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Heavy Oil

Controlled Document

Quest CCS Project

Operation and Maintenance Philosophy

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Summary

This document is an update to the DEFINE phase Operations and Maintenance Philosophy, with a focus on how the project will be integrated into the existing Operations & Maintenance organisations at Scotford. It also provides a list of key tie-ins to existing infrastructure, major chemicals introduced, and main process parameters.

This document is intended:

- for internal alignment of the Quest Operation & Maintenance (Operation Readiness, Operation Implementation, normal Operation) team members.
- for consistency of interaction at the interface between the Quest Operation & Maintenance team and the key opportunity stakeholders: project, business, regulatory and subsurface.

Keywords

Scotford, Quest, CCS, Operation, Maintenance, Asset Integrity

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY 3
2. INTRODUCTION 6
2.1 Project Objective 6
3. PROJECT DESCRIPTION 6
3.1 Scope overview 6
3.1.1 Process Interconnects 6
3.1.2 New Chemicals 7
3.1.3 Process Overview 7
4. OPERATIONS & MAINTENANCE OBJECTIVES & STRATEGIES, WORK PROCESSES AND FUNCTIONAL REQUIREMENTS 8
4.1 Framework and Standards 8
4.2 Asset Ownership 8
4.3 Production 9
4.3.1 Objectives 9
4.3.2 Operation Excellence (OE) Strategy 9
4.3.3 Scotford Operation of the New Technologies 9
4.4 Work Process 9
4.4.1 Asset Reference Planning 9
4.4.1.1 Wells Data Management 10
4.4.1.2 Maintenance and Technical Integrity Management 10
4.4.1.3 Normal Operation Phase 11
4.4.2 Production Operation 11
4.4.3 Well and Reservoir Management 11
4.5 Maintenance and Technical Integrity Management 12
4.5.1 Strategies 12
4.5.2 Work Process 13
4.5.2.1 Inventory and Spare Parts Management 13
4.5.2.2 Demand Management 13
4.5.2.3 Availability / Reliability Modeling (RAM) 13
4.5.2.4 Turnaround Philosophy 14
4.5.3 Control & Automation 14
4.5.3.1 Control, Instrumentation & Functionality 14
4.5.3.2 Integrated Control Philosophy 14
4.5.4 Process Facilities 16
4.5.4.1 Control Centers 16

4.5.4.2 Isolation philosophy 16
4.5.4.3 Drains & Vents 16
4.6. **Pipeline Operations... 17**
4.6.1 Wells *16*
4.6.1.1 Wells including Reservoir .... ***Error! Bookmark not defined.***
4.6.1.2 Well Kill Operations Functional RequirementsError! Bookmark not defined.
5. Permanent Manpower.. 18

APPENDIX 1. REFERENCES 18
APPENDIX 2. T&OE GLOBAL PROCESSES 18
APPENDIX 5. OPERATION WORK FORCE PLAN... 19

1. INTRODUCTION

The Operations and Maintenance philosophy document outlines the operations objectives, strategies and work processes to ensure the safe operation and sustained delivery of the CO_2 Capture and Sequestration production targets of the integrated Quest CCS project (Capture, pipeline and storage sections).

This document is intended to gain alignment of the Quest Operation & Maintenance philosophy with Site practices & processes including the key opportunity stakeholders: project, business, regulatory and subsurface.

1.1. PROJECT OBJECTIVE

The Quest CCS Project will capture, transport, and store up to 1.2 Mt/a of CO_2 from the Scotford Upgrader Hydrogen Manufacturing Facilities (HMU's).

As a large industrial emitter of greenhouse gases in Alberta, Shell is required under the Specified Gas Emitters Regulation to reduce emission intensity. The Quest CCS Project is needed as a key component of the greenhouse gas abatement strategy for Shell Canada Limited.

• Reductions of up to 1.2 Mt/a of CO_2 from 2016 onward

• Demonstrating and unlocking CO_2 storage capacity in a deep saline formation

2. PROJECT DESCRIPTION

2.1. SCOPE OVERVIEW

This entails the installation of a CO_2 Absorber at each of the three Upgrader HMU's. The CO_2 rich amine from the Absorbers is transported to a central Stripper tower for recovery of the CO_2. The recovered CO_2 is dehydrated in a Triethylene Glycol (TEG) unit, and then compressed into the 12" disposal pipeline. The pipeline is 64 km long, terminating at three wellsites, where the CO_2 is injected into the Basal Cambrian sands at a depth of 2.4 km.

