



Maintenance Engineering & Technical Assurance (Civil Maintenance Engineering Discipline)

STRUCTURAL INTEGRITY ASSESSMENT OF PIPE SUPPORTS & CONDENSATE TANK FOUNDATION AT SOKU GAS PLANT

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<ul style="list-style-type: none"> 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
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Reviewer	Ajiri Ivovi		
Approver	Tamunoemi Efebeli		

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

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1. INTRODUCTION

Following reported structural failures at Soku Gas Plant, a structural integrity assessment was carried out by META Civil/Structural Engineering team on the 1st of February 2022. The aim of the assessment is to investigate the cause of the structural failures in the facility in order to determine short and long term solution.

Assets inspected include 2" Rich glycol line pipe supports at GRU train 1 and train 2, spiking pumps pipe supports, condensate tank T5501 and Condensate Surge Drum. The assessment involved General Visual Inspection (GVI), physical measurements and taking pictures of observed defects.

2. OBSERVATIONS/FINDINGS

The following observations were made during the drain inspection:

A. 2" Rich Glycol Lines at GRU train 1 & 2 –

- Failed pipe support foundation and tilted stanchion
- Excessive spacing between pipe supports (7.8m & 5.1m). Required distance is **2.5m max**
- Failed/insufficient length of angle iron piping seats, and loose/missing U-clamps.

These defects are escalated by excessive vibrations (up to 90 bar) released by the glycol contactor valve into the 2" Rich glycol lines.

B. Pipe Supports at Spiking Pump –

- Moderate to severe subsidence of pipe supports
- Detachment of pipes from supports,
- Excessive distance between pipe supports circa 6m
- Displacement of pipe supports from original positions, and missing anchor bolts.

These defects are escalated by excessive vibrations from the spiking pumps which are propagated to the flow lines.

C. Condensate Tank T5501 –

- Severe cracks on bituminous Tank pad
- Degraded expansion joint fillers and vegetation growth on expansion joints.

D. Condensate Surge Drum –

- Severe subsidence on pipe supports, tilted pipe supports and moderate cracks on concrete floor. These defects are escalated by excessive vibrations from nearby spiking pumps.

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Details of these findings, risk categorizations and associated immediate corrective actions are provided in this report. Further review of the excessive vibration issues at the Soku Gas Plant should be carried out with Process, Mechanical and Pipeline Engineering Disciplines to determine a long term, permanent solution.

3. RISK CATEGORIZATION TABLE

The table below is an extract from the Table 5.1 of Civil InfoBase – Steel Structural Elements, GS.06.50607 for the Steel Structures. The observed defects would be categorized using the classification in the table below

Priority	Action	Danger	Possible reasons	Examples
1	Immediate action required	High	Corrosion/deterioration, Construction error, Design error, Deficient repair, Missing parts, Mechanical damage, others.	Major corrosion, deterioration or damage, seriously effecting current structural integrity. Missing, damaged or seriously corroded parts which may affect personnel safety such as for instance missing or damaged floor elements, railings, and ladders/stairs.
2	Action required at short term, i.e. within 1-2 years	Medium	Corrosion/deterioration Construction/ Design error Deficient repair Missing parts Mechanical damage Other	Medium to serious corrosion or deterioration, which does not affect structural integrity at short term Ri 4Table 5.3. Deformed stair treads due to overloading. Missing bolt and/or nut. Limited damage to stair or ladder footing, not leading to instability. (Personnel safety not at risk).
3	Action required at longer term, i.e. 2-5 years	Limited	Corrosion Mechanical damage Other	Limited corrosion or deterioration up to Ri 3-4 Table 5.3. Minor mechanical damage or deformations. (Personnel safety not at risk).
4	No action required	Not existing		

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4. TABLE OF OBSERVATIONS AND REMEDIAL ACTIONS FOR 2" RICH GLYCOL RETURN LINE FROM CONTACTOR - REGENERATION UNIT AT GRU **TRAIN 1**

