PETROBRAS	**TECHNICAL SPECIFICATION**	No. I-ET-3010.2Q-1260-940-P4X-001	
	CLIENT: MARLIM LESTE E SUL		SHEET: 1 of 34
	JOB: BASIC DESIGN – REVIT I		
	AREA: MARLIM LESTE E SUL		
SRGE	TITLE: **CHEMICAL INJECTION**		ESUP
			INTERNAL

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SUMMARY

1 INTRODUCTION

The Floating Production Storage and Offloading (FPSO) Unit of MARLIM LESTE E SUL 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

Marlim Leste and Marlim Sul oil fields are deep water post-salt fields located in the Campos Basin, southeastern 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-3010.2Q-1200-940-P4X-002	CHEMICAL INJECTION POINTS
3	I-ET-3010.2Q-1200-200-P4X-001	PIPING SPECIFICATION FOR TOPSIDES
4	I-RL-3010.2Q-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-3010.2Q-1200-800-P4X-005	FIELD INSTRUMENTATION
12	I-ET-3010.00-1200-940-P4X-002	GENERAL TECHNICAL TERMS
13	I-RL-3010.2Q-1350-960-P4X-002	MOTION ANALYSIS
14	I-ET-3010.00-1200-588-P4X-001	SAMPLE CONNECTIONS
15	I-ET-3010.2Q-1400-196-P4X-001	ERGONOMICS REQUIREMENTS FOR TOPSIDE
16	I-FD-3010.2Q-5400-947-P4X-001	SAFETY DATA SHEET - TOPSIDES

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 Bisulfite, 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)
SUBSEA	Scale Inhibitor	2	30	L/h (per well)
	Wax Inhibitor	6	60	L/h (per well)
	Hydrate Inhibitor (Ethanol / MEG)	200	5000	L/h
	Asphaltene Inhibitor	6	60	L/h (per well)
	H_2S Scavenger	6	60	L/h (per well)
	Demulsifier	5	50	L/h (per well)
GAS	Gas Corrosion Inhibitor	0.5	1	L/10^6 scf gas
	Hydrate Inhibitor (Ethanol / MEG)	120	1200	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)
	Oxygen Scavenger	100	200	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
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
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

A preliminary estimative for pumps power, discharge pressures and chemical flowrates for each injection point is presented on Chapter 7, on tables 6, 7 and 8, alongside with the facilities configurations. These calculations were based on preliminary piping arrangement and shall be confirmed/updated during Detailed Design.

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 high pressure separator level control valve (train A and train B).
- Test manifold downstream liquid sample point.
- Upstream test separator level control valve.

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. 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.
- Pre-Oil Dehydrator (train A and train B) upstream oil/oil pre-heater.
- Oil Dehydrator (train A and train B) upstream mixing valve.
- Test manifold downstream liquid sample point.

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. 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 (train A and train B).
- Oil inlet line on off spec oil tank, TQ-1223501.
- Produced water inlet line on Produced water tank, TQ-5331501A/C.
- Transfer header in HULL system

Injection Fluid Basis: Oil flowrate (for pumps and tanks points); Offloading flowrate (for transfer header).

H_2S Scavenger will be pumped to the above cited injection points by injection pumps B-UQ-1261001-03A/B. 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.

6.1.4 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.
- Upstream Settling tanks – TQ-1223501A/C.
- Upstream Pre-Oil Dehydrator (train A and train B).
- Test Manifold.

Injection Fluid Basis: Produced water flowrate.

Acetic acid will be pumped to the above cited injection points by injection pumps B-UQ-1261001-04A/B. 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.

6.1.5 SCALE INHIBITOR TOPSIDE

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.
- Test manifold downstream liquid sample point.
- Downstream the Settling Tank oil pump and upstream oil/oil pre-heater (P-1223002A/D), train A and train B
- Oil Dehydrator (train A and train B) upstream mixing valve.

Injection Fluid Basis: Produced water flowrate.

Scale Inhibitor will be pumped to the above cited injection points by injection pumps B-UQ-1261001-05A/C. 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.

6.1.6 GAS CORROSION INHIBITOR

Corrosion inhibitor shall be injected continuously into the following points:

- Condensate from fuel gas K.O. drum (V-5135001)
- Fuel gas K.O drum (V-5135001), upstream fuel gas pressure control valve
- Gas export pipeline.

Injection Fluid Basis: Gas flowrate.

Gas Corrosion Inhibitor will be pumped to the above cited injection points by injection pumps B-UQ-1261001-11A/B. 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 HYDRATE INHIBITOR TOPSIDE

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

- Condensate line from FT-1233001A/B
- Condensate line from V-1235001

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.

- Condensate line from FT-1233001A/B: 1 L/h (continuous)
- Condensate line from V-1235001: 23 L/h (continuous)

Hydrate inhibitor will be pumped to the above cited injection points by injection pump B-UQ-1261001-13A/B. 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.

