INDEX OF REVISIONS

REV.	DESCRIPTION AND/OR REVISED SHEETS
0	ORIGINAL (published as ET-3A46.00-1210-010-P8J-001 Rev. 0).
A	Included completion fluids and reservoir stimulation (published as ET-3000.00-00-1210-010-1DO-001 Rev. 0).
B	Added new fluids (published as ET-3010.2L-1200-010-P3W-001 Rev. 0).
C	Added considerations about fluids, depending on well/reservoir type, added additives concentration in all brines/solutions, included a pumping rate section and edited the document description.

	REV. 0	REV. A	REV. B	REV. C	REV. D	REV. E
DATE	06/09/2016	17/08/2020	08/03/2022	26/09/2025		
EXECUTION	FRBV/CXSB	PEP/PROJ-CA, BUZIOS	PROJ-CA	FRBV		
CHECK	HM25	POCOS/EP/IDE/COMP	IDE/COMP	HM25		
APPROVAL	CXMQ	POCOS/EP/ITC/ETP	PROJ-CA	POCOS/EP/ITC/EPS		

INDEX

1. INTRODUCTION

This document is related to operations in which acid or other chemical products are pumped to the well from a Stimulation vessel through the Offshore Production Unit and/or through subsurface equipment. Such pumping jobs may be required more than once during the wells lifetime.

Different fluids may be required depending on project scenario and objectives. In general, these fluids will be pumped for removal of organic/inorganic deposits, scale inhibition or formation stimulation, using special purpose boats and through installations on the FPSO and subsea equipment (risers, flowlines and Wet Christmas Trees).

This list is not extensive and the use of other fluids may be designed and required by Petrobras during the operation of the field. Typical commercial compositions are not mentioned since chemical products may be provided by different suppliers depending on valid contracts at the time.

2. FLUIDS DEPENDING ON WELL/RESERVOIR TYPE AND OBJECTIVES

2.1 Production vs. Injection wells

Producer and Injection wells may require chemical treatments during lifetime, but it should be considered, especially regarding reservoir type and associated treatment fluids as well as returns from the well:

- Chemical treatments pumped to injection wells are not expected to return to the Production Unit;
- Chemical treatments pumped to producer wells may return to surface facilities but with different properties depending on reservoir characteristics.

2.2 Carbonate reservoirs (Pre salt or Post Salt) vs. Sandstone reservoirs (Post Salt)

If acid treatment is required in a carbonate reservoir, fluid returns should present pH around 5, with most of the acid spent by reaction with formation. This is a concern in case the treated well is a producer, since there should not be fluid return from an injection well.

For sandstone reservoirs, complete consumption of acid is not expected, therefore in case the well is a producer and flowback to production unit is expected, lower pHs are expected. Thus, acid treatments in sandstone producer wells are preferably performed with organic acids, to avoid corrosion issues to subsurface and surface equipment and facilities, due to returns.

3. COMPLETION FLUIDS

This section lists fluids that were used in completion of the wells and might return to production facilities.

Brine I:

Product	Concentration	Description
Salt	24% m/m	Sodium Chloride
Surfactant	0,4 % v/v	Ethoxylate and quaternary ammonium salts
Biocide	200 ppm	Glutaraldehyde

Brine II:

Product	Concentration	Description
Salt	36% m/m	Calcium Chloride
Surfactant	0,4 % v/v	Ethoxylate and quaternary ammonium salts
Biocide	200 ppm	Glutaraldehyde

Spent Acid I:

Product	Concentration	Description
Acetic Acid	5% m/m	Acid
Surfactant	0,4 % v/v	Ethoxylate and quaternary ammonium salts

Spent Acid II:

Product	Concentration	Description
Acetic Acid + Formic Acid	3,5 / 2,5 % m/m	Acid
Surfactant	0,4 % v/v	Ethoxylate and quaternary ammonium salts

Spent Acid III:

Product	Concentration	Description
Formic Acid	5 % m/m	Acid
Surfactant	0,2 % v/v	Ethoxylate and quaternary ammonium salts

4. SCALE REMOVAL AND INHIBITION

This Section lists the fluids that may be pumped to the wells in order to remove well string and/or formation scale deposits or to inhibit scale deposition. Scale removal treatments are usually injected in the formation after soaking time either in carbonates or sandstones reservoirs.

