PETROBRAS	**TECHNICAL SPECIFICATION**	No. I-ET-3010.2D-1260-940-P4X-001	
	CLIENT: AGUP		SHEET: 1 of 36
	JOB: HIGH CAPACITY FPSO - GAS EXPORTATION ALL ELECTRIC		
	AREA: ATAPU 2 AND SÉPIA 2		
SRGE	TITLE: **CHEMICAL INJECTION – BASIS OF DESIGN**		INTERNAL
			ESUP

MICROSOFT WORD / V. 365 / I-ET-3010.2D-1260-940-P4X-001_A.docx

INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL ISSUE
A	REVISED WHERE INDICATED

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E	REV. F	REV. G	REV. H
DATE	MAY/20/22	DEC/16/22							
DESIGN	ESUP	EPS							
EXECUTION	CDV2	UP7Z							
CHECK	BXB3	BXB3							
APPROVAL	UPU1	UPU1							

SUMMARY

1 INTRODUCTION

The Floating Production Storage and Offloading (FPSO) Unit of ATAPU 2 AND SÉPIA 2 area for HIGH CAPACITY FPSO - GAS EXPORTATION ALL ELECTRIC shall be equipped with an OIL & GAS CHEMICAL INJECTION UNIT, a PRODUCED WATER CHEMICAL INJECTION UNIT and an INJECTION WATER CHEMICAL INJECTION UNIT to improve operation condition for the equipment, lines, and pipelines.

1.1 PROJECT INFORMATION

ATAPU 2 and SÉPIA 2 oil field are large ultra-deep water oil development located in the Santos Basin Pre-Salt fields, located at São Paulo Plateau, southern Brazilian oceanic region.

1.2 OBJECTIVE

The objective of this document is to define the design basis for the OIL & GAS CHEMICAL INJECTION UNIT, PRODUCED WATER CHEMICAL INJECTION UNIT and INJECTION WATER CHEMICAL INJECTION UNIT.

2 REFERENCE AND APPLICABLE DOCUMENTS

#	REFERENCE	TITLE
1	I-ET-3010.00-1200-940-P4X-005	CHEMICAL INJECTION POINTS
2	I-FD-3010.2D-1200-940-P4X-002	CHEMICAL INJECTION POINTS
3	I-ET-3010.2D-1200-200-P4X-001	PIPING SPECIFICATION FOR TOPSIDES
4	I-RL-3010.2D-1200-940-P4X-003	DRAINAGE SYSTEM GUIDELINES
5	I-ET-3010.00-1200-510-P4X-001	METALLIC TANKS DESIGN FOR TOPSIDES
6	API STANDARD 2000	VENTING ATMOSPHERIC AND LOW-PRESSURE STORAGE TANKS
7	NFPA 30	FLAMMABLE AND COMBUSTIBLE LIQUIDS CODE (FOR FIRE CASE)
8	I-ET-3010.00-1200-310-P4X-002	POSITIVE DISPLACEMENT PUMPS SPECIFICATION
9	I-ET-3010.00-5140-712-P4X-001	LOW-VOLTAGE INDUCTION MOTORS FOR OFFSHORE UNITS
10	I-ET-3010.00-1200-800-P4X-013	GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS
11	I-ET-3010.2D-1200-800-P4X-005	FIELD INSTRUMENTATION
12	I-ET-3010.00-1200-940-P4X-002	GENERAL TECHNICAL TERMS
13	I-RL-3010.2D-1350-960-P4X-002	MOTION ANALYSIS
14	I-ET-3010.00-1200-588-P4X-001	SAMPLE CONNECTIONS
15	I-ET-3010.2D-1400-196-P4X-001	ERGONOMICS REQUIREMENTS FOR TOPSIDE
16	I-FD-3010.2D-5400-947-P4X-001	SAFETY DATA SHEET

3 DEFINITIONS AND ABBREVIATIONS

3.1 DEFINITIONS

The latest revision of I-ET-3010.00-1200-940-P4X-002 – General Technical Terms defines general technical terms in order to equalize understanding of all design documents.

3.2 ABBREVIATIONS

g:	Gravitational acceleration
SS:	Stainless Steel
API	American Petroleum Institute
CONAMA	Brazilian National Council of Environment (Conselho Nacional do Meio Ambiente)
DBNPA	2,2-dibromo-3-nitrilopropionamide
FPSO	Floating Production Storage Offloading
HDPC	Hydrocarbon Dew Point Control Unit
HP	High Pressure
L/h	Liter per hour
LP	Low Pressure
ppm_w	parts per million (on a weight basis)
ppm_v	parts per million (on a volume basis)
PW	Produced Water
PWT	Produced Water Treatment
SRU	Sulphate Removal Unit (Package)
THPS	Tetrakis Hydroxymethyl Phosphonium Sulfate
WCT	Wet Christmas Tree
WI	Water Injection
SCF	Standard Cubic Feet
P&ID	Piping and Instrument Diagram

4 SCOPE OF SUPPLY

4.1 GENERAL

PACKAGER scope of supply shall include the following CHEMICAL INJECTION UNITS:

Table 1 – PACKAGER Scope of Supply.

TAG	DESCRIPTION	QUANTITY
UQ-1261001	OIL AND GAS CHEMICAL INJECTION UNIT	1 x 100%
UQ-1262001	PRODUCED WATER CHEMICAL INJECTION UNIT	1 x 100%
UQ-1263001	INJECTION WATER CHEMICAL INJECTION UNIT	1 x 100%

Each CHEMICAL INJECTION UNIT shall include pumps, tanks, structures, piping, instrumentation, and all necessary accessories according to the following items.

5 SYSTEM DESCRIPTION

5.1 GENERAL

Chemical injection system is used to improve and enhance the operating conditions of topsides equipment and subsea lines. The oil, gas, produced water and injection water treatment systems shall be designed to inject the following chemicals, as stated on Table 2.

The chemical injection for seawater treatment system, included Sodium Bisulphite, SRU Scale Inhibitor, WI Biocide (DBNPA), WI Biocide (THPS), WI Scale Inhibitor, WI Bio Fouling Disperser, Citric Acid, Sodium Hypochlorite of Sulphate Removal Unit (SRU) and Ultrafiltration Unit (UFU) shall be covered inside the package of each of this units.

5.2 CHEMICALS DOSAGES

5.2.1 The following chemicals and dosages shall be provided for the INJECTION UNITS systems:

Table 2 – Minimum and maximum injection dosage.

	Chemical Product	Dosage		
		Min.	Max.	Unit
OIL - TOPSIDE	Defoamer	20	200	mL/m³ (ppmv)
	Demulsifier	10	100	mL/m³ (ppm_v)
	Scale Inhibitor	20	200	mL/m³ (ppm_v)
	H_2S Scavenger Offloading	20	200	mL/m³ (ppm_v)
	Acetic acid (75%)	100	1000	mL/m³ (ppm_v)
	Sodium Hydroxide (50%)	4.4	44	mg/kg of oil
SUBSEA	Scale Inhibitor	2	200	L/h (per well)
	Wax Inhibitor	20	200	L/h (per well)
	Hydrate Inhibitor (Ethanol / MEG)	200	7000	L/h
	Asphaltene Inhibitor	20	200	L/h (per well)
	H_2S Scavenger	25		L/kg H_2S
	Demulsifier	50	500	mL/m³ (ppm_v)
GAS	Gas Corrosion Inhibitor	0.5	1	L/10^6 scf gas
	Hydrate Inhibitor (Ethanol / MEG)	1	15	L/h per well in *gas lift line*
PRODUCED WATER	Polyelectrolyte (continuous)	10	100	mL/m³ (ppm_v)
	Scale Inhibitor	5	50	mL/m³ (ppm_v)
	Biocide shock in tanks (shock)	200 2h (twice a week)		mL/m³ (ppm_v)
	Biocide (continuous)	10	50	mL/m³ (ppm_v)
	Oxygen Scavenger (continuous)	5	25	mL/m³ (ppm_v)
	Oxygen Scavenger (shock)	100	200	mL/m³ (ppm_v)
	Concentrated biocoagulant	10	60	mL/m³ (ppm_v)

INJECTION WATER	Oxygen Scavenger (continuous)	5	25	mL/m³ (ppm_v)
	Oxygen Scavenger shock (without deaerator)	100	200	mL/m³ (ppm_v)
	Biodispersant	5	20	mL/m³ (ppm_v)
	Biocide shock	100	1000	mL/m³ (ppm_v) 2 x week/1 hour
	Scale Inhibitor	1	20	mL/m³ (ppm_v)

5.2.2 The calculation of the chemical injection flow rate is performed as follows:

Minimum Flow = Minimum Process Flow x Minimum Chemical Dosage

Maximum Flow = Maximum Process Flow x Maximum Chemical Dosage.

5.3 CHEMICALS PROPERTIES

The following chemical properties may be used in chemical unit's design. It shall be confirmed and may be updated during Detailed Design phase.

Table 3 – Chemical Products Properties for Oil and Gas.

