Eskom	Technical Specification	Technology

Title: **Duvha HPWJ cleaning - Scope of work**

Document Identifier:	**382-170401**
Alternative Reference Number:	
Area of Applicability:	**Duvha Power Station**
Functional Area:	**Engineering**
Revision:	**1**
Total Pages:	**20**
Next Review Date:	**N/A**
Disclosure Classification:	**Controlled Disclosure**

Compiled by	Functional Responsibility	Authorized by
[redacted]		

Table of Contents

1. Introduction

Most shell and tube heat exchangers used at Duvha suffer from some sort of fouling or scaling. For the condenser this scaling and fouling of the tubes leads to vacuum load losses. For the other heat exchangers it can lead to high operating or bearing temperature for the components they are connected to. One way to clean the tubes and reduce the load losses are by means of High Pressure Water Jet Cleaning (HPWJ).

2. Supporting Clauses

2.1 Scope

2.1.1 Purpose

To propose of the document is the provide a scope of work for a Service Contract for heat exchanger cleaning by means of high pressure water jet at Duvha Power Station. The following heat exchangers are included:

- Main condenser
- BFPT condenser
- EFP lube oil coolers
- EFP working oil coolers
- EFP motor coolers
- BFPT lube oil coolers
- Main oil coolers
- Seal oil coolers
- FRF cooler

2.1.2 Applicability

This document shall apply to Duvha Power Station.

2.2 Normative/Informative References

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] 240-107677940 – Specification Standard for High Pressure Water Jetting of Condenser and Heat Exchanger Tubes

[2] 240-56030499: Condenser Healthcare Guideline, Revision 1

2.2.2 Informative

N/A

2.3 Definitions

Definition	Description
None	

2.4 Abbreviations

Abbreviation	Explanation
BFPT	Boiler Feed Pump Turbine
CE	European Economic Area Conformity Marking
EFP	Electric Feed Pump
HD	High Definition
HPWJ	High Pressure Water Jetting: Pressure from 700 – 1700 bar
ID	Internal Diameter
IP	Internet Protocol
MP	Mega Pixel
MPa	Mega Pascal
OD	Outside Diameter
QCP	Quality Control Plan

2.5 Roles and Responsibilities

Engineering: Compile scope of work/ works information, Inspections

Asset Management: Review scope of work, conduct Inspections.

Outages: Manage the contract during outages, and co-ordinate scope execution, conducts inspection.

Maintenance: Manages, supervise the contractor during execution, conducts inspection, Employer QC.

3. Scope of Work Overview

The scope of work is to clean various heat exchangers by means of high pressure water jet (HPWJ) at Duvha power station. Full compliance to Eskom standard *240-107677940 – Specification Standard for High Pressure Water Jetting of Condenser and Heat Exchanger Tubes* is required.

The following heat exchangers are include:

- Main Condenser
- BFPT condenser
- EFP Lube oil coolers
- EFP working oil coolers
- EFP motor coolers
- BFPT lube oil coolers
- Main oil coolers
- Seal oil coolers
- FRF Coolers

The cleaning will be conducted from 200 up to 1000 bar pressure. The equipment must meet the 1000 bar requirements stated in this document and referenced standard. Based on test results, the final cleaning pressure will be agreed upon between the *Employer* and *Contractor.*

HP cleaning of the tubes in certain areas may require a second or even a third pass of HPWJ thus the end goal of the *Contractor* is to get the heat exchangers and condensers clean and free of scale and not do a single pass through each tube. This will be confirmed during inspection.

The *contactor* shall also make provision to pull / remove condenser or BPFT condenser tubes and plug the remaining holes in the tube sheet. These pulled tubes will be used for testing or verification after cleaning.

4. Heat Exchanger Information

The following condensers and coolers needs to be included in the contract. Details of each is given below.

4.1 Main condenser

Duvha Power Station condensers consist of a total of four sections. The condenser is divided into the Cold Condenser (CC) and the Hot condenser (HC). Each condenser has an A and B pass. The condensers have brass tubes in the condensing zones. The air extraction zone is fitted with Copper-Nickel tubes and titanium in some cases.