3.1.1 PROCESS INTERCONNECTS

Since the project is integrating all three HMU's, in addition to the stripping and compression facilities on the capture plot, there is a large number of plant interconnects.

- The Absorbers each tie into one HMU furnace process stream to re-route the syngas through the Absorbers for CO_2 recovery before entering the Pressure Swing Absorber (PSA) vessels.
- 12" Fire Water
- 4" Flare tie-ins at HMU3, 10" at HMU's 1 and 2.
- 36" Low Pressure Steam is used in the Stripper reboilers. supplies up to 160 T/hr.

- 2" High Pressure, Low Temp. steam is used to regenerate the TEG dehydration unit, at rates up to 0.5 T/hr
- 6" Condensate return to Utilities
- 4" Condensate from Utilities (intermittent)
- 18" Cooling water 5900 T/hr,
- 2" Utility water at each Absorber and the capture plot (intermittent flow)
- 2" Potentially Oily Water System (POWS) 9 T/hr
- 2" Instrument Air at each Absorber and the capture plot
- 2" Utility Air at each Absorber and the capture plot
- 2" Nitrogen at each Absorber and the capture plot
- 2" Natural gas to the Compressor building HVAC
- "B" Bus for electricity to drive the 21,000 kW compressor motor and various pump motors.

3.1.2 NEW CHEMICALS

New chemicals to Site are also required. They are:

- Dow GT Amine MDX1 (N-METHYLDIETHANOLAMINE) to absorb CO_2
- Anti-foam (Polyglycol) Is an additive for controlling amine foaming
- Piperazine is an additive to the amine to enhance CO_2 selectivity
- Triethylene Glycol (TEG) is used to dehydrate the CO_2 between compression stages 6 and 7.

3.1.3 PROCESS OVERVIEW

Figure 1 below is an overview of the Carbon capture and sequestration facilities integrated into the Scotford Hydrogen Manufacturing Units (HMU's).