6.2 OIL AND GAS CHEMICALS (SUBSEA)

6.2.1 H_2S SCAVENGER SUBSEA

Hydrogen sulfide (H_2S) scavenger for oil shall be injected into downhole or subsea Christmas trees through umbilical. The injection is planned to be continuous.

H_2S scavenger will be pumped to the above cited injection points by injection pumps B-UQ-1261001-07A/N. One pump head shall be dedicated for each well (43 heads). The pump flow rate shall be based on a maximum dosage rate.

6.2.2 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.

Injection Fluid Basis: Produced water flowrate.

Scale Inhibitor will be pumped to the above cited injection points by injection pumps B-UQ-1261001-08A/N. One pump head shall be dedicated for each well (43 heads). The pump flow rate shall be based on a maximum dosage rate.

6.2.3 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).

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-1261001-10A/D (4 x 25%). The pump flow rate for each pump is 1,250 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-1261001-14A/F (6 x 20%, 5 heads each, 25 pump heads in operation) shall pump subsea hydrate inhibitor to 2 gas lift injection lines, gas lift header and exportation header. The pump flow rate for each pump is 1200 L/h (each pump head shall also have the capacity of 1200 L/h).

6.2.4 MULTIFUNCTIONAL

A multifunctional pumping system is required to work with the following products for subsea injection: defoamer, H_2S scavenger, scale inhibitor, asphaltene inhibitor, wax inhibitor and demulsifier. These products shall be injected into downhole or subsea Christmas trees through umbilical.

Application rate: 6 to 60 L/h (per well)

The products will be pumped to the above cited injection point by injection pumps B-UQ-1261001-06A/N. One pump head shall be dedicated for each well.

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.

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. 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 TOPSIDE

To prevent scaling in the produced water treatment system, scale inhibitor shall be continuously injected into the points below. This product shall be the same scale inhibitor injected into the oil plant.

- Water outlet line of TQ-1223501A/C (Settling Tank)
- Water outlet line of Test separator
- Water outlet line of pre-oil dehydrator (TO-1223001A/B)
- Water outlet line of oil dehydrator (TO-1223002A/B)
- Downstream of FT-5331001A/C (produced water filter)

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. 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 twice a week during two hours).

The chemicals shall be injected into the following points:

- Off-spec water inlet line on Produced water tanks - TQ-5331501A/C (shock dosing).
- Oil inlet line on Settling tanks – TQ-1223501A/C (shock dosing).
- Inlet line on Slop tanks (shock dosing).
- Off-spec oil inlet line on Off-spec oil tank - TQ-1223502 (shock dosing).

Injection Fluid Basis: Effective Tank volume (shock dosing).

Biocide THPS will be pumped to the above cited injection points by injection pumps B-UQ-1262001-04A/B. 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-5331501A/C), off-spec oil tank (TQ-1223502) and slop tanks before the oxygen analyzer.

Injection Fluid Basis: Produced water flowrate (for the produced water tanks injection point) and Oil Skimming flowrate from slop tank to slop vessel.

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

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 (booster injection pumps suction header) in two conditions: continuously when the deaeration column is in operation and with shock dosage when the deaeration column is out of operation.

This product shall be the same oxygen scavenger injected into the produced water plant.

Oxygen scavenger shall also be continuously injected into produced water pumps suction header when reinjecting.

Injection Fluid Basis: Injection water flowrate (for normal and shock dosing).

Oxygen scavenger injection is also required in the inlet and outlet lines of TQ-5115002 (Dilution Water Storage Tank) and in the outlet line of TQ-5115003 (Flare and Slop Vessel Fresh Water Make-up Tank), since the seawater derivation for UD-5122002A/B is located downstream Ultrafiltration Unit (UT-1251001), therefore upstream deaeration column.

Injection Fluid Basis: RO first pass flowrate for TQ-5115002 and RO second pass flowrate for TQ-5115003 (normal dosing).

Oxygen scavenger will be pumped to the above cited injection points by injection pumps B-UQ-1263001-01A/B (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.

Injection Fluid Basis: Injection water flowrate.

Biodispersant will be pumped to the above injection point by injection pumps B-UQ-1263001-02A/B. 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 two hours). The chemicals will be injected downstream or upstream the deaeration column.

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

6.4.4 SCALE INHIBITOR FOR INJECTION WATER

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). This produt shall be diferent from the one inject into the oil/produces water plant.

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. 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.

Flow control shall be automatic and shall include a remote control system that shall be done from platform PLC. All additional control instruments and devices, such as PLCs, shall be provided by Seller.

Each pump shall receive an automatic shutdown signal in case there is a shutdown in the system or equipment receiving the chemical injection. The exceptions are the oxygen scavenger pumps (B-UQ-1263001-01A/B), which shall have SDVs located on each injection line – these SDVs will receive the automatic shutdown signal instead of the pumps.

