The majority of the equipment is static and therefore spare equipment items are not generally required. The exception is the flare knock drum pumps which are spared due the lower reliability inherent with some rotating machinery. | ignition of emergency gas release.<br>Manual ignition back up.<br>Flare Knock Out Drum Pumps. |

<u>Maintenance Strategy</u>

Essar Oil UK (EOUK), who would operate and maintain the plant, utilise a functional group structure for Stanlow Refinery maintenance; departments are split by discipline: Rotating Equipment, Electrical & Instrument, Mechanical (Production Support and Central Maintenance). All disciplines report to the site Maintenance General Manager.

The Maintenance Organisation is supported by the Engineering Assurance organisation.

In order to fit with this model and given that the Plant will be owned by a separate legal entity, a Service Level Agreement (SLA) will be developed between the Vertex Hydrogen and EOUK to ensure correct and fair prioritisation of maintenance activities between The Plant and the remainder of Stanlow Manufacturing Complex.

Invasive plant maintenance required for the reliable operation of the HPP will be completed during scheduled plant turnaround (TA), during which time the entire Plant will be shut down and isolated.

The Plant has been designed based on a TA frequency of 4 years; the first major TA for Phase 1 to be after 4 years of operation. Opportunities to extend the TA cycle will be investigated once operating experience and data has been gained (catalyst life, machine performance etc.). Any equipment that requires maintenance or catalyst change more frequently than 4-yearly has been spared to ensure a 4-year run length can be achieved.