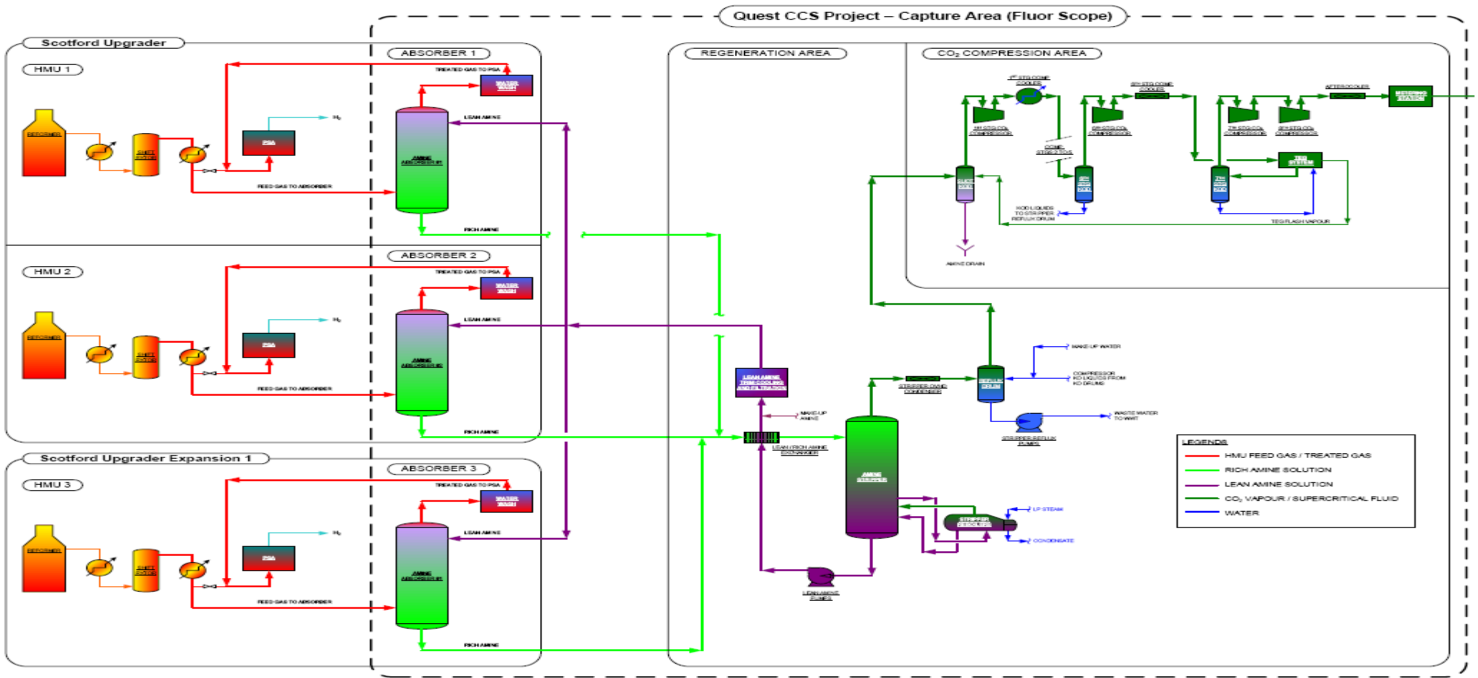

Figure 1: Project Process Overview

4 OPERATIONS AND MAINTENANCE OBJECTIVES & STRATEGIES, WORK PROCESSES, AND FUNCTIONAL REQUIREMENTS

4.1 Framework and Standards

The Quest Operation and Maintenance objectives and strategies have been set-up to be consistent with the existing Scotford processes, procedures, and systems. This includes systems such as Operational Integrity (OI), INTOOLS, Intelitrac, Computerised Maintenance Management System (CMMS), E-SPIR, and SAP.

The Shell standards have been supplemented by the Operation Excellence OE and Operational Readiness standards.

4.2 Asset Ownership

The Quest integrated facilities (Capture, pipeline and storage) are an addition to the existing production facilities of the Scotford Upgrader which is part of the AOSP Joint Venture (60% Shell, 20% Chevron, 20% Marathon). Shell is the Operator and the General Manager – Scotford Upgrader is the Asset Owner. Within the Upgrader there are 5 Production Units and Quest will fall within the PU1 area, day to day management will be under the PU1 manager.

The storage (wells) containment performance will be monitored and reported by the Well surveillance department reporting into the Site Technology Manager, per the Measurement, Monitoring, and Verification (MMV) plan.

4.3 Production

4.3.1 Objectives

- Yearly production capacity of the CCS facilities has set by design at 1.08 Mt CO_2/calendar year:
  1.08 MT/ year = nameplate capacity (1.2 MT) x on-stream factor (90%)
- The objectives are the combined maximization of the CO_2 production and containment in the pipeline and storage reservoir.

4.3.2 Operation Excellence (OE) Strategy

Quest, along with the rest of Scotford must comply with Group and EP standards and manuals in Production and represent the minimum level of control that is expected of an Asset.

4.3.3 Scotford Operation of the New Technologies

Quest CCS leads to the introduction of a number of technologies with new issues for the Scotford site.

- HSSE: toxicology of CO_2 (occupational exposure limits, detection, dispersion modeling)
- Process: thermodynamic properties of CO_2 under multiple phases and in transition
- Asset integrity management: prevention and monitoring of carbonic acid corrosion and maintenance & inspection of high pressure remote assets (pipeline and wells)
- Well Engineering and Production Technology: operating and maintaining CO_2 injection wells. Scotford operations will be supported by the Quest Subsurface and the SCAN Surveillance teams.
- MMV: monitoring a disposal operation with a strong subsurface component using multiple new monitoring technologies. Scotford operations will be supported by the Quest Subsurface and the SCAN Surveillance teams.

4.4 Work Process

4.4.1 Asset Reference Planning

It is expected that the content of the systems in place should meet the requirements set by the Asset Reference Planning Guide [ref. 4].

- The new Capture section will be subject to the Operation Excellence standards of the Scotford operation. In particular the operating procedures and definition of the operating envelope will come as an addition to the existing operation documentation of the Production Unit 1 (PU1) of the Scotford Upgrader.
  This will define the business utilization of the Quest assets, including the planned

turnarounds of the Scotford site.
The new 12"pipeline will be operated and maintained according to Shell and Alberta standards, including a leak detection system. The pipeline has been sized to allow additional commercial capacity to approximately 3 million tonnes/year.