The water boxes will not be removed from the tube sheet for the cleaning process. The Contractor will therefore access the tube ends from within the confined space of the water box. Therefore, all equipment needs to enter via the water box access manholes. (800 mm).

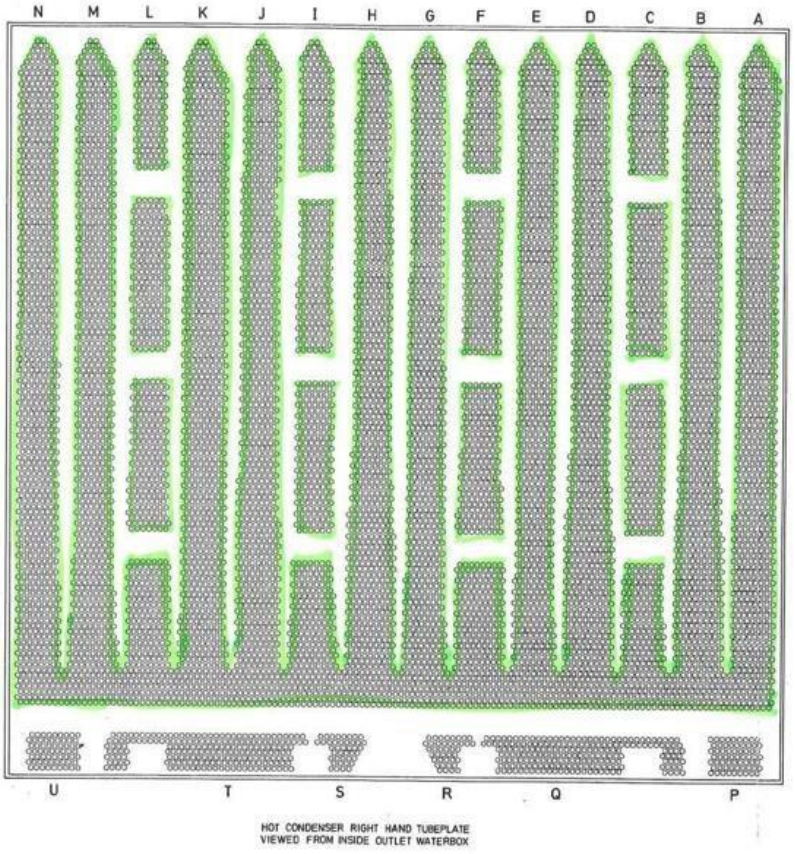


Figure 1: Typical tube sheet layout, as viewed from one of the water boxes

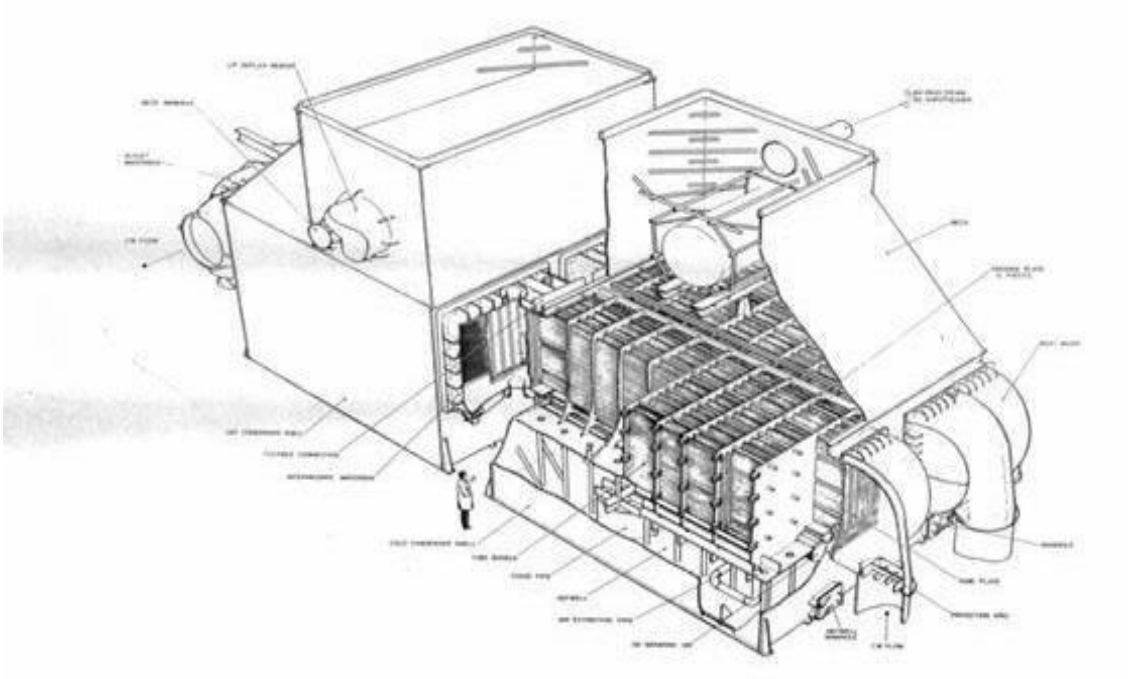


Figure 2: Main condenser

Table 1: Table Summarizing Main condenser technical data

General	
Manufacturer	Hamon Sobelco
Tube Material	Re-tubed. Brass in main sections and Copper Nickel in Air extraction zones
Number of Tubes:	
Cold Condensers	22 552
Hot Condensers	23 730
Condenser Height:	
Overall	10 300 mm
Neck	5 450 mm
Shell	4 580 mm
Condenser Length:	
Overall (between water box centers)	24 600 mm
Cold Condensers	12 000 mm
Hot Condensers	12 600 mm
Tube Details:	
Cold Condensers	9992 mm
Hot Condensers	10922 mm
Tube Outside Diameter	19mm
Tube Wall Thickness	General sections – 1 mm
Total Tube Volume	103 m^3
Material and Volume:	
Steam Side Shell	Carbon steel BS1501-151-grade 43 A
Water box Material	Carbon steel lined with rubber BS1501-151- grade 43 A
Water box Volume	113.3 m3 (estimated total for all six water boxes,
Tube Sheets	Material BS 1501-161-360, 27mm thick to with a 5mm stainless steel cladding
Cooling Water Details:	
Inlet / Outlet Pipe Bore Diameter	1 600 mm
Cooling Water Flow	11.277 m^3/sec
Supply Temperature	19°C
Shell Volumes (steam side):	
Cold Condensers	640 m^3
Hot Condensers	680 m^3

4.2 BFPT condenser

The BFPT condensers have an inlet water box and an outlet water box on the west side, with an intermediate water box on the east side. The cooling water enters the condenser through the inlet water box, flowing east through the bottom tubes, before entering the intermediate water box and then flowing back through the top tubes back to the outlet water box. Each condenser has admiralty brass tubes in the condensing zones and CuNi tubes in the air-cooling zones.

