Horse Hill Developments Ltd

Title: Water Injection Procedure

Document Number: HH-PR-Q27

Rev. 3

3	Final	EA comments incorporated	19/01/2022	KB	KB	KB
2	Final	RS Comments Incorporated	27/08/2021	KB	RS	KB
1	Final	Comments incorporated	26/08/21	KB	DAW / MC	KB
0	Draft	New procedure	25/08/21	KB	DAW	KB
Rev.	**Status**	**Reason for issue**	**Revision Date**	**Written by**	**Reviewed by**	**Approved by**
Revision History						

	REVISION DESCRIPTION SHEET		
This sheet must be completed in detail, at each revision, once this document has been issued at revision 0. Details to include revision number, a description of the revision indicating paragraphs and pages that have been revised, together with the date and approved signature.			
Revision	Description	Date	Approved By
0	New procedure to carry out water injection	25/08/21	KB
1	Comments incorporated	26/08/21	KB
2	RS Comments incorporated	27/08/2021	KB
3	KB incorporate EA comment	19/01/2022	KB

TABLE OF CONTENTS

1.0 Introduction

HHDL are proposing to harness collected surface water from containment bunds (bund water) and using it as re-injection water (together with produced water) for the purpose of aiding production performance of the Horse Hill field.

2.0 Treatment of Bund Water and Produced Water

Water collected within containment bunds shall be sampled and sent for offsite third-party analysis (e.g. Intertek) to establish its chemical properties and to identify which treatments may be needed to ensure it can be used as part of the re-injection water. Should the analysis (or visual inspection) confirm that the bund water (rain water) has become significantly contaminated with hydrocarbons or other such chemicals whereby the current proposed treatment methods are not suitable to rectify then the bund water will be collected via a vacuum tanker to be disposed of at an approved waste treatment facility. The bund will then be the subject of cleaning and remediation

Both surface water and produced water require appropriate technological, chemical, and bacteriological processing before re-injection can take place. It is necessary to remove all the components that adversely affect injection into the reservoir formation. Water, either surface water or produced water, will require the removal of dissolved and dispersed organic components as well as suspended solids and adjustment of the compatibility with the receiving groundwater system, if needed. To remove components from produced water, biological, physical, and chemical methods are available.

Surface water collected within the containment bunds shall be transferred to the produced water tank pending treatment prior to re-injection.

Such treatments may, if required, include the following:

- Fine filtration;
- Oxygen scavenger;
- Biocides;
- H_2S scavenger; and
- Corrosion inhibitor.

2.1 Fine Filtration

Prior to injection of bund or produced water into the reservoir formation, the water will be run through both coarse and fine filters. The filters shall clean the water and remove any impurities, such as solids (e.g. sand and silt, scales, etc). Typical filtration is <100 micron, but will depend on reservoir requirements. The filters are fine so as not to block the pores of the reservoir which can reduce injection performance. The filters will be maintained and regularly cleaned as part of the site process and maintenance.

2.2 Oxygen Scavenger

Oxygen often needs to be removed from the water because it promotes corrosion and growth of certain bacteria. Bacterial growth in the reservoir can produce Hydrogen Sulphide (H_2S), a source of serious production problems, and block the pores in the rock. In order to reduce oxygen content, an oxygen scavenging agent can be added to the bund/produced water prior to injection. Dosage amounts are subject to laboratory tests and product technology.

2.3 Biocide Treatment

Both surface and produced water contain biological constituents (primarily bacteria) that can contaminate the water treatment or injection systems. Because bacteria have the ability to multiply rapidly into colonies, they can cause plugging of surface and downhole equipment and geological formations, promote corrosion of surface piping and downhole tubulars, and generate H_2S that can cause pitting corrosion and hydrogen embrittlement. Therefore, it is essential to develop means to control bacteria growth in surface water treatment and injection systems. Biocides can be added to the process prior to injection to reduce and/or eliminate damaging bacteria. Testing of waters will be required to determine any necessary and optimised biocide solution.

2.4 H_2S Scavenger

Whilst currently not an issue in the Horse Hill reservoir, should hydrogen sulphide production become a problem, then H_2S scavenger can be introduced with the injection fluids to prevent H_2S related corrosion, reduce risk to safety and improve asset integrity management.

2.5 Corrosion Inhibitors

Corrosion is defined as the destruction of metal by either chemical or electrochemical reaction in the given environment. Because piping and processing equipment are normally made of metals that are in contact with produced water, chemical or electrochemical reactions can occur. The likelihood and rate of corrosion is dependent upon various factors including water pH, metallurgy, dissolved oxygen, dissolved salts, acid gases in water, temperature, pressure, and fluid velocity. Corrosion inhibitors can be added to the injection fluids to slow or prevent corrosion occurring. Testing of waters will be required to determine any necessary and correct inhibitor solution.