The injection and observation wells will be operated by Scotford Operations with technical support from the Scotford subsurface surveillance team. These wells are also subject to the and Wells and Reservoir surveillance plan described in the MMV Plan of the Quest Storage Development Plan. Maintenance from the wellhead down will be managed by the subsurface Surveillance team.

4.4.1.1 Wells Data Management

Data management including data gathering, data transmission, data retrieval for interpretation, and data archiving will be managed by the subsurface team using PI, PRISM, Operations Integrity Assurance, Field Monitoring Applications and Production Accounting.

4.4.1.2 Maintenance and Technical Integrity Management

The maintenance and technical integrity management of the Quest assets covers capture, pipeline, and wells.

The maintenance and integrity of the reservoir and wells is described in the Measurement, Monitoring and Verification (MMV) and will be managed by the Calgary surveillance organization.

The Capture areas and pipeline will be managed by the Quest CSU team during the Operation Development & Implementation phase (maintenance and integrity planning, equipment quality control and acceptance), and handed over to the Asset (running) at the completion of the performance tests.

The Operation Implementation team includes a maintenance and engineering department in charge of:

- Setting-up-up the Maintenance, Turn Around (TA) and Asset Integrity technical and cost targets for the Quest facilities, in line with the Asset Integrity and Process Safety Management standards (AIPSM) and Scotford performance targets. (e.g. reliability targets and alignment on TA frequency.)

- Setting-up and managing the Quest Maintenance and Engineering team, hiring plan and competence development for the team members. Jointly with the

Quest project Engineering and CSU teams, it identifies the vendor support requirement for Commissioning and Start-Up

4.4.1.3 Normal Operation Phase

The operation (production, maintenance, turnaround) of Quest facilities will be integrated in the on-site planning functions of the Scotford Upgrader, as part of the PU 1.

The essential difference for the integration of the activities introduced by Quest is the new interface created between the site and the SCAN Surveillance Team (based in Calgary) in charge of organizing the daily and monthly, quarterly and annual surveillance reviews and coordinating the planned well interventions with the site maintenance.

4.4.2 Production Operation

The wells will be operated by flow rate set points to spread injection over the three wells, with built-in automated shut downs.

- The flow rate will be measured at each well site and at the pipeline inlet
- If the pipeline pressure decreases below 8.5 MPa, the well chokes will start to close to maintain the minimum pipeline pressure
- If the wellhead pressure increases above the maximum allowable injection pressure (10 to 12 MPa depending on wellhead pressure), the well chokes will start to close to decrease wellhead injection pressure
- If the wellhead pressure drops below 8 MPa the well isolation valve will close automatically.
- If the water content goes above specifications (proposed threshold is 8 lb/MMscf, 128 kg/MMsm3), the compressor will automatically go into recycle mode.
- If the Hydrogen content goes above specifications (proposed threshold is 2.5%), the compressor will automatically go into recycle mode.

For full capacity, it is expected that 2 of the 3 wells will need to be in service.

4.4.3 Well and Reservoir Management

Well and Reservoir Management (WRM) will be done by the subsurface surveillance team. They will provide direction to Scotford Operations if required, including flow adjustments, which well to put into service, and duration of injection. They will also monitor & direct when workovers or other subsurface work is required, which will be executed by a third party.

4.5 Maintenance and Technical Integrity Management

4.5.1 Strategies

The strategies, based on the principles of Risk & Reliability Management (RRM) which include Reliability Centered Maintenance (RCM), Risk Based Inspection (RBI) and Instrument protective functions (IPF) techniques will result in one or a combination of the following maintenance options:

- On-line condition based performance monitoring.
- Off-line condition based performance monitoring.
- Non intrusive monitoring.
- Preventive maintenance.
- Corrective maintenance (following breakdown or condition assessment).
- Opportunity maintenance.
- Operate to failure.

The strategy appropriate to each item of equipment will be established and be incorporated into existing maintenance systems at Scotford. Strategies will be developed, during the execute phase to ensure availability per the project premise. The Reliability and Availability will be used as an input into the maintenance strategies developed. The following graphic outlines the required performance of the Quest assets.