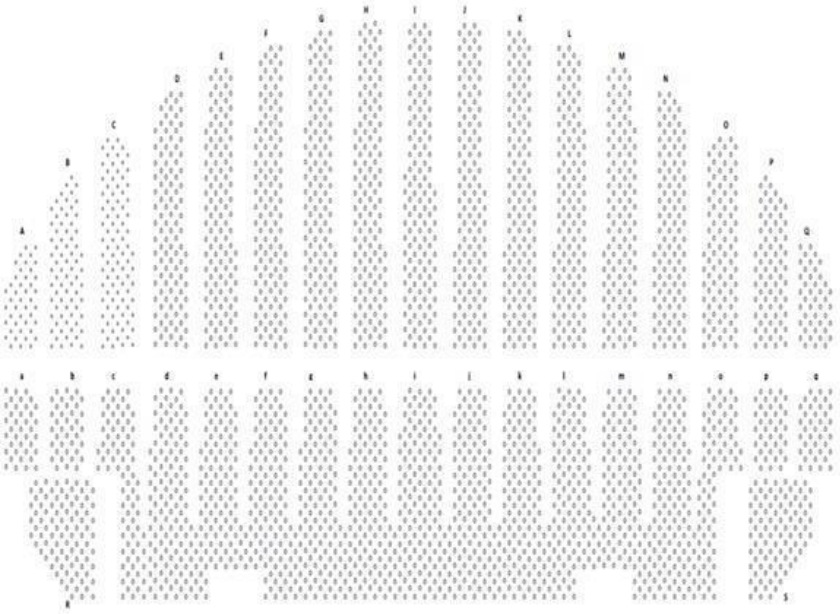
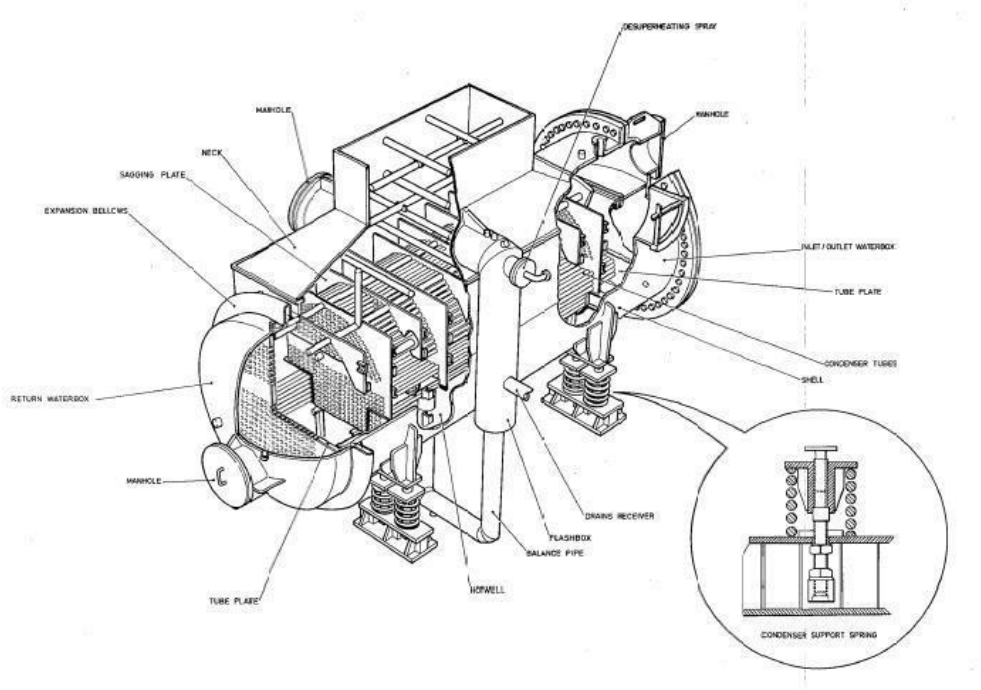


Figure 3: BFPT tube sheet layout, as viewed the intermediate water box.



.

Figure 4: General layout of BFPT condenser

Table 2: BFPT Condenser Technical Data

General:	
Manufacturer	Hamon Sobelco
Tube Details:	
Main Water Cooling Zones	Admiralty brass
Air-Cooling Zones	Copper nickel (CuNi 9010)
Number of Tubes:	3460
Tube Length	6.2 m
Tube Outside Diameter	19 mm
Tube Wall Thickness	1mm
Total Tube Volume	14 m^3
Materials:	
Steam Side Shell	Carbon steel BS1501-151
Waterboxes Material	Carbon steel lined with rubber BS1501-151
Tube Sheets	27mm thick to BS 1501-161-360 with a 5mm cladding to BS 1501-304 (L)
Cooling Water Details:	
Inlet / Outlet Pipe Bore Diameter	700 mm
Cooling Water Flow	0.826 m^3/s
Supply Temperature	22 °C
Shell Volume (Steam side):	35 m^3

4.3 EFP Lube oil coolers

Horizontal, shell and tube heat exchangers. To be cleaned in-situ.
2 x installed per unit.
Amount of tubes: 490
Tube Size: 12 mm OD and 1 mm wall thickness
Material: Brass

4.4 EFP working oil coolers

Horizontal, shell and tube heat exchangers. To be cleaned in-situ.
2 x installed per unit.
Amount of tubes: 694
Tube Size: 12 mm OD and 1 mm wall thickness
Material: Brass

4.5 EFP motor coolers

Small heat exchangers inside EFP motors. To be cleaned in-situ or can be removed for cleaning.
2 x installed per unit.
Sizes to be confirmed.