Chemical Product	Viscosity (cP)		Ref. Temp. Visc.	Density (kg/m³)		Ref. Temp. Density	Toxic	Corrosive	Flammable
	Min.	Max.	°C	Min.	Max.	°C			
Defoamer	160		25	778	865	20	YES	NO	YES
Demulsifier	100		25	1003		20	YES	NO	YES
Scale Inhibitor - Topsides	100		25	1140		16	YES	NO	YES
H_2S Scavenger - Offloading	4	750	21	1005	1167	21	YES	YES	YES
Acetic acid (75%)	1.21		20	1051		20	YES	YES	YES
Sodium Hydroxide (50%-60%)	53.2		25	1530		20	YES	YES	NO
Scale Inhibitor - Subsea	26		16	1119		16	YES	NO	YES
Wax Inhibitor - Subsea	40		23	890		25	YES	YES	YES
Asphaltene Inhibitor - Subsea	20		25	920	932	16	YES	NO	YES
H_2S Scavenger - Subsea	44		23	1110		20	YES	YES	YES
Hydrate Inhibitor (Ethanol)	1	2	20	785	800	20	YES	YES	YES
Hydrate Inhibitor (MEG)	20.9		20	1115		20	YES	YES	YES
Gas Corrosion Inhibitor	20		14~37	902		14~37	YES	YES	YES
Dilution Water	0.7	1.2		998	1016		NO	YES	NO

Table 4 – Chemical Products Properties for Produced Water.

Chemical Product	Viscosity (cP)		Density (kg/m³)		Toxic	Corrosive	Flammable
	Min.	Max.	Min.	Max			
Polyelectrolyte	1	100	970	1020	NO	YES	YES
Scale Inhibitor	1	100	1050	1380	NO	YES	YES
Biocide shock (THPS 35%)	20	50	1300	1450	YES	YES	YES
Oxygen Scavenger	1	15	1250	1450	YES	YES	NO
Biocoagulant	6	451	1025	1150	YES	YES	NO
Dilution Water	0.7	1.2	998	1016	NO	YES	NO

Table 5 – Chemical Products Properties for Injection Water.

Chemical Product	Viscosity (cP)		Density (kg/m³)		Toxic	Corrosive	Flammable
	Min.	Max.	Min.	Max.			
Oxygen Scavenger	1	15	1250	1450	YES	YES	NO
Biodispersant	50	250	900	1130	YES	NO	NO
Biocide Shock	20	50	1300	1450	YES	YES	YES
Scale Inhibitor	1	100	1050	1380	YES	NO	YES

6 CHEMICAL DESCRIPTION AND INJECTION POINTS

6.1 OIL AND GAS CHEMICALS (TOPSIDES)

6.1.1 DEFOAMER

To prevent foaming in the topsides facilities, defoamer shall be injected continuously into the following points:

- Production manifolds (train A and train B) downstream liquid sample point.
- Upstream free water separator level control valve (train A and train B).
- Oil Dehydrator Degasser (train A and train B) upstream mixing valve.
- Test manifold downstream liquid sample point.
- Upstream test separator level control valve.

Application rate: 20 to 200 ppmv.

Injection Fluid Basis: Liquid flowrate (oil + produced water).

Defoamer will be pumped to the above cited injection points by injection pumps B-UQ-1261001-01A/C (3 x 50%, 4 pump heads each). The pumps shall have dedicated pump heads, one for each injection point.

Each pump head flow rate shall be based on a maximum dosage rate.

6.1.2 DEMULSIFIER

To break water-in-oil emulsions in the topsides facilities, demulsifier shall be injected into the following points:

- Production manifolds (train A and train B) downstream liquid sample point.
- Upstream free water separator level control valve (train A and train B).
- Oil Dehydrator Degasser (train A and train B) upstream mixing valve.
- Test manifold downstream liquid sample point.
- Upstream test separator level control valve.

Application rate: 10 to 100 ppmv.
Injection Fluid Basis: Liquid flowrate (oil + produced water).

Demulsifier will be pumped to the above cited injection points by injection pumps B-UQ-1261001-02A/C (3 x 50%, 4 pump heads each). The pumps shall have dedicated pump heads, one for each injection point.

Each pump head flow rate shall be based on a maximum dosage rate.

6.1.3 H_2S SCAVENGER OFFLOADING

Hydrogen sulfide (H_2S) scavenger for oil shall be injected into the following points:

- Upstream oil transfer pumps.
- Off spec oil tank, TQ-1223501.
- Produced water tank, TQ-5331501P/S.
- Transfer header in HULL system

H_2S Scavenger will be pumped to the above cited injection points by injection pumps B-UQ-1261001-03A/C (3 x 50%, 4 pump heads each). The pumps shall have dedicated pump heads, one for each injection point.

Application rate: 20 to 200 ppmv.
Injection Fluid Basis: Oil flowrate (for pumps and tanks points); Offloading flowrate (for transfer header).

6.1.4 ACETIC ACID

The purpose of acid injection is to reduce the dissolved oil content in the produced water in order to comply with CONAMA regulation and the analytical Standard Method (SM) SM-5520B for produced water discharge to overboard.

Acetic acid shall be injected continuously into the following points:

- Production Manifold A/B.
- Test Manifold.

Application rate: 100 to 1000 ppmv.
Injection Fluid Basis: Produced water flowrate.

Acetic acid will be pumped to the above cited injection points by injection pumps B-UQ-1261001-04A/C (3 x 50%, 2 pump heads each). The pumps shall have dedicated pump heads, one for each injection point.

The pump head flow rate shall be based on a maximum dosage rate.

6.1.5 SODIUM HYDROXIDE

To reduce the acidity of oil, Sodium hydroxide solution may be injected into the following points:

- Upstream P-1223003A and P-1223003B (single point to both trains A and B).
- Upstream B-1223003A/B and B-1223003C/D.

Application rate: 44 mg/kg of oil (Injection solution of 18%w/w NaOH).
Injection Fluid Basis: Oil flowrate.

The injections in each production trains are not simultaneous and shall be diluted with water. Sodium hydroxide solution will be pumped to the above cited injection points by injection pumps B-UQ-1261001-05A/C (3 x 50%, 2 pump heads each) and dilution pumps B-UQ-1261001-16A/C (3 x 50%, 2 pump heads each). The pumps shall have dedicated pump heads, one for each injection point.

The pump head flow rate shall be based on a maximum dosage rate.

6.1.6 SCALE INHIBITOR TOPSIDES

To prevent scaling in the topsides facilities, scale inhibitor shall be injected continuously into the following points:

- Production manifolds (train A and train B) downstream liquid sample point.
- Upstream free water separator level control valve (train A and train B).
- Oil Dehydrator Degasser (train A and train B) upstream mixing valve.
- Test manifold downstream liquid sample point.
- Upstream test separator level control valve.

Application rate: 20 to 200 ppmv.

Injection Fluid Basis: Produced water flowrate.

Scale Inhibitor will be pumped to the above cited injection points by injection pumps B-UQ-1261001-06A/C (3 x 50%, 4 pump heads each). The pumps shall have dedicated pump heads, one for each injection point.

Each pump head flow rate shall be based on a maximum dosage rate.

6.1.7 GAS CORROSION INHIBITOR

Corrosion inhibitor shall be injected continuously into the following points:

- Low pressure fuel gas header.
- Gas export pipeline.

Application rate: 1.0 L / 10^6 scf for wet gas lines.

Injection Fluid Basis: Gas flowrate.

Gas Corrosion Inhibitor will be pumped to the above cited injection points by injection pumps B-UQ-1261001-12A/B (2 x 100%).

The pump head flow rate shall be based on a maximum dosage rate.

6.1.8 HYDRATE INHIBITOR TOPSIDES

The hydrate inhibitor injection may be required on the following points:

- Gas lift injection lines.
- Coalescer filter condensate outlet of molecular sieve entrance (one in each camera).
- Gas export pipeline.

The hydrate inhibitor shall be defined estimating its concentration in each stream to keep the hydrate formation temperature at least 5°C below the stream temperature.

The following flowrates below were estimated for each point listed above and shall be confirmed/updated during Detailed Design. The hydrate inhibitor injection in these points is expected only in case of a malfunction of the Gas Dehydration Unit (GDU). In this case, a maximum water content of 40 ppmv (downstream GDU) may be considered in order to estimate the necessary hydrate inhibitor flowrates.

- Gas lift injection lines: 86 L/h (continuous).

- Coalescer filter condensate outlet of molecular sieve entrance: 7 L/h (continuous).
- Gas export pipeline: 300 L/h (continuous).

Hydrate inhibitor will be pumped to the above cited injection points by injection pump B-UQ-1261001-13A/B (2 x 100%, 4 pump heads each). The pump shall have dedicated pump heads, one for each injection point.

Each pump head flow rate shall be based on a maximum dosage rate.

6.1.9 SODIUM HYDROXIDE DILUTION WATER

The sodium hydroxide dilution water pump is used to dilute concentrated sodium hydroxide (50% to 60% wt) to 18% wt solution. The sodium hydroxide tank TQ-UQ-1261001-05 and pump B-UQ-1261001-05A/C shall be sized with the most dilute solution (50%) of sodium hydroxide to obtain the maximum injection flow and the maximum power required from the pumps. The dilution water pump B-UQ-1261001-16A/C shall be calculated for the solution more concentrated (60%), also to obtain the maximum injection flow rate and the maximum required pump power.

The sodium hydroxide dilution water pump shall be designed to mix the dilution water with sodium hydroxide in the discharge of:

- Sodium Hydroxide Injection pumps B-UQ-1261001-05A/C discharge. A proper mixing device shall be provided downstream sodium hydroxide and water mixing.

Fresh water from reverse osmosis unit shall be pumped to discharge of Sodium Hydroxide Injection pumps (B-UQ-1261001-05A/C) by sodium hydroxide dilution water pump B UQ-1261001-16A/C (3 x 50%, 2 pump heads each). The pumps shall have dedicated pump heads.

