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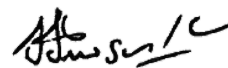
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1. INTRODUCTION

This document provides the technical specifications for the replacement of the BFPT Condenser tubes of Units 1 to 6 at Lethabo Power Station.

2. SUPPORTING CLAUSES

2.1 SCOPE

This document covers the applicable work to be done, as well as the requirements and specifications regarding the work. This includes quality assurance and inspection requirements.

2.1.1 Purpose

The purpose of this document is to provide the Contractor with all relevant details required to perform the works as defined in the scope and to ensure consistent quality according to the requirements prescribed herein.

2.1.2 Applicability

This document shall apply to all relevant stakeholders involved in the planning and execution of the Lethabo Units 1 – 6 BFPT condenser retube project.

2.2 NORMATIVE/INFORMATIVE REFERENCES

2.2.1 Normative

- [1] LBT00081 – Drawing Office Procedure
- [2] 0.63 5885 Surface Condenser
- [3] 0.63 1200 Shell
- [4] 0.63 1196 Waterbox I
- [5] 0.63 1197 Waterbox II
- [6] 0.63 1199 Tube Plate
- [7] B45 03112-0203 Sag Plate
- [8] C45 04100-0043 Hotwell
- [9] C45 99088 0080 Manhole NB600
- [10] 0.63 1193 Manhole NB600

2.2.2 Informative

- [11] ISO 9001:2015 Quality Management System
- [12] 240-109607332 – Eskom Plant Labelling abbreviation standard
- [13] LIM103 – Lethabo Information Manual
- [14] 36-681 General Plant Safety Regulations
- [15] LBS00067 Lethabo Health, Safety and Environmental Specification for Contractors
- [16] 240-106628253 Standard for Welding Requirements on Eskom Plant Rev 2

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- [17] 240-83539994 Standard for Non Destructive Testing (NDT) on Eskom Plant
- [18] 240-101712128 Standard for the Internal Corrosion Protection of Water Systems, Chemical Tanks and Vessels and Associated Piping with Linings
- [19] 240-55864767 Chemistry Standards for Cooling Water
- [20] HEI 11th edition Heat Exchange Institute Standards for Steam Surface Condensers
- [21] 240-56030499 Condenser Healthcare Guideline Rev 2

2.3 DEFINITIONS

Description	Definition
Eskom	Eskom Holdings SOC Limited, its divisions and wholly owned subsidiaries.
(Turbine Generator) Unit	Boiler, Turbine, generator, cooling system, precipitator and including all auxiliary and ancillary plant and systems associated with the above.
Stakeholder	Is considered to be anyone that has an interest in the outcome of the project.
Turbine Plant	A collection of the turbine centreline and auxiliaries plants.

2.3.1 Disclosure Classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 ABBREVIATIONS

Abbreviation & Acronyms	Description
AKZ	Anlagen-Kennzeichnungs System
ASTM	American Society for Testing and Materials (Now ASTM International)
ANSI	American National Standards Institute
BS	British standard
CEP	Condensate Extraction pump
BFPT	Boiler Feed Pump Turbine
CW	Circulating (Cooling) Water
EDMS	Eskom Document Management System
HEI	Heat Exchange institute
ID	Internal Diameter
ISO	International Standards Organization
LP	Low Pressure
NEC	New Engineering Contract
NDT	Non Destructive Testing
MPI	Magnetic Particle Inspection

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Abbreviation & Acronyms	Description
OD	Outside Diameter
PPE	Personal Protective Equipment
PT	Dye Penetrant Non-destructive Test
PQR	Procedure qualification Record
QA	Quality Assurance
QC	Quality Control
QCP	Quality Control Plan
SANS	South African National Standards
SHEQ	Safety, Health, Environment and Quality
UCLF	Unplanned Capacity Loss Factor
UNS	Unified Numbering System
UT	Ultrasonic Testing
WBS	Work Breakdown Structure
WPS	Weld Procedure Specification

2.5 ROLES AND RESPONSIBILITIES

The system engineer shall ensure that this specification is utilised for the compilation of an enquiry for the installation of the tubes on Units 1 to 6 BFPT condensers.

This specification will form the basis for fair and accurate tender evaluations by the evaluation team.

3. TECHNICAL SPECIFICATION/WORKS INFORMATION

3.1 DESCRIPTION OF THE WORKS

3.1.1 EXECUTIVE OVERVIEW

Lethabo Power Station is equipped with six BFPT condensers (one per unit) which is responsible for the condensation of steam leaving the last stage of the boiler feedpump turbine. These surface type condensers consist of admiralty brass tubes in the condensing zone and titanium tubes in the air extraction zone.

The average life expectancy of admiralty brass condenser tubes is 20 years. The Lethabo BFPT condensers have managed to exceed this limit due to good cooling water chemistry and frequent high pressure washing to maintain tube cleanliness. However, with more than 30 years of service on all six units, a deterioration in condenser performance and efficiency can be observed. It has therefore become necessary to retube the BFPT condensers with a like-for-like tube replacement in order to restore the BFPT condensers to their original designs to ensure plant availability, integrity and reliability.

The high level scope of work is as follows:

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- The *Contractor* shall be responsible for the removal of the old brass and titanium tubes and for the installation of the admiralty brass tubes in the condensing zone and with titanium tubes in the air extraction zone. The tubes will be a free issue from the Employer.
- The scope will also include the refurbishment, if necessary, of the water boxes, shell, tubesheets, support plates, stay-bars and air extraction lines.
- The *Contractor* shall be responsible for the coating of the tubesheets after the new tubes are installed and rubber lining of the water boxes.
- The Contractor shall be responsible for the replacement of the water box seals.
- A flood test is required to provide assurance of tube to tubesheet joint seal integrity.
- In addition, weld repairs may be required.

3.1.2 EMPLOYER'S OBJECTIVES AND PURPOSE OF THE WORKS

The objectives of the BFPT condenser retube project are to improve the condenser efficiency, reliability and availability; to eliminate any UCLF caused by high backpressure/vacuum conditions and to prevent any chemical excursions caused by condenser tube leaks.

3.1.3 SCOPE OF WORK

This Works Information defines the minimum requirements to be achieved by the Contractor when executing the BFPT Condenser re-tube work.

The Contractor will be responsible for removing the old tubes and for installing the new tubes (Tube specification as per document 23817597 - Technical Specification for Lethabo Brass Tubes) supplied by the Employer. The Contractor shall refurbish the water boxes, shell, tubesheets, support plates, stay-bars and air extraction lines, if necessary. The scope includes epoxy coating of the tubesheets and rubber lining of the waterboxes. The Contractor shall also be responsible for the replacement of the water box seals.

This Works Information details the minimum quality, testing, inspection, certification and cleaning requirements; and these are to be supplemented by the Contractor's suggested actions based on inspections during the project.

The Contractor is responsible for compliance with all the detailed requirements presented in this Works Information. Approval of any drawings, specifications and procedures by the Employer or its representatives shall in no way relieve the Contractor of these responsibilities.

Scrap tubes remain the property of the Employer who will dispose of them. However, it is the responsibility of the Contractor to transport the old tubes to the indicated laydown area.

The following table outlines the high level scope of work:

Table 1: High Level Scope of Work

Scope of Work	Responsible Person
Transport of new tubes from storage area to condenser	Contractor
Application for permit to work	Employer
Issue permit to work for condenser	Employer
Isolation of condenser	Employer
Supply of new tubes	Employer
Scaffolding	Contractor

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Load test of permanent crawl beams and rigging structures	Employer
Inlet and outlet water box removal and replacement	Contractor
Weld repairs, if necessary	Contractor
Tubesheet inspection, preparation, tubesheet hole cleaning and repairs	Contractor
Removal of existing tubes	Contractor
Support plate inspection, support plate hole cleaning and repairs if necessary	Contractor
Tube to tubesheet joint mock up tests	Contractor
Tube installation and tube to tubesheet joint seal	Contractor
Water box door seal procurement and installation	Contractor
Steam space (demin) high level test	Contractor/Employer
Tube side (CW) waterbox leak test	Contractor
Final inspection	Contractor/Employer
Tubesheet coating	Contractor
Water box rubber lining and waterbox repairs if necessary	Contractor
Transport of scrap tubes to on-site storage area	Contractor

3.2 THE CONSTRUCTION SITE

3.2.1 SITE SERVICES AND FACILITIES

- The *Employer* provides a non-covered laydown area for boxes of tubes. Protection of these boxes against weather damage and theft is the *Contractor's* responsibility. A Site for the *Contractor's* yard will be provided within a reasonable period after access to the *works* (the exact position will be determined on Site). The *Contractor* is responsible for further treatment of the yard area that he considers necessary. The *Contractor's* layout of its yard is subject to approval by the *Employer*. The *Contractor* shall not occupy areas other than that allocated to him by the *Employer*.
- The *Contractor* is responsible for the transport of the new tubes from Lethabo stores to the site.
- The *Contractor* is responsible for all materials stored in his yard and for all activities which occur in his yard including compliance with environmental risks and conditions.
- On completion of the works, the yard and all areas allocated to the *Contractor* shall be re-instated to their former condition to the satisfaction of the *Employer*.

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3.2.2 SUPPLY OF ELECTRICITY

The *Employer* shall supply the *Contractor* with a temporary 220/230/380 Volt AC electricity supply free of charge from the closest existing point of supply. The cost of cabling from point of supply to the *Contractor's* yard / offices shall be borne by the *Contractor*. The cost of additional connection or points shall be borne by the *Contractor*. The *Contractor* makes provision for the necessary extensions and plug points. Any changes made to existing supplies shall be for the *Contractor's* account.

3.2.3 SUPPLY OF WATER

The *Employer* shall supply the *Contractor* with reasonable quantities of water and potable water required for the purposes of this contract. Demin water will also be made available for the high level tests. The *Contractor* provides, at its own cost, all connection equipment necessary to lead the water from the *Employer's* point of supply to where it is required. Such fittings must be compatible with the *Employer's* fitting to prevent galvanic corrosion. The *Contractor* is responsible for maintaining the equipment and removing it on completion of the *works*.

3.2.4 SUPPLY OF COMPRESSED AIR

Compressed air to be provided with an external compressor (hired) by the Contractor. The Employer will therefore not provide any compressed air.

3.3 EMPLOYER'S DESIGN

The BFPT condenser is a surface type condenser and its design data is as follows:

Number of flows:	1
Number of water passes:	3
Tube sheet material:	Muntz metal
Water box material:	Carbon steel lined with rubber (BS1501-151-430A)
Steam shell material:	Carbon steel (BS1501-151-430A)
Total number of tubes:	3230
Tube length:	6040 mm
Tube specification:	Admiralty brass 23 mm (tolerance +0; -0.2 mm) by 1.0 mm thick – condensing zone Titanium 23 mm (tolerance +0; -0.2 mm) by 0.5 mm thick – air extraction zone

The BFPT condenser is a single pressure condenser with three water passes but only one cooling water inlet and one cooling water outlet.

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The tube sheet layout is shown below, with the tube bundles outlined in blue being the air extraction zone:

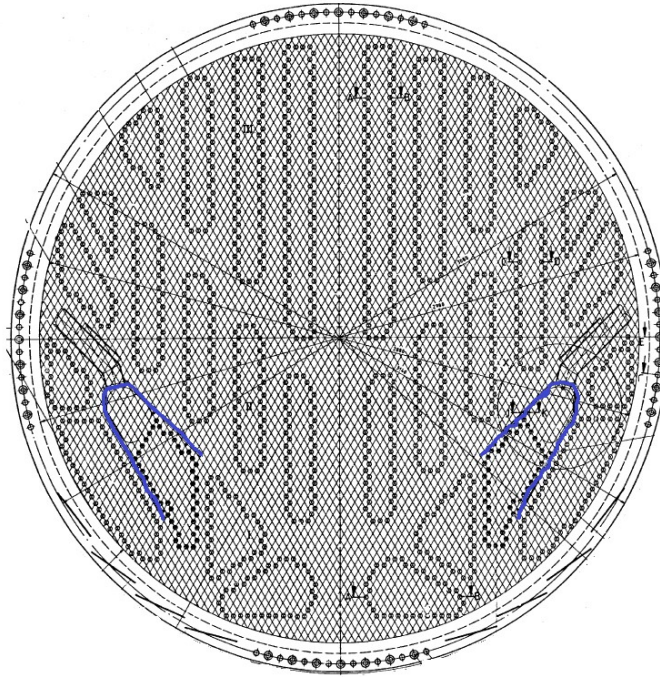


Figure 1: Indication of New Tube Position Based on Tube Material

This is a like-for-like replacement with admiralty brass tubes in the condensing zone and titanium tubes in the air extraction zone. Each bundle contains the following tube counts are as follows:

Condensing zone: 3004 admiralty brass tubes

Air extraction zone: 226 titanium grade 2 tubes

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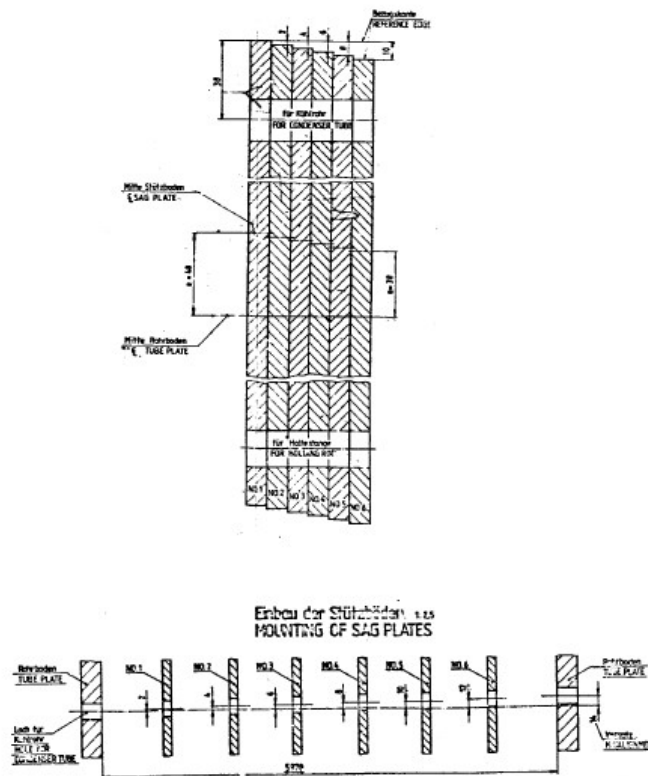


Figure 2: Details of Tube Slope

3.4 DOCUMENTS TO BE SUPPLIED BY THE CONTRACTOR

3.4.1 DATA BOOK

The *Contractor's* scope of work includes but is not limited to providing the following documentation:

- Set of drawings which record tube expansion and tube plugging maps as well as tube expansion records in Excel format.
- Copies of all inspections & test reports & photographs as specified.
- Non-conformance reports.
- Cleanliness clearance certificate.
- Generic reports on all other findings and corrective measures used.
- Completed QCP's
- Copies of all procedures and method statements
- NDT operator qualifications
- WPS, PQR and welder qualifications

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- Certificate of manufacture, NDT reports, material certificates, consumable certificates, weld repair maps
- Organogram specific reference to be made to personnel performing expansions, QC and supervisors.
- List of names and signatures of employees that read the Works Information. The list should include site supervisor, safety supervisor, QC supervisors, team leaders and new employees
- A map indicating the length of welding that was performed to be included in data book.
- Certificates of free issue tubes to be included in data book. Certificates will be supplied by Employer.