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 and FAH 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 PSL/PSH/PSLL/PSHH and their respective alarms 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 PSL/PSH/PSLL/PSHH and their respective alarms 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.

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

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 pressure at suction flange= 101.3 kPa abs. Shall be confirmed during Detailed Design.

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 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.

7.2.5 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.

7.2.6 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

The following pumps shall be designed to be mutually interchangeable, with each equipment being able to perform any of the services required by each one of the other pumps:

- B-UQ-1261001-01A/C, B-UQ-1261001-02A/C and B-UQ-1261001-05A/C;
- B-UQ-1261001-06A/N, B-UQ-1261001-07A/N and B-UQ-1261001-08A/N.

Table 6 – Chemical Injection Pumps for Oil and Gas.

Pump tag	Pump load sharing/sparing	Head	Chemical product	Injection points	Cap. / head	Injection point pressure		Power	Design pressure (selected)	Operat. Temp.	Design Temp.
					(L/h)	(kPa-a)	(kgf/cm²a)	(bkW)	(kPa-g)	°C	°C
B-UQ-1261001-01A/C	3 X 50%	1A	Defoamer	Production manifolds (Train A) downstream liquid sample point	199	1000	10,2	0,1	**2226**	14-37	60
		2A		Upstream high pressure separator level control valve (train A)	199	960	9,8	0,2	**2511**	14-37	60
		3A		Test manifold downstream liquid sample point	84	1000	10,2	0,1	**2940**	14-37	60
		4A		Upstream test separator level control valve	84	960	9,8	0,1	**2446**	14-37	60
		1B		Production manifolds (Train B) downstream liquid sample point	199	1000	10,2	0,1	**2226**	14-37	60
		2B		Upstream high pressure separator level control valve (train B)	199	960	9,8	0,2	**2511**	14-37	60
		3B		Test manifold downstream liquid sample point	84	1000	10,2	0,1	**2940**	14-37	60
		4B		Upstream test separator level control valve	84	960	9,8	0,1	**2446**	14-37	60
B-UQ-1261001-02A/C	3 X 50%	1A	Demulsifier	Production manifolds (Train A) downstream liquid sample point	100	1000	10,2	0,1	**1904**	14-37	60
		2A		Test manifold downstream liquid sample point	42	1000	10,2	0,0	**1904**	14-37	60
		3A		Upstream pre-oil dehydrator (Train A)	59	1420	14,5	0,1	**2588**	14-37	60
		4A		Upstream oil dehydrator mixing valve (Train A)	52	1350	13,8	0,0	**2146**	14-37	60
		1B		Production manifolds (Train B) downstream liquid sample point	100	1000	10,2	0,1	**1904**	14-37	60
		2B		Test manifold downstream liquid sample point	42	1000	10,2	0,0	**1904**	14-37	60
		3B		Upstream pre-oil dehydrator (Train B)	59	1420	14,5	0,1	**2588**	14-37	60
		4B		Upstream oil dehydrator mixing valve (Train B)	52	1350	13,8	0,0	**2146**	14-37	60
B-UQ-1261001-03A/B	2 X 100%	1A	H2S Scavenger - topside	Downstream Oil Cooler (P-1223005A/D) - Train A	93	980	10,0	0,0	**1610**	14-37	60
		2A		Downstream Oil Cooler (P-1223005A/D) - Train B	93	980	10,0	0,0	**1610**	14-37	60
		3A		TQ-1223502 (Off-Spec Oil Tank)	93	101	1,0	0,0	**537**	14-37	60
		4A		TQ-5331501A/C (Produced Water Tanks)	93	101	1,0	0,0	**1117**	14-37	60
		5A		Transfer header (HULL)	1440	101	1,0	0,7	**1456**	14-37	60
B-UQ-1261001-04A/C	3 X 50%	1A	Acetic Acid (75%)	Production manifold (Train A)	1103	1000	10,2	0,8	**2182**	14-37	60
		2A		Upstream Settling Tanks - Tanks A or C Upstream pre-oil dehydrator (Train A)	1103	1420	14,5	0,9	**2588**	14-37	60
		3A		Test manifold	528	1000	10,2	0,3	**1767**	14-37	60