4.1 Carbonate scale removal

Aqueous Solution I, with Acetic Acid up to 20% m/m as main product:

Product	Concentration	Description
Acetic acid 98%	5- 20% m/m	Raw organic acid
Water	As required	Diluent
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Isopropanol + quaternary ammonium salt surfactants
Surface tension reducer	0,1 % v/v	Ethoxylate + quaternary ammonium salt surfactants

Aqueous Solution II, with Formic Acid 10% as main product:

Product	Concentration	Description
Formic acid 85%	10% m/m	Raw organic acid
Water	As required	Diluent
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Ethoxylate + quaternary ammonium salt surfactants
Surface tension reducer	0,1 % v/v	Ethoxylate + quaternary ammonium salt surfactants

Aqueous Solution III, with Acetic Acid 13% and Formic Acid 9% as main products:

Product	Concentration	Description
Acetic acid 98%	13% m/m	Raw organic acid
Formic acid 58%	9% m/m	Raw organic acid
Water	As required	Diluent
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Isopropanol + quaternary ammonium salt surfactants
Surface tension reducer	0,1 % v/v	Ethoxylate + quaternary ammonium salt surfactants

Aqueous Solution IV, Hydrochloric acid 15% m/m as main product:

Product	Concentration	Description
Hydrochloric acid 32%	15% m/m	Raw inorganic acid
Water	As required	Diluent
Corrosion inhibitor	Up to 1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Isopropanol + quaternary ammonium salt surfactants

Aqueous Solution V, with EDTA chelating agent as main product:

Product	Concentration	Description
EDTA diammonium/tetra ammonium salt	10 % m/m	Chelant
Water or completion fluid	As required	Diluent
Emulsion preventer	0,3 % v/v	Ethoxylate + quaternary ammonium salt surfactants
Wetting agent	0,1 % v/v	Wettability modifier
pH buffer	As required	Citric acid or sodium hydroxide (to adjust to 7 – 9 final pH)

Aqueous Solution VI, with EDTA and EGMBE(Butyl glycol) as main products:

Product	Concentration	Description
Diammonium/tetra ammonium salt	10 % m/m	Chelant
Water or completion fluid	As required	Diluent
Emulsion preventer	0,3 % v/v	Ethoxylate + quaternary ammonium salt surfactants
EGMBE	10% v/v	Ethylene glycol monobutyl ether
pH buffer	As required	citric acid or sodium hydroxide (to adjust to 7 – 9 final pH)

Aqueous Solution VII, with GLDA chelating agent as main product

Product	Concentration	Description
GLDA monosodium salt	20% v/v	Chelant
Water	As required	Diluent
Emulsion preventer	0,3 % v/v	Ethoxylate + quaternary ammonium salt surfactants
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
EGMBE	10% v/v	Ethylene glycol monobutyl ether

4.2 Sulfate scale removal

Aqueous Solution VIII, with EDTA chelating agent as main product:

Product	Concentration	Description
EDTA tetrassodium/ dissodium or ammonium salt	10 % m/m	Chelant
Water or completion fluid	As required.	Diluent
Emulsion preventer	0,3 % v/v	Ethoxylate + quaternary ammonium salt surfactants
Wetting agent	0,1 % v/v	Ethoxylate + quaternary ammonium salt surfactants
pH buffer (pH 4.3 to 13)	As required	citric acid or sodium hydroxide, if needed

Aqueous Solution IX, with DTPA chelating agent as main product (alkaline solution):

Product	Concentration	Description
DTPA pentapotassium salt + EDTA diammoniun salt	10% m/m	Chelant
Water	As required	Diluent
Emulsion preventer	0,3 % v/v	Ethoxylate + quaternary ammonium salt surfactants
Wetting agent	0,1 % v/v	Ethoxylate + quaternary ammonium salt surfactants

4.3 Organic scale removal

Solvent mixture I, Xylene as main product:

Product	Concentration	Description
Xylene	100% v/v	Aromatic solvent

Solvent mixture II, mixture with diesel:

Product	Concentration	Description
Butyl glycol	10% v/v	Solvent
Diesel	90% v/v	Aliphatic solvent

Solvent mixture III, hydrocarbon solvents mixture

Product	Concentration	Description
Xylene	50% v/v	Aromatic solvent
Diesel	50% v/v	Aliphatic solvent

