



# SHELL PETROLEUM DEVELOPMENT COMPANY OF NIGERIA LIMITED

## EA DPA SURFACE LINES CHEMICAL DESCALING PROPOSAL

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## 1. BACKGROUND

Mineral scale deposition was anticipated in the EA field, as reflected in the Basis for Design and inclusion of a scale inhibition system on the EA topsides design. Scale deposition was however not expected on the three well head platforms; DPA, DPB and DPJ, hence no provision was made for subsurface or well head scale inhibition. In recent years however, and as water production increased, mineral scale deposition has been observed on select wells on EA DPA.

Solid deposits observed on some EA DPA flowlines [1, 2, 3, 4] were investigated and confirmed to be predominantly carbonate scale ca. 90%. This led to chemical descaling of 8 DPA flowlines and HP header manifold in June 2021 [5]. Descaled wells included EA W/19S, W/24, W/26, W/36, W/46, W/50, W/51 & W/54, unlocking >2.1kbopd. The Multi-Phase Flow Metering package on DPA was also chemically descaled in September 2022 [6]. Both descaling activities were successfully executed using engineered chemicals Amsolv6920 and Amsolv6100, technically qualified for EA DPA scale [7] and successfully deployed in other SPDC operations [8].

Observations in Q3 2022 indicate severe scale deposition on DPA with urgent need for chemical descaling of all surface lines and manifolds. The observations include;

- Stuck open flow line valves, which includes valves descaled in H2 2021, indicative of flowlines scale deposition
- Increased FTHP & FLP on EA54 post well intervention in August 2022, with higher production when opened to both LP & HP headers, indicative of constriction on the headers
- Actual scale deposits on the LP header manifold (Fig2) sighted during descaling of 8 flow lines and HP header manifold in 2021



DP-A HP west header internals



EA-36 FL tie-in to HP header



EA-36 diverter valve

Figure 1: EA DPA Scale Picture



Figure 2: EA DPA LP header west manifold (scale deposits at the unboxed EA26 flow line tie-in point)

The long-term mitigation for controlling scale deposition on the platform is the application of scale inhibitor as proposed in MOC88207. Scale inhibition at the wellheads is expected to be commissioned in Q1' 2023. Sampling has been initiated to enable scale modelling of the EA field for further insights on managing inorganic scale deposition.

## 2. OPPORTUNITY STATEMENT AND PROPOSED ACTION

### Opportunity Statement

There exists an opportunity to increase EA DPA platform production by ca 20% (3,000bopd), through chemical descaling of all surface lines on the platform. This would facilitate DPA wells testing by removing downstream flow restriction on the MPFM test lines.

### Proposed Action

It is proposed to execute chemical descaling of all EA DPA surface lines, from wells FCV to the DPA HP and LP headers boundary valves. Scope includes;

- All 21 flow lines on DPA, from well FCV to the production/test headers manifold
- LP header east and west manifolds and 12" LP header terminating at the 18" boundary valve to the pig-able subsea LP line
- HP header east and west manifolds and 12" HP header terminating at the 18" boundary valve to the pig-able subsea HP line.
- Test header east and west manifolds and 8" test header terminating at the MPFM boundary valve.