ASSET	FAILED CONCRETE SUPPORT AT GRU TRAIN 1		
COMPONENTS INSPECTED	DEFECTS OBSERVED	MEASURE/SIZE OF DEFECTS/REMEDIAL ACTION	PRIORITY
2" RICH GLYCOL RETURN LINE FROM CONTACTOR - REGENERATION UNIT AT GRU TRAIN 1	Failed concrete foundation and tilted stanchion <ul style="list-style-type: none"> Stanchion: 100 x 80mm IPE, 5m length Foundation stubs: 300x300x 405mm. Anchor bolts: 18.7mm dia. 	Demolish and reconstruct failed concrete foundation and straighten titled stanchion.	1
	Excessive spacing between pipe supports.	Fabricate and install additional pipe supports midway between the existing supports to reduce the spans to a maximum of 2.5m.	1
	Loose/missing U-clamps	Replace missing clamps and fix loose clamps.	
	Failed and insufficient length of piping seats 30 x 30mm E.A, 0.6m length, 6 Nos.	Provide equal angle section, cut to L-shape to provide sufficient seats for the 2" Rich glycol pipes 50 x 50mm E.A, 0.9m	1
	Excessive vibrations (up to 90 bar) released by the glycol contactor valve into the 2" Rich glycol lines	Use Neoprene Packing placed between the Pipeline and Supports to dampen the effects of vibrations from the Pipe.	1
		Carry out further review of the excessive vibration issues with Process, Mechanical and Pipeline Engineering disciplines	2

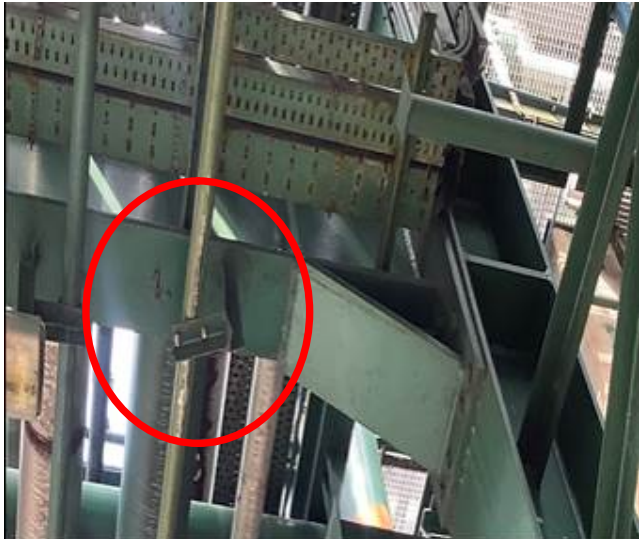
PICTURES OF OBSERVED DEFECTS AT THE 2" RICH GLYCOL RETURN LINE FROM CONTACTOR - REGENERATION UNIT AT GRU TRAIN 1

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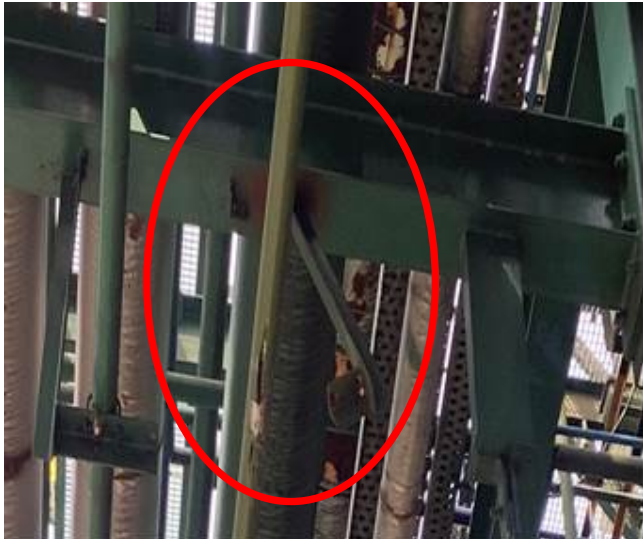
STRUCTURAL INTEGRITY ASSESSMENT OF PIPE SUPPORTS & CONDENSATE TANK FOUNDATION AT SOKU GAS PLANT



FAILED CONCRETE SUPPORTS



INSUFFICIENT LENGTH OF ANGLE IRON SEATS



FAILED L-SHAPED EQUAL ANGLE SUPPORT FOR THE 2" LINE.