3.4.2 QCPs, METHOD STATEMENTS AND PROCEDURES

QCPs, method statements and procedures shall be issued to the *Employer* for acceptance. QCPs shall be issued to the *Employer* to mark up with witness and hold points. The method statements shall address the following minimum key activities. Intervention points as per method statement will be indicated on a QCP.

- Approval of procedures
- Mock up and pull out test
- Mark solid plug position on tube map
- Activities for tube removal
- Cleaning of support plates
- Cleaning of tubesheet and measure holes
- Go-No-Go test of tubesheet
- Condenser steam side inspection
- Condenser waterbox side inspection
- Activities as per tube installation
- Expansion register
- Tubesheet straightness checks (3 off)
- 95% fill factor bullet test
- Coating of tubesheets
- Rubber lining of CW waterboxes
- Flood test condenser steam space
- Leak test CW waterbox and pipework

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3.4.3 REQUIRED PROCEDURES

Method statements / procedures as listed below can be combined and does not need to be a separate method statement for each activity, provided all activities as listed are covered.

- Inlet/Outlet waterbox removal rigging study
- Tube removal & scrap removal & storage
- Tube transportation & handling from storage
- Tubesheet hole cleaning
- Tube installation, and tube sheet hole sleeving for oversized holes
- Tube expanding
- Tubesheet mock-up & tube pull out test
- Tube plugging
- Grit blasting and Coating
- Flood test of steam space
- Cooling water side leak testing
- Rigging of the waterbox
- Scaffolding
- Plug removal (solid and flexible)
- Welding related procedures

3.5 GENERAL REQUIREMENTS FOR RE-TUBING THE CONDENSERS

3.5.1 CODES AND STANDARDS

Editions of codes, standards, and recommended practices referenced herein shall be those in effect on the date of the purchase order. The fabrication, inspection, testing, and materials for all components, equipment, and apparatus shall be in full compliance with the following unless otherwise specified:

- Adherence to all state and local laws, codes and regulations shall be the responsibility of the *Contractor*.

In the event of any apparent conflict among codes and standards and this *Works Information*, the *Contractor* shall notify the *Employer* to obtain written resolution of such conflict prior to proceeding with work.

No departure from the *Works Information* shall be binding on any party until an addendum or revision to this *Works Information* has been issued by the *Employer*, or the *Employer* has approved the deviation through its Supplier Deviation Request Process.

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3.5.2 LUBRICANTS

Lubricants used shall not result in intergranular or other forms of corrosion of the tubes, or carbonisation of lubricant during expansion process. Lubricant shall be water soluble.

3.5.3 ACCESS TO FACILITIES

The *Employer* and/or representatives of the *Employer* shall, during normal working hours, be provided with access to the *Contractor's* facilities for the purpose of obtaining information on production progress, determining status, visual inspection of materials and equipment to determine conformance to specifications and drawings, and witnessing tests and inspections. Such access shall include full access to inspection records and work areas directly concerned with the works.

3.6 SPECIFIC REQUIREMENTS FOR RE-TUBING THE CONDENSERS

3.6.1 TOOLING AND EQUIPMENT

All required tooling, as per Appendix D, shall be available which has been developed against the specific requirements of large surface condenser re-tubing projects. Such tooling reduces the risk of damage to critical components (e.g. tubesheets and support plates) and also reduces outage duration required to complete the re-tubing process.

It is the responsibility of the *Contractor* to ensure the correct tooling and equipment is used in order to satisfactorily complete this project. The *Contractor* will be required to demonstrate knowledge of the operation and maintenance of the tooling and provide evidence that they have access to the required tooling and equipment to complete the project. The minimum tool quantities as indicated in Appendix D shall be submitted by the *Contractor* 8 weeks before the contract access date for the condenser, for inspection by the *Employer*. The minimum tool quantities shown in the table is the minimum compulsory equipment that needs to be on site for the total duration of the specific condenser under refurbishment. These tools will not be removed from site to assist any other condenser refurbishment projects, which runs concurrent with this contract.

3.7 RE-TUBE ACTIVITIES

3.7.1 CONDENSER PREPARATION

3.7.1.1 GENERAL

Prior to the commencement of tube removal work, the condenser and surrounding area must be thoroughly prepared. The following elements of the Works Information are included to ensure that the *Contractor* is

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aware of the scope of preparation work required by the contract and *Employer's* expectations with regard to work area organization.

The Contractor is responsible for providing a solid cover for all openings in the condenser floor such as CEP suction, cooling water ducts, drains and sidewalls to a height of 150 mm above the floor.

3.7.1.2 REMOVAL OF WATER BOXES

The *Contractor* shall remove the water boxes for access.

The water box / tubesheet areas shall be cleared of all debris to allow the de-tube process to begin.

The areas around the tubesheets shall be cleared of all equipment, pipework etc. as necessary to ensure that the replacement tubing can be installed without bending of tubes. The *Contractor* is responsible for the removal of any such equipment and for re-instatement prior to contract completion.

3.7.1.3 SCAFFOLDING

The *Contractor* shall supply and erect exterior and interior scaffolding to provide safe access to all levels of the condenser tubesheets.

All scaffolding is to be designed to bear such loads as will be imposed during use, including the load imposed by tube boxes where appropriate. The *Contractor* shall allow for spare scaffolding and scaffold personnel at all times to adjust scaffold needs at all times without delay.

All scaffolding has to comply with *Employer* safety standards and must be declared safe before any work commences. The *Contractor* provides scaffold proposals to the *Employer* to get the scaffold declared as a safe working platform to eliminate the need for safety harnesses.

3.7.1.4 ENTRY POINTS

The *Contractor* shall ensure that adequate entry into the steam space and hotwell space is available or created to satisfy both safe working requirements and the requirements of the refurbishment tasks as set out in this Works Information.

The *Contractor* shall prepare a contingency plan for creating access to the air- extraction zones if required. This access will only be required if difficulties are encountered in the de-tubing / re-tubing of the air-extraction zones. A method statement shall be submitted to the Employer for approval.

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3.7.1.5 LIGHTING

Safe, waterproof lighting shall be installed by the *Contractor* in the steam space and other areas of the condenser as required, facilitating contract execution. The use of electric grinders or drills is prohibited and only pneumatic power tools shall be used.

3.7.1.6 WATER SPRAY SYSTEM

The *Contractor* shall install a temporary water spray system to provide lubrication and therefore assist in the removal and replacement of tubes. The system should provide sufficient water so that lubrication will lessen the risk of support plate and tubesheet bending. The water must also be installed during installation of tubes in order to minimise the tubes from scoring / scratching, or excessive friction between tube and sagging plates during insertion.

The *Contractor* is responsible for the design and installation of the spray system. An illustration is provided below in Figure 3 as an example of a typical spray system consisting of water hoses 25 to 30mm OD with sprays inserted 600mm intervals. The *Contractor* is responsible for implementing additional water lubrication of the support plates if required to reduce pulling loads on any problematic tubes. The *Contractor* is to connect a drain line on one of the hotwell drains to the nearest station drain.

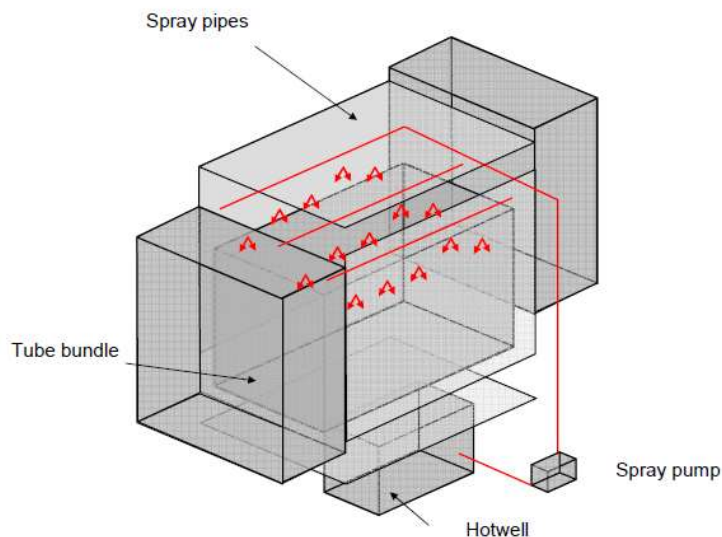


Figure 3: Typical Spray Water System

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3.7.2 WATER BOX REQUIREMENTS

3.7.2.1 GENERAL

The *Contractor* should take note of the fact that any refurbishment work on water boxes will need to be integrated with the other refurbishment work on the condensers (i.e. the de-tube/re-tube process).

3.7.2.2 PIPING AND WATER BOX REMOVAL

The *Contractor* shall remove the condenser outlet water box (west side of station) and move them to a location previously agreed to with the *Employer*. Any dismantling of the cooling water pipework shall be agreed to with the *Employer* and exposed ends of the pipework shall be protected throughout the re-tubing period.

3.7.2.3 WATER BOX REPAIRS

The level of repairs required will only be determined when the water boxes are removed. This section presents some of the options on scope of work with detailed specification guidelines on rubber lining in Appendix B.

The *Contractor* will be required to present the possible options to the *Employer* once the unit is isolated and work has begun. However if the opportunity presents itself before this the *Employer* will notify the *Contractor* to visit Site.

The following shall be done before the removal of the water box:

- Before inlet/outlet water boxes are removed. Grit blasting the first 70mm depth of tube to remove any deposits or previously applied internal tube coating that might hinder the tube extraction spear effectiveness.
- 100% NDT on the lifting lugs on water box / water box covers before removal.

The following shall apply once adequate access / water box removal is completed.

- The *Contractor* is requested to take note of the *Employer's* specification for corrosion protection of plant and equipment with rubber lining as outlined in Appendix B. If the *Contractor* is using a sub-*Contractor* for rubber lining then such sub-*Contractor* must be approved by the *Employer*.
- Checking of external welds for any evidence of rusting and visual damage.

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- Checking of external welds for any evidence of weld cracks / defects. Any suspect weld from visual inspection to be tested by means of surface NDT technique (MPI or PT for stainless components). Defective welds or areas should be reported to the *Employer* for review and acceptance; such report must include a repair procedure that outlines all the welds and what defect is to be repaired.
- Inspect manway and manway gasket sealing surface for mechanical defects, and also for corrosion damage, and repair as required. Ensure that gasket face is suitably finished to ensure gasket integrity after rubber lining.
- Wall thickness inspection by UT inspection of manway plate if lining is worn, and record the plate thickness as compared to the design thickness (as per C45 99088 0080 Manhole NB600). If indication is that all the corrosion allowance of 1 mm has been used then the *Contractor* is to propose a suitable weld repair or component replacement for approval.
- The main water box sealing face on condenser shell / tubesheet interface will be vacuum blasted and coated with approximately 100 micron epoxy coating. Care to be taken to allow for flange interface integrity as above for manholes.
- All bolting / fasteners threads will be lubricated before assembly of fasteners, this applies to all items of bolted configuration.
- If any areas have suffered visible corrosion, the Contractor shall carry out wall loss measurements by means of a profile gauge or UT, and provide an inspection report and repair proposal to the Employer for acceptance.

The Contractor is to supply the box-up procedure for approval, especially mentioning the envisaged bolting sequences. Water box to tubesheet retention stay bolts and rods are to be 100% visually inspected for signs of wear/corrosion. If the bolt/stay is reduced in diameter in any area by more than 10% it is to be either weld overlay repaired or replaced. Any wear or damage or erosion on threads must be repaired back to its original condition. Any visual signs of damage on the staybolt to tubesheet seal should be addressed by removing the staybolt and replacing the seal.

The Contractor will be responsible for carrying out inspection and repair of water box rubber lining as required. The Employer's rubber lining specification minimum requirements are detailed in the Appendix B. It is the Contractor's responsibility to provide procedures and guarantees from their suppliers. In the event there is a conflict between the specification and the Contractor's rubber lining supplier's specifications the Contractor is to present it to the Employer for review.