Solvent mixture IV, DBX mixture of solvents:

Product	Concentration	Description
Diesel	45% v/v	Aliphatic solvent
Butyl glycol	10% v/v	Biodegradable solvent
Xylene	45% v/v	Aromatic solvent

4.4 Carbonate scale Inhibition

Aqueous Solution X, scaling inhibitor as main product:

Product	Concentration	Description
Scaling inhibitor	10% m/m	Polyphosphonate, polyacrylates or polysulphonates
Water	As required	Diluent
Emulsion preventer	0,3 % v/v	Ethoxylate + quaternary ammonium salt surfactants
Potassium Chloride solution	3 % m/m	Diluent (clay inhibition)

4.5 Sulfate scale Inhibition

Aqueous Solution XI, scaling inhibitor as main product with pH adjuster:

Product	Concentration	Description
Scaling inhibitor	10% m/m	Polyphosphonate, polyacrylates or polysulphonates
Water or completion fluid	As required	Diluent
Emulsion preventer	0,3 % v/v	Ethoxylate + quaternary ammonium salt surfactants
Potassium Chloride solution	3 % m/m	Diluent (clay inhibition)
Sodium hydroxide	As required	Alkali/ pH adjustment to reach 5 – 6 pH

5. CARBONATE RESERVOIR STIMULATION SOLUTIONS

This Section lists the fluids that are usually pumped to the wells in reservoir stimulation operations. There is no stablished frequency of these jobs depending on well/reservoir characteristics. These operations will be performed during well lifetime if required only. The frequency shown in Section 7.1 is based on a conservative estimate.

Aqueous Solution XII, with Acetic Acid up to 20% m/m as main product:

Product	Concentration	Description
Acetic acid 98%	5- 20% m/m	Raw organic acid
Water	As required	Diluent
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Isopropanol + quaternary ammonium salt surfactants
Surface tension reducer	0,1 % v/v	Ethoxylate + quaternary ammonium salt surfactants

Aqueous Solution XIII, with Formic Acid 10% as main product:

Product	Concentration	Description
Formic acid 85%	10% m/m	Raw organic acid
Water	As required	Diluent
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Ethoxylate + quaternary ammonium salt surfactants
Surface tension reducer	0,1 % v/v	Ethoxylate + quaternary ammonium salt surfactants

Aqueous Solution XIV, with Acetic Acid 13% and Formic Acid 9% as main products:

Product	Concentration	Description
Acetic acid 98%	13% m/m	Raw organic acid
Formic acid 58%	9% m/m	Raw organic acid
Water	As required	Diluent
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Isopropanol + quaternary ammonium salt surfactants
Surface tension reducer	0,1 % v/v	Ethoxylate + quaternary ammonium salt surfactants

Aqueous Solution XV, Hydrochloric acid 15% m/m as main product:

Product	Concentration	Description
Hydrochloric acid 32%	15% m/m	Raw inorganic acid
Water	As required	Diluent
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Isopropanol + quaternary ammonium salt surfactants

Aqueous Solution XVI, HCl- based Viscoelastic Surfactant based diverter

Product	Concentration	Description
Hydrochloric acid 32%	15 % m/m	Raw inorganic acid
Diverting agent	6 % v/v	Viscoelastic surfactant
Water	As required.	Diluent
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Isopropanol + quaternary ammonium salt surfactants
Viscosity breaker	0,2 % v/v	Ethoxylate, paraffin and mineral oil mixture

Aqueous Solution XVII, polymer based acid system as a diverter

Product	Concentration	Description
Hydrochloric acid 32%	Up to 5% m/m	Raw inorganic acid
Friction loss reducer	0,2 % v/v	Hydrosoluble polymer
Water	As required	Diluent
Corrosion inhibitor	0,3 % v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Isopropanol + quaternary ammonium salt surfactants
Temperature activated polymer breaker	0,5 % v/v	Calcium peroxide
Gelling agent	2 % v/v	Hydrosoluble polymer
Crosslinker agent	0,2 % v/v	Inorganic salt

Aqueous Solution XVIII, HCl 15% Emulsified acid system as main product:

Product	Concentration	Description
Hydrochloric acid 32%	Up to 45 % v/v	Raw inorganic acid
Water	As required	Diluent
Diesel	Up to 32 % v/v	Aliphatic solvent
Corrosion inhibitor	1 % v/v	Amine-based corrosion inhibitor
Iron Scavenger	1 % v/v	Chelating agent
Emulsifier	6 % v/v	Surfactant
Friction loss reducer	0,2 % v/v	Oil base friction reducer

6. SANDSTONE RESERVOIR STIMULATION SOLUTIONS

This Section lists the fluids that are usually pumped to injector wells in sandstone reservoirs (Post Salt projects) to remove drilling damage or to regain lost injectivity during well lifetime.