5MM CLEARANCE BETWEEN BASE PLATE & CONCRETE SUPPORT.



LOOSED PIPE CLAMP.

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STRUCTURAL INTEGRITY ASSESSMENT OF PIPE SUPPORTS & CONDENSATE TANK FOUNDATION AT SOKU GAS PLANT

5. TABLE OF OBSERVATIONS AND REMEDIAL ACTIONS FOR CONCRETE SUPPORT OF 2" RICH GLYCOL RETURN LINE FROM CONTACTOR - REGENERATION UNIT AT GRU **TRAIN 2.**

Note: Though Train 2 is yet to show visible, many failure modes are already presents and the same design/execution errors are present

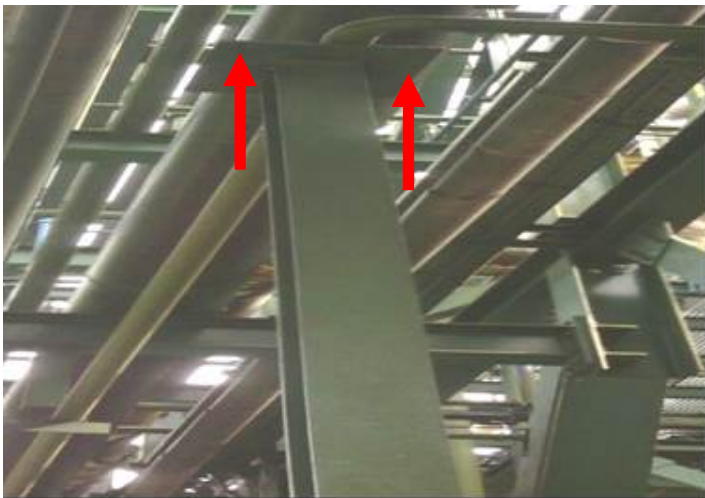
ASSET	CONCRETE SUPPORT AT GRU TRAIN 2		
COMPONENTS INSPECTED	DEFECTS OBSERVED	MEASURE/SIZE OF DEFECTS/REMEDIAL ACTIONS	PRIORITY
CONCRETE FOUNDATION AND STEEL PIPE SUPPORTS	No sign of failure as at time of inspection	No action Required	4
	Excessive spacing between pipe supports.	Fabricate and install additional pipe supports midway between the existing supports to reduce the spans to a maximum of 2.5m.	1
	Insufficient Length of L-shaped equal angle piping seats 30x30mm E.A, 0.6m, 6Nos.	Provide equal angle section, cut to L-shape to provide sufficient seats for the 2" Rich glycol pipes 50 x 50mm E.A, 0.9m x 10Nos.	2
	Missing U-clamps	Replace missing clamps	1
	Excessive vibrations (up to 90 bar) released by the glycol contactor valve into the 2" Rich glycol lines	Use Neoprene Packing placed between the Pipeline and Supports to dampen the effects of vibrations from the Pipe.	1
		Carry out further review of the excessive vibration issues with Process, Mechanical and Pipeline Engineering disciplines	2

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PICTURES OF OBSERVED DEFECTS AT 2" RICH GLYCOL RETURN LINE FROM CONTACTOR – REGENERATION UNIT AT GRU TRAIN 2



CONCRETE SUPPORT AND STEEL STANCHIONS: NO SIGN OF FAILURE AS AT THE TIME OF INSPECTION.



MISSING PIPE CLAMPS U-CLAMPS.