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The Contractor's accepted program should take into consideration that no sandblasting or solvent activities will be allowed while re-tubing takes place (not be done in parallel). It is the responsibility of the Contractor to make sure the rubber lining company checks and accepts the respective components regarding their conformity to being able to rubber line on site. This includes the responsibility to obtain all the necessary information regarding corrosion protection, surface treatment etc. which could have an effect on the rubber lining activity. A conformance inspection certificate is to be submitted to the Employer.

3.7.3 TUBE PLUG REMOVAL

All tube plugs shall be removed prior to the de-tube process without damaging the tubesheet. In all cases where solid taper plugs (non-rubber) were used, the position of these plugs shall be recorded on a tubesheet drawing and photographs taken to indicate all solid plugs and initial condition of tubesheets. The majority of tubes were plugged with rubber plugs and solid metal plugs were only used in isolated cases. Special care must be taken when measuring these holes to ensure that the holes are not oversized. Oversized holes will be handled on a case by case basis with approval from the *Employer, either by sleeving or plugging*.

3.7.4 CONDENSER TUBE REMOVAL

The method used to remove tubes shall be to cut the tube internally at least 6-10mm behind the tubesheet, and pull the resulting two sections through the tubesheets. External cutting of the tubes from the steam space shall not be employed except for those tubes where the pulling method has failed (e.g. as a result of a broken tube). The *Employer* shall be notified before any cutting inside of the steam space is being done.

The condenser tubes shall be cut via the return water box (west side of station) with an internal tube cutter 6-10 mm behind the tubesheet. The short tube stubs shall be pulled into either of the two water boxes.

The short tube stubs shall be removed using a hand held tube stub puller (hand held hydraulic ram type with internal jaws). The tube stubs shall be removed from the condenser area and packaged for scrap as agreed with the *Employer*.

The long tube sections are to be extracted by using hydraulic and/or pneumatic tube puller with tube extraction jaws. It is recommended that only jaw type extraction pullers are to be used as conventional spears will increase the possibility of the worn tubes snapping during pulling and damaging the tubesheets. Should the *Contractor* propose to use pulling spears he shall demonstrate that the tubesheets will not be damaged. No manual bending against tubesheets shall be allowed neither will rotating power tools be used to rotate the tube in the tubesheet as this damages the tubesheet and support plate IDs.

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In the event that tubes break during extraction they shall be marked and left insitu until all other tubes are removed. The *Contractor* is required to later remove such tubes from inside the condenser steam space. This shall be done by cutting with a grinder in between each support plate and pulling out the resulting sections. Under no circumstances will any cutting by grinder be done closer than 200mm to a tubesheet.

All tubes and tube sections shall be removed from the condenser area and packaged for scrap as agreed with the *Employer*. The *Contractor* shall state in their proposal whether the *Employer's* overhead cranes will be required for this purpose.

The *Contractor* must at all times ensure that working areas are kept clean and free of debris, therefore pulled tubes must be immediately removed from the working platforms and working area kept free of debris.

The air- extraction zones shall be de-tubed on a remove-and-replace basis. The installation of new tubes shall conform to the requirements of tube installation as detailed elsewhere in this Works Information, with the exception that no feeders will be used for tubes in the air extraction zone. As no tube feeders are used the tube ends shall be inspected for damage / deformation before any expansion will commence. The contractor will not continue working on the air extraction zone if a tube broke off. The tube will first be removed before the remainder of the tubes are loaded.

Where tubes in the air- extraction zone cannot be completely removed by the internal cutting and pulling method the *Contractor* shall inform the *Employer* before taking further action. The approval of the *Employer* is required before attempting to access the air- extraction zone steam space under the *Contractor's* contingency plan. For this reason it is imperative that the air extraction zone is completely retubed before the condensing side tubes are loaded.

Scrap Tubes

- All scrap tubes remain the property of *Employer*, and will be removed on an on-going basis to the laydown area identified by the *Employer*. Tubes will not be stored in the turbine hall next to working areas.
- Under no circumstances shall more than 20 scrap tubes be on the work site at any given time. The *Contractor* shall ensure that scrap tubes are frequently removed to the laydown area.

3.7.5 TUBESHEET INSPECTION AND PREPARATION

Once all the old tubes have been removed from the condenser, a cleanliness inspection will be conducted on the tubesheets and internals to determine whether any repairs are required. This shall be a hold point on the *Contractors* QCP.

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The purpose of this section of the Works Information is to state the *Employer's* requirements for inspection, specify the methods to be used for any repairs and to provide the *Contractor* with criteria for decisions which must be taken at this point.

On completion of the inspection phase, the *Contractor* shall submit a proposal for repair scope of work subject to the *Employer's* approval for any tubesheet repair.

3.7.5.1 TUBESHEET CLEANING

The *Contractor* shall ensure that the condenser tubesheets are cleaned prior to inspection. This shall comprise the following as a minimum:

- 100% of tube holes shall be cleaned with rotary wire /cylindrical flapper discs,
- Tubesheet face to be carefully cleaned by rotating stainless steel cup brushes.

3.7.5.2 TUBESHEET INSPECTION

Where tubesheet holes were fitted with solid plugs, the tubesheet hole & ligament are to be tested by means of PT in a square of 5 tubes high and 5 tubes wide either side of the plugged tube hole.

The *Contractor* shall provide a marked up tubesheet drawing indicating the tubes that will be used as calibration tubesheet holes to verify and test the wall thinning during the expansion process, these will represent no less than 1% tubesheet hole quantity. Under no circumstances shall more than 300 tubes be expanded without a reference tube. These holes shall be clearly marked on the tubesheet, recorded on a tubesheet drawing, and measured with a 3 pin bore gauge before loading of tubes into tubesheet. These measurements are to be recorded on an electronic spreadsheet.

In addition to the tube hole measurement requirements, the *Contractor* shall test 100% of tube holes on each tubesheet with a go-no-go gauge. This gauge shall be used to identify and mark all tube holes with a diameter greater than 23.9 mm. Tube holes with a diameter greater than 23.9 mm are considered oversized and the *Contractor* shall report to the *Employer* for a decision. The tubesheets shall be further inspected for the following:

- Tube hole surface finish (longitudinal or spiral grooves in the tubesheet hole are not acceptable).
- Tubesheet surface erosion/corrosion/pitting (visual).
- Local and general distortion of tubesheet (using flat edge to assess).
- Tube-hole ovality (visual)

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- Check tube-hole edges on cooling water side for any sharp-edges
- Check tube-hole edges on steam side to see tube hole is edge rounded
- Visual check for any cracked or distorted tube hole ligaments

3.7.5.3 TUBESHEET REPAIRS

On completion of the inspection phase, the Contractor is responsible for determining the requirements for any tubesheet repair.

- Provided a tube hole is within HEI tolerance the Contractor can correct its surface finish or ovality by reaming up to a maximum of 23.8mm. The employer will approve any reaming before retubing starts
- Any damaged, oval or scored tube holes can be reamed up to a maximum of 23.8mm. Sharp edges or burrs are to be removed (applicable to both the waterbox and steam side of tubesheet faces).
- Where reaming cannot be used to bring a tube hole into a state for which an adequate expansion seal can be expected this to be reported to the Employer for a decision, one option of repair is sleeving the tube hole, or alternatively as a last resort to plug the hole. Larger than 23.9mm tubesheet holes will require that these holes be restored to acceptable limits (23.4mm to 23.6mm ID) by means of sleeving the tubesheet hole.
- Mutually agreed holes are to be plugged with expandable rubber plugs sized for the tubesheet hole size. The contractor will purchase plugs to cover a range of oversized holes as per Appendix D.
- Where inspection of the tubesheet holes indicates that tube hole ligaments have cracked, the Contractor is to propose a procedure to plug, and or repair the respective area which may involve special procedures to repair a large damaged area. The tube holes surrounding this repair shall be thoroughly cleaned and checked for size to ensure no distortion or shrinkage has taken place during the repair process (as a minimum PT will be done).

3.7.6 SUPPORT PLATE INSPECTION AND PREPARATION

3.7.6.1 SUPPORT PLATE CLEANING

- Both surfaces of all the support plates shall be cleaned by means of wire cup brush.
- Spherical carbide ball burrs with an outside diameter 23.4mm and driven by a hand held pneumatic tool shall be used and passed through each support plate hole. This ball burr will also act as a go-no-go gauge.

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- During cleaning a test block will be made available with a hole of minimum 23.3mm. After every 20 holes of cleaning with a ball burr, the burr OD will be verified to be at least $\geq 23.3\text{mm}$ by testing the ball burr. The ball burr must not pass through the test block, if it does the ball burr must be discarded and replaced with a new one, and the last 20 holes will then be re-addressed with the new ball burr.
- Should it be evident that the support plate holes are smaller than the 23.3mm, and that the ball burr actually removes support plate material, these holes are to be clearly marked and agreement in form of site instruction must then be sourced from the *Employer*. The holes can then be increased to a maximum of 23.8mm by means of a milling tool bit or by means of a mechanical reamer. Care must be taken to ensure that the hole is still parallel and not tapered.
- Each support plate hole will be cleaned thus with either a ball burr or by means of reamer / milling tool bit as in point above.
- Check edges of holes, de-burr as required
- Visual check for any cracked or distorted tube hole ligaments.
- Check all (100%) support plate stay bars and welds on the stay bars by PT or MPI to ensure no indications are evident, and report any erosion damage noted.



Figure 4: Photograph of typical spherical carbide ball burr

3.7.7 CONDENSER INTERNAL INSPECTIONS AND REPAIRS

Prior to re-tubing visual inspections shall be carried out around the steam shell, hotwell, neck and other shell components for signs of damage, distortion, corrosion or erosion. Where visual inspection identifies a problem area, further ultrasonic testing may be required to determine whether actual metal thicknesses

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have depleted beyond safety margins. Minimum thickness should be based on Heat Exchange Institute (HEI), and drawings. The inspection scope includes but is not limited to the following:

- Visual inspection of internal shell plate checking for any erosion or mechanical damage.
- Visual inspection on internal ribs, stay bars, stiffeners or other structural members.
- 10% attachment welds (excluding the areas specified below) to be surface tested by means of PT or MPI.
- 100% NDT on air extraction equipment (boxes and interconnecting pipes) weld areas.
- External air extraction section shroud and extraction pipe NDT (Pipe to shroud weld) & corrosion checks.
- After de-tubing wall thickness will be done on eroded sections. Where required, the Contractor shall provide repair proposals for eroded areas to the Employer for acceptance. The Contractor shall make provision for 40 m of linear welding in the pricelist.

As soon as access is possible the Contractor shall do visual inspections for signs of damage, distortion, corrosion or erosion. The Contractor is responsible to analyse inspection results and propose repairs required. Specific repairs can only be clarified at the point of which damage is found. In the unlikely event that the air cooler sections require repair the Contractor is required to submit an appropriate procedure to the Employer for approval. A method statement for this work should be submitted to the Employer for approval.

Following completion of the shell internal inspection the steam space area is to be cleaned and cleared of all debris, vacuum cleaned and all unnecessary materials and equipment, prior to the installation of the new tubes.

3.7.8 CONDENSER TUBE INSTALLATION

3.7.8.1 GENERAL

Internal surfaces of condensers and support plates shall be washed by means of a high pressure water washer before any tubes are loaded into the condenser (air-extraction zone is excluded from this requirement).

Once the *Contractor* has satisfactorily completed all the inspections, repairs and preparatory work as required by this Works Information the *Contractor* obtains approval from the *Employer's* supervisor/inspector before commencing with tube installation. It is the responsibility of the *Contractor* to

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ensure the condenser is fully cleaned and free of all debris before re-tubing begins. The exception is the tubes in the air- extraction zones which are inserted in conjunction with the tube removal process.

Provided that the tubesheets and support plates have been properly prepared the tube installation process should proceed without difficulty. Nevertheless there are critical procedures to be followed for tube installation and these are detailed below.

The stick out will be 2 to 3mm for the inlet and outlet tubesheet.

The tube boxes shall be brought into the condenser area using adequate lifting and handling apparatus to avoid damage to the boxes and/or the tubes. The *Contractor* shall state in its proposal whether the *Employer's* overhead cranes will be required for this purpose.

An appropriate working platform shall be employed in order to facilitate the installation of the tubes at the BFPT condenser outlet tubesheets (west side of station). The working platform shall be kept clear of unnecessary materials. All waste materials shall be cleared from the platform and surrounding area promptly.

Tubes shall be installed into the condenser directly from their packaging, with each tube visually inspected for:

- Surface finish (no scoring or grooves on the tube inside or outside surfaces)
- Straightness
- Absence of mechanical damage (dents, flat spots etc.)
- Tube length (checked after insertion into both tubesheets)
- Tube wall thickness (5% spot checks using a tube gauge micrometer)

Defective tubes shall not be installed in the condenser and shall be clearly marked as scrap and shall be removed from the working area. The Project Manager shall be informed of these defective tubes on a daily basis for record keeping. These tubes, depending on damage, can be used for the purpose of mock-up testing.

The *Contractor* must ensure that spray water is operational before the tubes are loaded into the tubesheet. Under no circumstances will any other means of lubrication other than a water spray system and cloth drenched in water to be used on tube outside surfaces, any other lubricant affects the joint strength, and could lead to tube joint slipping in service.

All tubes in the main bundle shall be fitted with aluminium tube feeder guides at the leading end to ensure the tubes readily self-align as they are pushed through the support plates and tubesheets.

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The *Contractor* is responsible for positioning the necessary number of personnel inside the steam space to guide the tubes between support plates.

Tube feeder guides shall be removed once the tubes are positioned in both tubesheets.

All the requirements of the Works Information shall be met with regard to air- extraction zone tube installation, including tubesheet tube hole inspection and preparation, excluding baffle plate cleaning and tube feeders.

