Eskom	Scope of work	Majuba Power Station

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1. INTRODUCTION

Due to scaling in the condenser tubes at Majuba power station, the condenser needs to be cleaned. There has been an attempt to clean unit 4 condenser using HPWJ during a 10 day HSSD in April 2020 but the scaling could not be removed. This meant that an alternative method needed to be used to clean the condenser tubes. The alternative method chosen is chemical cleaning and this document gives the specification and scope of work for the chemical cleaning of Majuba unit 4-6 condensers.

1.1 SCOPE

The scope is provision of chemical cleaning service to clean units 4 – 6 condenser tubes at Majuba power station. The scope includes the supply and installation of spades (4 off) that will be installed in the condenser inlet and outlet ducting as indicated on drawing in Annex B. These spades will remain in place for duration of chemical clean, and will only be removed after final flushing on completion of chemical cleaning. Details of spades are defined in section 2.5.1. The *Contractor* shall provide a chemical cleaning method statement requirement to the *Employer* for acceptance.

Furthermore before chemical cleaning can take place in the condensers, an inspection of the waterbox corrosion protection must be done to ensure that there aren't any defects, thus the service shall also include repair/reinstallation of the corrosion protection in the waterbox based on the inspection when the unit is down. The *Employer* advises that to its knowledge the corrosion protection for unit 4 is rubber lining, however the *Contractor* need to also provide method statement and repair procedure should epoxy coating be noted in certain areas.

1.2 APPLICABILITY

This document applies to Majuba Power Station, on units 4-6.

1.3 REFERENCES

[1] ISO 9001 Quality Management Systems.

[2] 240-101712128 Standard for the internal Corrosion Protection of Water Systems, Chemical Tanks and Vessel and Associated Piping with Linings

[3] 240-162132332 Tender Technical Evaluation Strategy – Condenser acid cleaning

[4] 240- 56030499 Condenser healthcare guideline

[5] 240-107677940 Specification for HP Jetting of condensers and HEX

1.4 DRAWINGS

[6] 0.66/81535

[7] 0.66/80994

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2. SCOPE OF WORK

2.1 CONDENSER INFORMATION

See *APPENDIX A* at the back of this document for Majuba condenser tubes information

2.2 SELECTION OF THE CHEMICAL CLEANING SOLVENT TO BE USED

The *Employer* uses a guideline to properly select the correct material to be used which will be an effective combination of the scale removal and prevention of damage to rest of the condenser. Table 1 and 2 below provide a guide in terms of solvent choice versus scale and condenser material of construction. If required, Majuba cooling water chemistry data can be made available in addition to Table 1 and 2 to assess and properly select an effective chemical cleaning solvent for condenser cleaning as there will be available condenser tube sample to test the cleaning solvent efficacy.

TABLE 1: COMPATIBILTY TABLE FOR CHEMICAL CLEANING SOLVENTS AND SCALE

Solvent/ Chemical Name	Major Deposit Component (see key and notes)						
	Carbonates	Phosphate	Sulphate	Silica	Copper Oxides	Iron Oxides	Sulphides
Hydrochloric Acid	C	C			C	C	C
Hydrochloric Acid and Ammonium Biflouride	C	C		C	C	C	C
Sulphuric Acid						C	C
Sulphuric Acid and Ammonium Bifluoride				C		C	C
Phosphoric Acid	C					C	
Citric Acid						C	

KEY

C = COMPATIBLE

BLANK = NOT COMPATIBLE.

The selection criteria however does not end with the compatibility table as this would leave the materials in the condenser exposed to acids that it might not be compatible to, thus a second table was put in place, one that considers the material of the condenser tubes. Table 2 is the compatibility table between the tube materials and the chemical cleaning solvent, this table only includes Titanium since Majuba condenser tubes are all made of Titanium, however for a table that includes all materials, please see Table D.5 of document 240-56030499*Condenser health care guideline Rev 2

TABLE 2: COMPATIBILITY TABLE BETWEEN TITANIUM AND THE TITANIUM AND CHEMICAL CLEANING SOLVENTS

Inhibited solvent	**Titanium**
Hydrochloric Acid	C5
Hydrochloric Acid and Ammonium Bifluoride	X8
Hydrochloric Acid and Thioure	C5
Sulphuric Acid	S
Sulphuric Acid and Ammonium Biflouride	X8
Phosphoric Acid	S
Hydroxyacetic-Formic Acid	?
Hydroxyacetic-Formic Acid and Ammonium Bifluoride	X
NaEDTA	S
Ammoniated EDTA	?
Ammoniated Citric Acid	S
Ammoniated Citric Acid and Ammonium Bifluoride	X

Key

S - Can be used safely

C – Care require for satisfactory use (strictor limitations of pH, Temperature, and/or solvent concentrations), Special inhibitors may be required.