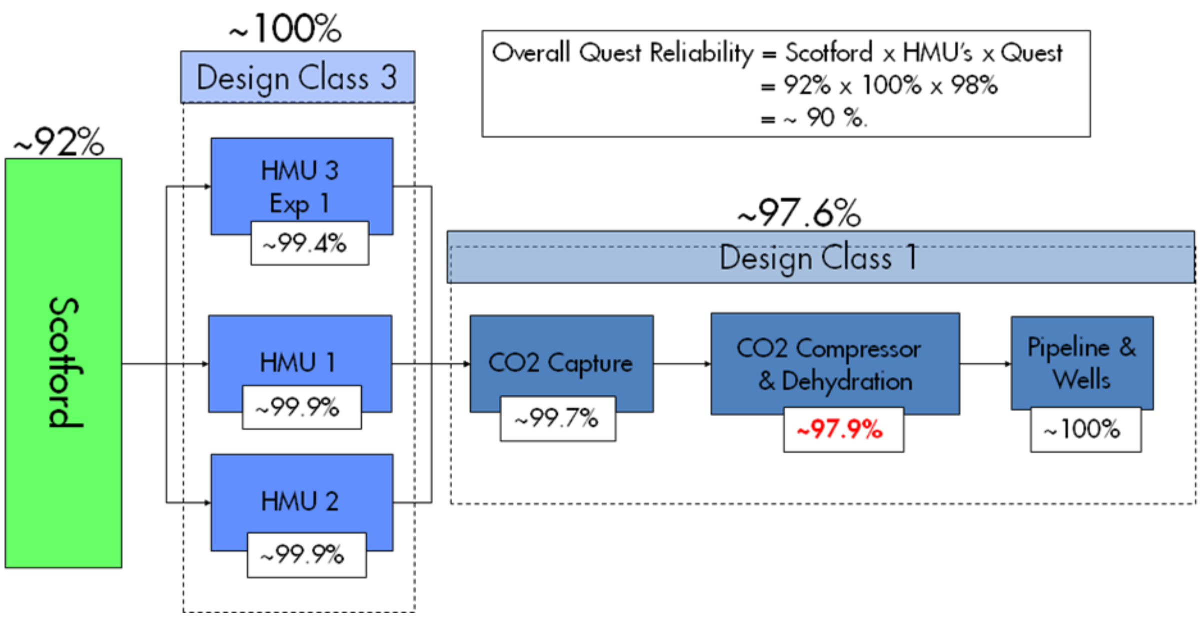

Figure 2: Design Class for the Carbon Capture and sequestration facilities.

Existing management controls and systems at Scotford will be used to ensure the efficient execution of maintenance and the collection of data reflecting equipment and work group performance.

Equipment performance will be monitored primarily via the DCS system for Capture, pipeline, and wells.

Integrity of the equipment will assured via use of existing Scotford systems with new sections added for the new equipment. The project will be responsible for providing corrosion manual updates for the site and completing the input forms for the new equipment to ensure it is added to Visions (electronic tool for managing equipment).

4.5.2 Work Process

For Capture section standard Scotford work processes will be used to manage maintenance and integrity of the new equipment. At Scotford the Blade 10 process is currently used to manage maintenance execution. The basic premise of this process is to use Operation Maintenance Coordinators to review work as it arises and assign priority to it for execution based on the Blade 12 SCE classification and CMPT ranking. Blade 10 also outlines the requirements for planning and procurement for work and the measures used to show effectiveness of the maintenance organization. A link to the operational excellence elements is attached below.

http://sww.wiki.shell.com/wiki/index.php/Operational_Excellence_elements

4.5.2.1 Inventory and Spare Parts Management

Spare parts will be managed per standing Scotford Processes once project is handed over. This will include optimization of parts (E-SPIRS) repair and return and stock addition or reduction based on operating experience. Spares ordered by the project are already logged into Stores. Process guidance for determination of which parts to stock will be per DEP 70.10.90.11

4.5.2.2 Demand Management

The demand management for the maintenance and turnaround work of the Quest facilities will be done through the existing work processes in Scotford for the Capture and pipeline parts, and through the support of SCAN Surveillance for the wells (work-overs).

4.5.2.3 Availability / Reliability Modeling (RAM)

In line with the capacity and cost management objectives of the opportunity, Quest has been designed with an on stream factor target of 90% to meet the production target of 10.8 MT CO_2 over 10 years (average 1.08 Mtpa). This target translates into a design class 1 for the Capture section (no excess capacity, sparing only the critical HMU interface elements, not to impact the HMU on stream factor).