4.6 BFPT lube oil coolers

Vertical, shell and tube heat exchangers. To be cleaned in-situ.
2 x installed per unit.
Amount of tubes: 1424
Tube Size: 14 mm OD and 1 mm wall thickness
Material: Brass

4.7 Main oil coolers

Vertical, shell and tube heat exchangers. To be cleaned in-situ.
2 x installed per unit.
Amount of tubes: 1430
Tube Size: 14 mm OD and 1 mm wall thickness
Material: Brass

4.8 Seal oil coolers

Vertical, shell and tube heat exchangers. To be cleaned in-situ.
2 x installed per unit.
Amount of tubes: 316
Tube Size: 14 mm OD and 1 mm wall thickness
Material: Brass

4.9 FRF Coolers

Vertical, shell and tube heat exchangers. To be cleaned in-situ.
2 x installed per unit.
Small FRF coolers. Sizes to be confirmed.
Material: Stainless Steel

5. Employer Supply

The following are supplied by the employer:

1. Isolation and Permit to Work.
2. Site access to main and BFPT condensers.
3. Potable quality water at a pressure of about 7 bar to be used for HP cleaning. Note that pressure may reduce to 3.5 bar
4. Termination point is about 50 m away from water boxes at most (to access intermediate water boxes); Contractor to confirm exact distance.

5. Electricity for lights, termination point is about 50 m away from water boxes at most (to access intermediate water boxes).
6. Scaffolding: consideration should be given to constructing the scaffolding in such a manner as to avoid or as far as possible ensure unrestricted access to all tubes. Ensure that the condenser water-box coating does not get damaged.
7. Opening of manhole covers on all water boxes. The Contractor to provide and install barricading to the non- working end water boxes to ensure no unauthorised access.
8. Ventilation fans on water boxes may be provided on request if the Employer has it available. As a precaution, the Contractor should assume that the Employer will be unable to provide fans.

6. Roles and Responsibilities

The following table gives the roles and responsibilities during execution:

Scope of Work	**Responsible Person**
Isolation and Permit to Work on condenser.	*Employer*
Scaffolding is available on request.	*Employer*
Removal of water box manholes.	*Employer*
Initial condenser inspection	*Contractor & Employer*
Removal of foreign matter and cleaning of water boxes.	*Contractor*
Rodding of blocked tubes.	*Contractor*
High pressure cleaning of all tubes at specified pressure (secondor even third passes in the problem area as required).	*Contractor*
Flood/bubble test and plugging of leaking tubes (procedurewill be provided – 15ENG TURB-8008).	*Employer*
Endoscope inspection to check for cleanliness	*Contractor* (*Employer* to witness)
Pulling of selected condenser tube samples for quality purposes (minimum of 2 tubes). Tube samples must only be taken upon the request of the employer.	*Contractor (Request from Employer)*
Water boxes cleaning	*Contractor*
Recording of all plugged tubes (new and pre-existing) on tubemaps.	*Employer*
Water box and tube sheet inspection to check for coating damage.	*Contractor & Employer*
Final inspection and handover (water boxes, steam spaces and surrounding site).	*Contractor* and *Employer*

7. HPWJ Requirements

7.1 Acceptance Criteria

The internal surfaces of all tubes as described above shall be cleaned by means of High Pressure Water Jetting (HPWJ). The acceptance criteria is that all scale shall be removed from the internal surfaces of the tubes, i.e. the entire internal tube surface of all the tubes shall be completely cleaned to a uniform metallic color with no traces of corrosion product or other scales and deposits.

This shall be validated by means of high resolution endoscope inspection (with minimum endoscope specifications as outlined below) and / or destructive analysis of “cleaned tube” where applicable. Failure to achieve the aforementioned acceptance criteria shall be considered as non-performance with respect to the contract.

7.2 Contractor Experience

The Contractor shall provide verifiable Reference list of HPWJ cleaning contracts using a minimum of 800 bar working pressure, of power station main condenser in the last 5 years. Verifiable references of at least three (3) projects successfully conducted in the past 5 years are required.