		1B		Production manifold (Train B)	1103	1000	10,2	0,8	**2182**	14-37	60
		2B		Upstream Settling Tanks - Tanks B or C Upstream pre-oil dehydrator (Train B)	1103	1420	14,5	0,9	**2588**	14-37	60
		3B		Test manifold	528	1000	10,2	0,3	**1762**	14-37	60
B-UQ-1261001-05A/C	3 X 50%	1A	Scale inhibitor - topside	Production manifolds (Train A) downstream liquid sample point	166	1000	10,2	0,1	**2052**	14-37	60
		2A		Test manifold downstream liquid sample point	80	1000	10,2	0,1	**2239**	14-37	60
		3A		Downstream Settling Tanks oil pumps (upstream P-1223002A/D) - Train A	166	1720	17,5	0,2	**3100**	14-37	60
		4A		Upstream oil dehydrator mixing valve (Train A)	166	1420	14,5	0,1	**2669**	14-37	60
		1B		Production manifolds (Train B) downstream liquid sample point	166	1000	10,2	0,1	**2052**	14-37	60
		2B		Test manifold downstream liquid sample point	80	1000	10,2	0,1	**2239**	14-37	60
		3B		Downstream Settling Tanks oil pumps (upstream P-1223002A/D) - Train B	166	1720	17,5	0,2	**2912**	14-37	60
		4B		Upstream oil dehydrator mixing valve (Train B)	166	1420	14,5	0,2	**2910**	14-37	60
B-UQ-1261001-06A/N	13 X 9%	1 - 43	Defoamer - subsea	Wet Christmas Tree / inside the wells	60	20000	203,9	0,5	**21969**	14-37	60
			H2S Scavenger - subsea	Wet Christmas Tree / inside the wells	60	20000	203,9	0,5	**21880**	14-37	60
			Scale inhibitor - subsea	Wet Christmas Tree / inside the wells	60	20000	203,9	0,5	**21878**	14-37	60
			Asphaltene inhibitor - subsea	Wet Christmas Tree / inside the wells	60	20000	203,9	0,5	**21943**	14-37	60
			Wax inhibitor - subsea	Wet Christmas Tree / inside the wells	60	20000	203,9	0,5	**21962**	14-37	60
			Demulsifier - subsea	Wet Christmas Tree / inside the wells	50	20000	203,9	0,4	**21943**	14-37	60
B-UQ-1261001-07A/N	13 x 9%	1 - 43	H2S Scavenger - subsea	Wet Christmas Tree / inside the wells	60	20000	203,9	0,5	**21880**	14-37	60
B-UQ-1261001-08A/N	13 X 9%	1 - 43	Scale inhibitor - subsea	Wet Christmas Tree / inside the wells	30	20000	203,9	0,2	**22289**	14-37	60
B-UQ-1261001-10A/D	4 X 25%	1A	Hydrate inhibitor (Ethanol)	Wet Christmas Tree	1250	20000	203,9	10,1	**22317**	14-37	60
		1A	Hydrate inhibitor (MEG)	Wet Christmas Tree	1250	20000	203,9	10,0	**22235**	14-37	60
		1A	Hydrate inhibitor (Ethanol)	Wet Christmas Tree	1250	20000	203,9	10,1	**22317**	14-37	60
		1A	Hydrate inhibitor (MEG)	Wet Christmas Tree	1250	20000	203,9	10,0	**22235**	14-37	60
B-UQ-1261001-11A/B	2 X 100%	1A	Corrosion inhibitor	Condensate line from Fuel Gas K.O. Drum (V-5135001)	1	4930	50,3	0,0	**6217**	14-37	60
		2A		Fuel Gas K.O. Drum (V-5135001) inlet line, upstream the fuel gas pressure control valve	1	5025	51,2	0,0	**6331**	14-37	60
		3A		Export Header	2	20000	203,9	0,0	**22401**	14-37	60
B-UQ-1261001-13A/B	2 X 100%	1A	Hydrate inhibitor (Ethanol)	Condensate line from coalescer filter (FT-1233001A/B) upstream TEG Contactor	1	5200	53,0	0,0	**6654**	14-37	60
	2 X 100%	2A	Hydrate inhibitor (Ethanol)	Condensate line from Amine Inlet Gas K.O. Drum (V-1235001)	23	5510	56,2	0,1	**6995**	14-37	60
	2 X 100%	1A	Hydrate inhibitor (MEG)	Condensate line from coalescer filter (FT-1233001A/B) upstream TEG Contactor	1	5200	53,0	0,0	**6606**	14-37	60
	2 X 100%	2A	Hydrate inhibitor (MEG)	Condensate line from Amine Inlet Gas K.O. Drum (V-1235001)	30	5510	56,2	0,1	**6947**	14-37	60
B-UQ-1261001-14A/F	6 X 20%	1-24	Hydrate inhibitor (Ethanol)	22 gas lift injection lines, gas lift header and export header	1200	20000	203,9	9,8	**22670**	14-37	60
			Hydrate inhibitor (MEG)	22 gas lift injection lines, gas lift header and	1200	20000	203,9	9,8	**22711**	14-37	60

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 10 microns in the pump discharge.