CONCRETE FOUNDATION IN GOOD CONDITION

STRUCTURAL INTEGRITY ASSESSMENT OF PIPE SUPPORTS & CONDENSATE TANK FOUNDATION AT SOKU GAS PLANT



INSUFFICIENT L-SHAPED EQUAL ANGLE PIPING SEATS.

6. TABLE OF OBSERVATIONS AND REMEDIAL ACTIONS FOR CONCRETE AND STEEL SUPPORT AT SPIKING PUMP AREA.

ASSET	CONCRETE AND STEEL SUPPORT AT SPIKING PUMP AREA		
COMPONENTS INSPECTED	DEFECTS OBSERVED	MEASURE/SIZE OF DEFECTS/REMEDIAL ACTION	PRIORITY
SPIKING PUM A AND B	Missing anchor bolts	Provide and install galvanized fischer anchor bolts.	1
	Displacement of pipe supports from original positions due to excessive vibrations from the spiking pump		
	Moderate to severe subsidence of concrete foundations leading to detachment of pipings from supports.	Demolish and reconstruct affected pipe supports.	1
	Excessive spacing between pipe supports.	Fabricate and install additional pipe supports midway between the existing supports to reduce the spans to a maximum of 2.5m.	1
	Excessive vibrations from spiking pumps	Use Neoprene Packing placed between the Pipeline and Supports to dampen the effects of vibrations from the Pipe.	1

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		Carry out further review of the excessive vibration issues with Process, Mechanical and Pipeline Engineering disciplines	2
SPIKING PUMP C AND D	Missing anchor bolts	Provide and install galvanized fischer anchor bolts.	1
	Displacement of pipe supports from original positions due to excessive vibrations from the spiking pump		
	Excessive spacing between pipe supports.	Fabricate and install additional pipe supports midway between the existing supports to reduce the spans to a maximum of 3.m.	1
	Excessive vibrations from spiking pumps	Use Neoprene Packing placed between the Pipeline and Supports to dampen the effects of vibrations from the Pipe.	1
		Carry out further review of the excessive vibration issues with Process, Mechanical and Pipeline Engineering disciplines	2

PICTURES OF OBSERVED DEFECTS AT SPIKING PUMP A & B



MISSING ANCHOR BOLTS & DISPLACEMENT OF PIPE SUPPORT FROM ORIGINAL POSITION

STRUCTURAL INTEGRITY ASSESSMENT OF PIPE SUPPORTS & CONDENSATE TANK FOUNDATION AT SOKU GAS PLANT



SEVERE SUBSIDENCE OF PIPE SUPPORTS FOUNDATION & DETACHMENT OF PIPING FROM PIPE SUPPORT



MISSING ANCHOR BOLTS.



DISPLACEMENT OF PIPE SUPPORTS FROM ORIGINAL POSITIONS DUE TO EXCESSIVE VIBRATIONS FROM THE SPIKING PUMP.

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STRUCTURAL INTEGRITY ASSESSMENT OF PIPE SUPPORTS & CONDENSATE TANK FOUNDATION AT SOKU GAS PLANT

PICTURES OF OBSERVED DEFECTS AT SPIKING PUMP C AND D



MISSING ANCHOR BOLTS.