3.7.8.2 TUBE TO TUBESHEET JOINT EXPANSION

With all the replacement tubes loaded into the condenser and mock-up testing complete, the *Contractor* may proceed to make the tube-to-tubesheet joints. The joints will be created through the use of mechanical (5 pin roller) expansion. The contractor will start the expansion process by expanding a number of tubes in a predetermined holding pattern style for both tubesheets of the loaded tubes.

The following formula will be used for wall thinning calculations:

$$Tw = ((T-t)-(D-d))/(d-t)*100$$

D= Diameter of tubesheet hole, mm

d= Outside diameter of tube, mm

T= Tube inside diameter after expansion, mm

t= Tube inside diameter before expansion, mm

Tw = % wall thinning

Example recording: The following is provided to the *Contractor* as an example of recording the tube expansion data.

Table 2: Tube expansion data example

	Tube Test Number	1	2	3
D	Tubesheet hole size	23.600	23.660	24.000
d	Tube outside diameter	23.000	23.200	23.200
t	Tube inside diameter before expansion	22.000	22.000	22.100
T	Tube inside diameter after rolling	22.640	22.520	22.950
Tw	% Expansion	4.00	4.85	4.600

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3.7.9 TUBE-TO-TUBESHEET JOINT MOCK-UP TESTS

3.7.9.1 GENERAL

Mock-up test and pull out test must be completed 2 weeks before the contractual (actual retubing) start date and will be a key-date in the programme.

There is considerable uncertainty in advance of the re-tubing project with regard to the ability to make adequate tube-to-tubesheet joints within the existing tubesheets. The condition of the tubesheets is not accurately known until the tubes have been removed, and the *Contractor* must be prepared to deal with a number of potential problems. The tube materials being considered for the re-tube present potential difficulties for roller expansion, especially with regard to over-size tube holes.

In order to prepare for all eventualities, as far as possible, a series of mock-up tests are specified to be completed ahead of the outage. These tests provide information regarding the torque settings required for the expansion tooling, and the largest tube hole size which can be successfully expanded and sealed. In order to conduct the mock-up tests the *Contractor* will require access to a quantity of replacement tubing from the bulk of the free-issue tubing supplied. The *Employer* will provide the tube samples for these tests while the *Contractor* must provide the material representing the tubesheets. This material supplied by the contractor will have available material certification to EN10204 3.1 as a minimum. Hardness in HB shall also be provided. If certification is not supplied the blocks will not be accepted.

3.7.9.2 MINIMUM PULL OUT FORCE

The wall thinning will be calculated as described in section 3.8.8.2.

3.7.9.3 MOCK-UP/PULL OUT BLOCK TEST PIECES

A set of test blocks (detailed below) shall be manufactured. These blocks shall be similar to the current condenser tubesheet, pitch, material hardness and thickness. A set of mock-ups will be required for both brass and titanium tubes.

The mock-up test blocks will have full mechanical and chemical material certification in accordance to EN10204 3.1 requirements.

In addition to the 3.1 certificate as above, hardness test results will be required of the mock-up test blocks after final machining.

Min 6 blocks with ID of 23.25 mm (tolerance -0 mm and +0.05 mm)

Min 2 blocks with ID of 23.15 mm. (tolerance -0 mm and +0.05 mm)

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Min 2 blocks with ID of 23.6 mm (tolerance-0 mm and + 0.05 mm)

Min 2 block with ID of 23.8 mm (tolerance-0 mm and + 0.05 mm)

After every expansion record the torque output of expander device and perform pull out test. Record the pull out values and wall thinning in the wall thinning/expansion spreadsheet. The desired wall thinning range will be 7-8% for brass tubes and 4-5% on the titanium tubes.

When the 23.25 mm tests are completed the remainder of the blocks (23.15 mm and 23.6 mm) need to be expanded with the within the selected wall thinning range as determined above, for at least 3 different wall thinning values within the selected range.

Finally at same torque value perform test on 23.8 mm block.

The option to perform additional tests with serrated (grooved) test blocks is left to the Contractor's discretion for acceptance by the Employer.

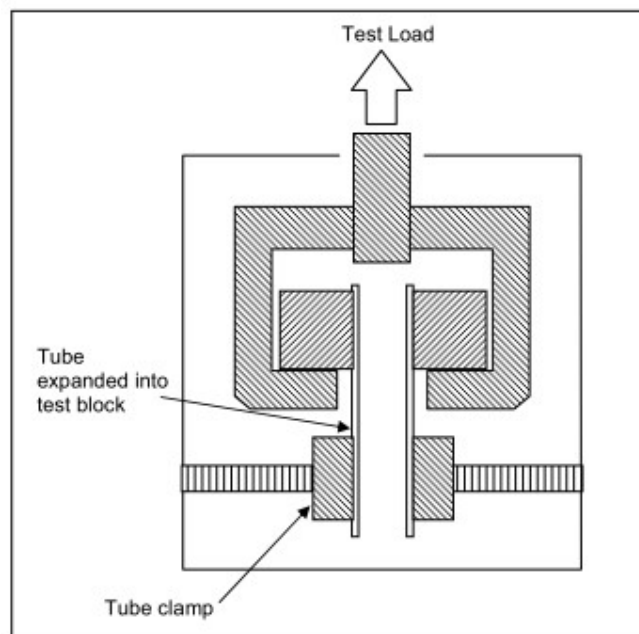


Figure 5: Typical Pull-Out Test Apparatus

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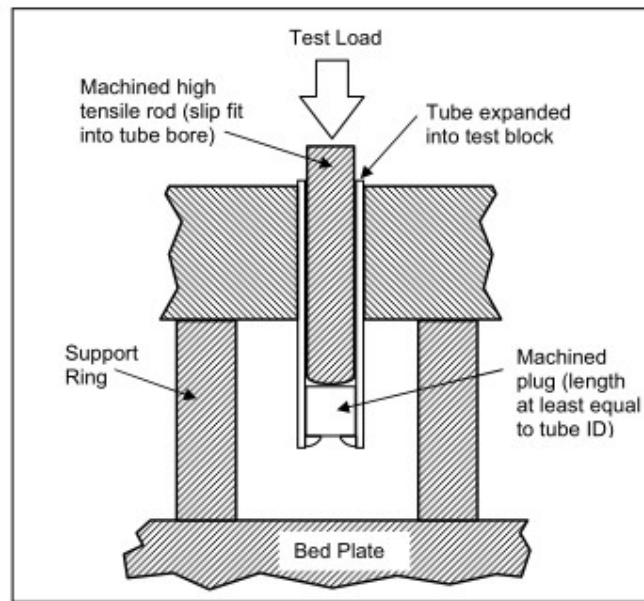


Figure 6: Typical Pull-Out Test Apparatus

3.7.10 WATER BOX INSTALLATION

- Reinstall water box with new gasketing such as GP45 Natural rubber blend (see Appendix C). Gasket will be supplied with material certification.
- All joints on the gaskets will be by means of dove tail joints and not on 90° or axial jointing (See Figure 7)
- Secure any CW connections that may have been dismantled during the outage and remove any blocking on bellows that might have been installed.
- Externally inspect water box gaskets & manway for any visual evidence of localised bulging (extrusion) from the water box cover to water box joint.
- If stagnant water is present in the inlet and outlet ducting the contractor shall be responsible to prove that the ducts are free of debris.

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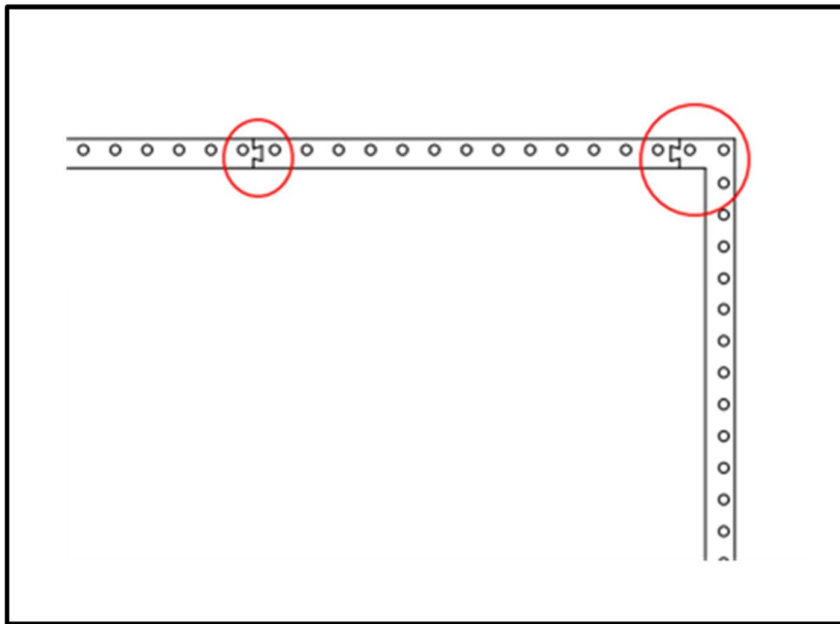


Figure 7: Typical gasket dove tail jointing

3.7.11 COATING OF TUBESHEETS

Only after the shell side flood test as detailed in section 3.9.1 is complete and all tube-to-tubesheet joints have been checked for leaks and defects corrected, the Contractor shall coat the inlet/outlet tubesheet and return tubesheets as per the requirements in Appendix A.

3.8 COMPLETION TESTING, COMMISSIONING AND CORRECTION OF DEFECTS

3.8.1 SHELL FLOOD TEST AND WATER BOX LEAK TEST

It is the *Contractor's* responsibility to check the tube side water box gasket joints, manways and openings, CW pipe connections and water box integrity. The *Contractor* shall perform an online test with the CW flowing at normal operating pressure. The *Contractor's* scope of work includes but is not limited to the following:

- Reinstall water boxes using an approved procedure and bolting sequence.
- All bolting will be assembled in a lubricated state.
- Remove all covers on CW valves.
- Secure any CW connections that may have been dismantled during the outage.
- Fill shell side with demin water ensuring all the tubes are covered and the water is a minimum 1000 mm above the top row of tubes. (Site to ensure witness point to prevent overfilling).
Note that no fluorescene should be used during the test.

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- During filling of steam side any leaking expansion joints shall be repaired and marked up on a register (QCP verify point).
- Leave steam side full of water for a minimum period of 12 hours after last joint was repaired and re-inspect tube to tubesheet joints and all plugged tubesheet holes for leaks.
- On completion of the steam side the CW side can be filled and monitored on the waterbox side if any leaks are evident.
- Inspect 100% of shell construction for any leaks. In the event of shell side construction leaks, these can be repaired after the flood test and tested by surface NDT. (PT or MPI).
- Inspect all shell side manways and openings for any leaks.
- Drain condenser and verify operation of all hotwell drains.
- Close and seal all water box manholes and other openings.
- Open CW isolation valves and circulate CW at the operating pressure for a minimum 2 hour period.
- Under no circumstances will double rubber gaskets be used – meaning if the manhole is rubber lined and seal cannot be achieved, the face to be inspected, and repaired.

In the event of any gasket joint leaks the bolting can be lightly tightened to affect a seal. However excessive tightening and extrusion of gasket joints are not permitted.

In the event that the gasket joints cannot be sealed the water box covers have to be removed, inspected, rectified, reinstalled and re-tested, all bolts to be tightened again to specified torque.

Silicone sealant shall not be applied to any part of the water box to tubesheet joint.

3.8.2 FINAL INSPECTION

The *Contractor's* scope of work includes but is not limited to the following:

- Check to ensure all relevant QA documents are completed, NCRs are closed out and filed in a condensers refurbishment databook.
- Verify that all temporary working platforms are removed and permanent access fixtures are re-instated.

3.8.3 COMMISSIONING

The *Contractor* will be present during commissioning of the re-tubed condensers.

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3.8.4 ACCESS FOR CORRECTION OF DEFECTS

The *Project Manager* will make arrangements for the *Contractor* to have access to the *works* including *works* which have been taken over, for the purpose of correction of Defects by the *Contractor*.

Special arrangements will have to be made for the correction of Defects after the *works* have been put into operation.

3.9 TESTS, TEST CERTIFICATES AND INSPECTION

3.9.1 NDT

All NDT mentioned in this scope of work will form part of the contract and the Contractor will include this in the pricing.

The Contractor to make allowance for:

- 2.5 m² PT
- 2.5 m² MPI
- 30 Wall thickness measurements
- 5 Hardness tests (to be performed on the actual tube plate)

3.9.2 NON CONFORMANCES

Where Non-Conformance Report (NCR) notifications are issued, the Contractor acknowledges receipt within the period of reply and proposes corrective and preventive actions to the Supervisor. The corrective and preventive actions will include the implementation and completion dates. Progress on all NCR notifications issued to the Contractor must be reported to the Supervisor on a weekly basis.

- The Contractor's Quality Manager maintains a register of all NCRs issued, and provide dates for close out of NCRs.
- Records of NCR notifications and close out reports are kept and form part of the data book records.
- During the contract execution phase, the Contractor will be monitored by the *Employer's* Supervisor for performance on quality related aspects. The monitoring will be in the form of audits and assessments.

3.9.3 QUALITY CONTROL PLAN

The Contractor submits to the Project Manager within 30 days of Contract Date for review and acceptance prior to the commencement of work. A QCP which will detail the Contractor's organisation, quality assurance and quality control procedures within that organisation specific to this project will be supplied.

The QCP shall be subject to the Employer's approval and shall indicate all inspection and test points, method statement and procedures to be used as well as acceptance criteria to be applied. Following review

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by the Employer, agreed quality surveillance requirements such as witness points and hold points shall be indicated on the QCP for the Employer's interventions.