Each pump head flow rate shall be based on a maximum dosage rate.

6.2 OIL AND GAS CHEMICALS (SUBSEA)

All tanks and pumps to subsea chemical products shall be able to operate with any of these chemical products:

- Scale inhibitor subsea
- Wax inhibitor
- Asphaltene inhibitor
- H_2S scavenger

- Hydrate inhibitor
- Demulsifier subsea.

As a basis for design, it shall be considered among the chemicals above, the one that demands the highest power and flowrate. The following data below was based on demulsifier (most viscous product) and shall be confirmed/updated during Detailed Design.

6.2.1 SCALE INHIBITOR SUBSEA

To prevent scaling, scale inhibitor shall be injected into downhole or subsea Christmas trees through umbilical. The injection is planned to be continuous, either one up to all trees at the same time or in the chemical injection points of the topsides.

Application rate: 2 to 200 L/h (per well)
Injection Fluid Basis: Produced water flowrate.

Scale Inhibitor will be pumped to the above cited injection points by injection pumps B-UQ-1261001-07A/E (5 x 25%, 14 pump heads in operation). One pump head shall be dedicated for each well.

The pump flow rate shall be based on a maximum dosage rate.

6.2.2 WAX INHIBITOR

To prevent wax in the topsides facilities, wax inhibitor shall be injected into downhole or subsea Christmas trees through umbilical, during production stop.

Application rate: 20 to 200 L/h
Injection Fluid Basis: Oil flowrate.

Wax inhibitor will be pumped to the above cited injection points by injection pumps B-UQ-1261001-08A/E (5 x 25%, 14 pump heads in operation). One pump head shall be dedicated for each well.

The pump flow rate shall be based on a maximum dosage rate.

6.2.3 ASPHALTENE INHIBITOR

To prevent asphaltene deposition, asphaltene inhibitor shall be injected into downhole or subsea Christmas trees through umbilical, using asphaltene inhibitor pumps B-UQ-1261001-09A/E (5 x 25%, 14 pump heads in operation). One pump head shall be dedicated for each well.

Application rate: 20 to 200 L/h

Injection Fluid Basis: Liquid flowrate (oil + produced water).

The pump flow rate shall be based on a maximum dosage rate.

6.2.4 H_2S SCAVENGER SUBSEA

Hydrogen sulfide scavenger shall be injected into the WCT or downhole, using umbilical lines.

Application rate: 25 L/kg H_2S.

Injection Fluid Basis: Total mass of H_2S in the oil before the choke valve.

H_2S Scavenger will be pumped to the above cited injection points by injection pumps B-UQ-1261001-10A/E (5 x 25%, 14 pump heads in operation). One pump head shall be dedicated for each well.

The pump flow rate shall be based on a maximum dosage rate.

6.2.5 HYDRATE INHIBITOR SUBSEA

Under combinations of high pressure and low temperature, well fluids shall be in the hydrate formation region. To inhibit hydrate formation, ethanol or monoethyleneglycol (MEG) shall be injected into the producing wells wet Christmas trees (WCTs). The injection is not planned to be continuous, however in the (WCTs), it shall be possible to inject it in up to two points at the same time.

Ethanol or monoethyleneglycol may also be injected to help remove any hydrates that are inadvertently formed, and to equalize pressure across tree valves prior to opening.

The subsea hydrate inhibitor shall be pumped to a distribution header from where it shall flow through each production well via service line or via their respective well umbilical by injection pumps B-UQ-1261001-11A/B (2 x 50%). The pump flow rate for each pump is 3,500 L/h. If this high capacity pumps are used to inject via well umbilical, the flowrate may be reduced and therefore a variable control device shall be provided for each of this pumps.

Additionally, B-UQ-1261001-15A/B (2 x 100%, 4 pump heads each) shall pump subsea hydrate inhibitor to 4 distribution headers from where it shall flow through each gas injection line. The pump flow rate for each pump is 800 L/h (200 L/h each pump head).

6.2.6 DEMULSIFIER SUBSEA

To break water-in-oil emulsions in subsea facilities, demulsifier shall be injected into the following points:

- Inside the wells.

Application rate: 50 to 500 ppmv.
Injection Fluid Basis: Liquid flowrate (oil + produced water).

Demulsifier will be pumped to the above cited injection point by injection pumps B-UQ-1261001-08A/E (5 x 25%, 14 pump heads in operation). One pump head shall be dedicated for each well.

Each pump head flow rate shall be based on a maximum dosage rate.

6.3 PRODUCED WATER CHEMICALS

6.3.1 INVERTED EMULSION INHIBITOR (POLYELECTROLYTE)

To break oil-in-water (reverse) emulsions in the produced water treatment system, polyelectrolyte will be injected continuously upstream the flotation units.

Application rate: 10 to 100 ppmv.
Injection Fluid Basis: Produced water flowrate.

Inverted emulsion inhibitor will be pumped to the above cited injection points by injection pumps B-UQ-1262001-01A/B (2 x 100%).

The pump flow rate shall be based on a maximum dosage rate.

The dilution of the polyelectrolyte in water shall be through pumps B-UQ-1262001-02A/B (2x100%).

Automatic dilution of the product in water shall be provided using Dilution Blending Unit (Z-UQ-1262001-01A/B - 2x100%), with no need for tank dilution. This dosage rate considers dilution in water, in a ratio of 1 (polyelectrolyte): 10 until 30 (water). The diluted polyelectrolyte will be injected upstream the flotation unit by Z-UQ-1262001-01A/B.

6.3.2 INVERTED EMULSION INHIBITOR (POLYELECTROLYTE) DILUTION WATER

Fresh water from reverse osmosis unit will be pumped to the above cited injection points by Inverted Emulsion Inhibitor (Polyelectrolyte) Dilution Water B-UQ-1262001-02A/B (2 x 100%). The pumps shall have dedicated pump heads.

Each pump head flow rate shall be based on a maximum dosage rate.

6.3.3 SCALE INHIBITOR

To prevent scaling in the produced water treatment system, scale inhibitor shall be continuously injected into the following points:

- Water outlet line of SG-1223001A/B (Free water separator)
- Water outlet line of SG-1223002 (Test separator)
- Water outlet line of pre-oil dehydrator (TO-1223001A/B)
- Water outlet line of oil dehydrator (TO-1223002A/B)

Application rate: 5 to 50 ppmv.
Injection Fluid Basis: Produced water flowrate.

Scale inhibitor will be pumped to the above cited injection points by injection pumps B-UQ-1262001-03A/C (3 x 50%, 4 pump heads each). The pumps shall have dedicated pump heads, one head for each injection point.

Each pump head flow rate shall be based on a maximum dosage rate.

6.3.4 BIOCIDE THPS 35%

To kill bacteria in the produced water treatment system, facilities shall be provided for periodic shock dosing of biocide THPS (tetrakis(hydroxymethyl) phosphonium sulfate - typically once per week during one hour).

The chemicals shall be injected into the following points:

- Produced water tanks - TQ-5331501P/S (shock dosing).
- Slop tanks - TQ-5336506P/S (shock dosing).
- Off-spec oil tank - TQ-1223501 (continuously and shock dosing).

Application rate: 10 to 200 ppmv (shock dosing).
Injection Fluid Basis: Effective Tank volume (shock dosing).

Application rate to TQ-1223501 continuous injection: 10 to 50 ppmv.
Injection Fluid Basis: Produced water flowrate (continuously dosing).

Biocide THPS will be pumped to the above cited injection points by injection pumps B-UQ-1262001-04A/B (2 pump heads each). The pumps shall have dedicated pump heads, one for each injection point.

The pump flow rate shall be based on a maximum dosage rate.

6.3.5 OXYGEN SCAVENGER

Injection point shall be provided at the outlet line of the produced water tanks (TQ-5331501P/S), off-spec oil tank (TQ-1223501) and slop tanks (TQ-5336506P/S) before the oxygen analyzer.

Application rate: 5 to 25 ppmv (normal dosing).
Injection Fluid Basis: Produced water flowrate (normal dosing).

Application rate: 100 to 200 ppmv (shock dosing).
Injection Fluid Basis: Oil Skimming flowrate from slop tank to slop vessel (shock dosing).

Oxygen scavenger will be pumped to the above cited injection points by injection pumps B-UQ-1262001-05A/B (2 pump heads each). The pumps shall have dedicated pump heads.

6.3.6 BIOCOAGULANT (CONCENTRATED)

Injection points shall be provided at the inlet and outlet of hydrocyclones.

Application rate: 10 to 60 ppmv.
Injection Fluid Basis: Produced water flowrate.

Biocoagulant (concentrated) will be pumped to the above cited injection points by injection pumps B-UQ-1262001-06A/B (2 x 100%). The pumps shall have dedicated pump heads.

Automatic dilution of the product in water shall be provided using Dilution Blending Unit (Z-UQ-1262001-02A/B - 2x100%), with no need for tank dilution. This dosage rate considers dilution in water, in a ratio of 1 (biocoagulant): 19 (water). The diluted biocoagulant will be injected upstream the flotation unit by Z-UQ-1262001-02A/B.

6.3.7 BIOCOAGULANT DILUTION WATER

Fresh water from reverse osmosis unit will be pumped to the above cited injection points by Biocoagulant Dilution Water Pump B-UQ-1262001-07A/B (2 x 100%). The pumps shall have dedicated pump heads.