4.5.2.4 Turnaround Philosophy

Since the Upgrader facility can run independent of the operation of the carbon capture and sequestration (CCS) facility, the outages for Quest can be done at any time required. Typically the outage will be timed to align with the PU1 & 2 outages, or with Co-gen, because of utilities tie-ins. The Turn Around organisation will manage the outages within the PU1/2 T/A windows.

4.5.3 Control & Automation

4.5.3.1 Control, Instrumentation & Functionality

The control system used will be the DCS panel of Production Unit 1 (PU1) providing full control of the Capture plot (including the HMU1 /2 Absorbers) and pipeline to the PU1 / HMU panel operator. The Production Unit 3 (PU3) HMU panel operator will have full control of the absorber system in HMU3.

An overview of the proposed SCADA Data Flow for the Quest Project to Scotford and Proposed Quest Project Data Flow to Shell Centre in Calgary below is given in [ref. 5].

4.5.3.2 Integrated Control Philosophy

The production is driven by the flow control at the well head and limited by the CO_2 production capacity from the HMU's. The boundaries are the minimum pressure at the inlet of the pipeline (8.5 MPa) to keep the system in one phase and the maximum pressure at the well head (about 12 MPa).

The following table shows the integrated system operational envelope and the controls and alarms related to it.

Measurement	Measurement point	Minimum Operating value	Maximum Operating value	Alarms*	Control
Pipeline Pressure	Pipeline inlet	8.5 MPa	13.9 MPa	High: 14* MPa	High: Spillback of compressor starts in order to reduce pipeline pressure below maximum setpoint. ***This alarm overrides any other control as it is safety critical.***
	LBVs	8.5 MPa	13.9 MPa	7* MPa	In case the pipeline pressure drops below normal minimum pressure (even with the ESD valves closed), the LBVs will close automatically (pipeline leak detection). ***This alarm overrides any other control as it is safety critical.***
Pipeline Inlet Temperature	Pipeline inlet	43 °C	60 °C	Level 1: 49* ° C Level 2: 60* ° C	Level 1: alarm in Scotford control room to investigate abnormal performance of the cooling system. Level 2: shutdown to protect pipeline.
Pipeline flowrate	Pipeline inlet	0 Mtpa	1.2 Mtpa	No alarm required	Pipeline flowrate is controlled by the wells flowrate operator setpoints.
Wellhead Pressure	Downstream of well choke	3.5 MPa	12 MPa	Low alarm: 1* MPa High alarm: 10*-12* MPa (will depend on wellhead temperature, to ensure bottom hole pressure does not exceed 28 MPa)	Low alarm: Alarm in Scotford and closing of the SC-SSSV (blowout detection). High alarm: Well choke will automatically start to close until wellhead pressure is below maximum allowable value. ***This alarm overrides any other control as it is safety critical.***
Well flowrate	Upstream of well choke	0 Mtpa	0.6 Mtpa	No alarm required	The flowrate is an operator setpoint. The choke will automatically open or close to meet the set point, within the allowable pressure envelope.

****Note:*** *exact value will be confirmed during Commissioning & Start-up.*

Table 1: Pipeline operations limits

4.5.4 Process Facilities

4.5.4.1 Control Centers

The implementation of control and safeguarding for the Quest CCS Project spans two separate plants, Base Plant and Expansion, where each plant has a different vendor for the basic process control system (BPCS). All equipment within the physical boundary of a plant is controlled and maintained by that plant.

The Quest CCS Project instrumentation and control design premise is to define each process unit as a stand-alone unit in terms of safeguarding and control. Therefore, the Expansion 1 amine supply and demand control is independent of the amine supply to the base plant absorbers. Both plants appear as "customers" to the Amine Regeneration unit; the lean amine supply from the Amine Regeneration unit is capable of dealing with any demand changes from either customers.

4.5.4.2 Isolation philosophy

The isolation philosophy has considered the codes, standards and the Scotford operating practices. Scotford practices will be followed for on Site and off Site facilities.

4.5.4.3 Drains & Vents

The Quest CCS Project introduces new HSE complexities into the Shell Scotford Upgrader. Concentrated CO_2 presents toxic and asphyxiation risks. Therefore, CO_2 specific guidelines have been developed for the Quest CCS Project.

