Onshore Maintenance, Corrosion and Inspection Organisation (Civil/Struct Asset Integrity Insp.& Mtce)

STRUCTURAL INTEGRITY ASSESSMENT OF SOKU FLOWSTATION – ANALYSIS OF INCREASED VIBRATION LEVELS

11th December, 2017

SPDC-2017-12-00000008 Document Revision: R02 ECCN: Not Applicable

Revision History

REVISION STATUS			SIGNATORIES		
Rev	**Date**	**Description**	**Originator**	**Reviewer**	**Approver**
R01	05.12.17	Issued for Review	Tamunoemi Efebeli	Forster Ezenwelu	Forster Ezenwelu
R02	11.12.17	Issued for Review	Tamunoemi Efebeli	Forster Ezenwelu	Forster Ezenwelu

- Preliminary issue will be issued as P01
- Revisions for review will be issued as R01, with subsequent come as R02 etc.
- Revisions approved for Implementation/Design Issue/Eng. will be issued as A01, with subsequent come as A02 etc.
- Revisions approved for Tender will be issued as T01, with subsequent come as T02 etc.
- Revisions approved for Construction (AFC)/Purchase will be issued as C01; with subsequent comes as C02 etc.
- Highlights of sections revised from previous approved issues or reasons for version change are to be listed in the description box
- All revisions to this document must be signed by the relevant Technical Authority (TA1, TA2 or TA3)

Signatures for This Revision

Role	Name	Signature	Date
Originator	Tamunoemi Efebeli		12.12.2017
Reviewer	Forster Ezenwelu		12/12/2017
Approver	Forster Ezenwelu		

More field(s) could be added for signature if additional agreement/approval is required.

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STRUCTURAL INTEGRITY ASSESSMENT OF SOKU FLOWSTATION – ANALYSIS OF INCREASED VIBRATION LEVELS.

EXECUTIVE SUMMARY

Following reports of increased vibrations on the platform of SOKU Flowstation, the Asset Team requested for a structural integrity assessment of the Flowstation to determine the cause of the vibrations and risks associated with the high levels of vibrations at the Flowstation. The integrity assessment was carried out at Soku Flowstation on Wednesday, 29th November 2017.

The work scope was limited to General Visual Assessment of the pipelines and pipe supports arrangement to assess the cause of the increased vibration levels and recommend solutions that will impede any disruptions to production from the Flowstation.

The main objective was to qualitatively assess for structural degradations, and provide solutions that will mitigate against any impending risk from the increased vibrations on the piping and piping supports arrangement.

The result of the assessments revealed that there is currently no damage on the piping support structures however, some of the piping for the export lines are not properly fastened with U bolts on their pipe supports. This has created freely supported arrangements which do not restrain lateral forces. The recommendation to tackle this increased vibration is to provide proper anchorage for the pipelines and review the operating philosophy of the Pumps, Generators and other vibrating machinery to ensure that they are currently functioning within the integrity operating window. Other recommendations are as stated in the report.

These are localised defects and the exact areas where they were identified are indicated in the report. The risk categorization table shows that the anomalies pose a medium risk to people, asset, environment and reputation.

On receipt of this report, please raise Z1 notifications on SAP to enable effective tracking and close out of the identified defects.

STRUCTURAL INTEGRITY ASSESSMENT OF SOKU FLOWSTATION – ANALYSIS OF INCREASED VIBRATION LEVELS.

1. INTRODUCTION

The Soku Field is in OML-23 in the coastal swamp's deposit of SPDC's Eastern Division, about 40km southwest of Port Harcourt. The field was discovered in 1957 and production commenced in 1971. 36 of the wells were targeted for oil development while the remaining 16 wells were for gas development. Soku field oil production facilities consist of a dual bank Flowstation located approximately 3.2km from the Soku Gas Plant. The dual bank arrangement consists of an original field production facility; a single bank standard Flowstation built in 1971, the Oil Rim Development (ORD) bank built in 1998. Each bank is located on a separate, piled structure in the swamp. The Soku oil production facility is a semi-manned facility that has its field logistic base located in the manned Soku Gas Plant. The two banks have a total design processing capacity of 56Mbpd and 54 MMscfd (2014 Operating Envelop). The station's operating point is 5.88 Mbpd (gross liquids) and 3.68MMscfd (gas) from 6 conduits with BS&W of 56.6%.

The Flowstation has undergone some upgrades between 2006 and 2014 on pumps, instrumentation, export systems and safeguarding.

2. RESPONSIBILITIES & SCOPE

The work scope for this integrity assessment are as detailed below:

- General Visual Inspection of the Soku Flowstation piping, manifold and structural supports to ascertain cause of vibration.
- Physical measurements and pictures of the pipe support and span.
- Investigation into the current vibration levels from previous reports
- Short and long-term recommendations for mitigating against the risk of high vibrations levels at the Flowstation.