Each pump head flow rate shall be based on a maximum dosage rate.

6.4 INJECTION WATER CHEMICALS

6.4.1 OXYGEN SCAVENGER

Oxygen scavenger injection is required to reduce the oxygen content in the deaeration column from typically 50 ppb (mechanical deaeration alone, i.e., no chemicals) to 10 ppb. The chemical will be injected into accumulator or downstream the deaeration column by-pass line in two conditions: continuously when the deaeration column is in operation and with shock dosage when the deaeration column is out of operation.

Application rate: 5 to 25 ppmv (normal dosing).
Injection Fluid Basis: Injection water flowrate (normal dosing).

Application rate: 100 to 200 ppmv (shock dosing).
Injection Fluid Basis: Injection water flowrate (shock dosing).

Oxygen scavenger injection is also required in the outlet line of UD-5122002A/B (Fresh Water Maker for Oil Dilution) tanks, since the seawater derivation for UD-5122002A/B is located downstream Ultrafiltration Unit (UT-1251001), therefore upstream deaeration column.

Oxygen scavenger will be pumped to the above cited injection points by injection pumps B-UQ-1263001-01A/B (2 x 100%, 1 pump head supplying for multiple injection points). Each consumer shall have dedicated control valves.

The pump flow rate shall be based on a maximum dosage rate.

6.4.2 BIODISPERSANT

Biodispersant will be continuously injected downstream the deaeration column by-pass line.

Application rate: 5 to 20 ppmv.
Injection Fluid Basis: Injection water flowrate.

Biodispersant will be pumped to the above injection point by injection pumps B-UQ-1263001-02A/B (2 x 100%). The pump flow rate shall be based on a maximum dosage rate.

6.4.3 BIOCIDE

Biocide injection is required to kill bacteria in the injection water system. Facilities are provided for periodic shock dosing of biocide THPS (tetrakis(hydroxymethyl) phosphonium sulphate - typically twice per week for one hour). The chemicals will be injected downstream or upstream the deaeration column.

Application rate: 100 to 1000 ppm.
Injection Fluid Basis: Injection water flowrate.

Biocide THPS will be pumped to the above cited injection point by injection pumps B-UQ-1263001-03A/B (2 x 100%). The pump flow rate shall be based on a maximum dosage rate.

6.4.4 SCALE INHIBITOR

Scale inhibitor injection is required to prevent scaling in the injection water system, mainly during Sulphate Removal Unit (SRU) by-pass. Scale inhibitor shall be provided to be injected continuously upstream the Ultrafiltration Unit (UFU).

Application rate: 1 to 20 ppm.
Injection Fluid Basis: SRU entrance flowrate.

Injection water scale inhibitor will be pumped to the above cited injection point by injection pumps B-UQ-1263001-04A/B (2 x 100%). The pump flow rate shall be based on a maximum dosage rate.

7 CHEMICAL INJECTION PUMPS

7.1 DESIGN PARAMETERS

The Chemical Injection Pumps shall include pumps, respective drivers, suction strainers, discharge filters, pressure safety valves, process piping, pressure indicators, calibration pots, pulsation suppression devices and manual valves.

The injection unit shall use individual pumps or multi-head pumps.

For each pump, the respective operation range shall take into account the minimum flow rate of 1 (one) injection point up to the maximum flow rate of all injection points (considering simultaneous operation of all points, unless a different criteria is indicated for any injection point).

Metering pump type shall be double diaphragm. Hazardous materials shall require the use of double diaphragm pump design with leak detection between diaphragms.

The Chemical Injection Pumps shall be protected with all necessary instruments to operate safely, adequately and without interruption. Process design includes piping and instruments within battery limits.

Each pump shall have a stand-by one to all chemicals to guarantee continuous performance. The flow control shall be done by manual stroke length adjustment.

Capacity control shall be means of manual stroke adjustment (typical 0 to 100%) or by control valves for the cases where it is used.

Instruments and its accessories (e.g., flushing ring, manifolds, pipings, strainers, pulsation dampers, calibration pot, standpipes, block and instrument valves including PSV's) shall be included at Manufacturer's scope of supply.

FIT with FAL shall be installed at all the topsides and subsea chemical injection lines. Signals, including chemical products' density, shall be available at Central Control Room (CCR). Flow meter shall be Coriolis type.

PITs with PAL/PAH/PSLL/PSHH shall be installed at all the subsea chemical injection lines. The PSHH action will stop the related pump that is in operation and the set point pressure is to be defined later by Buyer's subsea team according to subsea lines maximum allowable working pressure (MAWP). The PSLL will stop the related pump that is in operation and the set point pressure is to be defined later by Buyer's subsea team considering the liquid column in subsea pipes. Signals shall be available at Central Control Room (CCR).

PITs with PAL/PAH/PSLL/PSHH shall be installed at all the other chemical injection lines. The PSHH and PSLL action will stop the related pump that is in operation and the set point pressure shall be defined during Detailed Design. Signals shall be available at Central Control Room (CCR).

The spec of the piping included in the scope of supply must be compatible with the pressure spec of piping from outside the scope of supply, otherwise overpressure protection devices (e.g., Pressure Safety Valves, Pressure Control Valves) must be foreseen inside scope of Manufacturer's scope of supply.

Pump heads sequence shall be defined by manufacturer to minimize the momentum of pump and P&ID shall be comply with defined sequence.

7.2 ASSUMPTIONS FOR CALCULATIONS OF CHEMICAL INJECTION PUMPS PERFORMANCE:

7.2.1 Adopted suction pressure = 101.3 kPa abs.

7.2.2 Pump efficiency: minimum of 70%, it shall be confirmed by Pumps Vendor.

7.2.3 Flow for calculation = maximum dosage.

7.2.4 The Chemical Injection units shall prioritize the use of tubing for the injection lines.

7.2.5 The discharge pressure and design pressure of pump or pump head shall take into account the design pressure of the system where the product is to be injected.

7.2.6 The following values and criteria may be considered for pressure drop in accidents, these had been used in the presented estimative in this document:

- Filter = 49 kPa
- Flow meter = 49 kPa
- Control valve = 69 kPa
- Dynamic mixer = 108 kPa
- Static mixer = 10 kPa
- Injection device:
  - Quill type - considered as a percentage of 100% of the pressure drop in the line.
  - Open type - considered as a percentage of 100% of the pressure drop in the line.
  - Spray type = 681 kPa.

7.2.7 At static height between pumps and injection points:

- When the pump has more than one injection head, the power of the drive shaft shall be considered as the sum of the powers of each head.
- Design Pressure (or fixed pressure from the relief valve in the pump discharge line) = Rated Pressure + Back Pressure. For discharge pressure up to 9,807 kPa-a, a minimum of 20% back pressure shall be used and, for discharge pressure above 9,807 kPa-a, a minimum of 10% back pressure shall be used. If the calculated design pressure is less than the pressure design at the injection point, this will be adopted.
- Preliminary calculation of the Pump's Hydraulic Power (or per pump head) - the power on the pump shaft is calculated according to Equations (1) and (2) below and the values represent a preliminary assessment, the final values shall be defined by the supplier of the chemical units:

$$Ph = 2.724069 \times Q \times \frac{(Pd - Ps)}{(100 \times 98.0665)} \quad (1)$$

$$P = \frac{(Ph)}{e} \quad (2)$$

Where:
P = Power on the shaft, bkW.
Ph = Power, kW.
Q = Volumetric Flow, m³/h.
Pd = Discharge Pressure, kPa-a.
Ps = Suction Pressure, kPa-a.

e = Estimated efficiency.

The following Table 6, Table 7 and Table 8 below present preliminary estimative for pumps power and chemical flowrates for each injection point. It was based on preliminary piping arrangement and shall be confirmed/updated during Detailed Design.

7.3 CHEMICAL INJECTION PUMPS FOR OIL AND GAS

Table 6 – Chemical Injection Pumps for Oil and Gas.