**DISPLACEMENT OF PIPE SUPPORTS FROM ORIGINAL POSITIONS
DUE TO EXCESSIVE VIBRATIONS FROM SPIKING PUMP.**



PIPE SUPPORTS INSTALLED WITHOUT ANCHOR BOLTS

STRUCTURAL INTEGRITY ASSESSMENT OF PIPE SUPPORTS & CONDENSATE TANK FOUNDATION AT SOKU GAS PLANT

7. TABLE OF OBSERVATIONS AND REMEDIAL ACTIONS FOR CONDENSATE TANK T5501 AND CONDENSATE SURGE DRUM.

ASSET	CONDENSATE TANK T5501 AND CONDENSATE SURGE DRUM		
COMPONENTS INSPECTED	DEFECTS OBSERVED	MEASURE/SIZE OF DEFECTS/REMEDIAL ACTION	PRIORITY
CONDENSATE TANK T5501	Multiple cracks on bituminous tank pad	Remove and cart away degraded bituminous layer. Provide, mix and place BRC reinforced concrete grade 20 and make good 276m x 3.5 x 0.15m	1
	Pipe supports, personal access ladder/platform and Concrete bondwall – In good condition	No action is required	4
	Degraded expansion joint on concrete floor and vegetation growth along expansion joints	Remove vegetations with hand tools. Keep surface free and clean from debris. Provide and inject expansion joints with epoxy joint fillers and make good 256m x 0.1m x 10mm	2
CONDENSATE SURGE DRUM	Moderate cracks on concrete floor	Open up crack, prepare surface and treat with cement sand mortar or Epoxy Resin 21m x 0.1m x 5mm	2
	Personal access platform and elevated concrete foundation – In good condition	No action is required	4
	Severe subsidence on pipe supports.	Demolish and reconstruct affected pipe supports	1
	Tilted pipe supports	Straighen tilted pipe supports and connect them with crossed bracings	1
	Excessive vibrations from spiking pump	Use Neoprene Packing placed between the Pipeline and Supports to dampen the effects of vibrations from the Pipe.	1
		Carry out further review of the excessive vibration issues with Process, Mechanical and Pipeline Engineering disciplines	2

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STRUCTURAL INTEGRITY ASSESSMENT OF PIPE SUPPORTS & CONDENSATE TANK FOUNDATION AT SOKU GAS PLANT

PICTURES OF OBSERVATIONS AT CONDENSATE TANK T5501



MULTIPLE CRACKS ON BITUMINOUS TANK PAD.



PIPE SUPPORTS, PERSONAL ACCESS LADDER/PLATFORM AND CONCRETE BONDWALL – IN GOOD CONDITION.



GRASSY PUP OUT ON DEGRADED EXPANSION JOINT FILLER ON CONCRETE FLOOR.

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PICTURES OF OBSERVATIONS AT CONDENSATE SURGE DRUM

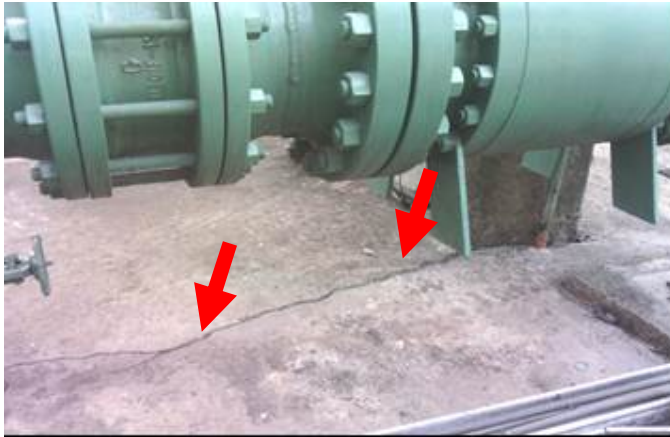


PERSONAL ACCESS PLATFORM AND ELEVATED CONCRETE FOUNDATION – IN GOOD CONDITION.



SEVERE SUBSIDENCE ON PIPE SUPPORTS

STRUCTURAL INTEGRITY ASSESSMENT OF PIPE SUPPORTS & CONDENSATE TANK FOUNDATION AT SOKU GAS PLANT



MODERATE CRACKS ON CONCRETE FLOOR.



TILTED PIPE SUPPORTS.

CHALLENGES:

No as built drawings were not available as at time of inspection.

REFERENCES

The following Civil Infobases were referenced for the assessment;

- GS.06.50620: Civil Infobase on Steel Structural Elements.
- GS.06.50617: Civil Infobase on Personnel Access Facilities.
- GS.06.50624: Civil Infobase on Roads and Pavings.
- GS.06.50607: Civil Infobase on concrete structures and foundations.

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