X – Do not use

NOTES

1 – Maximum temperature (49C)

2 – Maximum temperature (60C)

3 – Should be used at lower temperatures to reduce corrosion rates, should not be used on sulphide penetrated stainless steel

4 – Do not use in the presence of ferric ions or other oxidizing materials

5 – Recommend adding 0.2% of ferric chloride to protect titanium

6 - Free ammonia in the presence of oxygen can lead to stress corrosion cracking, even with ammoniated EDTA or citric acid based solvents with an initial pH of 5-6, pH values often rise above 7.5 during dissolution of deposits; cracking is possible at or above pH 7.5

7 – May be used for low initial pH procedure provided the pH is kept below 7.5 during deposit dissolution. The standard passivation stage must not be performed.

8 - Hydrochloric acid and/or ammonium bi-flouride shall never be used on stainless steels (particularly austenitic grades such as “300”) and titanium tubing. Austenitic stainless steels are susceptible to pitting, crevice corrosion and stress corrosion cracking (SCC) in hydrochloric acid in a variety of concentrations and temperatures.

From the table above an acid to clean can be chosen and a recommendation made to Majuba which will then be tested in The *Employer’s* laboratory for effectiveness, in terms of cleaning and risk to the tube material (Titanium Grade 2)

2.3 GENERAL REQUIREMENTS

1. All the work mentioned in this scope of work is the responsibility of the *Contractor* except where specifically noted otherwise.
2. The *Contractor* shall install spades on the inlet and outlet ducts as indicated on drawing 0.66/80994 as marked in red (see Appendix B) to prevent the chemical cleaning solvent (acid) in the CW ducting and valves as well as the tube cleaning system strainers. All rigging equipment will be the responsibility of the *Contractor*.
3. The *Contractor* shall recommend the chemical cleaning solvent to be used for cleaning the condenser, this chemical cleaning solvent shall be approved by The *Employer* before it can be used for cleaning the condenser. Table 2 is of typical cleaning solvents but the list is not exhaustive, the *Contractor* can make recommendations that are not listed in table 2, recommendations are subject to approval by the *Employer* before use.
4. The *Contractor* shall inspect the condenser waterboxes and tubes. Remove any loose debris and unblock any tubes blocked with on-line cleaning balls or other debris. Before chemical cleaning can be executed, the tubes must be unblocked using HP water forward facing nozzle, the purpose of HP Water is not to remove the scaling on the tubes but rather to remove residual sludge in the tubes and to unblock tubes that are blocked Remaining restricted tubes which was not cleared shall be plugged prior to proceeding with chemical cleaning, The *Employer’s* system engineer must be given a time slot to update to tube map for all the new tubes that are plugged before cleaning commences. The requirement is that tubing be “unblocked” to allow passage of the chemical cleaning solution through the entire length of the tube.
5. The risk of blockage on waterbox piping systems such as vent or drain lines and the consequence in terms of pressure build-up in the waterbox during the chemical clean shall be carefully evaluated and appropriately mitigated.

6. This work will be executed during outages and the *Contractor* shall attend the daily outage meeting, otherwise a meeting is to be held every morning with the system engineer to give progress feedback.
7. It is the responsibility of the *Contractor* to familiarize him/her self with the layout of the plant and the area of where the condenser is relative to the turbine hall.
8. If compressed air is required, the *Contractor* shall provide dedicated compressors.

2.4 CORROSION PROTECTION REQUIREMENTS

1. When the waterbox is accessible, an inspection of the corrosion protection has to be done then the *Contractor* shall recommend a repair method and give a method statement of the repair to be done based on the installed lining and product, this method statement shall be approved by the *Employer* before repairs are executed.