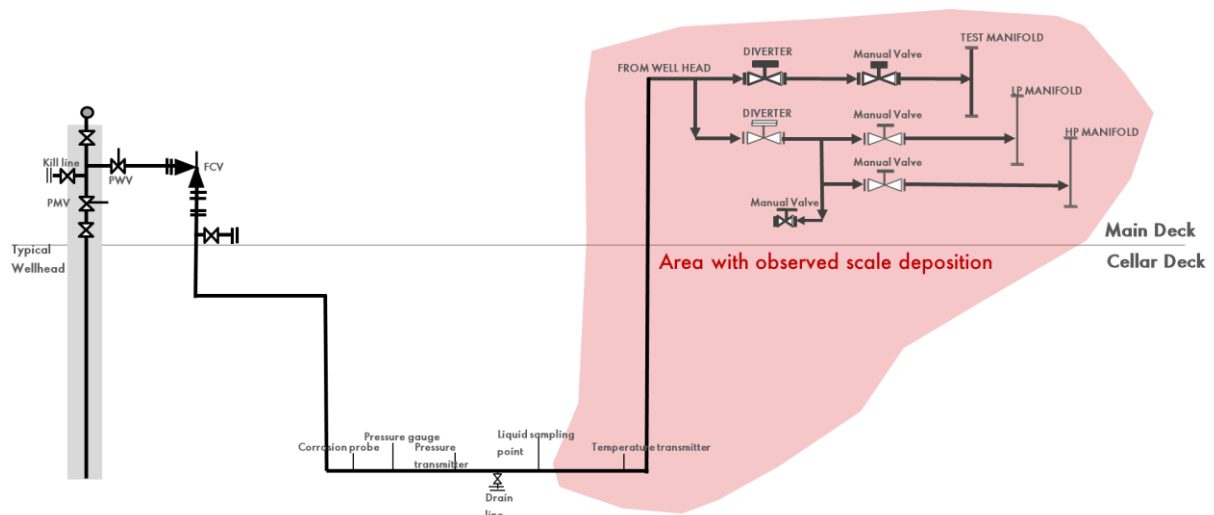


Figure 3: Schematic of typical well flowline configuration on DPA

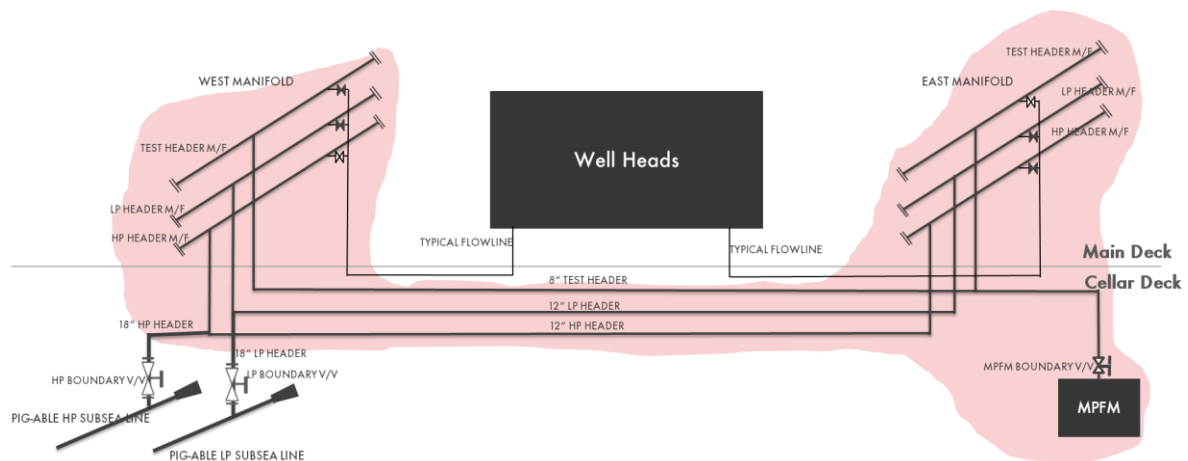


Figure 4: Schematic for DPA surface lines

### 3. CHEMICAL DESCALING

The chemical descaling operation will be carried out on positively isolated, depressurised and drained line sections. The current challenge of multiple stuck open or passing valves on the platform with potential impact on positive isolation is a threat to executing scope under live platform conditions. For safety and effectiveness of the chemical treatment, preference is to execute scope under complete platform shutdown. The production deferment impact of a platform shutdown is ca. 15.5kbopd. If positive isolation can be achieved, proposed chemical descaling can be phased to minimize total production deferment from the activity.

A chemical circulation loop approach will be implemented. This will prevent the reaction from achieving chemical equilibrium and as such reduce required treatment time to dissolve deposited scale. This will also enable continuous removal of the dissolution reaction by-product (gaseous CO<sub>2</sub>)

and its associated pressure build up. An electrical pump would provide driving force for fluid in the circulation loop and power will be taken from the platform electrical power supply.