The Contract Quality Plan (CQP) will make reference to the Contractor's QMS documents to be used in this Contract:

- The Contractor's QMS compliance with the requirements of ISO 9001
- Contractor's quality manual
- Contractor's quality procedures
- Contractor's quality forms and work instructions
- Contractor's quality system documents referenced in this Works Information
- Employers Works Information, drawings, specifications, standards and codes, etc.

3.9.3.1 INSPECTIONS AND TESTS

All plant and materials are comprehensively tested in accordance with the agreed ITP/ QCPs prior to delivery. The Employer reserves the right to appoint others to inspect all parts during manufacturing, erection and commissioning to be present at any of the tests specified. The witnessing of tests by the Supervisor or others, and if the Supervisor chooses to waive the witnessing of any tests, it does not relieve the Contractor of his responsibilities.

The Supervisor inspects parts of the plant at his discretion during manufacturing stages and before shipment as per the agreed ITP/QCP;

- The Contractor is responsible for the inspection of all the work that is performed, and the Supervisor only verifies that the work is conducted as per the Works Information and interventions as per QCP.
- The Contractor conducts all inspections in accordance with the accepted ITP/QCP.
- The Contractor provides suitably qualified personnel to conduct on-site inspections
- The Contractor ensures that all are inspected and approved before the Supervisor is invited for verification.
- The Contractor provides a minimum of 24 hours for local on-site inspection. The notice contains copies of the Contractor's inspection reports.

3.9.3.2 QUALITY RESPONSIBILITY

The Contractor responsibilities include but are not limited to the following:

- The Contractor is accountable for the quality of the output and liable for any failures

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- Implementation of their QMS on site
- Administration of their QA/QC systems on site
- Verification of approval status of Subcontractor's Quality programmes, that is, CQPs, QCPs, NCRs, Defects, operational procedures and works instructions for onsite inspections
- Weekly progress reporting on quality performance
- The Contractor is responsible for defining the level of intervention of QA/QC or inspections in line with the Employer's requirements
- The Contractor is responsible for defining the level of intervention of QA/QC or inspections to be imposed on his Sub-contractor, suppliers and must ensure that these are in line with the Employer's requirements

The Supervisor will be responsible for the following:

- Reviews of the quality of either inspections or document submissions
- Verification of the Contractor's intervention points
- Reviews the Contractor's ITP/QCP documents (procedures, test results)

4. TENDER RETURNABLES

For the purpose of an equitable technical evaluation of the tenders the *Contractor* shall provide all information and documentation as per the requirements below. **If not provided the tender will be considered non-compliant and will not be evaluated.**

1. Verifiable evidence that the Contractor, Sub-Contractor and/or Joint Venture partner has replaced all the tubes of steam condensers connected to a turbine size greater than 100 MW, in the last 5 years
2. A valid copy of the ISO 3834 certificate (part 4), for the company doing the welding, must be supplied with tender
3. Any technical deviations or qualifications to the Works Instruction shall be clearly indicated in the tender. If no deviations or qualifications a specific statement is to be made.
4. An example of Contractor's procedures (mock-up and pull out test, tube removal, installation and expansion procedure)
5. An example of the Contractor's QCP for a typical condenser installation
6. The tool list (Appendix D in the Works Information) shall be included in the tender with column 2 and 4 completed. These tools need to be on site for the total duration of the specific condenser under refurbishment, these tools will not be removed from site to assist any other condenser refurbishment projects, which runs concurrent with the unit that is contracted.

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7. The coating and rubber lining of condenser waterboxes shall only be performed by contractors who can produce verifiable references of similar corrosion protection on CW systems, chemical tanks and associated piping & ducts, done during the last 5 years.
8. Supply of the latest revisions of the specified Material Product Data Sheets and Material Safety Data Sheets
9. Detailed QCP for similar work done as per coating specification in Appendix A and rubber lining specification in Appendix B of Work Instruction 375-172141
10. Detailed method statement/procedure as per coating specification in Appendix A and rubber lining specification in Appendix B of Work Instruction 375-172141

5. AUTHORISATION

This document has been seen and accepted by:

Name & Surname	Designation

6. REVISIONS

Date	Rev.	Compiler	Remarks
December 2021	0	K Ramalingum	First draft

7. DEVELOPMENT TEAM

8. ACKNOWLEDGEMENTS

- All team members

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APPENDIX A: TUBESHEET COATING SPECIFICATION

Tube sheet coatings are applied to tubesheets and tubesheet-to-tube joints that have been damaged by corrosion. The tubesheets can be coated to prevent any further corrosion taking place. Coatings can fail because of misapplication, physical damage in service or due to scaffolding damage during inspections, cracking due to flexing or movement of the tube sheet during operation. The coating can also be severely damaged due to inadequate protection of the coating during high-pressure water cleaning. If damage occurs to the coating, the area may be subject to selective galvanic attack with potentially catastrophic results. Coating is also done on tubesheet faces after retube to eliminate the galvanic effect between dissimilar tubesheet materials and tube materials and will also prevent dezincification of brass tubesheets.

The Project Engineer shall issue the relevant Eskom Protective Coating Specification with the enquiry document. These documents include 240-101712128: Specification for the Internal Corrosion Protection of Water Systems, Chemical Tanks and Vessels and Associated Piping with Linings [27] as well as the project specific Corrosion Protection Specification as attached below.

Table to be considered as Annexure D of 240-101712128: “Specification for the Internal Corrosion Protection of Water Systems, Chemical Tanks and Vessels and Associated Piping with Linings”	
Component/s	Condenser Tubesheets
Internal Immersed (Material/Substrate)	Muntz Metal (Copper/Zinc Alloy) – Epoxy coated
Internal Immersed (Environment)	Immersed, cooling water, pH 8.1 to 8.6, temperature range 25°C to 45°C.
Generic System	<ul style="list-style-type: none"> • (Optional) Two component Solvent Free Amine Cured Epoxy Primer or as specified by coating manufacturer. • Two component solvent free amine cured epoxy coating 2 coats. • Coating dry film thicknesses in this specification shall be adhered to.
Step 1	All tubesheet and protruding tube surfaces shall be high pressure water washed to remove salt and other loose contaminants. Washing may need to be repeated in accordance with requirements of 240-101712128 in order to cater for possible soluble salts. Greases, lubricants etc. shall be removed

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<u>High Pressure Water Washing</u>	<p>during washing by including the use of a suitable degreaser/detergent. Ensure thorough rinsing with clean potable water followed by complete drying, in particular the interface of tubes and tubesheets, as far as practically possible.</p>
<p>Step 2</p> <p><u>Plugging of Condenser Tubes:</u></p>	<p>In order to avoid damage as well as contamination of the internal surfaces of the condenser tubes, the tubes shall be temporarily plugged by a means that will provide adequate protection to unwanted abrasive blasting of the tube internal inlet surfaces.</p>
<p>Step 3</p> <p><u>Surface Preparation:</u></p>	<p>Remove all traces of corrosion product, scale and other foreign matter by abrasive blast cleaning to Grade Sa 3 - a bright metal colour. Surface profile as specified by coating manufacturer.</p> <p>Abrasive material to be selected such that the surfaces are suitably profiled to ensure a good bond between coating and base metal. Remove all temporary plugs prior to final dust removal. In terms of final surface preparation and cleanliness refer to "General Requirement" below specifically for time duration between dust removal and application of the primer or first coat.</p>
<p>Step 4</p> <p><u>Plugging of Condenser Tubes:</u></p>	<p>In order to avoid inadvertent introduction of paint to the internal surfaces of the condenser tubes, the tubes shall be temporarily plugged by a means that allows easy removal once the coating has been applied. It is extremely important that the material used for protecting the internal surfaces of the tubes from paint ingress be removed prior to curing of the coating to avoid the temporary plug permanently being stuck in the tube/s. Any build-up of paint inside the tubes will have to be removed prior to final acceptance of the work.</p>
<p>Step 5</p> <p><u>Application of Primer (Optional)</u></p>	<p>Apply by brush, one coat – Two component Solvent Free Amine Cured Epoxy Primer.</p> <p>Dry film thickness 50 to 75 microns</p>
<p>Step 6</p> <p><u>Plugging of Condenser Tubes:</u></p>	<p>Remove all temporary plugs before complete curing of the primer. Once the primer coat has cured sufficiently as per manufacturer's recommendation install a new set of temporary plugs for the next coating step.</p>

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<p>Step 7</p> <p><u>Application of First Coat:</u></p>	<p>After allowing sufficient time for the primer coat to cure, the manufacturer's recommendations shall be strictly adhered to in this regard, apply by brush, one coat – Two Component Solvent Free Amine Cured Epoxy Coating.</p> <p>Dry film thickness 250 to 300 microns</p>
<p>Step 8</p> <p><u>Plugging of Condenser Tubes:</u></p>	<p>Remove all temporary plugs before complete curing of the coating in Step 7 above. Once the coating in Step 7 above has cured sufficiently install a new set of temporary plugs for the next coating step.</p>
<p>Step 9</p> <p><u>Application of Second Coat:</u></p>	<p>After allowing sufficient time for the coating in Step 7 to cure, the manufacturer's recommendations shall be strictly adhered to in this regard, apply by brush, one coat – Two Component Solvent Free Amine Cured Epoxy Coating. The second coat shall be of a different colour than the first coat for easy identification.</p> <p>Dry film thickness 250 to 300 microns</p> <p>Total dry film thickness of the coating system: from 500 to 600 microns</p>
<p>Step 10</p> <p><u>Plugging of Condenser Tubes:</u></p>	<p>Remove all temporary plugs before complete curing of the coating in Step 9 above.</p>
<p>Step 11</p> <p><u>Sealing of Tubesheet/Waterbox Interface Areas:</u></p>	<p>A combination of a viscous and permanently elastic mastic system (tape/bandage and paste form) may be used for sealing of the tubesheet/waterbox interface. The requirement is that the product does not cure or dry out - is permanently flexible and surface tolerant and easy to apply (no special skills needed).</p>
<p>Step 12</p> <p><u>Coating Inspection:</u></p>	<p>Since the close arrangement of the tubes precludes any holiday detection testing of the surfaces, all surfaces (<u>especially at the tube/tubesheet interface</u>) shall be thoroughly visually inspected to identify any areas where the coating is discontinuous or uncured. At the end of the curing period the full cure of the applied coating shall be verified by the applicator and/or coating manufacturer.</p> <p>Any faults located shall be marked up and repaired to Eskom's satisfaction.</p>

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<p><u>Final DFT's as estimated/correlated with "Wet Film" comb monitoring.</u></p>	<p>Two Component Solvent Free Amine Cured Epoxy Coating 2 coats @ 300 micron per coat</p> <p>Total dry film thickness of the coating system: from 550 to 675 micron (with the use of a primer).</p> <p>Total dry film thickness of the coating system: from 500 to 600 micron (without the use of a primer).</p>
<p>With respect to aspects not mentioned in the above coating specification table (e.g. mixing ratios, pot life, straining, thinning, induction times, over-coating and curing times), the manufacturer's recommendations shall be strictly adhered to.</p>	
<p>This specification sheet is applicable to the application of protective coating to the entire tubesheet surface with specific emphasis of ensuring continuous coating of the interface surfaces between the tubesheet and onto the protruding section of tubing.</p>	
<p>Specific Project Requirements</p> <ol style="list-style-type: none"> 1. A detailed visual inspection shall be carried out by the Eskom engineer and contractor to identify tube ends that may require re-flaring, mark-up of tubesheet surfaces that need to be repaired/reinstated OR completely coated/recoated. 2. Care should be taken when re-flaring the damaged condenser tubes as incorrect flaring can lead to cracking of tubes. Prior to any work the Contractor shall successfully demonstrate the ability to re-flare condenser tubes. 3. Eskom will instruct the applicator whether to perform patch repairs of the coating or complete recoating. Specific requirements for patch repairing a coating system are defined further in this specification sheet and in section 4.8.6 of 240-101712128. 4. At all times care shall be taken to ensure adequate protection of any surfaces and parts of components or systems not requiring blast cleaning and coating (as an example valve seats/trim, pump inlets) and every effort shall be taken to prevent grit, water and other dirt entering drain systems, tank/vessel inlet/outlet piping or settling on isolating valves seats, shafts etc. 5. All materials, i.e. paint, solvents and cleaning agents for a specific paint system shall be supplied by the same manufacturer. The solvents used shall be those recommended and manufactured by the paint manufacturer. Where the recommended 'solvent' and 'clean-up thinners' for a material differs, the 'clean-up' solvent must not be added to the paint for dilution purposes. 	

6. The method of surface preparation shall be by conventional sweep blasting and coating application by brush.
7. In cases where the existing lining/coating is significantly deteriorated or completely removed and the substrate badly corroded then the substrate shall be tested for chloride contamination, according to ISO 8502-6.
8. For soluble salts, testing shall be performed by the Bresle soluble salt test method. If not within acceptable limits (as per the manufacturer requirement but not exceeding 100mg/m²), the surfaces shall be washed/decontaminated by High Pressure (HP) water washing using fresh/clean water (with a conductivity reading of maximum 100 µS/cm) at a minimum pressure of 300 bar. A salt decontamination chemical additive with demonstrated capability of removing salts may be used in conjunction with HP cleaning.
9. Testing shall be repeated on representative test patches which shall be blast cleaned to Grade Sa 3 (ISO 8501-1). If acceptable then proceed with blasting and application steps – if not then repeat HP washing until the salt contamination has been removed to within acceptable limits.
10. Prior to any surface preparation all surfaces that are, or are likely to be contaminated with oil or grease as a result of the tube flaring process shall be solvent cleaned with a suitable water-soluble biodegradable alkaline cleaner/detergent or with appropriate organic solvents.
11. Cleaning may be performed by using rags for small areas, or a spray gun for large areas. The detergent/solvent-cleaned surfaces shall then be thoroughly washed down with fresh/clean water ensuring that the oil-water emulsion formed is completely removed from the metal.
12. Degreased and water washed surfaces shall be checked for residual oil and grease using the atomized water spray test as per ASTM F21 and further degreasing shall be carried out if residual oil or grease is found to be present.
13. A black light test shall be used to check for oil contamination. Zero oil and grease contamination is the acceptable limit. Washing with fresh/clean water containing a suitable degreasing agent of partially painted components shall take place between coats, if surfaces are found to be contaminated.
14. Surface preparation by abrasive blasting shall be performed by means of conventional hand held blasting equipment capable of removing mill scale, old coating, rust and suitably preparing the substrate to the required cleanliness of Grade Sa 3.