3.0 Integrity Testing of Re-injection Well(s)

Prior to the undertaking of the groundwater activity, each re-injection well shall be the subject of a test to confirm the casing and wellhead integrity. Well construction, operation and maintenance shall be conducted in accordance with **HHDL Well Planning, Design and Operating Standards** (HH-PR-Q13). The standards are applied to each well during construction and throughout its lifecycle, including integrity management for production and injection wells. The results of the integrity tests shall be made available to the Health and Safety Executive and, if requested, the Environment Agency.

A new drilled well has its casing pressure tested during construction. If a well is to be recompleted to an injector from a producer, then it shall have its casing pressure tested again during workover operations to confirm full integrity and therefore zonal isolation of the injection zone (in this case the Portland Sandstone) from all other formations. This integrity test will be completed prior to any injection operations. Well integrity eliminates the risk to groundwater from injection operations.

Prior to implementation of long term water injection, it will be necessary to conduct short term injectivity testing to determine maximum and most likely injection rates and pressures for the well.

3.0 Injectivity Testing

Produced water will be separated, filtrated and chemical dosed (if necessary, subject to lab tests) to ensure it is suitable for reservoir re-injection.

Prior to injection the specific gravity (SG) of the water will be confirmed in order to accurately calculate:

- downhole pressure of the injection fluid column (hydrostatic head)
- maximum allowable surface pressure (MASP) for 90% of formation fracture pressure

Water will be re-injected into the Portland Sandstone at a bottomhole pressure below the Portland fracture pressure in order to ensure formation integrity. The top of the Portland Sandstone at HH-1 is at 2,042 ft TVDBRT and estimated fracture pressure (SHMin) is ~1,600 psi at this depth. The water injector will have a bottomhole injection limit of 90% of formation fracture pressure to ensure injection pressure is always lower than the fracture pressure.

The water will be injected down the well at low initial rates at **0-0.25 barrels per minute (bpm**) until downhole (surface back pressure) is observed on the surface pressure gauges. As the Portland reservoir is low pressure then it is possible that back pressure may be minimal or not observed at all. The injection rate will be stepped up in increments to a maximum of **1 bpm** to obtain the maximum achievable injection rate and corresponding surface pressures whilst maintaining the downhole pressure below 90% of formation fracture pressure and surface pressure well below any wellhead and casing design pressures. If the downhole pressure reaches 90% of formation fracture pressure, the rates will not be increased but held constant or reduced accordingly. All rates and pressures will be chart recorded.

Injectivity testing is likely to be a short term operation of 3-24 hours (estimate) due to limited volumes of available water on surface. Duration will be only that needed to collect data required for long term injection design.

Prior to, during and post injectivity testing, the wells A, B and C annuli will be monitored for any change in pressure behaviour and confirm full well integrity. It is common to see some small pressure fluctuations due to thermal and tubing ballooning effects.

This will provide the maximum allowable surface/downhole injection pressures and the maximum achievable injection rate. It should be noted that these pressures/rates are likely to be much greater than rates/pressures needed for sustained water injection into the HH field.

This injectivity test information will be used in the design for long term water injection.

4.0 Long Term Water Injection

Water injection facilities constructed in the field, subject to final design, will include:

- Water process tank
- Injection flowlines
- Water injection pump with VSD control panel, trips and ESD
- Inline filtration
- Inline chemical injection dosing
- Pressure monitoring gauges on tubing head, A/B/C annuli
- Downhole pressure gauge

Produced water will be separated, filtrated and chemically dosed (if necessary subject to lab tests) so ensure it is suitable for reservoir re-injection.

Prior to injection the water specific gravity (SG) will be confirmed in order to accurately calculate:

- downhole pressure of the injection fluid column (hydrostatic head)

- maximum allowable surface pressure (MASP) such that bottomhole pressure is < 90% of formation fracture pressure

Surface trips will be set on the injection pump to shutdown automatically if the injection pressure reaches 90% of formation fracture pressure.

Water injection volumes, wellhead pressures and casing annuli pressures will be monitored and recorded daily in line with the normal field operational routine. This typically involves the monitoring and log recording of hourly pressure and flow readings at various positions across the process but is subject to modification (increase or decrease in frequency) depending upon operational requirements and necessity. Any deviation from normal operating parameters that is not understood shall result in suspension of water injection until clarified or rectified.

The pipework, pumps and filters will be regularly checked and maintained to suppliers’ specifications.