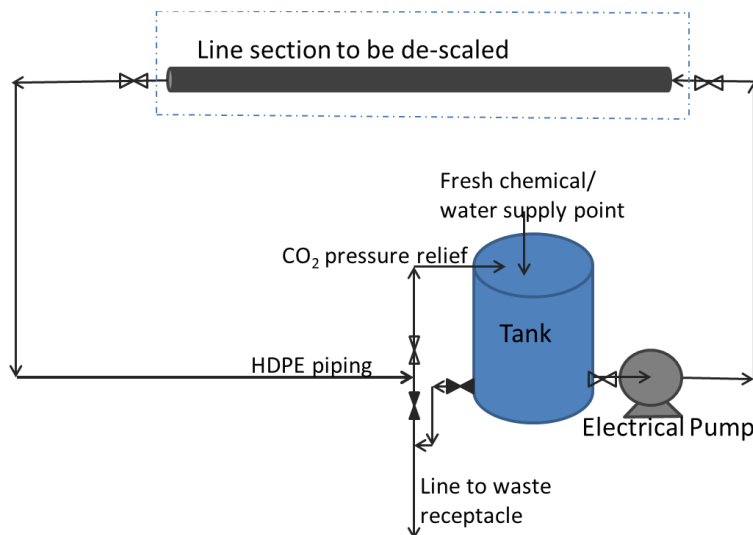


Figure 5: Schematic of circulation loop for chemical descaling

Each line section to be descaled would involve a three-stage process, pre-treatment, main treatment and post treatment. In addition to these stages, there will be a leak test with fresh water before introducing chemicals to ensure containment is not lost upon introduction of chemicals. Water will be used to completely flush chemicals from the lines before being boxed-up post treatment.

- **Pre-treatment:** Displacement of residual oil in the lines and water wetting of solid deposit to ensure effective chemical contact during main treatment.
- **Main treatment:** Introduction of inhibited acid for descaling
- **Post treatment:** Neutralization treatment to stop further reactions and passivate the lines. Post treatment chemicals will be displaced with fresh water.

Descaling procedure is summarised thus

- 1) Site preparation  
Positively isolate, depressurize and drain lines to be descaled and prepare work area for activity execution
- 2) Set up treatment circulation loop  
Circulation loop schematic shown in Figure 5
- 3) Leak test circulation loop and function test circulation pump  
Verify that plumbing connections are watertight and would not fail under the fluid circulation pressure to prevent chemical spill
- 4) Execute chemical descaling
  - a) Pre-treatment - degrease lines and make scale deposits water wet
  - b) Main treatment - dissolve carbonate scale and clear flow constriction in the lines
  - c) Post-treatment - neutralize residual inhibited acid in process lines and stop acid dissolution reactions
- 5) Flush treated lines with fresh water
- 6) Box-up lines and restore facility to as-is

## 4. PRODUCTION GAIN ESTIMATE

3kbopd production gain is estimated, based on gains from 2021 chemical descaling. Table 1 shows total validated gains of over 2kbopd from descaling of 8 flow lines and the HP header manifolds, representing a 35% production gain. Proposed descaling will in addition to scope covered in 2021, include descaling of additional 13 flow lines, HP header, LP header and header manifold. Table 2 shows production rates of all DPA wells indicating that the 3kbopd is a conservative estimate.