Pump Tag	Pump Load Sharing/ Sparing	Head	Chemical Product	Injection Point	Cap. / head (L/h)	Injection point pressure (kPa-a)	Power (bkW)	Design Pressure (SELECTED) (kPag)	Operat. Temp. °C	Design Temp. °C	Cap. p/Pump L/h
B-UQ-1261001-01A/C	3 X 50%	1	Defoamer	Production manifolds (train A) downstream liquid sample point	183	2000	0.2	3000	14-37	60	366
		2		Test manifold downstream liquid sample point	92	2000	0.08				
		3		Upstream free water separator level control valve (train A)	183	1960	0.2				
		4		Oil Dehydrator Degasser (train A) upstream mixing valve	183	930	0.1				
		1		Production manifolds (train B) downstream liquid sample point	183	2000	0.2				
		2		Upstream test separator level control valve	92	1960	0.08				
		3		Upstream free water separator level control valve (train A)	183	1960	0.2				
		4		Oil Dehydrator Degasser (train B) upstream mixing valve	183	930	0.1				
B-UQ-1261001-02A/C	3 X 50%	1	Demulsifier	Production manifolds (train A) downstream liquid sample point	92	2000	0.1	2727	14-37	60	184
		2		Test manifold downstream liquid sample point	46	2000	0.04				
		3		Upstream free water separator level control valve (train A)	92	1960	0.1				
		4		Oil Dehydrator Degasser (train A) upstream mixing valve	92	930	0.04				
		1		Production manifolds (train B) downstream liquid sample point	92	2000	0.1				
		2		Upstream test separator level control valve	46	1960	0.04				
		3		Upstream free water separator level control valve (train B)	92	1960	0.1				
		4		Oil Dehydrator Degasser (train B) upstream mixing valve	92	930	0.04				
B-UQ-1261001-03A/C	3 X 50%	1	H2S Scavenger - offloading	B-1223003 A/B Suction	150	216	0.04	783	14-37	60	450
		2		B-1223003 C/D Suction	150	216	0.04				
		3		TQ-1223501 (Off-Spec Oil Tank)	150	101	0.02				
		3		TQ-5331501P/S	150	101	0.02				
		4		Transfer Header (HULL)	120	101	0.01				
B-UQ-1261001-04A/C	3 X 50%	1	Acetic acid (75%)	Production manifold (train A)	300	2000	0.3	2613	14-37	60	600
		1		Production manifold (train B)	300	2000	0.3				
		2		Test manifold	300	2000	0.3				
B-UQ-1261001-05A/C	3 X 50%	1	Sodium Hydroxide (50%)	B-1223003 A/B Suction	38	216	0.00	1658	14-37	60	114
		1		B-1223003 C/D Suction	38	216	0.00				
		2		In the dilution line upstream of the P-1223003A/B	76	1389	0.04				
B-UQ-1261001-06A/C	3 X 50%	1	Scale Inhibitor - topsides	Production manifolds (train A) downstream liquid sample point	133	2000	0.12	2799	14-37	60	399
		2		Oil Dehydrator Degasser (train A) upstream mixing valve	133	930	0.06				
		3		Test manifold downstream liquid sample point	88	2000	0.08				
		4		Upstream free water separator level control valve (train A)	133	1960	0.12				
		1		Production manifolds (train B) downstream liquid sample point	133	2000	0.12				
		2		Upstream free water separator level control valve (train B)	133	1960	0.12				
		3		Upstream test separator level control valve	88	1960	0.07				
		4		Oil Dehydrator Degasser (train B) upstream mixing valve	133	930	0.06				
B-UQ-1261001-07A/E	5 X 25%	14	Scale Inhibitor - subsea	Wet Christmas Tree / Inside the wells	609	55000	4.4	60934	14-37	60	609
B-UQ-1261001-08A/E	5 X 25%	14	Wax Inhibitor - subsea	Wet Christmas Tree / Inside the wells	651	55000	4.4				651
			Demulsifier Subsea	Wet Christmas Tree / Inside the wells	920	55000	5.0				920
B-UQ-1261001-09A/E	5 X 25%	14	Asphaltene Inhibitor - subsea	Wet Christmas Tree / Inside the wells	797	55000	4.4				797
B-UQ-1261001-10A/E	5 X 25%	14	H2S Scavenger - subsea	Wet Christmas Tree / Inside the wells	679	55000	0.5				679
B-UQ-1261001-11A/B	2 X 50%	1	Hydrate Inhibitor Subsea (Ethanol)	Wet Christmas Tree	3500	55000	76.4	60908	14-37	60	3500
	2 X 50%	1	Hydrate Inhibitor Subsea (Ethanol)	Service Header	3500	55000	76.8				
	2 X 50%	1	Hydrate Inhibitor Subsea (MEG)	Wet Christmas Tree	3500	55000	76.4				
	2 X 50%	1	Hydrate Inhibitor Subsea (MEG)	Service Header	3500	55000	76.9				
B-UQ-1261001-12A/B	2 X 100%	1	Gas Corrosion Inhibitor	LP Fuel Gas Header	1	4770	0.0	27666	14-37	60	10
		2		Gas Export Header	9	25000	0.1		14-37	60	
B-UQ-1261001-13A/B	2 X 100%	1	Hydrate Inhibitor (Ethanol)	Gas lift injection lines (before each Pig Launcher)	86	25000	0.9	28535	14-37	60	399
		2		Condensate upstream of molecular sieve coalescing filter lower chamber level control valve (FT-1233001A/B)	7	5960	0.02				
		3		Condensate upstream of molecular sieve coalescing filter upper chamber level control valve (FT-1233001A/B)	7	5960	0.02				
		4		Export Header	300	25000	3.1				
	2 X 100%	1	Hydrate Inhibitor (MEG)	Gas lift injection lines (before each Pig Launcher)	86	25000	0.9				
		2		Condensate upstream of molecular sieve coalescing filter lower chamber level control valve (FT-1233001A/B)	7	5960	0.02				
		3		Condensate upstream of molecular sieve coalescing filter upper chamber level control valve (FT-1233001A/B)	7	5960	0.02				
		4		Export Header	300	25000	3.1				
B-UQ-1261001-15A/B	2 X 100%	1	Hydrate Inhibitor (Ethanol)	Injection wells	200	55000	4.4	61566	14-37	60	800
		2		Injection wells	200	55000	4.4				
		3		Injection wells	200	55000	4.4				
		4		Injection wells	200	55000	4.4				
	2 X 100%	1	Hydrate Inhibitor (MEG)	Injection wells	200	55000	4.4				
		2		Injection wells	200	55000	4.4				
		3		Injection wells	200	55000	4.4				
		4		Injection wells	200	55000	4.4				
B-UQ-1261001-16A/C	3 X 50%	1	Sodium Hydroxide Dilution Water	B-UQ-1261001-05A/C discharge to B-1223003A/B	133	218	0.02	1817	14-37	60	133
		2		B-UQ-1261001-05A/C discharge to B-1223003C/D	133	225	0.02				
		2		B-UQ-1261001-05A/C discharge to P-1223003A/B	265	1417	0.2				

7.3.1 CHEMICAL INJECTION VIA UMBILICAL IN WCT OR DOWNHOLE

7.3.1.1 SAMPLING POINTS

A sampling point should be provided right upstream of the entry into the umbilical head to allow monitoring of the quality of the injected products. The following items shall be followed for each sampling point:

- Located and positioned so as to minimize segregation of product components;
- Preferentially located in vertical sections, with ascending flow. In case it is not possible, points with turbulent flow shall be selected to ensure that the product ar properly mixed;
- Do not use on pipe ends or dead zones;
- Use construction materials compatible with the sampled fluid, to avoid corrosion;
- Provide all sampling points with a blocking valve and two control valves (needle or globe type);
- A gap of at least 20 cm between the sampling point and the drainage point shall be considered.

7.3.1.2 FILTRATION

A stainless steel filter element filter shall be installed, with 100 mesh in the pump suction and 400 mesh upstream umbilical.

The filters shall be provided with differential pressure indicators and spare in order to be replaced and cleaned periodically.

7.4 CHEMICAL INJECTION PUMPS FOR PRODUCED WATER

Table 7 – Chemical Injection Pumps for Produced Water.

Pump Tag	Pump Load Sharing/ Sparing	Head	Chemical Product	Injection Point	Cap. / head	Injection point pressure	Operat. Temp.	Design Temp.	Design pressure (SELECTED)	Cap. p/Pump
					(L/h)	(kPa-a)	°C	°C	(kPag)	L/h
B-UQ-1262001-01A/B	2 X 100%	1	Polyelectolyte (Concentrated)	Float inlet line (dow nstream of sampling point)	134	780	14 - 37	60	1276	134
B-UQ-1262001-02A/B	2 X 100%	1	Dilution w ater for Polyelectolyte	Float inlet line (dow nstream of sampling point)	4020	780	14 - 37	60	1588	4020
B-UQ-1262001-03A/C	3 X 50%	1	Scale Inhibitor	Water outlet line of Free w ater separator	34	1278	14 - 37	60	1852	85
		2		Water outlet line of pre-oil dehydrator	25	890	14 - 37	60		
		3		Water outlet line of oil dehydrator	5	216	14 - 37	60		
		4		Water outlet line of Test separator	22	1278	14 - 37	60		
B-UQ-1262001-04A/B	2 X 100%	1	Biocide	TQ-1223501	2905	101	14 - 37	60	1328	2905
		2		Slop tank / Produced w ater tanks	837	101	14 - 37	60		
B-UQ-1262001-05A/B	2 X 100%	1	Oxygen Scavenger	Output line from the produced w ater tank, upstream of the Oxygen analyzer	121	2198	14 - 37	60	2693	128
		2		TQ-1223501 outlet	8	601	14 - 37	60		
B-UQ-1262001-06A/B	2 X 100%	1	Biocoagulant (Concentrated)	Inlet of hydrocyclones	80	1180	14 - 37	60	1774	80
				Outlet of hydrocyclones	80	780	14 - 37	60		
B-UQ-1262001-07A/B	2 X 100%	1	Dilution w ater for biocoagulant	Inlet of hydrocyclones	1528	1180	14 - 37	60	1792	1528
				Outlet of hydrocyclones	1528	780	14 - 37	60		

7.5 CHEMICAL INJECTION PUMPS FOR INJECTION WATER

Table 8 – Chemical Injection Pumps for Injection Water.