2.5 CHEMICAL CLEANING SCOPE OF WORK

1. Isolate condenser from the main cooling water system by installing spades as per appendix B.
2. This scope will be executed during outages and as a result *the Employer* cannot guarantee electrical power supply at all times therefore the *Contractor* shall provide alternative options such as diesel driven high pressure machines as part of this contract.
3. Before the chemicals are introduced the *Contractor* will perform an inspection of the waterbox corrosion protection applied to the waterboxes. The corrosion protection can be a combination of rubber lining as well as prior epoxy coating. Where the protection coating / lining is damaged the *Contractor* will propose a repair procedure for acceptance by the *Employer* before the actual chemical cleaning process commences. This will be deemed a temporary repair and all repaired areas to be recorded. During the next planned half station shut down (toward end 2022) a detailed and permanent repair of the corrosion protection system will be executed. The *Contractor* will take photographs of the complete waterbox internals to allow record keeping of what protection system is installed inclusive of prior patch repairs
4. All water box sacrificial anodes to be removed prior to chemical cleaning.
5. Fit any necessary temporary connections and spades for any other openings and connections other than the main CW duct spades and as selected by the chemical *Contractor* to allow for proper circulation of the solvent through all the condenser tubes. It must be remembered that the chemical selected will also affect different part of the condenser thus protection of those parts may be required before chemical cleaning can commence. The *Contractor* shall consider his particular pumping capabilities to ensure immersion and circulating flow of cleaning solvent through ALL tubes. The Method statement shall consider venting of air pockets and build-up of gasses.
6. Fill the steam side of the condenser with demineralised water to 9m level (just below the M3 door), the condenser must be soaked for a duration of 24hours before a tube leak inspection can commence. After 24hours inspect for any tubes that are leaking from the water box. Any tubes found to be leaking must be plugged. The water in the steam space will be used to dilute the chemicals should there be minor tube leaks that were not identified or newly developed tubes leaks while chemical cleaning is taking place.

7. Fill the water side (Tube side) of the condenser with raw water (or portable water) from station supply. The *Contractor* will connect his circulation pump station and establish circulation, the circulation velocity in each tube must be between 0.2m/s and 0.3m/s. Pump/s shall produce a maximum pressure of 130KPa at 0 m^3/h flow measured directly at pump discharge. The pump(s) will be fitted with a pressure cut out switch that will cut the power source to the pump/s should the pump discharge pressure exceed 130KPa. This operation will be proven to the system engineer before the actual chemical cleaning commences.
8. Furthermore a safety relief valve will be fitted that is sized to allow for the maximum output flow of the pump and set to a value not exceeding 300KPa, this is to protect the condenser CW side from overpressure in event of failure of the pump cut out switch. This shall be detailed in a procedure and accepted by the system engineer before the work commence.
9. The correct operation of the above mentioned protection equipment shall be confirmed prior to the chemical cleaning operation. In all cases the waterbox pressure shall be recorded by means of an electronic recorder with a recording frequency of not less than once every 30 seconds. Pressure monitoring shall appear on the QCP and shall be monitored prior to cleaning up to when the condenser is drained. The *Contractor* shall designate a suitable employee to monitor this intervention accordingly and record this in the QCP documentation.
10. Circulate the potable or raw water for 1 - 2 hours and check for leaks on the system/temporary piping before injecting the chemical cleaning solvent. Once satisfied that there are no leaks that would force premature termination of the chemical clean stop circulation and drain off an amount of water equivalent to the amount of the chemical cleaning solvent to be added to achieve the desired acid concentration.
11. Commence circulation and begin acid injection strictly as per the compositions/concentrations for the titanium tube material as detailed below. The chemical solution will be inhibited with the correct concentration of appropriate inhibitor. Only inhibitors that have previously been tested and approved by the *Employer* for titanium tube material shall be used. If new/untested inhibitors are proposed then these shall be tested for effectiveness by the *Employer* before any use. A “steel wool” test shall be conducted hourly to ensure the effectiveness of the inhibitor is satisfactory. The test involves dropping a ball of steel wool into a sample of the cleaning solution and to monitor any bubble formation and/or physical rise of the ball to the surface. In the case of the later more inhibitor shall be added to the solution circulating in the condenser and the “steel wool” test repeated. The acid concentration shall not at any time exceed 7.5% by mass. Continue circulation and ensure adequate gas release.
12. The cleaning proceeds on the basis of circulation, usually for approximately 6 hours, although this could vary depending on the nature of the scale/deposit to be removed.