S/N	Well	Pre descaling Well Production (bopd)	Post descaling Well Production (bopd)	Post descaling Validated Production Gain (bopd)	Percentage Production Gain
1	EA019S	1,110	1,261	151	13.6 %
2	EA026	349	1,133	784	224.6%
3	EA036	1,133	1,073	-	-
4	EA046	1,018	1,955	937	92.0%
5	EA050	328	454	126	38.4%
6	EA051	868	Not tested	-	-
7	EA054	1,231	1,325	95	7.6%
8	EA024	577	Not tested	-	-
Total gain				2,093bopd	

Table1: 2021 EA DPA chemical descaling validated gains

SN	WELL	STRING	WELL STATUS	WELL TYPE	TEST DATE (DD/MM/YY)	BS&W (%)	CURRENT RATES (BOPD)
1	EA019	L	Flowing	GL	16-Aug-2021	59	1292
2	EA019	S	Flowing	NF	13-Aug-2021	14	1009
3	EA020	T	Flowing	GL	01-Aug-2018	1	199
4	EA021	T	Flowing	GL	22-Aug-2021	87	645
5	EA023	T	Flowing	GL	20-Jul-2021	88	320
6	EA024	T	Flowing	NF	18-Apr-2021	85	577
7	EA025	T	Flowing	GL	22-Jul-2021	85	977
8	EA026	T	Flowing	GL	24-Aug-2021	83	410
9	EA036	T	Flowing	GL	17-Aug-2021	83	1116
10	EA045	T	Flowing	GL	16-Aug-2021	87	492
11	EA046	T	Flowing	GL	19-Aug-2021	66	1455
12	EA047	T	Flowing	GL	23-Aug-2021	70	1917
13	EA050	T	Flowing	GL	20-Jul-2021	87	454
14	EA051	T	Flowing	GL	22-Apr-2021	84	868
15	EA054	T	Flowing	NF	14-Aug-2021	82	1063
16	EA055	T	Flowing	NF	04-Jul-2021	67	214
17	EA056	T	Flowing	NF	18-Aug-2021	16	904



18	EA057	L	Flowing	GL	15-Jul-2021	60	608
19	EA057	S	Flowing	GL	20-Jan-2021	84	387
20	EA058	L	Flowing	GL	30-Aug-2021	92	54
21	EA058	S	Flowing	GL	14-Jan-2021	69	486
<b>Total Production</b>							<b>15,446bopd</b>

Table2: EA DPA Production Data (Based on last comprehensive well test data)

Production data in table 2 is based on last validated well test, mostly from 2021 due to lack of test facility. Descaling is expected to help restore this. Table 3 however shows latest (November 2022) estimates based on most recent monthly water cut data and last known gross rate.

SN	WELL	STRING	WELL STATUS	WELL TYPE	Current BS&W (%)	Current Rate (BOPD) - Estimated
1	EA019	L	Flowing	GL	72.0	925
2	EA019	S	Flowing	NF	66.7	450
3	EA20	T	Flowing	GL	36.0	224
4	EA021	T	Flowing	GL	91.6	339
5	EA023	T	Flowing	GL	93.1	156
6	EA024	T	Flowing	NF	57.0	1,615
7	EA025	T	Flowing	GL	87.7	803
8	EA026	T	Flowing	GL	91.7	218
9	EA036	T	Flowing	GL	89.2	696
10	EA045	T	Flowing	GL	86.9	553
11	EA046	T	Flowing	GL	70.5	1,276
12	EA047	T	Flowing	GL	80.7	1,222
13	EA050	T	Flowing	GL	96.7	118
14	EA051	T	Flowing	GL	93.3	307
15	EA054	T	Flowing	NF	83.5	1,036
16	EA055	T	Flowing	NF	67.2	277
17	EA056	T	Flowing	NF	22.0	1,239
18	EA057	L	Flowing	GL	85.9	223
19	EA057	S	Flowing	GL	86.9	282
20	EA058	L	Flowing	GL	96.7	26
21	EA058	S	Flowing	GL	92.0	171
<b>Total Production</b>						<b>12,155bopd</b>

Table3: EA DPA November 2022 Estimated Production Data

## 5. COST ESTIMATE

Cost estimate based on similar scope previously executed is F\$520k±5%.