Pump Tag	Pump Load Sharing / Sparing	Head	Chemical Product	Injection Point	Cap. / head	Injection point pressure	Operat. Temp.	Design Temp.	Design pressure (SELECTED)	Cap./Pump
					(L/h)	(kPa-a)	°C	°C	(kPag)	(L/h)
B-UQ-1263001-01 A/B (Case 1)	2 X 100%	1	Oxygen Scavenger (continuous)	Deaerator vessel	111	50.0	14 - 37	60	430	490
B-UQ-1263001-01 A/B (Case 2)	2 X 100%	1	Oxygen Scavenger (continuous)	Dow nstream of the deaerator by-pass line	490	200.0	14 - 37	60	290	
B-UQ-1263001-02 A/B	2 X 100%	1	Biodispersant (continuous)	Dow nstream of the deaerator by-pass line	40	200.0	14 - 37	60	309	40
B-UQ-1263001-03 A/B	2 X 100%	1	Biocide (shock)	Deaerator upstream	1955	101.0	14 - 37	60	812	1955
	2 X 100%	1		Dow nstream of the deaerator by-pass line	1955	200.0	14 - 37	60	569	
B-UQ-1263001-04 A/B	2 X 100%	1	Scale Inhibitor (continuous)	Upstream of ultrafiltration (UT-1251001)	74	511.0	14 - 37	60	842	74

8 CHEMICAL STORAGE

8.1 DESIGN PARAMETERS

Atmospheric chemical storage tanks shall be provided for all chemical injection pumps of the Injection Water Chemical Injection Unit.

All vent nozzles shall be designed according to API Std 2000 - Venting Atmospheric and Low-Pressure Storage Tanks and NFPA 30 - Flammable and Combustible Liquids Code, including the external fire scenario, whichever it is more restrictive. In the vent design, the reduction factor foreseen in API Std 2000 and NFPA 30 shall not be considered. Vent diameters indicated in ANNEXES 1, 2 and 3 had already been estimated based on these criteria and they shall be confirmed/updated by Packager.

All atmospheric tanks shall be provided with an atmospheric vent, a level gauge and transmitter, an overflow, a dedicated fill connection, and a manway as a minimum.

According to API Std 2000 - Venting Atmosphere and Low Pressure Storage Tanks (newest edition) flame arrester (detonation type) shall be provided for tanks handling flammable products with a capacity greater than 9.5 m³.

For general specifications and for material specification see I-ET-3010.00-1200-940-P4X-005 - Chemical Injection Points.

A filling station, with individual lines shall be provided to fill up all tanks. Minimum diameter for filling lines shall be 2”. Each individual line shall have a 10 mesh net in order to avoid the product contamination. Strainers and inlet nozzle shall be provided in all storage tanks.

Connections for nitrogen injection shall be foreseen in each filling line, to allow purging of the tanks.

The storage of hydrate inhibitor shall be consisted of two tanks, both tanks shall be prepared to storage ethanol or MEG (monoethylene glycol).

Detailed design shall provide a rigid piping for each continuous chemical products for make-up of storage tanks of the units UT-1251001, located in module M-11, UD-5122002A/B and UT-1251002, located in module M-15. It shall be considered the quantity of continuous chemical products defined by each unit´s packager. Detailed design shall guarantee that each continuous product flow from M-14 to the respective storage tank in M-11 (UT-1251001) and M-15 (UD-5122002A/B and UT-1251002). If necessary, pumps for these services shall be provided, it is part of detailed design scope of supply. In case pump is necessary, the same pump shall not be shared between different chemical products or between different packages, the only exception may be in case of chemical products integration between units (UT-1251001, UT-1251002 and UD-5122002A/B). This integration shall be submitted for Buyer approval.

Drainage system shall be dimensioned to avoid flammable / combustible liquid accumulation under the tanks and in the skid basins, according to requirements in I-RL-3010.2D-1200-940-P4X-003 - DRAINAGE SYSTEM GUIDELINES.

The location of chemical storage tanks shall consider the compatibility between products. Preliminary information is provided in Annex 9 (Item 12.9). More details will be provided during Detailed Design.

8.2 GENERAL NOTES

8.2.1 The bottom of the tanks shall be designed to guarantee full drainage.

8.2.2 Fabrication, assembly and tests shall be in accordance with:

I-ET-3010.00-1200-510-P4X-001 - Metallic Tanks Design for Topside, where applicable.

8.2.3 The package/manufacturer must define the type of support more appropriated to each case.

8.2.4 The equipment shall be able to operate under the conditions indicated in:

I-RL-3010.2D-1350-960-P4X-002 – Motion Analysis.

8.2.5 The spec of the piping included in the scope of supply must be compatible with the pressure spec of piping from outside the scope of supply, otherwise overpressure protection devices (e.g. Pressure Safety Valves, Pressure Control Valves) must be foreseen inside scope of supply by MANUFACTURER.

8.2.6 The tank's bottom shall have a slope between 1:100 and 1:25 (refers to tank width) towards the tank drain outlet. The pump suction outlet shall be on opposite side of drain outlet.

8.2.7 The liquid outlet nozzle shall be located in order to avoid the acquisition of debris that can be accumulated at the bottom of the tank. MANUFACTURER shall consider minimum height of 150 mm. Internal piping is for sealing purpose. The overflow is below low level inside the tank. The overflow line shall be provided with siphon breaker at its highest point.

8.2.8 Packager shall include the chemical product properties (e.g., cloud points) used for storage tank design in the tank data sheet.

8.2.9 For further information related to Level Gauge and Transmitters installation requirements regarding nozzle positioning and sizing, refer to I-ET-3010.00-1200-800-P4X-013 - GENERAL CRITERIA FOR INSTRUMENTATION PROJECTS and I-ET-3010.2D-1200-800-P4X-005 - FIELD INSTRUMENTATION.

8.2.10 A sample connection shall be foreseen in the outlet of each chemical product storage tank.

8.3 DESIGN BASIS

8.3.1 The storage of chemical products shall be sufficient for at least 10 days of consumption normal, calculated using 80% of the maximum injection rate indicated in the dosage table of Chemicals**.**

8.3.2 Exception for the storage of the following products, which must have a minimum useful volume of 45 m^3:

- Scale Inhibitor - subsea
- H_2S Scavenger – subsea
- Asphaltene Inhibitor – subsea
- Wax Inhibitor – subsea
- Hydrate Inhibitor (Ethanol / MEG) – subsea

8.3.3 Tanks shall have a minimum volume of 3 m^3.

8.3.4 The useful volume shall be the volume contained between the LLSL and LLSH levels of the tanks.

8.3.5 For the very low level of all tanks, the value of 150 mm shall be adopted.

8.3.6 The dimensions of the tanks are only an estimate and shall be confirmed or revised during Detailed Design.

8.3.7 Tanks for flammable products shall have flame arresters.

8.3.8 The flow rate for calculating the tank capacity is calculated by adding the injection points with continuous dosing.

8.4 CHEMICAL STORAGE FOR OIL AND GAS

Table 9 – Chemical Storage for Oil and Gas.

Tank	Config.	Chemical Product	Injection flow rate (L/h)	Minimum Storage Volume (m^3)	Selected Storage Volume (m^3)
TQ-UQ-1261001-01A/B (1)	2 X 50%	Defoamer	732	175.7	180.0
TQ-UQ-1261001-02A/B (1)	2 X 50%	Demulsifier	368	88.3	100.0
TQ-UQ-1261001-03	1 X 100%	H_2S Scavenger - *offloading*	450	108.0	110.0
TQ-UQ-1261001-04	1 X 100%	Acetic acid (75%)	600	144.0	150.0
TQ-UQ-1261001-05	1 X 100%	Sodium Hydroxide (50%)	76	18.2	24.0
TQ-UQ-1261001-06A/B (1)	2 X 50%	Scale Inhibitor - topsides	798	191.5	200.0
TQ-UQ-1261001-07A/B (1)	2 X 50%	Scale Inhibitor - subsea	609	45.0	48.0
TQ-UQ-1261001-08	1 X 100%	Wax Inhibitor - subsea	651	45.0	48.0
TQ-UQ-1261001-09	1 X 100%	Asphaltene Inhibitor - subsea	797	45.0	48.0
TQ-UQ-1261001-10A/B	2 X 50%	H_2S Scavenger - subsea	340	45.0	48.0
TQ-UQ-1261001-11A/B	2 X 100%	Hydrate Inhibitor (Etanol / MEG)	399	95.8	100.0
TQ-UQ-1261001-12	1 X 100%	Gas Corrosion Inhibitor	10	3.0	4.0
TQ-UQ-1261001-13	1 X 100%	Hydrate Inhibitor (Ethanol / MEG) - subsea	200	45.0	48.0

Notes:

1. These tanks must be bipartite.

8.5 CHEMICAL STORAGE FOR PRODUCED WATER

Table 10 – Chemical Storage for Produced Water.

Tank	Config.	Chemical	Injection flow rate	Minimum Storage Volume	Selected Storage Volume
			(L/h)	(m^3)	(m^3)
TQ-UQ-1262001-01A/B (1)	2 X 50%	Polyelectrolyte	134	32.2	40.0
TQ-UQ-1262001-02	1 X 100%	Scale Inhibitor	798	191.5	200.0
TQ-UQ-1262001-03A/B (1)	2 X 50%	Biocide	203	48.6	56.0
TQ-UQ-1262001-04	1 X 100%	O_2 Scavenger	128	30.8	33.8
TQ-UQ-1262001-05	1 X 100%	Biocoagulant	80	19.3	22.5

Notes:
1. These tanks must be bipartite.

8.6 CHEMICAL STORAGE FOR INJECTION WATER

Table 11 – Chemical Storage for Injection Water.

Tank	Conf.	Chemical	Injection flow rate	Minimum Storage Volume	Selected Storage Volume
			(L/h)	(m^3)	(m^3)
TQ-UQ-1263001-01	1 X 100%	O_2 Scavenger	111	26.6	29.7
TQ-UQ-1263001-02	1 X 100%	Biodispersant	40	9.6	13.2
TQ-UQ-1263001-03A/B (1)	2 X 50%	Biocide	23	5.6	7.9
TQ-UQ-1263001-04	1 X 100%	Scale Inhibitor	74	17.8	19.8

Notes:
1. This tank must be bipartite.