3. INSPECTION TEAM

Ezenwelu Forster	-	Civil/Structural Asset Integrity/Maintenance Lead.
Efebeli Tamunoemi	-	Civil/Structural Asset Integrity/Maintenance Engineer

4. VIBRATION: DEGRADATION MECHANISM AND RISKS

The piping systems and structural supports used in transporting oil and gas from the wellheads to process facilities are usually susceptible to vibration from a wide range of sources. The nature of installations for vibrating machinery including Generators, Pumps and Compressors often represents an increased risk for high vibrating levels in the Flowstation. These increased risks for vibrations can lead to fatigue failures on components such as supports, instrumentation, piping and vessels. Fatigue failure is the tendency of a material to break by means of progressive cracking under alternating (tension and compression) stresses of an intensity considerably lower than the normal strength of the material. These failures result in significant costs in repairs and downtime as well as serious safety concerns for site personnel and the general population. Another common degradation mechanism is caused by flow Induced Acoustic Resonance. Dynamic stress increases as flow rate increases; hence some fatigue stress can be the result of high frequency of excitation which implies an acoustic resonance type flow induced excitation. In this condition, the piping and structures vibrate at higher amplitudes for small changes in excitation force.

5. CONDITION STATUS

The inspection carried out at the Soku Flowstation revealed that the pipe supports are in good condition. However, some pipeline anchorages and U-bolts are not firmly bolted to the piping supports. The vertical length of the piping at the export region is about 2m free span (from the splash zone to platform grating). The risk of increased vibration levels is higher when piping is not firmly anchored on the piping supports since it creates a free movement in the pipeline and structure when lateral loads are presented. Table 1 below shows the risk categorization.

6. TABLE 1-TABLE FOR DEFECT CATEGORIZATION

The observed defects would be categorized using the classification in Civil InfoBase, Steel Structural Elements. GS.06.50620. Table 6.1

Priority	Action	Danger	Possible reasons	Examples
1	Immediate action required	High	Construction error, Design error, Deficient repair, Missing parts, Mechanical damage, others.	Foundation or differential settlement. Cracks -Spalling (chloride attack) (Carbonic Acid) Corrosion of reinforcement (Chloride attack). Twisted and deflected member, buckling, Moisture penetration, Water ingress,
2	Action required at short term, i.e. within 1-2 years	Medium	Construction/ Design error Deficient repair Missing parts Mechanical damage Others	Medium to serious deterioration, which does not affect structural integrity,
3	Action required at longer term, i.e. 2-5 years	Limited	Corrosion. Mechanical damage, Other	Limited corrosion or Minor mechanical damage or deformations. (Personnel safety not at risk).
4	No action required	Not existing		

DOMINANT FAILURE MODES FOR TOPSIDES (SWAMP) BASED ON PML 208.05

Failure Modes	Hidden Failure	Age Related
Bolted Joint Failure – missing bolts, mis-aligned and damaged bolts	N	N
Seal failure – door seals, gas-tight compartment seals	Y	Y
Corrosion – which impairs serviceability of structural element	Y	Y
Coating failure – leading to corrosion. PFP deterioration impairing ability to protect steelwork	N	Y
Support Failure – buckling, excessive deflection, distortion	Y	N
Physical Damage – which impairs serviceability of structural element – denting, fracture, missing elements	N	N
Weld Defects – including cracks which impairs serviceability of structural element	Y	Y

7. TABLE 2 -TABLE OF OBSERVED DEFECTS AND RECOMMENDATIONS

FACILITY NAME	SOKU FLOWSTATION PIPING AND STRUCTURES		
INSPECTED SECTIONS	**FIELD OBSERVATIONS**	**REMEDIAL MEASURES**	**URGENCY**
SOKU FLOWSTATION PIPING & STRUCTURES	1. 3 no 6″ pipelines not clamped with U-bolts to their goal post type piping support at the export manifold. 2. Existing U bolt on line above grating not properly tightened. 3. Normal vibration levels observed at the time of inspection	Restrain lateral movement on the lines by introducing clamps with U-bolts to the lines located below the gratings. Tighten all loose clamps and U-bolts on the pipeline manifold. See Appendix for details. Continuous monitor changes in vibration levels via vibration study and surveys to determine the exact locations where high vibrations occur during operations.	2