7.3 Safety Requirements

The safety of the *Contractor* personnel is of extreme importance. The following are the minimum safety requirements shall apply:

1. Operators shall wear CE (European Economic Area Conformity Marking) certified water jetting suits, and face shields rated for the working pressure.
2. All foot and leg protection equipment to be appropriately rated for the working pressure.
3. The Contractor shall work in accordance with a safety procedure/instruction aligned to industry recognised HPWJ practices and standards to protect personnel using HPWJ equipment.
4. HPWJ operators shall be trained and certified by an independent industry recognised HPWJ authority. No operator will be allowed to use HPWJ lances on site without the required certification.
5. All HPWJ hoses, pressure accessories, pressure equipment and pressure vessels in the HPWJ system to be designed for a minimum design pressure of 1 035 bar (103.5 MPa). All previously mentioned equipment shall be pressure tested to 1.25 times the design pressure of the equipment. Test certificate to be provided.
6. All hose end connections to be fitted with the appropriate “hose checks” to prevent injury by restraining the hose in the event of an end fitting failure.
7. The HPWJ pump discharge shall be fitted with a calibrated pressure gauge and safety relief valve or rupture diaphragm. Test certificate to be provided.
8. Any manholes which are open for ventilation purposes shall be properly barricaded by the Contractor to eliminate unauthorised human entry while cleaning is in progress.
9. Barriers and Warning notices must be in place before any work commences.

10. Specific requirements related to Eskom's "Life Saving Rules" that would be applicable to this activity.
11. The Contractor's operator shall use a handheld pneumatic powered feeder, which incorporates a sleeve into which the nozzle retracts as it exits the tube. The feeding speed and dwell time shall be set during commissioning as defined in section 3.3.5. This equipment/device shall be used at all times to ensure operators are not exposed to water jets when moving the lance from one tube to another.

7.4 Minimum equipment requirements

1. For tubes with an internal diameter of 19.5 mm up to 20.5 mm, the minimum nozzle flow rate shall be 33 litre/min at 1 000 bar working pressure.
2. Rotating tube cleaning nozzles with multiple radical water jets shall be used. The cleaning nozzles shall be obtained from a recognised HPWJ equipment supplier including technical datasheets, providing technical information for a range of nozzle sizes, shall be available for all types of nozzles used on site. The maximum pressure rating of the nozzle shall be 1 035 bar or 15 000 psi. Nozzles with a higher pressure rating are not acceptable. The minimum number of nozzles available on site for the main and BFPT condensers are 6 and 2 respectively.
3. A technical data sheet shall be provided for the HPWJ pumps. The HPWJ pump shall maintain a minimum continuous working pressure of 1 000 bar at a flow rate of 50 litre/minute. This requirement assumes one pump will supply one cleaning nozzle. If a single pump is to supply more than one nozzle simultaneously, the pump shall maintain a minimum continuous working pressure of 1 000 bar and a minimum volume flow of 50 (litre/min) per each of the cleaning nozzles attached simultaneously to the pump.
4. The nozzles shall travel the full length of all the tubes
5. The HPWJ flexible hose from the foot valve to the tube cleaning nozzle shall have a minimum internal diameter of 6 mm. The maximum hose length is the condenser tube length plus an additional 7 m. The foot valve shall be positioned in the water box. The minimum number of hoses available on site for the main and BFPT condensers are 4 and 2 respectively.
6. The flexible hose from the pump outlet to the foot valve shall have a minimum internal diameter of 10 mm.
7. Provision of a reasonable set/number of spare equipment and tooling particularly nozzles, hoses, couplings, all wear and tear parts such as seals etc. These spares shall be available on site. In the event of HPWJ Pump breakdown then repair or suitable replacement shall be affectedwithin 2 hours. The latter shall only apply to eventualities involving unexpected major breakdownof HPWJ Pumps.
8. Under no circumstances will the tube sheet coating or tube ends be damaged by the HPWJ cleaning. The Contractor shall establish a system or method to ensure impinging water jets from the nozzle are not directly focused towards the tube sheet or onto the outside diameter of the exposed tube ends. Prior to any HPWJ cleaning activities and inspection shall be performed by the Contractor supervisor and the Engineer to record the existing condition of the tube sheet and tube ends. This activity shall be included in the QCP as a hold point. Any damage to coating will be for contractor's expense to repair; Eskom's coating standard shall be applied for any coating repairs.
9. The Contractor shall make provision of adequate number of handheld pneumatic powered feeders to ensure the required dwell time is achieved for every tube.