9 CHEMICAL LOADING

9.1 DESIGN PARAMETERS

Sufficient area shall be provided for receiving and storing a quantity of tote tanks corresponding to the consumption of chemicals in 7 days at 50% of the maximum injection rate indicated in this document at maximum gas, oil, produced water and injection water flowrates. Products of non-continuous use shall not be considered in this calculation. No stacking of tote tanks is allowed.

10 LAYOUT REQUIREMENTS

The Chemical Injection Packages will be installed outdoors in a marine environment on the same Module M-14. The design of the Chemical Injection Skids shall comply with the available footprint for the tanks and pumps.

The pumps shall be installed in a deck below the tanks, with available footprint of 25 m x 20 m x 2.8 m (L x W x H).

The tanks shall be installed in a deck above the pumps, with available footprint of 25 m x 20 m x 2.8 m (L x W x H).

The equipment within the packages shall be arranged such to allow safe and good personnel access for all operation and maintenance activities. The Ergonomic Requirements of I-ET-3010.2D-1400-196-P4X-001 shall be complied with.

11 SAFETY REQUIREMENTS

During Detailed Design, Chemical Injection System shall be analyzed in PHA and Hazop.

The system shall be designed in order to assure the correct fire detection system and firefighting system to protect equipment handling flammable / combustible fluids.

Information regarding fire risk category and fuels and ignition sources can be checked at Safety Data Sheet - I-FD-3010.2D-5400-947-P4X-001 for the fire zones related to the chemical units and products storage module (M-14), as well as the requirements for fire and gas detection system and firefighting system.

12 ANNEX

12.1 ANNEX 1 - DIAMETER OF THE VENTS NOZZLES FOR OIL AND GAS INJECTION SYSTEM

Tank	Chemical Product	Diameter of the vents nozzles
		in
TQ-UQ-1261001-01A/B	Defoamer	**6**
TQ-UQ-1261001-02A/B	Demulsifier	**6**
TQ-UQ-1261001-03	H2S Scavenger - offloading	**6**
TQ-UQ-1261001-04	Acetic acid (75%)	**8**
TQ-UQ-1261001-05	Sodium Hydroxide (50%)	**4**
TQ-UQ-1261001-06A/B	Scale Inhibitor - topsides	**4**
TQ-UQ-1261001-07A/B	Scale Inhibitor - subsea	**10**
TQ-UQ-1261001-08	Wax Inhibitor - subsea	**10**
TQ-UQ-1261001-09	Asphaltene Inhibitor - subsea	**10**
TQ-UQ-1261001-10 A/B	H2S Scavenger - subsea	**10**
TQ-UQ-1261001-11 A/B	Hydrate Inhibitor (Etanol / MEG)	**10**
TQ-UQ-1261001-12	Gas Corrosion Inhibitor	**6**
TQ-UQ-1261001-13	Hydrate Inhibitor (Ethanol / MEG) - subsea	**10**

12.2 ANNEX 2 - DIAMETER OF THE VENTS NOZZLES FOR PRODUCED WATER INJECTION SYSTEM

Tank	Chemical Product	Diameter of the vents nozzles
		in
TQ-UQ-1262001-01A/B	Polyelectrolyte	**3**
TQ-UQ-1262001-02	Scale Inhibitor	**4**
TQ-UQ-1262001-03A/B	Biocide	**4**
TQ-UQ-1262001-04	O2 Scavenger	**3**
TQ-UQ-1262001-05	Biocoagulant	**6**

12.3 ANNEX 3 - DIAMETER OF THE VENTS NOZZLES FOR INJECTION WATER INJECTION SYSTEM

Tank	Chemical Product	Diameter of the vents nozzles
		in
TQ-UQ-1263001-01	O_2 Scavenger	**3**
TQ-UQ-1263001-02	Biodispersant	**3**
TQ-UQ-1263001-03A/B	Biocide	**2**
TQ-UQ-1263001-04	Scale Inhibitor	**3**

12.4 ANNEX 4 – OIL AND GAS INJECTION SYSTEM CALCULATION

OIL DOSAGE										
Chemical Product	Injection Point	Number of points	Continuous (C) ou Shock (SK)	Dosage			Process Flowrate Basis (m³/d)		Injection Flowrate (L/h)	
				Min.	Max.	Unit	Min.	Max.	Min.	Max.
Defoamer	Production manifolds downstream liquid sample point	2	(C)	20	200	mL/m³ (ppm_v)	2,190	21,900	2	183
	Test manifold downstream liquid sample point	1					1,100	11,000	1	92
	Upstream free water separator level control valve	2					2,190	21,900	2	183
	Upstream test separator level control valve	1					1,100	11,000	1	92
	Oil Dehydrator Degasser upstream mixing valve (1)	2					2,190	21,900	2	183
Demulsifier	Production manifolds downstream liquid sample point	2	(C)	10	100	mL/m³ (ppm_v)	2,190	21,900	1	92
	Test manifold downstream liquid sample point	1					1,100	11,000	0	46
	Upstream free water separator level control valve	2					2,190	21,900	1	92
	Upstream test separator level control valve	1					1,100	11,000	0	46
	Oil Dehydrator Degasser upstream mixing valve (1)	2					2,190	21,900	1	92
Scale Inhibitor - topsides	Production manifolds downstream liquid sample point	2	(C)	20	200	mL/m³ (ppm_v)	1,590	15,900	1	133
	Upstream free water separator level control valve	2					1,590	15,900	1	133
	Oil Dehydrator Degasser upstream mixing valve	2					1,590	15,900	1	133
	Test manifold downstream liquid sample point	1					1,045	10,450	1	88
	Upstream test separator level control valve	1					1,045	10,450	1	88
H2S Scavenger - offloading	Upstream of the oil transfer pumps of each production train	2	(C)	20	200	mL/m³ (ppmv)	1,790	17,900	1	150
	TQ-1223501 (Off-Spec Oil) (2)	2	(SK)	20	200	mL/m³ (ppmv)	1,790	17,900	1	150
	TQ-5331501P/S (2)	2	(SK)	20	200	mL/m³ (ppmv)	1,790	17,900	1	150
	Transfer Header (HULL)	1	(SK)	20	200	mL/m³ (ppmv)	2,880	28,800	2	240
Acetic acid (75%)	Production manifold	2	(C)	100	1000	mL/m³ (ppm_v)	1,590	15,900	9	300
	Test manifold	1					1,045	10,450	6	300
Sodium Hydroxide (50%)	In the dilution line, upstream of P-1223003A/B	1	(C)	4.4	44	mg/kg de óleo	3,580	35,800	8	76
	Upstream B-1223003A/D	2					1,790	17,900	4	38

Notes:

1. Simultaneous injection was not considered at this injection point (defoamer and demulsifier upstream of the TO) with the others.
2. Non-continuous injection. 2 points served by just one head.

12.5 ANNEX 5 - SUBSEA INJECTION SYSTEM CALCULATION

SUBSEA DOSAGE												
Chemical Product	Injection Point	Number of points	Continuous (C) ou Shock (SK)	Injection Flowrate by Well (L/h)		Dosage (ppm)		Well Process Flowrate (m^3/d)	Vazão de processo (m^3/d)		Injection Flowrate (L/h)	
				Min.	Max.	Min.	Max.	Min.	Min.	Max.	Min.	Max.
Scale Inhibitor [1]	Inside the wells	14	(C)	2	200	-	-	10,450	3,180	31,800	1	609
Wax Inhibitor [2]	Wet Christmas Tree	14	(C) Injection into the production column only during production stop	20	200	-	-	11,000	3,580	35,800	7	651
Asphaltene Inhibitor [3]	Inside the wells	14	(C)	20	200	-	-	11,000	4,380	43,800	8	797
H2S Scavenger [4]	Inside the wells	14	(C)	25 L/kg H2S		-	-	-	-	-	68	679
Hydrate Inhibitor (Ethanol / MEG)	Wet Christmas Tree / Service Header	14 (2 x SDU) (service line of each well)	(SK), Up to two points on the TUTUs	-	-	-	-	-	-	-	200	7,000
	Injection lines	12	(SK), Up to 4 points simultaneously	200	200	-	-	-	-	-	800	800
Demulsifier [5]	Inside the wells	14	(C)	-	-	50	500	11,000	4,380	43,800	10	920

Notes:

1. The dosage of scale inhibitor was defined by the flow of water produced. The maximum flow of water produced per well-being 10,450 m^3/d and the produced water plant capacity of 31,800 m^3/d.
2. The paraffin inhibitor dosage was defined by the oil flow. Being the maximum oil flow per well of 11,000 m^3/d and the capacity of the oil plant of 35,800 m^3/d.
3. The asphaltene inhibitor dosage was defined by the crude oil + water flow. The maximum oil flow per well-being 11,000 m^3/d and the capacity of the 43,800 m^3/d liquid plant.
4. The dosage of H_2S scavenger was defined as a function of the highest molar flow of H_2S in the oil which represents the fluid before the choke valve, considering a dosage of 25 L/kg H_2S.
5. The demulsifier dosage was defined by the crude oil flow rate + Water (liquid flowrate). The maximum oil flow per well is 10,000 m^3/d and the liquid plant capacity is 43,800 m^3/d. The maximum dosage considered was 500 ppmv, totaling 230 L/h per well (500*11000/24/1000 = 230); and 920 L/h for all pumps (500*43800/24/1000 ≅ 920).