    The cleaning process is terminated on the basis of chemical analysis, which indicates stability of the residual acid strength of the bulk solution and no further increase in the concentration of the scale/deposit species in the bulk solution as monitored on at least a 30 minute interval.

    N.B. :Chemical analysis appropriate to the constituents in the type of scale being dissolved, as well as residual acid strength, shall be performed by the *Employer’s* Laboratory at a frequency of not less than once every 30 minutes.

- The free residual acidity of the cleaning solution must not be allowed to decrease to below 2.0 % by mass at any time.
- Chemical analysis for the dissolved species comprising the primary alloying constituents of condenser tube material shall be performed at a frequency not less than once every 60 minutes to monitor corrosion protection by the inhibitor.
- Analysis of the pH of the demineralised water in the steam space to check for acid in-leakage.

13. Stop circulation and drain the spent solvent to the sump (that will be indicated by the *Employer*) of the Unit. N.B.: All mineral acids must be neutralised with lime at the discharge point
14. Commence filling and flushing cooling water side of the condenser with potable water or raw water quality until the residual conductivity is less than 100 µS/cm above the potable water conductivity.
15. Circulate this water and add sufficient soda ash or tri-sodium phosphate to elevate the pH of this solution to 9.0 (± 0.2). Circulate for a further 60 minutes to neutralise any residual acid, then drain.
16. Repeat this process (Steps 14 – **Error! Reference source not found.**) for any condenser paths that could not be connected into the cleaning path in series.
17. The *Contractor* shall remove any temporary connections. Spades in main T1 and T2 ducts as well as any other spades shall be removed by the *Contractor*
18. Drain the steam side of the condenser. Should any acid in-leakage have occurred during the operation, flush the steam space with demineralised water dosed with ammonia to elevate the pH to 9.1 (± 0.2).
19. As soon as possible after the chemical clean i.e. not at the end of a long duration outage the remaining sludge in the tubes shall be removed by HP water washing using a forward jetting nozzle. In most cases Low Pressure washing will be required after chemical cleaning to remove sludge from the tubing. Pressures of >350 Bar should be avoided in the case of full length coated tubing. Experience has indicated that higher pressures could remove tube coating. The equipment used during HP water washing is part of this contract and the *Contractor* need to provide all the equipment for this activity. Because this scope shall be implemented during outages the *Employer* cannot guarantee electrical power at all times therefore the *Contractor* shall provide alternative options such as diesel driven high pressure machines as part of this contract.
20. After HP water washing an endoscope shall be provided by the Contractor that will be used to ensure that all the scaling was removed.
21. Perform a high level test and plug any tubes that have developed leaks during the cleaning process. The *Employer*'s system engineer to update the tube map.
22. Drain the steam side. If fluorescein was used for the high level test, flush until concentrations of Na < 10ppb.
23. On completion of the chemical cleaning activity the waterboxes will be inspected again, and any damage to the corrosion protection that might have occurred during the chemical cleaning will be repaired.

24. As soon as possible, apply normal cooling water flow by charging and operating the cooling water system. Where applicable put the on-line ball cleaning system in service.
25. Ensure that the Taprogge system is put in service when the CW system has been charged.

2.5.1 **BLANK SPADE SUPPLY**

1. This scope shall include the supply and installation of blanking Spades (4 off) to install during the chemical cleaning. These spades shall however remain the property of the *Employer* after the contract expires.
2. It will be the responsibility of the *Contractor* to supply and install these flanges.
3. The spade shall have 2 lifting lugs/attachments for lifting the spade into position. See figure below.
4. The spades are to be compatible with the chemical cleaning solvent that is chosen to clean the condenser i.e. it must resist any form of damage caused by the cleaning agent.