10. The Contractor's selection of all lances, nozzles, sleeves and hosing shall be suitable for the tubing diameters as defined above in "Table 1 and Table 2 of this document" as well as the coolers described in section 4.
11. Endoscope/Fiberscope to be supplied by the Contractor to be used for pre and post cleaning inspection. The fibre scope shall have a reach length of at least 6 m with a digital display. This endoscope shall meet the minimum requirements stated on the table below.

Table 3: Specification for Minimum Requirements for Endoscope

Camera Minimum Requirements	
Camera Lens	Dual (front and side)
Video Resolution	1080p HD (1920 x 1080 pixel) resolution
Picture Resolution	A4 page resolution: 2480 x 3508 pixels
Megapixel (MP)	2.1
Image Format	RAW or TIFF
Video Format	MP4
Focal Length	30 mm
Magnification	2x
Waterproof	IP67
Bore hole minimum size	10 m

7.5 Requirements and Commissioning before work start

Before any work is performed the *Contractor* shall demonstrate the following to the *Employer:*

1. The Contractor shall compile a method statement, safety work procedure and Quality Control Plan (QCP) and submit to the Employer for approval before the condenser cleaning may commence. The Employer shall have the opportunity to add witness or hold points on the QCP.
2. Provide all required certificates (equipment pressure tests, pressure gauge calibration, personnel training) as stipulated above.
3. The *Employer* shall verify that the equipment on site complies in all respects to the technical data sheets provided with the tender as well as that the number of pumps, hoses, foot valves, cleaning nozzles, etc. on site corresponds with the quantities provided in the tender returnables.
4. The *Contractor* shall demonstrate to the Employer that the HPWJ pump, hose and nozzle combination can supply a volume flow rate of 50 litre/min with the pump being operated at rated speed (container/stopwatch method). This test assumes one pump will supply one cleaning nozzle. If a single pump is to supply more than one nozzle simultaneously the pump shall maintain a minimum volume flow of 50 litre/min per each of the cleaning nozzles attached simultaneously to the pump.
5. The *Contractor* shall demonstrate that the lance safety device (with a handheld pneumatic powered feeder) prevents the lance from withdrawing from the tube during HPWJ and hence is safe for operators.

6. Before starting with the production cleaning activity the *contractor* in consultation with the *employer* shall establish an acceptable nozzle resident/dwell time (cleaning a minimum of 10 tubes) demonstrating the capability of meeting the acceptance criteria stipulated in section. The *contractor* QC representative shall ensure this is achieved at all times and record the actual dwell time on a check sheet every hour.
7. The Contractor shall supply and install suitable protection or cover on the cooling water inlet duct to eliminate any of the debris removed from the condenser tube falling down the CW inlet duct.
8. The Contractor shall supply suitable Endoscope/Fiberscope equipment to facilitate inspection pre- and post-cleaning.

7.6 HPWJ Execution

1. All tubes which are blocked or obstructed and which cannot be unblocked by HPWJ shall be marked on the tube sheet drawing and submitted to the Employer.
1. The Contractor shall keep a daily logbook with the number of tubes cleaned; working pressures and achieved dwell times.
2. Due to limited outage time the Contractor shall work in at least two water boxes simultaneously with the capacity to increase this to four if required.
3. Automated lance feeding equipment with variable speed control shall be used to ensure dwell times are achieved. This is also to enhance efficiency & consistency.
4. Lances and nozzles shall be fitted with an indexing front guide tube and stopper.
5. The cleaning duration will be calculated by the contractor based on the agreed dwell time per tube.
6. As stated above the minimum acceptance criteria is that all scale shall be removed from the internal surface of the tubes, i.e. the entire internal tube surface of all the tubes shall be completely clean with no traces of corrosion product or other scales and deposits on the tube inner surfaces.
7. The Contractor shall clean the water boxes and drain pipes after cleaning the tubes. All foreign materials and debris shall be removed from the water boxes and CW duct inlet and outlet. Note that this includes the area surrounding the water box inlet manhole where some scale has been flushed out.