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15. Removal of dust and debris shall be performed by vacuuming. The process shall be repeated until the required level of dust and debris removal is achieved.
16. The level of cleanliness required shall be less than “dust quality rating” 2 when tested in accordance with ISO 8502-3.

General Requirements:

1. The applicator shall be wholly responsible for the surface preparation and coating application. The coated surfaces shall meet the DFT as required by this specification sheet and aspects thereof in referenced documents.
2. Power and hand tool cleaning is only applicable to very localised touch ups or patch repairs. Specific requirements for patch repairing a coating system are defined in section 4.8.6 of 240-101712128. Hand-tool cleaning for isolated/localised areas may be utilised provided the required standard of finish is achieved. For all immersion applications final mechanical cleaning shall be by bristle blaster in order to create a required surface profile.
3. Cleaning by means of hand or power-tools, i.e. wire brushes, chipping hammers, scrapers, grinders, sanders, needle descenders, bristle blasters etc. may only be used where accepted by the Eskom engineer and where the position and condition of the substrate metal is such that efficient cleaning can be achieved.
4. Different grades and types of blasting media exist. It is important that the correct abrasive be used in combination with a specific coating system to achieve the specified surface profile. The required blast profile height should be carefully considered. The applicator shall select an appropriate abrasive type and mesh size to attain the specified surface profile.
5. Only inert mineral grit or steel grit abrasives shall be used. Steel grit is preferred in sensitive plant areas such as Water Treatment Plants in order to ensure no contamination of plant processes due to excessive dust. Sand or silica based abrasives shall not be used. Abrasive material for blast cleaning shall be used in line with local environmental regulations.
6. The abrasive shall be used in accordance to the manufacturer's specifications and shall be clean, sound, hard particles free from foreign substances such as dirt, oil, grease, toxic substances, organic matter and water soluble salts.
7. It is important that good quality abrasives are used in order to minimize the amount of waste grit and dust generated and contamination of the surfaces. The use of re-cycled blasting media for the final blast is strictly prohibited.

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8. All abrasive media shall be stored in an area that is completely dry, covered and protected from weather.
9. For complete coating removal the requirement for surface preparation of all metallic surfaces for immersion is strictly Grade Sa 3 (ISO 8501-1), in which case the surfaces shall be blast cleaned to a bright metallic finish where all traces of rust, mill scale and other foreign matter are removed.
10. All compressed air for blasting activities shall be free from entrained moisture and oil. All traps shall be in a functional condition. The compressed air shall be tested at regular intervals using clean white clothes to assess cleanliness and dryness. This requirement shall be included in the QCP.
11. After surface preparation, all dust, grit blasting media or any other deleterious matter shall be removed from the surfaces by vacuuming. The process shall be repeated until the required level of dust and debris removal is achieved. It is imperative that all surface dirt and contaminants (such as oil, grease, rust or other deposits) are completely removed before coating or the adhesion of the coating shall be impaired.
12. Immediately before coating, blast cleaned steel shall not exhibit more than “dust quantity rating” 2 when tested in accordance with ISO 8502-3.
13. The applicator shall ensure that during surface preparation and coating activities the relative humidity is less than 60% RH. Ambient temperatures shall be between 5°C and 30°C or as per the manufacturer recommendations, whichever is the more stringent.

The maximum/minimum substrate temperature at the time of coating application shall be strictly in accordance with the product data sheet. Environmental parameters shall be measured and recorded at least 4 times per shift. All measurements shall be recorded at the tubesheet surface. Dew point requirements shall be as per the Product Datasheet or 240-101712128.
14. For all inspections of all surface preparation and coating activities the surfaces shall be clean allowing unhindered visual access to the surface. The applicator shall provide sufficient and adequate lighting (Cool White) to enable inspections. Cell phone lighting is not acceptable.
15. In order to avoid recontamination and flash rusting of the surfaces, the primer or first coat shall be applied within 8 hours after final surface preparation of the steel surfaces. Under no circumstances shall the blast be permitted to stand overnight.
16. Many modern organic coatings can be applied without the use of a primer. However, should a primer coat be required for holding of the blast, or otherwise, the applicator shall indicate/describe

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the reasoning for the need of such a primer i.e. as a holding primer or as a means of enhancing adhesion of the system?

Details shall be provided in the Method Statement for the type of primer, generic resin, solvent borne or free, maximum DFT and compatibility with subsequent coats. The detailed Method Statement shall be submitted and reviewed by Eskom for acceptance/rejection prior to any work. Ultimately, the applicator shall be responsible for any risk that could arise or be attributed to this choice.

17. It is not possible to measure DFT's due to the area/surface/tube protrusion. The coating applicator shall be equipped with a "wet comb" and frequently monitor the wet film thickness to ensure DFT requirements in the table above in this specification sheet are achieved.
18. Multiple coats shall be applied as per the table at the top of this specification sheet. Single coat systems are not permissible.
19. Where more than one coat is applied, the colour of each coat shall be different from the previous coat.
20. Where the coating has completely cured or allowed to age before finishing, before application of a subsequent coat the surface shall be prepared by light abrasion, scrubbing with potable water using a bristle brush and drying before over-coating.
21. Application of subsequent coats shall be in accordance with the specified system. The required over-coating intervals as mentioned in the latest Product Data Sheet shall be observed and adhered to.
22. The coating shall be evenly applied to form a smooth, continuous, unbroken layer free from misses, sags, runs, tears and other defects that could affect the integrity of the coating.
23. After completion of the coating activities sufficient curing time of the coating system shall be given prior to immersion as per the requirements of the Product Data Sheet. Accelerated curing is not permitted. All coated surfaces shall be adequately ventilated until full cure has been achieved. At the end of the curing period and before immersion the full cure of the applied coating shall be verified by the applicator and/or coating manufacturer.

Safety Requirements and Considerations:

1. During the applications of all coatings/lining, care shall be taken to ensure adequate ventilation and lighting, to allow for good visibility and proper curing of the coatings and to avoid/minimise health and safety risks.

2. A confined spaces (CSs) may be defined as an enclosed, restricted, or limited space in which, because of its construction, location or contents, or any work activity carried on therein, a hazardous substance may accumulate and/or an oxygen-deficient atmosphere may occur, and/or in which a dangerous liquid or dangerous concentration of gas, vapour, dust or fumes may be present. It includes any chamber, tunnel, pipe, pit, sewer, container, valve, pump, sump, chute, bunker, silo, gearbox, tank, receiver, drum or any similar construction, equipment, machinery or object.
3. Flammable Atmospheres: Gases, vapours and dusts can become trapped in CSs and create flammable or explosive atmospheres, and include combustibles e.g. Hydrogen, Acetylene, Paint and thinning/cleaning solvents, etc.
4. Walking / Working Surfaces and Visibility: Poor lighting may add to hazards caused by an irregular, sloped, or constricted working surface.
5. Special care needs to be taken when working with all organic coatings. Prior to the use of any coating material, the Material Safety Data Sheets shall be obtained from the relevant coating manufacturer. The applicator shall be familiar with the contents of these safety data sheets and ensure that the necessary safety precautions are taken in order to comply with local and national safety and health requirements such as the OHS Act.
6. Any solid waste materials or liquids stripped or generated during the coating operations shall be discarded in accordance with the requirements of the appropriate national and/or local authorities or the requirements of Eskom.
7. The applicator shall ensure compliance with all statutory regulations, municipal by-laws, etc. concerning pollution and the health and safety of personnel and/or members of the public who may be affected by the work. The applicator shall provide the personnel with the appropriate required PPE.
8. The applicator shall provide for all necessary safety precautions and risk assessments.
9. The applicator shall advise Eskom of all hazardous materials to be brought on site.
10. All painting materials on site shall be stored in designated areas in storage facilities that meet the storage requirements of the paint manufacturer and the safety requirements of the specific site. The contractor shall be responsible for the provision of appropriate storage/shipping containers as required. These containers shall include the appropriate refrigeration/conditioning systems for temperature control. This requirement shall be dependent on where the container will be located

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(indoors/outdoors), typical ambient temperature for the particular season of the year and the maximum storage temperature limits as per the manufacturers recommendations.

11. The applicator's Safety File for the area to be worked it shall address all the hazardous activities of abrasive blast cleaning and coating. The applicator shall verify that the personnel carrying out these activities are suitably qualified.

12. The applicator shall ensure that the abrasive materials used conform to all National Health and Safety Standards.

Specifically with respect to CSs and based on the descriptions and definitions of safety risks as per the above points it is imperative that the contractor's/applicator's Method Statement shall describe in detail, the measures and mitigation steps for the risks and hazards as identified in this specification sheet. It is compulsory that these safety risks/mitigation measures and any others as identified by the contractor/applicator be included in the Method Statement. Prior to the commencement of any work the Method Statement shall be submitted for review, acceptance/rejection by the respective Lethabo Power Station Risk and Safety office/department.

Pre-job Method Statement and Quality Documentation review and acceptance:

1. The coating manufacturer/applicator shall supply individual product data sheets for all products, comprising the system which shall contain the following as a minimum:
 - A description of the generic type of paint.
 - Confirmation that the coating is suitable for the intended method of application.
 - Recommended and non-recommended uses.
 - Maximum recommended service temperature which shall be a minimum of 30% greater than the maximum temperatures as is indicated in the table at the top of this specification sheet. The coating rating shall consider the above temperatures as continuous service i.e. not intermittently.
 - Chemical resistance limits.
 - Surface preparation.
 - Application conditions and details including but not limited to: application temperatures, dilutions, pot-life, application techniques and DFT for the particular application method, over-coating intervals, and curing times required before immersion.
2. Prior to the application of any of the corrosion protection systems, the Product Data Sheet/s shall be signed by the manufacturer and applicator. This is to ensure that the manufacturer is aware of

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this specification, the conditions under which it will be applied and to allow for technical back-up where required.

3. The signed Product Data Sheet/s shall be deemed to be a binding reference document (as part of the QCP). It shall be specific to this project and any further/other subsequent revisions of the Product Data Sheet/s shall be submitted to Eskom for reacceptance clearly stating the variations/deviations. No further use/application of the related product, for this project, is permitted until acceptance is granted by Eskom.
4. A detailed Method Statement explaining all required steps as specified in this specification sheet shall be provided at the time of tender. The steps to be considered includes:
 - The methods, steps, sequence and equipment required for ventilation and dust mitigation.
 - Grease decontamination and washing.
 - Soluble salt decontamination.
 - The parameter setup for blasting and coating techniques i.e. sweep blasting and coating by brush, shall also be included in the Method Statement.
 - Methods for dust and debris removal, maintaining and ensuring cleanliness between coats shall be described.
 - The Method Statement shall detail the precise sequence and breakdown of work areas/activities in order to apply the system with due consideration of dust contamination onto adjacent surfaces still requiring additional coats.
 - The Method Statement shall also consider the most efficient methods and sequencing to avoid unnecessary delays between coats that may have an impact i.e. time required for removal of spent abrasive grit and dust/debris, delay due to material handling, time required to handle, rig and move the component etc.
 - All inspection interventions during and after completion of final coats shall be considered and included.
 - Specifically for confined spaces i.e. condenser water boxes, the Method Statement shall describe all measures and details for establishing and maintaining:
 - ✓ The environmental conditions as required by this specification.
 - ✓ The required ventilation for the prevention and/or management of fumes and dust build-up. The number of extraction fans; mounting diameters, sizes and mounting

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methods of fans to manholes; power rating of fans; positioning of fans and direction of intended air flow shall be described and detailed.

5. Given that the single most limiting aspect of working in CSs is access, the Method Statement shall describe and indicate how and where access will be established for (1) personnel, (2) general equipment – buckets, shovels, etc. (3) lighting equipment, (4) blast equipment, (5) grit removal and cleaning etc. in relation to and considering the manhole/access points already used for ventilation purposes.
6. The detailed Method Statement shall be submitted to Eskom for review and acceptance/rejection prior to the commencement of any work. Eskom reserves the right to request further revision, clarification or additions in accordance with or as required by this specification sheet.
7. The applicator shall submit a detailed, project specific QCP. The QCP shall be based on the detailed Method Statement and shall contain all intervention points and relevant acceptance criteria as per the information as described in the Product Data Sheet/s and this specification sheet. Eskom reserves the right to request further revision, clarification or additions in accordance with or as required by this specification sheet.
8. Under no circumstances shall any work be performed until the QCP and Method Statement have been accepted by the Eskom engineer.
9. The coating manufacturer shall provide technical surveys during the execution of the project. The applicator shall commit to this requirement in the Method Statement.

Reference Documents:

Since the compilation of the Eskom Standards 240-101712128: Standard for the internal corrosion protection of water systems, Chemical Tanks and Vessels and Associated Piping with Coatings there have been changes in terms of the referenced documents i.e. some documents have been withdrawn, replaced or superseded. The following list of references shall apply in addition to the requirements of 240-101712128. The latest revision of the referenced standards shall apply.