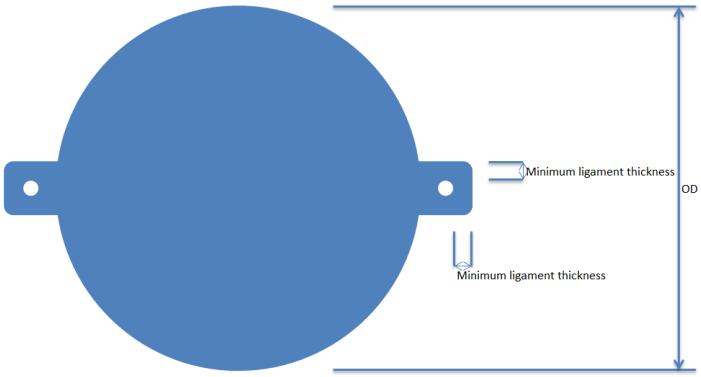


Figure 1: Typical CW Duct spade details

5. Spade details

Blank spade on CW inlet side of condenser (2 off)	**Blank spade on CW outlet side of condenser (2 off)**
• Material To be minimum ASME A516 Grade 70 • Outside diameter 1 970mm (spade will fit inside the existing flange bolting PCD) • Thickness is 14mm however this will be confirmed by *Employer* after performing an FEA	• Material To be minimum ASME A516 Grade 70 • Outlet diameter is 2 380mm (spade will fit inside the existing flange bolting on PCD) • Thickness is 10mm however this will be confirmed by *Employer* after performing an FEA

6. The spades shall fit inside the bolts at the PCD of the mating flanges
7. Should spades be manufactured as an assembly of pre-cut sections, all welding will then be done according to *240-106628253 Standard for Welding Requirements on Eskom Plant Rev 2.* Volumetric NDT shall be done on all the welds.

8. One side of the flange shall be completely covered with a 3 mm rubber gasket to protect against the acid during the cleaning process.

2.5.2 **ROLES AND RESPONSIBILITIES**

1. The *Employer* shall obtain isolation by closing the T1 and T2 (CW isolation valves) or additional isolation as maybe required.
2. Opening of the manway covers shall be the responsibility of the *Employer.*
3. Supply and Installation of the Main T1 and T2 duct spades as well as any other required spades shall be the responsibility of the *Contractor*
4. Gas testing shall be performed by the *Employer* once requested by the RP (Responsible Person obtaining the permit to work)
5. The *Contractor* shall supply their resources 3 months before the work starts to obtain the necessary training to become an RP. Please refer to the NEC contract data for more information.
6. The *Contractor* will be responsible for the permits taken on the condenser. This includes the confined space permit.
7. Scaffolding shall be supplied by the *Employer* when requested.

2.6 EQUIPMENT / TOOLS LSITS

The Contractor will complete the tables below to indicate the equipment as a tool list that will eb used during the chemical cleaning activities.

Table 1 (Chemical cleaning requirements)

Contractor to complete columns 1 and 3

Quantity provided by the Contractor per MTC condenser	**Tool / Equipment Description**	**Description**	**Units**
	Pumps		Head, m
			Flow m^3/h
	Mixing tank		m^3
	Flexible hoses for conveying of chemical solutions		Number off
			Diameter, mm
	Valves related to isolation of chemical solution		Number off
			Diameter (DN)

Table 2 (High pressure cleaning requirements)

Contractor to complete columns 1 and 3

Quantity provided by the Contractor per MTC condenser	**Tool / Equipment Description**	**Description**	**Units**
	HP pumps		bar
			m^3/h
	HP flexible hoses		Number off
			Internal Diameter, mm
			Length, m
	HP nozzles		Make
			Diameter, mm
	Foot Valves		Number off Size

2.7 DOCUMENTATION

The *Contractor* shall supply the following information:

1. A method statement detailing the chemical cleaning process shall be approved by the *Employer* before any work commences.
2. All QCP for both the Corrosion protection lining and cleaning shall be preapproved by the *Employer* before any work shall start. Hold points for engineering will be added after each major activity. *Contractor* QC will have hold points for each activity on the QCP.
3. On completion of the scope a tube map indicating all tube plugs will be submitted after the final high level test was concluded to *Employer's* system Engineer for verification and record keeping
4. Calculation of mass of scale removed per CW pass.

2.8 TENDER RETURNABLES

The *Contractor* shall supply the following information as tender returnable's as part of his tender. Should the mandatory returnable not be supplied tender will be rejected and considered non-complaint.