8. Man-Power Plan

8.1 Main condenser

HP cleaning shall be done on a 24 hours basis meaning day and night shift teams will be required for this service (two shifts).

- 8 x HPWJ operators per shift
- 2 x assistants per shift
- 1 x Technician per shift
- 1 x Supervisor per shift

8.2 BFPT condenser

HP cleaning shall be done on a 24 hours basis meaning day and night shift teams will be required for this service (two shifts).

- 2 x HPWJ operators per shift
- 1 x assistants per shift
- 1 x Supervisor per shift

9. Technical Tender Returnables

9.1 Mandatory Tender Returnables

1. Verifiable Reference list of HPWJ cleaning contracts using a minimum of 800 bar working pressure, of industrial main turbine condensers in the last 5 years. Verifiable references of at least 3 projects successfully conducted in the past 5 years are required.

9.2 Qualitative Technical Tender Returnables – Phase one Desktop Review

Phase one will consist of a desktop review of the following. If a score of more than 70% is achieved for phase one, phase 2 will be done and scored. Tenderers need to obtain a minimumweighted score of 70% overall or more for both phases to technically qualify for further evaluation

1. Exclusions or deviations from the above specification. If no exclusions or deviations, a specific statement to this effect is to be included in the tender.
2. Proof that the contractor owns automatic lance feeding equipment with variable speed control. Proof shall include data sheet as well as photos of equipment.
3. The Contractor shall complete Tables 4 to 7 below with the details of the equipment that will be available on site for the full duration of the contract to complete the cleaning of the condenser/heat exchanger within the allowed time period.
4. Technical datasheets for the rotating tube cleaning nozzles, HPWJ pumps and flexible hoses for cleaning the tubes as described in Table 1 and Table 2.
5. Provides a preliminary method statement for cleaning the heat exchanger/condenser tubes. The method statement includes amongst others items like safety requirements, commissioning, monitoring during the cleaning process, equipment, etc.

Table 4: HPWJ Nozzle Inventory

HPWJ nozzle #	Part number	Supplier name	Pressure rating or range, bar	Flow range, l/min
1				
2				
3				
4				

Table 5: HPWJ Pumping Capacity/Resource

HPWJ Pump #	HPWJ pump identification	HPWJ Pump flow rate (in litre/minute) at 1000 bar working pressure	Number of cleaning sets, i.e. cleaning nozzles, hoses, foot valves, etc., which will be connected simultaneously to the pump
1			
2			
3			
4			

Table 6: HPWJ Hose Inventory

HPWJ hose #	HPWJ hose series or part number	Hose internal diameter, mm	Hose external diameter, mm	Maximum working pressure, bar
1				
2				
3				
4				

Table 7: HPWJ Automatic lance feeding equipment

Number #	Automatic lance feederSeries or part number	Supplier Name	Feeding Speed range
1			
2			
3			
4			

9.3 Qualitative Technical Tender Returnables – Phase Two Site Visit

Phase two will entail a site visit to the contractor's works. The site visit will only be arranged for contractors who achieved a score of 70% or more for the phase one evaluation in section 9.2. . During the site visit the following will be evaluated and scored:

1. Overall Inspection of workshop and facilities.
2. Housekeeping and neatness of workshop and facilities.
3. Visual inspection of the following equipment:
    - Cleaning Nozzles
    - Automatic lance feeding equipment
    - High Pressure hoses
4. The contractor shall demonstrate the required flow rate as detailed in section 7.5 point 4. This test can be done by using a bucket & stopwatch method
5. The Contractor shall demonstrate the cleaning of a heat exchanger tube. During this demo the all the equipment that will be used on site, e.g. pump, hose, nozzle, feeder, safety features, etc. will be demonstrated and scored.
6. Interview with proposed site manager and qualification review.
7. Interview with proposed QC officer and qualification review.
8. Interview with 2 or more HPWJ cleaning operators and qualification review.

10. Acceptance

This document has been seen and accepted by:

Name	Designation

11. Revisions

Date	Rev.	Compiler	Remarks
Jan 2024	1		First Issue

12. Development Team

N/A

13. Acknowledgements

N/A