Where conflict exists between any of these documents the more stringent requirement shall apply.

1. 240-101712128: Standard for the internal corrosion protection of water systems, Chemical Tanks and Vessels and Associated Piping with Coatings.
2. ISO 9001: Quality Management Systems - "is defined as the international standard that specifies requirements for a quality management system (QMS). Organizations use the standard to

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- demonstrate the ability to consistently provide products and services that meet customer and regulatory requirements.”
3. ASTM D4414: Standard practice for measurement of wet film DFT by notch gauges.
 4. ASTM F21: Standard Test Method for Hydrophobic Surface Films by the Atomizer Test.
 5. ISO 2409: Paints and varnishes – Cross cut test.
 6. ISO 4628 – 1: Paints and varnishes – Evaluation of degradation of coatings – Designation of quantity and size of defects, and of intensity of uniform changes in appearance – Part 1: General introduction and designation system.
 7. ISO 4628 – 3: Paints and varnishes – Evaluation of degradation of coatings – Designation of quantity and size of defects, and of intensity of uniform changes in appearance – Part 3: Assessment of degree of rusting.
 8. ISO 8501-1: Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings.
 9. ISO 8502-3: Preparation of steel substrates before application of paint and related products – Test for the assessment of surface cleanliness – Part 3: Assessment of dust on steel surfaces prepared for painting (pressure sensitive tape method).
 10. ISO 8502-6: Preparation of steel substrates before application of paint and related products – Test for the assessment of surface cleanliness – Part 6: Extraction of soluble contaminants for analysis – The Bresle method.
 11. ISO 8503-4: Preparation of steel substrates before application of paint and related products – Surface roughness characteristics of blast-cleaned steel substrates.
 12. Part 4: Method for the calibration of ISO surface profile comparators and for the determination of surface profile – Stylus instrument procedure. (May be used as an alternative to SANS 5772).
 13. ISO 12944-3: Paint and varnishes – Corrosion protection of steel structures by protective paint systems. Part 3: Design considerations.
 14. SANS 5770: Preparation of steel substrates before the application of paints and related products – Test for the assessment of cleanliness of blast-cleaned steel surface – Freedom from certain soluble salts.

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15. SANS 5772: Preparation of steel substrates before the application of paints and related products
- Surface roughness characteristics of blast-cleaned steel surfaces – Profile of blast-cleaned surfaces determined by a micrometer profile gauge (Can be used as alternative to ISO 8503-4).
16. SIS 055900: Swedish Code of Practice - Pictorial surface preparation standard for painted steel surfaces. (Can be used as alternative to ISO 8501 – 1).

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APPENDIX B: WATER BOX RUBBER LINING

Table to be considered as Annexure D of 240-101712128: “Specification for the Internal Corrosion Protection of Water Systems, Chemical Tanks and Vessels and Associated Piping with Linings”	
Vessels	Condenser Waterboxes
Internal Immersed (Material/Substrate)	Steel/cast iron (rubber lined with natural rubber)
Internal Immersed (Environment)	Immersed, cooling water, pH 8,1 to 8,6, temperature range 25°C to 45°C, flowrates of up to 2.0 metres per second.
Internal Immersed (Surface Preparation and coating)	Abrasive blast clean to Grade Sa 3 (ISO 8501-1). The surface profile as specified by the rubber lining/adhesive manufacturer.
Generic System	<p>To be determined by inspection findings during retubing:</p> <p>Option 1: Rubber Patch Repairs – 6 mm pre-cured Natural Rubber (not less than 50 IRHD)</p> <p>Option 2: Complete Rubber Lining Replacement – 6 mm pre-cured Butyl Rubber (60-70 IRHD)</p>
<p>This specification sheet caters for repair of existing rubber lining, complete removal of rubber lining and relining, and is applicable to Lethabo Power Station BFPT Condenser waterboxes.</p> <p>The work will be performed in situ or when waterboxes are removed for tube replacement. The Eskom engineer will provide information on a case by case basis.</p> <p>In the event of conflict or contradiction between this specification sheet, the Eskom standards or referenced standards below, the most stringent requirement shall prevail.</p>	
<p>Option 1: Rubber Patch Repairs – 6 mm pre-cured Natural Rubber (not less than 50 IRHD)</p> <p>The scope of work for Option 1 will include the following:</p>	

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- Removal of waterboxes from the condenser for tube replacement
- Conduct a detailed visual inspection and pin-hole detection testing (no more than 3 volts per mm) on the existing rubber to check the condition of rubber lining and identify the defects. Identify and mark-up the defects or the areas requiring the repairs.
- Depending on the condition of the waterboxes; to enable proper inspection the waterboxes may require washing with potable water to remove mud/sludge covering the existing rubber lining and followed by drying.
- Before repair work commences the Contractor shall compile a rubber patch repair procedure and submit to Eskom for approval. The repair procedure shall include the following:
 - Cutting out, stripping and removal of the existing rubber in the marked areas as per the above inspections.
 - Surface preparation of the substrate after removal of the existing rubber. For smaller areas to be patch repaired where abrasive cleaning is impractical, the Rubber Liner or Contractor shall propose suitable cleaning method/s. The cleaning method shall be submitted to Eskom for review and approval before the commencement of the work.
 - The Rubber Liner or Contractor shall take cognisance of the fact that after initial surface preparation as above, Eskom may require access for a further inspection and assessment to determine the need for possible mechanical repairs on the shell i.e. welding. Unfortunately, this inspection can only be carried out once the surfaces have been blast cleaned in preparation for lining. Based on the damage on the waterboxes it may be required to conduct mechanical repairs before rubber lining.
 - Rubber lining patch repair of the affected areas. The total surface area to be rubber lined will be determined by inspection findings.
- Care shall be taken during welding and surface preparation to protect the remaining rubber lining from damage such as mechanical damage, welding/grinding sparks and welding spatter.

Option 2: Complete Waterboxes Rubber Lining

- Once a detailed inspection has been conducted as per Option 1 above and the findings indicate that a large area of the existing rubber lining requires repairs then Option 2 shall be considered.

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- The Contractor shall quote for all the options separately. The system engineer or Eskom representative will decide on the option to be implemented. This decision will take into account the condition of the existing rubber lining, waterboxes substrate material, time and cost required in completing the works.
- The Rubber Liner shall remove the existing rubber lining by initial removal techniques such as cutting out, stripping and flapper disc grinding.
- Subsequent surface preparation shall be by means of abrasive blast cleaning. Abrasive blast cleaning to Grade Sa 3 in accordance to ISO 8501-1 shall be adhered to.
- The Rubber Liner shall take cognisance of the fact that after initial surface preparation as above, Eskom may require access for a further inspection and assessment to determine the need for possible mechanical repairs i.e. welding. Unfortunately, this inspection can only be carried out once the surfaces have been blast cleaned in preparation for lining. Based on the damage on the vessel it may be required to conduct mechanical repairs before rubber lining.
- Install the new rubber lining.

Specific Project Requirements:

1. The Eskom standard 240-101712128 (Section 5 in particular), SANS 1201, SANS 1198 and BS 6374-5 shall apply for the manufacture, selection and installation of rubber lining. The Rubber Liner or Contractor shall take note of the type of rubber as specified above.
2. After the old rubber lining is removed and initial surface preparation is completed a detailed visual inspection shall be carried out to check for defects of the steel surface. Where necessary mechanical repairs i.e. welding and grinding shall be carried out before new rubber is installed. The Contractor shall propose substrate repair procedures and submit these to Eskom for approval. The procedure shall be agreed by both parties before commencement of work.
3. Rubber lining shall only proceed once all mechanical activities on the vessels have been completed and released in terms of the applicable manufacturing/fabrication Quality Control Plan (QCP).
4. Surface preparation by abrasive blasting shall be performed by means of conventional hand held blasting equipment capable of removing remaining/residual rubber, rust and suitably preparing the substrate to the required cleanliness of Grade Sa 3.

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5. The rubber lining thickness of 6 mm is specified. The Rubber Liner or Contractor shall confirm the specified thickness as satisfactory for the application.
6. The Rubber Lining Manufacturer, Adhesive Manufacturer and Rubber Liner shall select the relevant primer and or adhesive products/systems for the type of rubber lining, substrate and service conditions to ensure compatibility. All the products to be used on the system shall be supplied by the same Manufacturer.
7. After tender award and prior to project execution the Manufacturer shall submit test samples of the specified lining system in the tender submission. Two samples will be required for reference purposes. The samples (substrates) shall be prepared as per the requirements of the Manufacturer's datasheet and in compliance with the requirements of this standard. The size of the test sample panels shall be (200 mm X 300 mm X 3 mm). The Manufacturer shall supply the relevant batch certificate for each of the lining products used in the submitted test sample panels. Properties such as hardness will be evaluated by Eskom to ensure compliance to the Manufacturer's datasheet. The Manufacturer shall provide written commitment to this requirement at the tender stage.
8. During rubber lining of the vessels the Contractor shall prepare (200 mm X 300 mm X 3 mm) test panels in the same conditions as the vessels, meaning that the samples must be prepared inside the vessels. The prepared test panels shall be sent to Eskom RT&D for destructive analysis.
9. Prior to commencement of rubber lining the Rubber Liner shall submit detailed repair procedures in accordance with BS 6374-5. Any defects such as mechanical damage, cuts, blisters, lack of adhesion and poor joints shall be marked up and repaired according to BS 6374-5 5.2.4.
10. Individual rubber sheets shall be tailored to fit the surface to be lined. The lining shall be bonded to the manhole flange faces. The mating surface of the flange face to gasket shall be suitably dressed such that the face is acceptably flat to ensure sealing between the liner and the gasket. The application and flange arrangement shall be as per SANS 1201 Figure 7 a. or c.
11. All joints of lined rubber shall be strapped as per BS 6374.
12. The rubber lining Manufacturer and Rubber Liner or Contractor shall specify the test voltage and the length of spark (no less than 2 KV per mm). If the rubber Manufacturer

cannot comply with this requirement then a detailed motivation describing the reasons why this requirement can't be met shall be submitted for review, acceptance or rejection.

General Requirements:

1. The Rubber Liner shall be wholly responsible for the surface preparation or rubber lining.
2. The mechanical repairs as mentioned in the specific requirements shall be carried out on the vessels before the commencement of corrosion protection. It is strongly recommended that an engineering subject matter expert (welding engineer) be consulted as part of refurbishment activities.
3. Sharp edges shall be dressed to a radius of not less than 3 mm. All burrs and weld spatter shall be removed as per the requirements of ISO 12944-3.
4. Welds shall be free from imperfections (eg. Asperities, undercutting, blowholes, craters and spatter) which are difficult to cover effectively with a protective system.
5. All sharp edges from the original fabrication shall be rounded or chamfered and burrs around holes and along other cut edges shall be removed. All edges to be rounded off with a grinder to a radius of 3 mm or more. Weld beads with a surface irregularity exceeding 3 mm or with sharp crests having a radius less than 3 mm shall be ground.
6. All welds shall be free of slag, slag inclusions and pinholes. Adjacent areas shall be free of weld spatter, which shall be removed by grinding or scraping.
7. Corrosion protection shall only proceed once all mechanical activities on the vessels have been completed and released in terms of applicable manufacturing/fabrication Quality Control Plan (QCP).
8. All surfaces shall be completely dry and free from contaminants such as traces of oil, grease, etc., before surface preparation is carried out. Special attention shall be paid to drillings, bolt holes, etc.
9. No abrasive blasting or lining applications shall take place when conditions are likely to affect these operations. Clauses 4.1.1.2 to 4.1.1.5 of BS 6374-5 shall apply.
10. Surface preparation by abrasive blasting shall be performed by means of conventional hand held blasting equipment capable of removing mill scale, old rubber/residual rubber, rust and suitably preparing the substrate to the required cleanliness of Grade Sa 3.
11. Only inert mineral grit or steel grit abrasives shall be used. Steel grit is preferred in sensitive plant areas such as Water Treatment Plants in order to ensure no

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- contamination of plant processes due to excessive dust. Sand or silica based abrasives shall not be used. Abrasive material for blast cleaning shall be used in line with local environmental regulations.
12. The abrasive shall be used in accordance to the Manufacturer's specifications and shall be clean, sound, hard particles free from foreign substances such as dirt, oil, grease, toxic substances, organic matter and water soluble salts.
 13. All compressed air for blasting activities shall be free from entrained moisture and oil. All traps shall be in a functional condition. The compressed air shall be tested at regular intervals using clean white cloths to assess cleanliness and dryness. This requirement shall be included in the QCP.
 14. It is important that good quality abrasives are used to minimise the amount of waste grit and dust generated and contamination of the surfaces. The use of recycled blasting media for the final blast is strictly prohibited.
 15. All abrasive media shall be stored in an area that is completely dry, covered and protected from weather.
 16. On completion of grit blasting the surface shall be thoroughly vacuumed until no loose dust is evident. It is imperative that all surface dirt and contaminants are completely removed before corrosion protection shall be impaired. The process shall be repeated until the required level of dust and debris removal is achieved.
 17. The level of cleanliness required shall be less than "dust quality rating" 2 when tested in accordance with ISO 8502-3.
 18. Power and hand tool cleaning is only applicable to very localised touch ups or patch repairs. Hand tool cleaning for isolated/localised areas may be utilised provided the required standard of finish is achieved. For all immersion applications final mechanical cleaning shall be by bristle blaster in order to create a required surface profile.
 19. Cleaning by means of hand or power-tools i.e. wire brushes, chipping hammers, scrapers, grinders, sanders, needle descenders, bristle blasters, etc. may only be used where accepted by the Eskom engineer and where the position and condition of the substrate metal is such that efficient cleaning and surface profile can be achieved.
 20. Burnishing of the surface shall not be permitted.