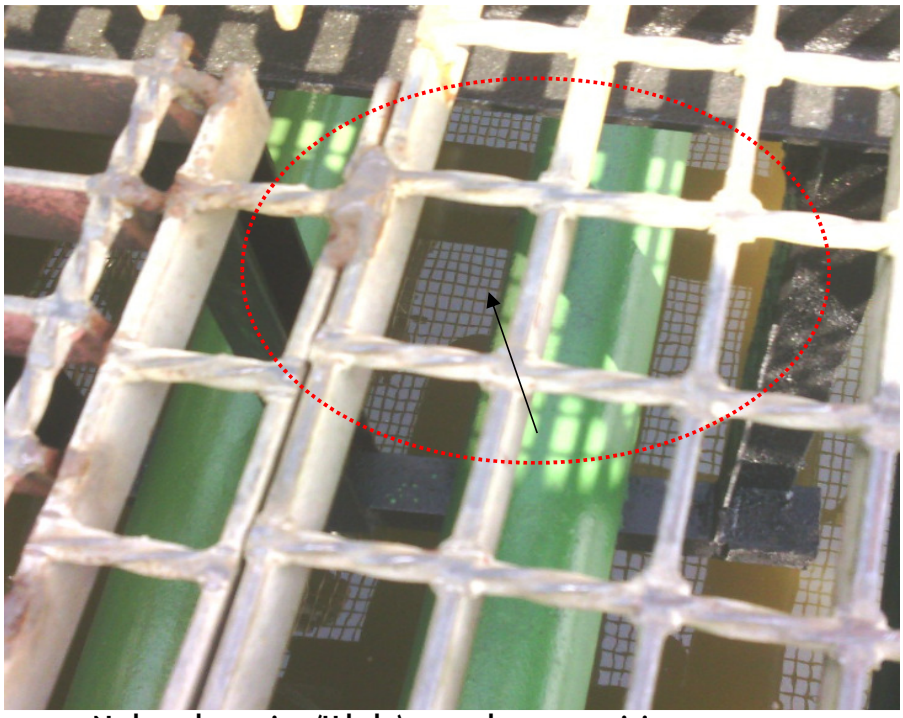
8. RECOMMENDATIONS

The current vibration report (Nov 15th and 16th) for the Soku Flowstation vibration analysis showed that the EMSCO Pump 2 and Gas Generator G3406 have vibration levels within the acceptable ranges. The recommendation is to continuously monitor the equipment at regular intervals.

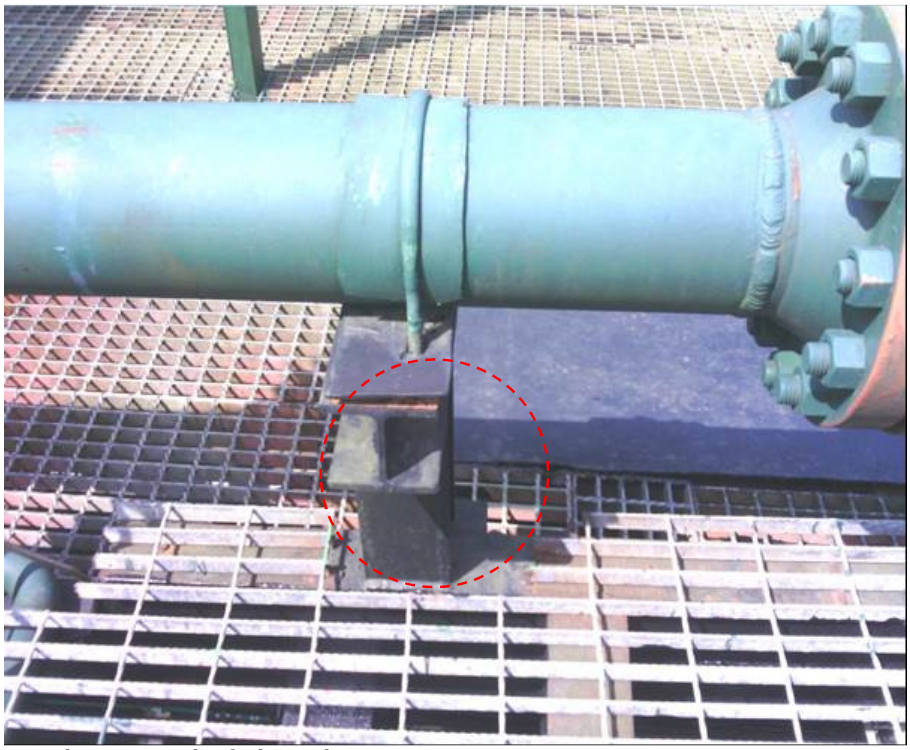
The following recommendations apply.