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
					(L/h)	(kPa-a)	°C	°C	(kPa g)
B-UQ-1262001-01A/B	2 X 100%	1A	Polyelectrolyte (concentrated)	Inlet line for gas flotation unit (downstream sampling point) - Train A	83	441	14 - 37	60	52184
		1B		Inlet line for gas flotation unit (downstream sampling point) - Train B	83	441	14 - 37	60	52184
B-UQ-1262001-02A/B	2 X 100%	1A	Dilution water for polyelectrolyte	Inlet line for gas flotation unit (downstream sampling point) - Train A	2490	441	14 - 37	60	53172
		1B		Inlet line for gas flotation unit (downstream sampling point) - Train B	2490	441	14 - 37	60	53172
B-UQ-1262001-03A/C	3 X 50%	1A	Scale inhibitor	Settling Tank water outlet - Tanks A or C	42	2.070	14 - 37	60	243858
		2A		Pre-oil dehydrator (TO-1223001) water outlet - Train A	6	1.393	14 - 37	60	164189
		3A		Oil dehydrator (TO-1223002) water outlet - Train A	3	1.275	14 - 37	60	150303
		4A		Test separator water outlet	20	981	14 - 37	60	115817
		5A		Water reinjection header (downstream produced water filter for reinjection)	83	1.176	14 - 37	60	138889
		1B	Scale inhibitor	Settling Tank water outlet - Tanks B or C	42	2.070	14 - 37	60	243858
		2B		Pre-oil dehydrator (TO-1223001) water outlet - Train B	6	1.393	14 - 37	60	164189
		3B		Oil dehydrator (TO-1223002) water outlet - Train B	3	1.256	14 - 37	60	148067
		4B		Test separator water outlet	20	981	14 - 37	60	115817
		5B		Water reinjection header (downstream produced water filter for reinjection)	83	1.196	14 - 37	60	141243
B-UQ-1262001-04A/B	2 X 100%	1A	Biocide	TQ-1223502 (Off-spec oil tank)	726	393	14 - 37	60	47027
		2A		Slop tank / Settling Tanks / Produced water tanks	1452	98	14 - 37	60	12312
B-UQ-1262001-05A/B	2 X 100%	1A	Oxygen scavenger	TQ-5331501A/C water outlet, upstream oxygen analyzer - Tank A or C	166	3.011	14 - 37	60	354571
		2A		TQ-5331501A/C water outlet, upstream oxygen analyzer - Tank B or C	166	3.011	14 - 37	60	354571
		3A		TQ-1223502 / TQ-5336501 outlets	60	3.011	14 - 37	60	354571

7.5 CHEMICAL INJECTION PUMPS FOR INJECTION WATER

The following pumps shall be designed to be mutually interchangeable, with each equipment being able to perform any of the services required by each one of the other pumps:

- B-UQ-1263001-01A/B, B-UQ-1263001-02A/B and B-UQ-1263001-04A/B;

Table 8 – Chemical Injection Pumps for Injection Water.

Pump tag	Pump Load Sharing/ Sparing	Head	Chemical Product	Injection Point	Cap/head (L/h)	Injection point pressure (kPa-a)	Operat. Temp. °C	Design Temp. °C	Design pressure (kPa g)
B-UQ-1263001-01 A/B (Case 1)	2 X 100%	1	Oxygen Scavenger (continuous)	Deaerator vessel	79	200,0	14 - 37	60	465
B-UQ-1263001-01 A/B (Case 2)	2 X 100%	1	Oxygen Scavenger (shock)	Downstream of the deaerator by-pass line	427	200,0	14 - 37	60	290
B-UQ-1263001-02 A/B	2 X 100%	1	Biodispersant (Continuous)	Downstream of the deaerator by-pass line	40	200,0	14 - 37	60	479
B-UQ-1263001-03 A/B	2 X 100%	1	Biocide (shock)	Upstream deaerator	1988	200,0	14 - 37	60	637
	2 X 100%	1		Downstream of the deaerator by-pass line	1988	200,0	14 - 37	60	442
B-UQ-1263001-04 A/B	2 X 100%	1	Scale inhibitor (Continuous)	Upstream ultrafiltration (UT-1251001)	69	491,0	14 - 37	60	595

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.

If different products (that may or may not have the same function) may be stored on the same tank, the design for the tank and the vent shall comply with the most restrictive one.

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 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, and Z-UG-5132001-02A/B. 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), M-15 (UD-5122002A/B and UT-1251002) and M-12 (Z-UG-5132001-02A/B). 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-3010.2Q-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. 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.

8.2.2 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-3010.2Q-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 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.

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

8.2.8 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-3010.2Q-1200-800-P4X-005 - FIELD INSTRUMENTATION.