S/N	Description	Cost SN	Cost S\$	Cost F\$
1	Descaling chemicals	0.00	382,347.94	382,347.94
2	Descaling execution services	56,576,250.00	0.00	131,572.67
Total Cost		56,576,250.00	382,347.94	513,920.61

Table 3: DPA Surface lines descaling estimate

## 6. ECONOMICS

### Basis and Assumptions

- F\$520k execution cost
- Crude oil price of \$75/bbl
- A 3kbopd restoration & 15k bopd pre descaling total platform production.
- Descaling deferment base case of 21days
  - Asset Operations exploring options for positive isolation to enable phased descaling on a live platform in order to minimize deferment
  - Phased descaling is currently an unlikely option due to stuck open and passing valves. Lack of positive isolation impacts effective and safe execution

### Calculations and Projections

Item	Calculation	Value
Production Gain	3,000bopd x \$75/bbl	\$225,000/day
Execution cost PBP	F\$520k ÷ \$225,000/d	<2days
Incurred deferment PBP	15.5kbopd x 21d ÷ 3,000bopd	108 days
Annualized gain	3kbopd x 365d x 95% x \$75/bbl	US\$78million
First year reward	3kbopd x (1yr – ∑PBP) x 95% x \$75/bbl	US\$55million

## 7. RISKS AND MITIGATIONS

ALL HSSE risks inherent in ALL operations carried out to realize this opportunity must be mitigated according to ALL relevant Shell group HSSE, and Sea Eagle production operations HSSE requirements. Table 4 details primary risks for proposed descaling and strategy for mitigating the risks. See link to MOC risk assessment [10].

RISKS	POTENTIAL (L/M/H)	IMPACT	RISK MANAGEMENT STRATEGY
Chemical impact on Personnel	L RAM P2C	Personnel chemical burn	<ul style="list-style-type: none"> <li>a. Personnel will wear appropriate PPEs including rubber gloves, rubber safety shoes, rubber aprons and face shields in addition to coveralls when working with chemicals</li> <li>b. Circulation loop will be tested for leaks prior to introduction of chemicals</li> <li>c. Only essential personnel will be in actual work area when chemical is introduced</li> </ul> <p>Spent inhibited acid would be neutralised onsite, before backloading onshore for incineration</p>
Chemical impact on Asset	M RAM A3C	Lines wall loss to uniform corrosion	<ul style="list-style-type: none"> <li>a. Inhibited acid will be used to mitigate metal corrosion. Procedure involves acid neutralization and water flushing before demobilization</li> <li>b. External surface of pipe and equipment in work area will be covered with water-proof material to prevent chemical contact</li> <li>c. Leak test must be carried out prior to chemical introduction to prevent any circulation loop chemical leaks.</li> </ul> <p>Spent chemicals will not be produced into the FPSO. All chemicals and water used would be backloaded onshore for incineration</p>
H <sub>2</sub> S Exposure	L RAM P3B	Loss of life	<p>H<sub>2</sub>S possible but unlikely to be present at high concentration</p> <p>Possible because acid is used and sulphide scales can be converted to H<sub>2</sub>S on contact with acid. Lab tests however show scale is predominantly carbonate and previous acid descaling on the platform have not detected H<sub>2</sub>S.</p> <p>However,</p> <ul style="list-style-type: none"> <li>a. personnel will wear organic nose masks and use gas monitors when chemical descaling is in progress.</li> <li>b. personnel will evacuate the area if gas monitors detect H<sub>2</sub>S presence</li> <li>c. circulation loop vent will be located at a well ventilated area</li> </ul>

Stuck open/ passing valves	M  RAM E2D  RAM P2D	Hydrocarbon release/ Loss of containment impacting environment and/or personnel.  Ineffective chemical treatment	a. Operations to verify positive isolation, drain and depressurize lines  b. If positive isolation cannot be achieved under live platform conditions, chemical descaling will be executed with complete platform shutdown
Temporary pumps for descaling	L	Potential ignition source	a. Pumps will be pre-mobbed for offshore use before movement to site  b. Asset electrical team to assess pumps before hookup to DPA power system and use for chemical descaling

Table 4: Primary risks for EA DPA surface lines descaling and proposed mitigations

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