Wells designed for the reinjection of produced water may require such operations more frequently for injectivity recovery. Estimates in Section 7.1 are conservative.

Aqueous Solution XIX, with Acetic Acid up to 20% m/m as main product:

Product	Concentration	Description
Acetic acid 98%	5- 20% m/m	Raw organic acid
Water	As required	Diluent
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Isopropanol + quaternary ammonium salt surfactants
Surface tension reducer	0,1 % v/v	Ethoxylate + quaternary ammonium salt surfactants

Aqueous Solution XX, with Formic Acid 10% as main product:

Product	Concentration	Description
Formic acid 85%	10% m/m	Raw organic acid
Water	As required	Diluent
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Ethoxylate + quaternary ammonium salt surfactants
Surface tension reducer	0,1 % v/v	Ethoxylate + quaternary ammonium salt surfactants

Aqueous Solution XXI, with Acetic Acid 13% and Formic Acid 9% as main products:

Product	Concentration	Description
Acetic acid 98%	13% m/m	Raw organic acid
Formic acid 58%	9% m/m	Raw organic acid
Water	As required	Diluent
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Isopropanol + quaternary ammonium salt surfactants
Surface tension reducer	0,1 % v/v	Ethoxylate + quaternary ammonium salt surfactants

Aqueous Solution XXII, Hydrochloric acid 15% m/m as main product:

Product	Concentration	Description
Hydrochloric acid 32%	Up to 15% m/m	Raw inorganic acid
Water	As required	Diluent
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Isopropanol + quaternary ammonium salt surfactants

Aqueous Solution XXIII, with Acetic Acid 20% m/m and HF 1,5 % m/m as main products:

Product	Concentration	Description
Acetic Acid 98%	20 % m/m	Raw inorganic acid
Hydrofluoric acid	1,5 % m/m	Raw inorganic acid
Water	As required	Diluent
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Isopropanol + quaternary ammonium salt surfactants
Surface tension reducer	0,1 % v/v	Ethoxylate + quaternary ammonium salt surfactants

Aqueous Solution XXIV, with HCl 13,5% m/m and HF 1,5 % m/m as main products:

Product	Concentration	Description
Hydrochloric acid 32%	13,5% m/m	Raw inorganic acid
Hydrofluoric acid	1,5 % m/m	Raw inorganic acid
Water	As required	Diluent
Corrosion inhibitor	1% v/v	Amine-based corrosion inhibitor
Emulsion preventer	0,3 % v/v	Isopropanol + quaternary ammonium salt surfactants
Surface tension reducer	0,1 % v/v	Ethoxylate + quaternary ammonium salt surfactants

7. OPERATION CONDITIONS

7.1 Frequency and time of exposition

The presented frequency and pumping time for each kind of treatment may vary depending on well conditions. The values below must be considered as a reference based on usual Petrobras operations and/or estimates, considering an average pump rate for usual pumped volumes.

Job name	Maximum pumping time (h)	Well clean up time (h)	Frequency	Pumping Temperature (ºC)	Max. Treating Pressure (psi)
Carbonate Scale Removal	24	24	2 jobs / year / well	25 - 30	4000
Sulfate scale removal					
Organic deposits removal					
Carbonate scale Inhibition					
Sulfate scale Inhibition					
Reservoir Stimulation Solutions	24	48	1 job each 5 years / well	25 - 30	4000
Injectivity Recovery (Produced water reinjection wells)	24	24	3 jobs / year Up to 3 wells per job	25-30	4000

7.2 Pressure rate during pumping

While pumping the fluids to the well, both pressure increase and pressure decline rates depend on well conditions. The values below must be considered as references based on usual recent Petrobras operations and/or estimates.

Pressure increase (psi/min)	up to 1500
Pressure decline (psi/min)	up to 4000