8.2.9 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 20 days of normal consumption, calculated using 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	Selected total volume	Total effective volume	Total volume per tank	Effective volume per tank
			L/h	(m³)	(m³)	(m³)	(m³)
TQ-UQ-1261001-01A/B[1]	2 X 50%	Defoamer - Topside	159	96,3	77,0	48,1	38,5
TQ-UQ-1261001-02A/B[1]	2 X 50%	Demulsifier - Topside	139	84,0	67,2	42,0	33,6
TQ-UQ-1261001-03A/B	2 x 50%	H2S Scavenger - Subsea	125	75,6	60,5	37,8	30,2
TQ-UQ-1261001-04A/F	6 x 17%	Acetic acid (75%)	1159	696,2	556,9	116,0	92,8
TQ-UQ-1261001-05A/B[1]	2 X 50%	Scale inhibitor - Topside	331	199,5	159,6	99,8	79,8
TQ-UQ-1261001-06A/D[1]	4 X 25%	Multifunctional (Subsea defoamer, topside H2S Scavenger, subsea scale inhibitor, asphaltene inhibitor, wax inhibitor, acetic acid 75%)	187	112,6	90,0	28,1	22,5
TQ-UQ-1261001-07A/B[1]	2 x 50%	Demulsifier - Subsea	233	140,0	112,0	70,0	56,0
TQ-UQ-1261001-08A/B[1]	2 X 50%	Scale inhibitor - Subsea	165	99,8	79,8	49,9	39,9
TQ-UQ-1261001-10A/B	2 x 50%	Subsea and topside hydrate inhibitor (ethanol / MEG)	185	112,0	89,6	56,0	44,8
TQ-UQ-1261001-11	1 X 100%	Corrosion inhibitor	4	3,9	3,1	3,9	3,1

Notes:

1. These tanks must be bipartite.

8.5 CHEMICAL STORAGE FOR PRODUCED WATER

Table 10 – Chemical Storage for Produced Water.

Tank	Conf.	Chemical product	Injection flow rate	Total volume	Total effective volume	Effective volume per tank	Total volume per tank
			(L/h)	(m³)	(m³)	m³	(m³)
TQ-UQ-1262001-01A/B[1]	2 X 50%	Polyelectrolyte	82,8	49,8	39,8	19,9	24,9
TQ-UQ-1262001-02A/B[1]	2 X 50%	Biocide	196,0	117,7	94,2	47,1	58,9
TQ-UQ-1262001-03	1 X 100%	Oxygen scavenger	27,8	16,7	13,3	13,3	16,7

Notes:
1. These tanks must be bipartite.

8.6 CHEMICAL STORAGE FOR INJECTION WATER

Table 11 – Chemical Storage for Injection Water.

Tank	Config.	Chemical product	Injection flow rate	Total volume	Total effective volume	Total volume per tank	Effective volume per tank
			(L/h)	(m³)	(m³)	(m³)	(m³)
TQ-UQ-1263001-02	1 X 100%	Biodispersant	30	18,1	14,4	18,1	14,4
TQ-UQ-1263001-03A/B[1]	2 X 50%	Biocide	18	10,7	8,6	5,4	4,3
TQ-UQ-1263001-04	1 X 100%	Scale inhibitor	69	16,6	13,3	16,6	13,3

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 10 days at 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. The considered capacity for the tote tanks shall be of 8,4 m³.

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 two decks above the pumps, with available footprint of 25 m x 20 m x 3.5 m (L x W x H) each. Other layout configurations can be considered and reverted to PETROBRAS to approval.

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-3010.2Q-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-3010.2Q-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 - Topside	**6**
TQ-UQ-1261001-02A/B	Demulsifier - Topside	**6**
TQ-UQ-1261001-03A/C	H2S Scavenger - Subsea	**6**
TQ-UQ-1261001-04A/C	Acetic acid (75%)	**6**
TQ-UQ-1261001-05A/B	Scale inhibitor - Topside	**4**
TQ-UQ-1261001-06A/B	Multifunctional (Subsea defoamer, topside H2S Scavenger, subsea scale inhibitor, asphaltene inhibitor, wax inhibitor, acetic acid 75%)	**10**
TQ-UQ-1261001-07A/B	Demulsifier - Subsea	**10**
TQ-UQ-1261001-08A/B	Scale inhibitor - Subsea	**10**
TQ-UQ-1261001-10A/C	Subsea and topside hydrate inhibitor (ethanol / MEG)	**10**
TQ-UQ-1261001-11 A/B	Corrosion inhibitor	**6**

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

Tanks	Chemical product	Diameter of the vent nozzles
		in
TQ-UQ-1262001-01A/B	Polyelectrolyte	**3**
TQ-UQ-1262001-02A/B	Biocide	**4**
TQ-UQ-1262001-03	Oxygen scavenger	**3**