12.6 ANNEX 6 - GAS INJECTION SYSTEM CALCULATION

GAS DOSAGE										
Chemical Product	Injection Point	Number of points	Continuous (C) ou Shock (SK) ou Continuous Abnormal (CA)	Dosage			Process Flowrate Basis (m³/d)		Injection Flowrate (L/h)	
				MEG	Ethanol	Unit	Min.	Max.	MEG	Ethanol
Hydrate Inhibitor (Ethanol / MEG)	Gas lift injection lines (before each Pig Launcher)	1	(CA)	15	15	L/h	200,000	2,000,000	86	86
	Condensate upstream of molecular sieve coalescing filter lower chamber level control valve (FT-1233001A/B)	1	(C)	6.7	6.7	L/h	-	-	7	7
	Condensate upstream of molecular sieve coalescing filter upper chamber level control valve (FT-1233001A/B)	1	(C)	6.7	6.7	L/h	-	-	7	7
	Export Header	1	(C)	300	300	L/h	-	-	300	300

GAS DOSAGE										
Chemical Product	Injection Point	Number of points	Continuous (C) ou Shock (SK)	Dosage			Process Flowrate Basis (m³/d)		Injection Flowrate (L/h)	
				Min.	Max.	Unit	Min.	Max.	Min.	Max.
Gas Corrosion Inhibitor	Low pressure fuel gas header	1	(C)	0.5	1	L/10^6 scf gas	47,800	478,000	1.0	1.0
	Gas export pipeline	1	(C)	0.5	1	L/10^6 scf gas	600,000	6,000,000	1.0	9.0

12.7 ANNEX 7 – PRODUCED WATER INJECTION SYSTEM CALCULATION

PRODUCED WATER DOSAGE

Chemical Product	Injection Point	Number of points	Continuous (C) ou Shock (SK)	Dosage (ppm_v)		Process Flowrate Basis (m^3/d)		Injection Flowrate (L/h)	
				Min.	Max.	Min.	Max.	Min.	Max.
Polyelectolyte (Concentrated)	Float inlet line (downstream of sampling point)	1	C	10	100	3216	32160	1.34	134
Dilution water for Polyelectolyte		-		-	-	-	-	13.4	4020
Polyelectolyte (Diluted)		-		-	-	-	-	14.7	4154
Scale Inhibitor	Water outlet line of Free water separator	2	C	5	50	3216	32160	0.67	67
	Water outlet line of Test separator	1	C	5	50	1045	10450	0.2	22
	Water outlet line of pre-oil dehydrator	2	C	5	50	2400	24000	0.5	50.0
	Water outlet line of oil dehydrator	2	C	5	50	480	4800	0.1	10.0
Biocide (1) (3)	Slop tank	1	CQ	-	200	Tank Volume	8370	m^3	837
	TQ-5331501P/S	1	CQ	-	200	Tank Volume	19531	m^3	1953
	TQ-1223501	1	C	10	50	3216	32160	1.3	67
	TQ-1223501	1	CQ	-	200	Tank Volume	29045	m^3	2905
Oxygen Scavenger	TQ-5331501P/S Outlet	2	C	5	90	1608	16080	0.3	60
	TQ-1223501 Outlet	1	C	5	25	720	7200	0.2	8
	TQ-5336501P/S Outlet	1	CQ	5	25	24	240	0.01	0.3
Biocoagulant (Concentrated) (2)	Inlet of hydrocyclones	1	C	10	60	3216	32160	1.3	80
Dilution water for biocoagulant				-	-			25.46	1528
Biocoagulant (Diluted)				-	-			26.8	1608
Biocoagulant (Concentrated) (2)	Outlet of hydrocyclones	1	C	10	60	3216	32160	1.3	80
Dilution water for biocoagulant				-	-			25.46	1528
Biocoagulant (Diluted)				-	-			26.8	1608

Notes:

1. The biocide chemical must be injected directly into the aqueous phase of the slop tanks and produced water settling tank.
2. The injection must be done in a diluted form. The dilution of the product must be done with fresh water in an "online" way and the biocoagulant concentration should be between 5% and 20%. Polymaster or similar pumps must be used for injection.
3. Continuous and shock dosing of biocide on the TQ-1223501. Estimated minimum and maximum dosages from the biocide dosages for the slop tank point. Only one injection point and only one head to meet the two conditions, continuous and shock dosing. The basis for calculating the continuous flow was the water flow produced.

12.8 ANNEX 8 – PRODUCED WATER INJECTION SYSTEM CALCULATION

INJECTION WATER DOSAGE									
Chemical Product	Injection Point	Number of points	Continuous (C) ou Shock (SK)	Dosage (ppm_v)		Process Flowrate Basis (m^3/d)		Injection Flowrate (L/h)	
				Min.	Max.	Min.	Max.	Min.	Max.
Oxygen Scavenger (continuous)	Deaerator vessel [1]	1	C	5	25	1100	11000	1	12
	Downstream of the deaerator by-pass line	1		5	25	11000	46900	3	49
	Dilution water tank downstream for TO-1223002A/B	1		100	200	384	3840	2	32
	Downstream of the make-up tank for UC-5412001/UC-1350001	1		100	200	48	480	1	4
	Upstream of dilution water generation (UD-5122002A/B)	1		100	200	1178.8	11788	5	99
Oxygen Scavenger (without dearator)	Deaerator vessel [1]	1	CQ	100	200	1100	11000	5	92
	Downstream of the deaerator by-pass line	1		100	200	11000	46900	46	391
Biodispersant	Downstream of the deaerator by-pass line	1	C	5	20	11000	46900	3	40
Biocide shock	Upstream/downstream of the deaerator (but not at the same time)	1	CQ	100	1000	11000	46900	46	1955
Scale Inhibitor (continuous)	Upstream of ultrafiltration (UT-1251001)	1	C	1	20	8880	88800	1	74

Notes:

1. The injection flow rates were calculated considering the extreme cases: minimum process flow with dosages minimum and maximum and maximum process flow with minimum and maximum dosages of the products. For O2 scavenger, both in shock and continuous dosages, these calculated flow rates apply to the two injection points, the upstream and downstream of the D-UT-1251003 deaerator.

12.9 ANNEX 9 – CHEMICAL PRODUCTS COMPATIBILITY

CHEMICAL PRODUCT	AREA	GROUP	TANK	PUMP
ACID	1261	G-1	TQ-UQ-1261001-04	B-UQ-1261001-04A/C
INVERTED EMULSION INHIBITOR	1262	G-1	TQ-UQ-1262001-01A/B	B-UQ-1262001-01A/B
BIOCIDE	1262	G-1	TQ-UQ-1262001-03A/B	B-UQ-1262001-04A/B
SODIUM HYDROXIDE SOLUTION	1261	G-2	TQ-UQ-1261001-05	B-UQ-1261001-05A/C
OXYGEN SCAVENGER	1262	G-2	TQ-UQ-1262001-04	B-UQ-1262001-05A/B
OXYGEN SCAVENGER	1263	G-2	TQ-UQ-1263001-01	B-UQ-1263001-01A/B
DEMULSIFIER	1261	G-3	TQ-UQ-1261001-02A/B	B-UQ-1261001-02A/C
H2S SCAVENGER - OFFLOADING	1261	G-3	TQ-UQ-1261001-03	B-UQ-1261001-03A/C
SCALE INHIBITOR - SUBSEA	1261	G-3	TQ-UQ-1261001-07A/B	B-UQ-1261001-07A/E
ASPHALTEN INHIBITOR	1261	G-3	TQ-UQ-1261001-09	B-UQ-1261001-09A/E
H2S SCAVENGER - SUBSEA	1261	G-3	TQ-UQ-1261001-10A/B	B-UQ-1261001-10A/E
HYDRATE INHIBITOR	1261	G-3	TQ-UQ-1261001-11A/B	B-UQ-1261001-13A/B B-UQ-1261001-15A/B
HYDRATE INHIBITOR - SUBSEA	1261	G-3	TQ-UQ-1261001-13	B-UQ-1261001-11A/B
BIODISPERSANT	1263	G-3	TQ-UQ-1263001-02	B-UQ-1263001-02A/B
BIOCIDE	1263	G-3	TQ-UQ-1263001-03A/B	B-UQ-1263001-03A/B
GAS CORROSION INHIBITOR	1261	I-1	TQ-UQ-1261001-12	B-UQ-1261001-12A/B
BIOCOAGULANT	1262	I-2	TQ-UQ-1262001-05	B-UQ-1262001-06A/B
DEFOAMER	1261	G-1, G-2 or G-3	TQ-UQ-1261001-01A/B	B-UQ-1261001-01A/C
SCALE INHIBITOR - TOPSIDES	1261	G-1, G-2 or G-3	TQ-UQ-1261001-06A/B	B-UQ-1261001-06A/C
WAX INHIBITOR	1261	G-1, G-2 or G-3	TQ-UQ-1261001-08	B-UQ-1261001-08A/E
SCALE INHIBITOR	1262	G-1, G-2 or G-3	TQ-UQ-1262001-02	B-UQ-1262001-03A/C
SCALE INHIBITOR	1263	G-1, G-2 or G-3	TQ-UQ-1263001-04	B-UQ-1263001-04A/B