1. Introduce U-bolts to restrain the 6″ pipelines that are currently located below the grating to prevent lateral movements.
2. Tighten all bolts and screws on clamps fastened on pipelines.
3. Service the valves (suction and discharge) to help reduce fluctuation in flow.
4. Ensure that current operation of Pumps and Generators are within their integrity operating window as specified in the equipment design manual.
5. Continuously monitor vibration levels of the vibrating machinery on the Soku Flowstation.

9. PICTURES SHOWING OBSERVED DEFECTS



No lateral restraints (U bolts) on goal post type piping supports



Loosely connected U bolts and piping supports structure

REFERENCES

- Civil Infobase - GS.06.50620 – Steel Structural Elements
- DEP 31.38.01.29 – Pipe Supports
- PML 208.05 – Offshore Topsides Structure Maintenance Strategy
- Global Performance Standard Template R9 – Operate Phase Performance Standards

APPENDIX:

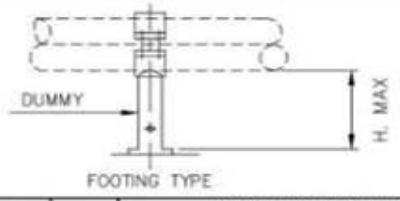
APPENDIX 5 CLAMPED BASE SUPPORTS – SELECTION CHART

CLAMPED BASE SUPPORT

SEE ST. DWG. S 44.041

IDENTIFICATION EXAMPLE

CB3 H=400 mm (16 in) BP1



TYPE	DN DUMMY	NPS DUMMY	ALLOWABLE VERT. LOAD kN (lbf) H 300–600 mm (12–24 in)	ALLOWABLE VERT. LOAD kN (lbf) H 601–1300 mm (24–51 in)
CB1	40	1–1/2	1.0 (225)	–
CB2	50	2	3.0 (674)	–
CB3	80	3	6.8 (1529)	3.1 (697)
CB4	100	4	11.0 (2473)	5.1 (1146)
CB5	150	6	25.0 (5620)	11.5 (2585)
CB6	200	8	27.5 (6182)	13.0 (2922)
CB7	250	10	40.0 (8992)	18.5 (4159)
CB8	300	12	57.5 (12926)	26.0 (5845)
CB9	400	16	70.5 (15848)	32.6 (7328)

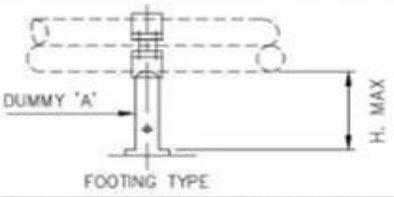
CB1 THRU CB9

ADJUSTABLE CLAMPED BASE SUPPORT

SEE ST. DWG. S 44.042

IDENTIFICATION EXAMPLE

ACB3 H=400 mm (16 in) BP1



TYPE	DN DUMMY A	NPS DUMMY A	ALLOWABLE VERT. LOAD kN (lbf) H 300–600 mm (12–24 in)	ALLOWABLE VERT. LOAD kN (lbf) H 601–1300 mm (24–51 in)
ACB1	65	2–1/2	3.0 (674)	–
ACB2	80	3	6.8 (1529)	–
ACB3	100	4	11.0 (2473)	3.1 (697)
ACB4	150	6	25.0 (5620)	5.1 (1146)
ACB5	200	8	27.5 (6182)	11.5 (2585)
ACB6	250	10	40.0 (8992)	13.0 (2922)
ACB7	300	12	57.5 (12926)	26.0 (5845)
ACB8	350	14	66.0 (14837)	30.5 (6856)
ACB9	400	18	70.5 (15848)	32.6 (7328)

CB1 THRU CB9

NOTES:

1. THERE ARE FABRICATION AND INSTALLATION DRAWINGS FOR EACH SUPPORT ON THIS SELECTION CHART

Snippet from Vibration Report on Nov. 2017

SHELL PETROLEUM DEV.CO EAST

Overall Vibration Readings SOKU FLOW STATION: GAS GENERATOR G3406					
Position	Type	Points	Overall Vibrations (RMS) mm/sec		
			H	V	A
E1	Engine Outboard Bearing	3	4.20	5.56	1.77
E2	Engine Inboard Bearing	3	4.63	8.06	1.16
G1	Generator Inboard Bearing	3	2.41	2.02	2.73
G2	Generator Outboard Bearing	3	3.12	3.53	2.95
Water temp. =187°F Engine oil pressure = 61psi Engine speed = 1514 rpm					

Fault, Severity and Recommended Action			
Machine Name	Status / Comments	Recommendations	Severity
EMSCO PUMP 2	Vibration level found within acceptable range	Continue monitoring equipment at regular interval	4
GAS GENERATOR G3406	Vibration level found within acceptable range	Continue monitoring equipment at regular interval	4

VIBRATION ANALYSIS REPORT