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

Tanks	Chemical product	Diameter of the vent nozzles
		in
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) or Shock (SK)	Dosage			Process Flowrate Basis (m^3/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)	2.385	23.850	2	199
	Test manifold downstream liquid sample point	1					1.000	10.000	1	84
	Upstream high pressure separator level control valve	2					2.385	23.850	2	199
	Upstream low pressure separator level control valve	2					2.385	23.850	2	199
	Upstream test separator level control valve	1					1.000	10.000	1	84
Demulsifier	Production manifolds (downstream liquid sample point)	2	(C)	10	100	mL/m³ (ppm_v)	2.385	23.850	1	100
	Test manifold downstream liquid sample point	1					1.000	10.000	1	42
	Upstream pre-oil dehydrator	2					1.394	13.938	1	59
	Upstream oil dehydrator mixing valve [1]	2					1.239	12.389	1	52
Scale Inhibitor - topsides	Production manifolds (downstream liquid sample point)	2	(C)	20	200	mL/m³ (ppm_v)	1.985	19.850	2	166
	Test manifold downstream liquid sample point	1					950	9.500	1	80
	Downstream Settling Tanks oil pumps (upstream P-1223002A/D)	2					1.985	19.850	2	166
	Upstream oil dehydrator mixing valve	2					1.985	19.850	2	166
H2S Scavenger - topsides	Downstream Oil Cooler (P-1223005A/D)	2	(SK)	20	200	mL/m³ (ppmv)	1.115	11.150	1	93
	TQ-1223502 (Off-Spec Oil Tank) [2]	2	(SK)				1.115	11.150	1	93
	TQ-5331501A/C (Produced Water Tanks) [2]	3	(SK)				1.115	11.150	1	93
	Transfer header (HULL)	1	(SK)				17.280	172.800	15	1440
Acetic Acid (75%)	Production manifold	2	(C)	-	1000	mL/m³ (ppm_v)	1.985	19.850	-	1103
	Test manifold	1					950	9.500	-	528

Notes:

1. Simultaneous injection was not considered at this injection point (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) or Shock (SK)	Injection flowrate per well / injection point (L/h)		Total injection flowrate (L/h)	
				Min	Max	Min	Max
Multifunctional (Defoamer, Scale inhibitor, asphaltene inhibitor, wax inhibitor)	Inside the wells	43	(C)	6	60	6	1.990
Demulsifier	Inside the wells	43	(C)	5	50	5	995
Scale Inhibitor	Inside the wells	43	(C)	3	30	3	160
H_2S Scavenger Subsea	Inside the wells	43	(C)	6	60	6	2.185
Hydrate inhibitor (Ethanol/MEG)	Wet Christmas tree	43	(SK)	-	-	200	5.000

12.6 ANNEX 6 - GAS INJECTION SYSTEM CALCULATION

GAS DOSAGE										
Chemical Product	Injection Points	Number of points	Continuous (C), Shock (SK) or Continuous Abnormal (CA)	Dosage			Process flowrate basis (m^3/d)		Injection flowrate (L/h)	
				MEG	Ethanol	Unit	Min	Max	MEG	Ethanol
Hydrate inhibitor (Ethanol/MEG)	Condensate line from coalescer filter (FT-1233001A/B) upstream TEG Contactor	1	(C)	1	1	L/h	1	5	1	1
	Condensate line from Amine Inlet Gas K.O. Drum (V-1235001)	1	(C)	29,74	22,88	L/h	1.590	15.900	30	23
	Gas lift injection lines	22	(CA)	1200	1200	L/h	100.000	1.500.000	1200	1200
	Gas lift header	1	(CA)	1200	1200	L/h	-	-	1200	1200
	Export header	1	(C)	1200	1200	L/h	300.000	3.000.000	1200	1200
Corrosion inhibitor	Condensate line from Fuel Gas K.O. Drum (V-5135001)	1	(C)	0,5	0,5	$L/10^6$ scf gas	1	5	1	1
	Fuel Gas K.O. Drum (V-5135001) inlet line, upstream the fuel gas pressure control valve	1					111.000	1.110.000	1	1
	Export header	1		-	2,2	L/h	300.000	3.000.000	1	2