4.5.4.4 Pipeline Operations

Refer to table: Pipeline Operating Conditions, below:

	Winter conditions	Summer conditions
Pipeline inlet temperature	43°C	49°C
Operating Pres		
Normal Min	8000 kPag	8000 kPag
Normal Max	11000 kPag	11000 kPag
Maximum	14000 kPag	14000 kPag
Flowrate		
Min	0.1Mtpa	0.1Mtpa
Expected	1.2 Mtpa	1.2 Mtpa
Water content	4 lbs/MMscfd (35 ppmw)	6 lbs/MMscfd (52 ppmw)
Ambient temperature	-40 degC	35 degC
Ground Temperature	0 degC	11 degC
OHTC		
Min	0.35 BTU/h/ft2/F	0.35 BTU/h/ft2/F
Max	1 BTU/h/ft2/F	1 BTU/h/ft2/F

Table 2: Pipeline Operating Conditions

4.5.4.6 Wells

4.5.4.7 Wells including Reservoir

The key operations functional requirements of the wells including the reservoir are detailed in the Storage Development Plan [ref. 5], based on the Well Functional Specifications and the Well Technical Specifications. The design envelope of the wells and some technical details are given in section 9 of [ref. 5]..

4.5.4.8 Well Kill Operations Functional Requirements

As described in the MMV Plan [ref. 12], the wells are planned for regular work-overs that will require killing operations. These planned interventions will be coordinated by the SCAN Surveillance Team.

5. Permanent Manpower

See appendix 2 for the overall project manpower curve. When the facility is handed over to base operations (PU1), the CSU organisation will transfer five panel operators, four field operators and two pipeline operators into the PU 1 headcount. In addition, two more Craft Team Members (CTM's) will be added, an instrument mechanic and a millwright.

APPENDIX 1. REFERENCES

Ref. 1: Operational Excellence in Production, The Production Standard, Volume 1 (http://knowledge.europe.shell.com/GetDoc?documentnumber=EP201002305710&instance=glasep03&guest=true)

Ref. 2: Operational Excellence in Production, OE Business Improvement, Volume 2 (http://knowledge.europe.shell.com/GetDoc?documentnumber=EP200911301430&instance=glasep03&guest=true)

Ref. 3: Operational Excellence in Production, OE Review, Volume 3 (http://epgraphics.europe.shell.com/restricted/report/2009/ep2009-9004/ep2009-9004.pdf)

Ref. 4: Asset Reference Planning process guide (Operational Excellence) – (http://sww.wiki.shell.com/wiki/index.php/Asset_Reference_Planning_process_guide_%28Operational_Excellence%29)

Ref. 5: Quest Storage Development Plan, document number 07-0-AA-5726-0001 (https://knowledge.shell.ca/livelink/livelink.exe/51136659/Quest_Storage_Development_Plan.doc?func=doc.Fetch&nodeid=51136659)

Ref. 9: Quest Capture Utility Integration Robustness Study (https://knowledge.shell.ca/livelink/livelink.exe/57358717/Quest_DRB22_Presentation_Utility_Integration_Robustness.pptx?func=doc.Fetch&nodeid=57358717)

Ref. 12: Quest CCS Project Measurement, Monitoring and Verification Plan https://knowledge.shell.ca/livelink/livelink.exe/open/57462666

Ref. 13: Quest Project Fluid Flow and Flow Assurance Strategy Report (FEED) https://knowledge.shell.ca/livelink/livelink.exe?func=ll&objid=55121302&objAction=browse&sort=name

Ref. 14: Quest Pipelines Flow and Flow Assurance Design and Operability Report, 07-2-LA-5507-0003, https://knowledge.shell.ca/livelink/livelink.exe/open/55802186

Ref. 15: Quest Discipline Delivery Plan – Information Management, 07-0-AA-5806-0001: https://knowledge.shell.ca/livelink/livelink.exe?func=ll&objid=55121302&objAction=browse&sort=name

Ref. 16: Quest Basic Design Engineering Package, 07-1-AA-7739-0001, https://knowledge.shell.ca/livelink/livelink.exe/open/58751705

T&OE Global Processes

Operation Philosophy Guideline, EP 2007-5097 [in ORAKLE Library, http://sww-orakle.shell.com/orakle/Homepage/Library/Guidance/PGindex.htm]

Operation Readiness Roadmap, http://sww.wiki.shell.com/wiki/index.php?title=OR_Aligned_process&printable=yes

APPENDIX 2. OPERATION WORK FORCE PLAN