The qualitative criteria will be used to evaluate the suitability and compliance of tender to the actual scope of work requirements.

a) The Contractor shall provide demonstrable evidence that the company has previously successfully chemical cleaned a Power Plant main turbine condenser (>200MW) in the previous 5 years. At least three references shall be provided.
b) List of exclusions or alterations to this Scope of Work, if no exclusions or deviations a clear statement must be provided as such, if no statement is provided then the tender will be negatively affected.
c) The completed list of equipment that will be used during the execution of the acid clean as in table 1 of this document Section 2.6)
d) The completed list of equipment that will be used for the HP cleaning / flush as in Table 2.
e) Provides demonstrable evidence that key personnel working for the Contractor or sub-contractor, which shall be responsible for the repairing the corrosion protection in the waterboxes, have previously successfully, reinstalled or repaired the corrosion protection in a power plant main turbine condenser waterboxes of a similar size in the previous 6 years. Proof of at least three full condenser waterboxes needs to be provided. References can be for either rubber lining of epoxy coating of waterboxes

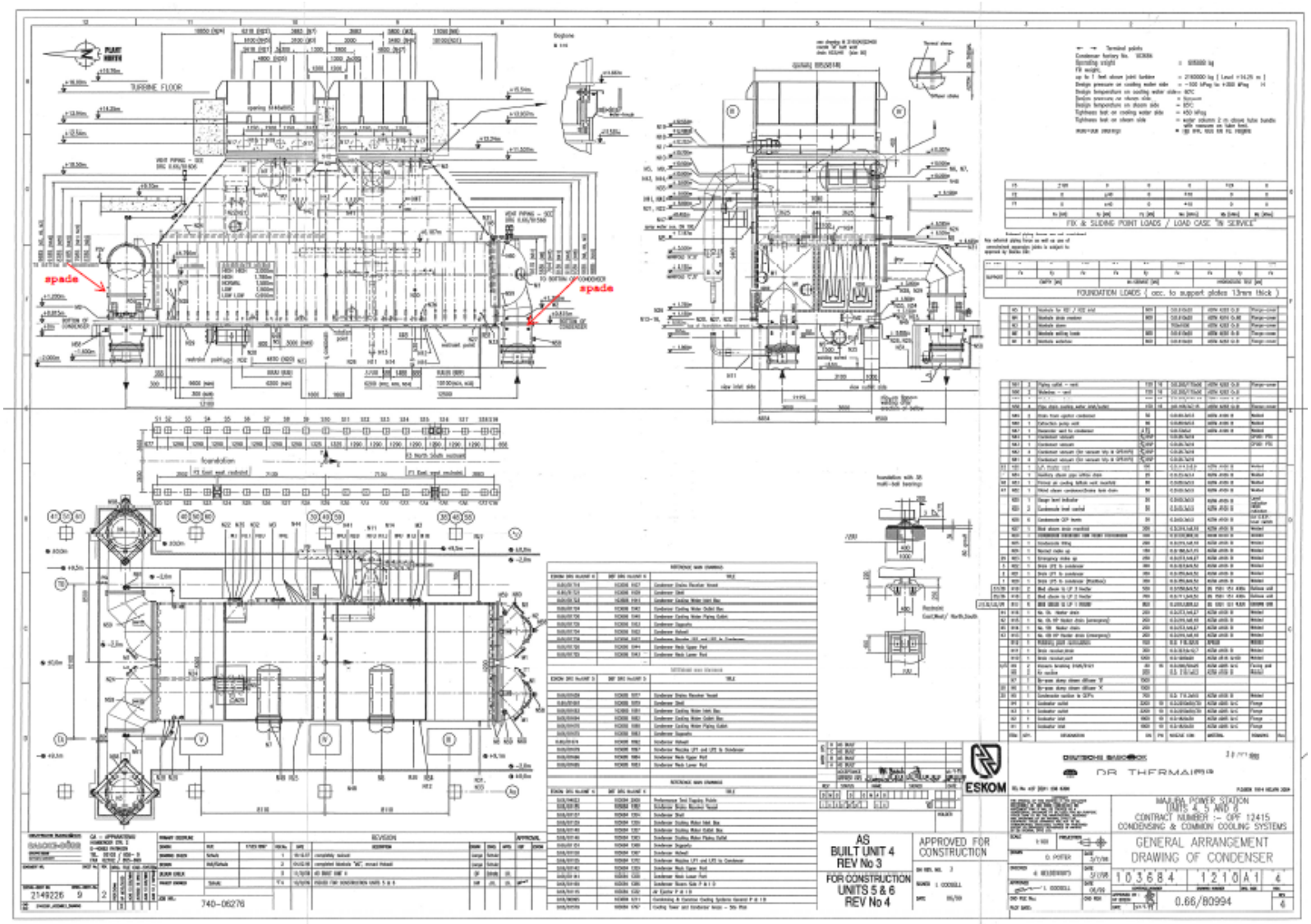
3. REVISIONS

Date	Rev.	Compiler	Remarks
April 2021	0	MI Mgenge	
May 2021	1	MI Mgenge	Updated with Specialist input

APPENDIX A: MAJUBA CONDENSER TUBE INFORMATION

CONDENSER INFORMATION:			
Power Station:	*Majuba Power Station*		
Unit:	*4,5,6*		
Component:	*Main Condenser*		
Scope:	*Chemical clean all tube (Including Air extraction & Impact tubes)*		
Access date:	*02/03/2021*		
Outage Duration:	*68 days*		
Reference drawings:	*See attached tube sheet layouts*		
The total number of tubes in the Unit 4 main condenser is 20 676, each 22m long, straight tubes with no bends. These tubes are arranged in 2 individual waterboxes, with 10338 tubes per waterbox			