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21. Prior to rubber lining the Rubber Liner or Contractor shall ensure that the metal surface is suitable for receiving the corrosion protection system. The onus is on the Applicator to ensure that the surfaces are ready for lining.
22. The system Supplier/Applicator shall supply (with the tender) individual product data sheets and material safety datasheets (MSDS) for all products comprising the system i.e. rubber lining, adhesives, tack coats and solvents. For the rubber lining as a minimum the following shall be submitted:
 - A description of the generic type of rubber lining
 - Physical and chemical properties as per table 3 of SANS 1198
 - Recommended and non-recommended uses
 - Service temperatures and chemical resistance limits
 - Surface preparation
 - Confirmation that the lining will not contaminate the material to be handled
23. At all times care shall be taken to ensure adequate protection of the surrounding areas (surfaces and parts of components or systems) not requiring blast cleaning and coating/lining (as an example valve seats/trim, pump inlets, condenser tubes) and every effort shall be taken to prevent grit, water and other dirt entering drain systems, vessel inlet/outlet piping or settling on isolating valve seats, shafts, etc.
24. The supply and cost of all testing, inspection and specialised testing equipment shall be the Rubber Liner's responsibility. QC shall be performed by the Rubber Liner and the Quality Assurance inspection shall be conducted by Eskom. A series of witness and hold points shall be agreed upon such that Eskom may witness any of the above tests. Eskom may elect to carry out its own tests at these times.
25. For all inspections of all surface preparation activities the surfaces shall be clean allowing unhindered visual access to the surface. The applicator shall provide sufficient and adequate lighting (cool white) to enable inspections.

Safety Requirements and Considerations:

1. During the applications of all coatings/lining, care shall be taken to ensure adequate ventilation and lighting, to allow for good visibility and proper curing of the corrosion protection and to avoid/minimise health and safety risks.
2. A confined spaces (CSs) may be defined as an enclosed, restricted, or limited space in which, because of its construction, location or contents, or any work activity carried on

therein, a hazardous substance may accumulate and/or an oxygen-deficient atmosphere may occur, and/or in which a dangerous liquid or dangerous concentration of gas, vapour, dust or fumes may be present. It includes any chamber, tunnel, pipe, pit, sewer, container, valve, pump, sump, chute, bunker, silo, gearbox, tank, receiver, drum or any similar construction, equipment, machinery or object.

3. Flammable Atmospheres: Gases, vapours and dusts can become trapped in CSs and create flammable or explosive atmospheres, and include combustibles e.g. Hydrogen, Acetylene, Paint and thinning/cleaning solvents, etc.
4. Walking / Working Surfaces and Visibility: Poor lighting may add to hazards caused by an irregular, sloped, or constricted working surface.
5. Any solid waste materials or liquids stripped or generated during the coating operations shall be discarded in accordance with the requirements of the appropriate national and/or local authorities or the requirements of Eskom.
6. The applicator shall ensure compliance with all statutory regulations, municipal by-laws, etc. concerning pollution and the health and safety of personnel and/or members of the public who may be affected by the work. The applicator shall provide the personnel with the appropriate required PPE.
7. The applicator shall provide for all necessary safety precautions and risk assessments.
8. The applicator shall advise Eskom of all hazardous materials to be brought on site.
9. All corrosion protection materials materials on site shall be stored in designated areas in storage facilities that meet the storage requirements of the manufacturer and the safety requirements of the specific site. The contractor shall be responsible for the provision of appropriate storage/shipping containers as required. These containers shall include the appropriate refrigeration/conditioning systems for temperature control. This requirement shall be dependent on where the container will be located (indoors/outdoors), typical ambient temperature for the particular season of the year and the maximum storage temperature limits as per the manufacturers recommendations.
10. The applicator's Safety File for the area to be worked it shall address all the hazardous activities of abrasive blast cleaning and rubber lining. The applicator shall verify that the personnel carrying out these activities are suitably qualified.

11. The applicator shall ensure that the abrasive materials used conform to all National Health and Safety Standards.

Specifically with respect to CSs and based on the descriptions and definitions of safety risks as per the above points it is imperative that the contractor's/applicator's Method Statement shall describe in detail, the measures and mitigation steps for the risks and hazards as identified in this specification sheet. It is compulsory that these safety risks/mitigation measures and any others as identified by the contractor/applicator be included in the Method Statement. Prior to the commencement of any work the Method Statement shall be submitted for review, acceptance/rejection by the respective Lethabo Power Station Risk and Safety office/department.

Pre-job Method Statement and Quality Documentation review and acceptance:

1. The rubber manufacturer/applicator shall supply individual product data sheets for all products, comprising the system which shall contain the following as a minimum:
 - A description of the generic type of rubber lining
 - Confirmation that the corrosion protection is suitable for the intended method of application.
 - Recommended and non-recommended uses.
 - Maximum recommended service temperature which shall be a minimum of 30% greater than the maximum temperatures as is indicated in the table at the top of this specification sheet. The corrosion protection system rating shall consider the above temperatures as continuous service i.e. not intermittently.
 - Chemical resistance limits.
 - Surface preparation.
 - Application conditions
2. Prior to the application of any of the corrosion protection systems, the Product Data Sheet/s shall be signed by the manufacturer and applicator. This is to ensure that the manufacturer is aware of this specification, the conditions under which it will be applied and to allow for technical back-up where required.
3. The signed Product Data Sheet/s shall be deemed to be a binding reference document (as part of the QCP). It shall be specific to this project and any further/other subsequent revisions of the Product Data Sheet/s shall be submitted to Eskom for reacceptance

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clearly stating the variations/deviations. No further use/application of the related product, for this project, is permitted until acceptance is granted by Eskom.

4. A detailed Method Statement explaining all required steps as specified in this specification sheet shall be provided at the time of tender. The steps to be considered includes:

- The methods, steps, sequence and equipment required for ventilation and dust mitigation.
- Grease decontamination and washing.
- Soluble salt decontamination.
- The parameter setup for blasting and lining techniques i.e. sweep blasting shall also be included in the Method Statement.
- Methods for dust and debris removal, maintaining and ensuring cleanliness between activities shall be described.
- The Method Statement shall detail the precise sequence and breakdown of work areas/activities in order to apply the system with due consideration of dust contamination onto adjacent surfaces still requiring additional coats.
- The Method Statement shall also consider the most efficient methods and sequencing to avoid unnecessary delays that may have an impact i.e. time required for removal of spent abrasive grit and dust/debris, delay due to material handling, time required to handle, rig and move the component etc.
- All inspection interventions during and after completion of corrosion protection shall be considered and included.
- Specifically for confined spaces i.e. condenser water boxes, the Method Statement shall describe all measures and details for establishing and maintaining:
 - ✓ The environmental conditions as required by this specification.
 - ✓ The required ventilation for the prevention and/or management of fumes and dust build-up. The number of extraction fans; mounting diameters, sizes and mounting methods of fans to manholes; power rating of fans; positioning of fans and direction of intended air flow shall be described and detailed.

5. Given that the single most limiting aspect of working in CSs is access, the Method Statement shall describe and indicate how and where access will be established for (1) personnel, (2) general equipment – buckets, shovels, etc. (3) lighting equipment, (4) blast

- equipment, (5) grit removal and cleaning etc. in relation to and considering the manhole/access points already used for ventilation purposes.
6. The detailed Method Statement shall be submitted to Eskom for review and acceptance/rejection prior to the commencement of any work. Eskom reserves the right to request further revision, clarification or additions in accordance with or as required by this specification sheet.
 7. The applicator shall submit a detailed, project specific QCP. The QCP shall be based on the detailed Method Statement and shall contain all intervention points and relevant acceptance criteria as per the information as described in the Product Data Sheet/s and this specification sheet. Eskom reserves the right to request further revision, clarification or additions in accordance with or as required by this specification sheet.
 8. Under no circumstances shall any work be performed until the QCP and Method Statement have been accepted by the Eskom engineer.
 9. The corrosion protection manufacturer shall provide technical surveys during the execution of the project. The applicator shall commit to this requirement in the Method Statement.

Reference Documents:

Since the compilation of the Eskom Standards 240-101712128: Standard for the internal corrosion protection of water systems, Chemical Tanks and Vessels and Associated Piping with Coatings there have been changes in terms of the referenced documents i.e. some documents have been withdrawn, replaced or superseded. The following list of references shall apply in addition to the requirements of 240-101712128. The latest revision of the referenced standards shall apply.

Where conflict exists between any of these documents the more stringent requirement shall apply.

1. 240-101712128: Standard for the internal corrosion protection of water systems, Chemical Tanks and Vessels and Associated Piping with Coatings.
2. ISO 9001: Quality Management Systems - "is defined as the international standard that specifies requirements for a quality management system (QMS). Organizations use the standard to demonstrate the ability to consistently provide products and services that meet customer and regulatory requirements."

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3. ASTM D4414: Standard practice for measurement of wet film DFT by notch gauges.
4. ASTM F21: Standard Test Method for Hydrophobic Surface Films by the Atomizer Test.
5. ISO 2409: Paints and varnishes – Cross cut test.
6. ISO 4628 – 1: Paints and varnishes – Evaluation of degradation of coatings – Designation of quantity and size of defects, and of intensity of uniform changes in appearance – Part 1: General introduction and designation system.
7. ISO 4628 – 3: Paints and varnishes – Evaluation of degradation of coatings – Designation of quantity and size of defects, and of intensity of uniform changes in appearance – Part 3: Assessment of degree of rusting.
8. ISO 8501-1: Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings.
9. ISO 8502-3: Preparation of steel substrates before application of paint and related products – Test for the assessment of surface cleanliness – Part 3: Assessment of dust on steel surfaces prepared for painting (pressure sensitive tape method).
10. ISO 8502-6: Preparation of steel substrates before application of paint and related products – Test for the assessment of surface cleanliness – Part 6: Extraction of soluble contaminants for analysis – The Bresle method.
11. ISO 8503-4: Preparation of steel substrates before application of paint and related products – Surface roughness characteristics of blast-cleaned steel substrates.
12. Part 4: Method for the calibration of ISO surface profile comparators and for the determination of surface profile – Stylus instrument procedure. (May be used as an alternative to SANS 5772).
13. ISO 12944-3: Paint and varnishes – Corrosion protection of steel structures by protective paint systems. Part 3: Design considerations.
14. SANS 5770: Preparation of steel substrates before the application of paints and related products – Test for the assessment of cleanliness of blast-cleaned steel surface – Freedom from certain soluble salts.
15. SANS 5772: Preparation of steel substrates before the application of paints and related products – Surface roughness characteristics of blast-cleaned steel surfaces – Profile of

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blast-cleaned surfaces determined by a micrometer profile gauge (Can be used as alternative to ISO 8503-4).

16. SIS 055900: Swedish Code of Practice - Pictorial surface preparation standard for painted steel surfaces. (Can be used as alternative to ISO 8501 – 1).

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APPENDIX C: GASKET RUBBER MATERIAL DATA SHEET



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Technical Data Sheet

GP 45

General properties and application

GP 45 has very good abrasion and rebound properties. It is not recommended for use in areas with hydrocarbons and oils. It does not have a high operating temperature but has good mechanical properties and is a very resilient material.

Basis	Natural Rubber Blend	
Temperature	Recommended maximum	70°C
Pressure	Recommended maximum	1 000 kPa

Typical Properties

Tensile Strength	10 Mpa
Compression set	40%
Hardness (A)	45 ± 5
Elongation at break	500%
Specific Gravity	1.2
Tear Strength	25 kg/cm
Ozone resistance	Poor

Available in rolls 1.2 metres wide and approximately 10 metres long.

Thickness range 1.5mm, 3mm, 4.5mm, 6mm, 10mm, 12.5mm, 15mm, 20mm and 25mm

This information represents typical values, which can vary according to the application. These values do not constitute a performance guarantee. Users should determine, prior to use, the suitability of this material for their particular application.

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APPENDIX D: TOOL LIST

Minimum quantity	Quantity available per BFPT condenser	Tool / Equipment Description	Description, Type or Make where applicable
4		Tube stub puller or spear	
2		Automatic puller	
4		Internal tube cutter mandrel	
10		Tube cutter replacement blades sets	
6		Tube expander drive	
10		5 Pin roller expanders	
10		Sets of spare rollers including taper pin	
		Lubricant for expansion	
5		Tube facing tools	
10		Tube facing tool replacement blades	
1		Torque analyser (Independent device to verify expander drive torque)	
1		Adjustable reamers from 23.0 – 24.0mm	
5		Set of replacement reamer blades	
2		Calibrated 3-Prong internal micrometer, min accuracy 0.01 mm	

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2		Calibrated external tube vernier, min accuracy 0.01 mm	
50		23.4 ±0.05 mm outside diameter spherical carbide ball burrs	
200		Cylindrical flapper disc / Wire brush for cleaning tubesheet holes. Diameter 21mm. Grit size 80 or finer	
2		Pneumatic Flaring tool mandrels	
1		Industrial vacuum cleaner	
1		High pressure water washer (minimum 150 Bar) to clean support plates before loading tubes	
2		Go-No-Go gauge with at least 7 intervals from 23.4 mm in 0.1 mm steps	
4		Pneumatic ball burr or brush driver	
5		Stainless steel wire cup brushes	
1		At least a 2 metre long straight edge	
One sets		Water spray piping and nozzles	

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20		Expandable rubber plugs catering for ranges from 21 to 22 ID of tube	
		Slings and rigging equipment for removal of waterboxes and CW duct with valid test certificates as per OHS Act	
5		95% fill factor based on internal area bullet test for blowing through tubes after installation. The outer diameter of the plugs shall be 95% fill factor.	

Consumables: The above quantities are required for one BFPT condenser at Lethabo Power Station

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