12.7 ANNEX 7 – PRODUCED WATER INJECTION SYSTEM CALCULATION

PRODUCED WATER DOSAGE									
Chemical Product	Injection Points	Number of points	Continuous (C) or Shock (SK)	Dosage (ppm_v)		Process flowrate basis (m^3/d)		Injection flowrate (L/h)	
				Min.	Max.	Min.	Max.	Min.	Max.
Polyelectrolyte (concentrated)	Inlet line for gas flotation unit (downstream sampling point)	2	C	10	100	1985	19850	1	83
Diluction water for polyelectrolyte		-		-	-	-	-	10	2490
Polyelectrolyte (diluted)		-		-	-	-	-	11	2573
Scale Inhibitor	Settling Tank water outlet	3	C	5	50	1985	19850	1	42
	Test separator water outlet	1	C	5	50	950	9500	1	20
	Pre-oil dehydrator (TO-1223001) water outlet	2	C	5	50	279	2788	1	6
	Oil dehydrator (TO-1223002) water outlet	2	C	5	50	124	1239	1	3
	Water reinjection header (downstream produced water filter for reinjection)	1	C	5	50	3970	39700	1	83
Biocide (1) (2)	Slop tank	2	SK	-	200	Tank volume	8370	m^3	837
	Settling tank	3	SK	-	200	Tank volume	14523	m^3	1452
	Produced Water Tanks	3	SK	-	200	Tank volume	14523	m^3	1452
	TQ-1223502	1	SK	-	200	Tank volume	14523	m^3	726,15
Oxygen Scavenger	TQ-5331501A/C water outlet, upstream oxygen analyzer	3	C	100	200	1985	19850	9	166
	TQ-1223502 outlet	1	C	100	200	720	7200	3	60
	TQ-5336501 outlet	1	SK	100	200	24	240	1	2

Notes:

1. The biocide chemical must be injected directly into the aqueous phase of the slop tanks and produced water settling tank.
2. 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) or 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	15000	47700	4	50
	Booster pumps suction header (1)	1		5	25	15000	47700	4	50
	Produced water pumps suction header (reinjection) (2)	2		5	25	1985	19850	1	42
	Upstream dilution water tank TQ-5115002	1		100	200	251	2510	2	21
	Downstream dilution water tank TQ-5115002	1		100	200	251	2510	2	21
	Downstream TQ-5115003	1		100	200	91,08	910,8	1	8
Oxygen Scavenger (without deaerator)	Deaerator vessel (1)	1	SK	100	200	15000	47700	63	398
	Booster pumps suction header (1)	1		100	200	15000	47700	63	398
Biodispersant	Downstream of the deaerator by-pass line (1)	1	C	5	20	15000	47700	4	40
Biocida shock	Upstream/downstream of the deaerator (but not at the same time)	1	SK	100	1000	15000	47700	63	1988
Scale Inhibitor	Upstream of ultrafiltration (UT-1251001) pre-treatment	1	C	1	20	8184	81840	1	69

Notes:

(1) Minimum process flowrate is the maximum injection flowrate per injection water slot (15.000Sm³/d) and maximum process flowrate is the system's nominal capacity (47.700 Sm³/d).

(2) Maximum process flowrate on produced water header is the flowrate o fone produced water train (19.850Sm³/d).

12.9 ANNEX 9 – CHEMICAL PRODUCTS COMPATIBILITY

CHEMICAL PRODUCT	AREA	GROUP	TANK	PUMP
ACETIC ACID	1261	G-1	TQ-UQ-1261001-04A/F	B-UQ-1261001-04A/B
INVERTED EMULSION INHIBITOR	1262	G-1	TQ-UQ-1262001-01A/B	B-UQ-1262001-01A/B
BIOCIDE	1262	G-1	TQ-UQ-1262001-02A/B	B-UQ-1262001-04A/B
OXYGEN SCAVENGER	1262/1263	G-2	TQ-UQ-1262001-03	B-UQ-1262001-05A/B and B-UQ-1263001-01A/B
DEMULSIFIER	1261	G-3	TQ-UQ-1261001-02A/B	B-UQ-1261001-02A/C
H2S SCAVENGER - TOPSIDES	1261	G-3	TQ-UQ-1261001-06A/D	B-UQ-1261001-03A/B
SCALE INHIBITOR - SUBSEA	1261	G-3	TQ-UQ-1261001-08A/B	B-UQ-1261001-08A/N and B-UQ-1261001-06A/N
ASPHALTEN INHIBITOR	1261	G-3	TQ-UQ-1261001-06A/D	B-UQ-1261001-06A/N
H2S SCAVENGER - SUBSEA	1261	G-3	TQ-UQ-1261001-03A/B	B-UQ-1261001-07A/N
HYDRATE INHIBITOR	1261	G-3	TQ-UQ-1261001-10A/B	B-UQ-1261001-10A/D and B-UQ-1261001-14A/F
HYDRATE INHIBITOR - SUBSEA	1261	G-3	TQ-UQ-1261001-10A/B	B-UQ-1261001-13A/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-1261001-11	B-UQ-1261001-11A/B
DEFOAMER	1261	G-1, G-2 or G-3	TQ-UQ-1261001-01A/B	B-UQ-1261001-01A/C
SCALE INHIBITOR - TOPSIDES	1261/1262	G-1, G-2 or G-3	TQ-UQ-1261001-05A/B	B-UQ-1261001-05A/C and B-UQ-1262001-03A/C
WAX INHIBITOR	1261	G-1, G-2 or G-3	TQ-UQ-1261001-06A/D	B-UQ-1261001-06A/N
SCALE INHIBITOR	1263	G-1, G-2 or G-3	TQ-UQ-1263001-04	B-UQ-1263001-04A/B