HEAT EXCHANGER SPECIFIC INFORMATION:			
Tube details:	*Main Condensing sections*	*Gas removal sections*	*Impingement sections*
Tube material:	*ASTM B338-91 Gr2*	*ASTM B338-91 Gr2*	*ASTM B338-91 Gr2*
Number of Tubes:	*17212*	*1040*	*2424*
Effective Tube Length:	22m	22m	22m
Overall Tube Length	22.09m	22.09m	22.09m
Tube OD:	*22mm*	*22mm*	*22mm*
Tube Wall Thickness:	*0.5mm*	*0.5mm*	*0.7mm*
Tube Profile:	*Straight*	*Straight*	*Straight*
Anticipated Scale Thickness:	*0.5mm-1mm*	*0.5mm-1mm*	*0.5mm-1mm*
Tube stick-out from tube sheet (inlet/outlet)	*0.045mm*	*0.045mm*	*0.045mm*
Tube Coating	*Tubes are not coated*	*Tubes are not coated*	*Tubes are not coated*
Water box Access	*Waterbox will not be removed*		
Water supply	Raw water available at the MCW duct drain line, it is however encouraged that the supply visits site to identify a water source which will be more suitable for their pump and piping.		
Electricity supply	Single and three phase supply available at 30m from the water box. However the *Contractor* to supply alternative options.		
Scaffolding	Scaffolding will be supplied by the *Employer*.		
Samples	No scaled tube samples available, attachment of the latest chemistry of the cooling water is in Appendix C..		

APPENDIX B: CONDENSER DRAWING SHOWING INSTALLATION OF SPADES



APPENDIX C: WATER CHEMISTRY ANALYSIS

Table 1 Water Chemistry analysis

Analysis	CA-HARD	CL-PPM	COD	CU-PPM	F-PPM	FE-PPM	K-PPM	K25	MG-HARD	NA-PPM	NO3-PPM-1	P-ALK	PH	PO4-PPM	PREC-POT	SIO2-PPM	SO4-PPM	TEMPERATURE	TOTAL-ALK	TOTAL-HARD	TURBIDITY	ZN-PPM
Limit - High	400	400					500	4000	100	500		7.5	8.1 - 8.6	0.5	30	150	1000		80 - 120		100	
Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	µS/cm	mg/kg	mg/kg	mg/kg	mg/kg		mg/kg	mg/kg	mg/kg	mg/kg	ºC	mg/kg	mg/kg	NTU	mg/kg
	230	171	102	<0.013	<1.00	1.09	78.9	2197	90.2	387	29.8	4.8	8.4	9	27.6	89.5	725	20.1	116	320	52.7	<0.001