Eskom	Technical specification	Technology

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CONTENTS

FIGURES

TABLES

1. INTRODUCTION

Arnot Power Station has two cooling systems, serving three units on the north (using polygrids packing) and south side (using asbestos cement packing). For each side, CW is distributed from a pump center well to three units. The CW passes through the condenser units to 3 cooling towers where it is cooled and drains back to the pump center well. The northern cooling water system is depicted in Figure 1.

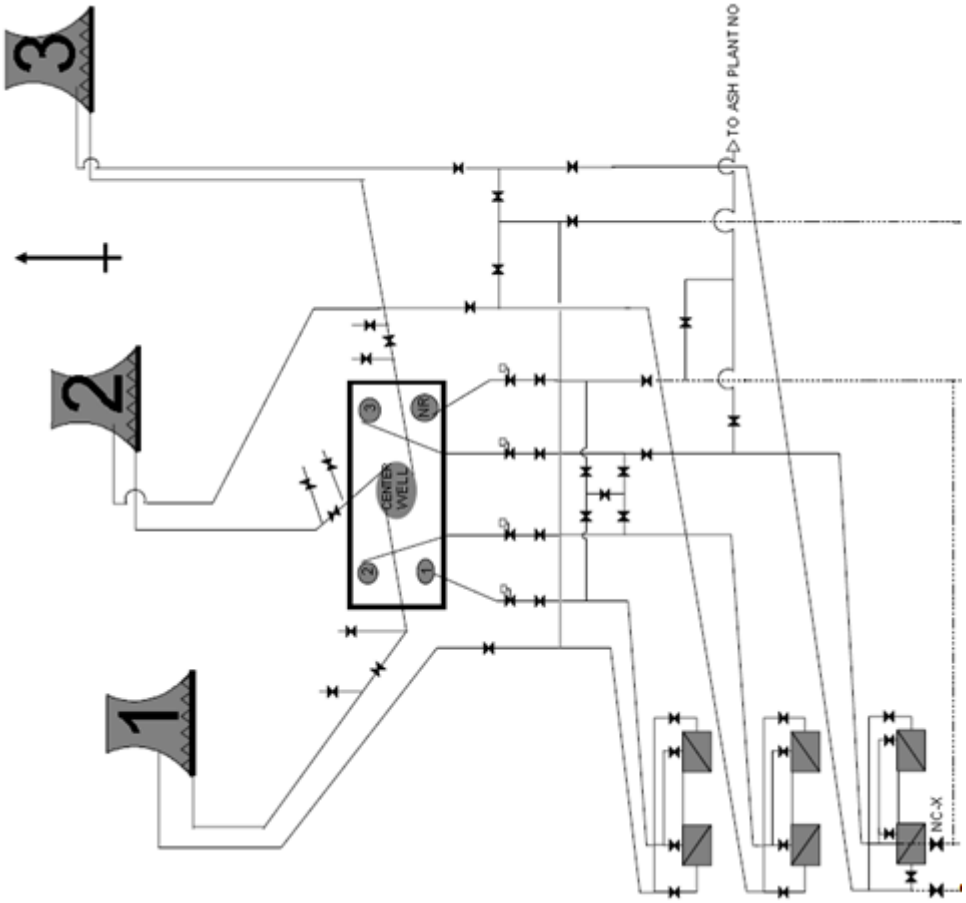

Figure 1: Arnot CW system

2. SUPPORTING CLAUSES

2.1 SCOPE

The report covers the technical specification for the refurbishment of Arnot power station cooling tower no.2.

2.1.1 PURPOSE

The purpose of the document is to provide technical requirements for the scope of work w.r.t. the manufacturing, supply and installation of new cooling tower fill at Arnot's north cooling tower no.2. It also includes the requirements for minor refurbishment related work which forms part of the scope of work.

2.1.2 APPLICABILITY

This document shall apply to Arnot PS.

2.2 NORMATIVE/INFORMATIVE REFERENCES

Parties using this document shall apply the most recent edition of the documents listed below:

2.2.1 NORMATIVE

[1] ISO 9001 Quality Management Systems

[2] OHS Act 85 of 1993

[3] BS 4485 Part 2: Cooling Tower Performance Testing

[4] GNR 155 of February 2002: Asbestos Regulations

[5] **240-55864841** Legionella Guideline

[6] **240-55864767** Chemistry and Microbiology Standard for Condenser Cooling Water

[7] **240-77801161** Structural Design and Engineering Standard

[8] **240-99527377** Inspection Manual for Civil Works at Eskom's Power Stations

[9] **SANS 893-2:2013** Legionnaires' disease Part 2: The control of Legionella in Water systems

[10] 32-303 Requirements for safe processing, handling, storing, disposal and phase-out of asbestos and asbestos containing material, equipment and articles

2.2.2 INFORMATIVE

[11] **240-56030508** Cooling Water System Health Care Guideline

[12] **384-ANT-MBBZ28-SP0008-3** Refurbishment of Arnot Power Station – North Cooling Towers 1-3 Stakeholder Requirements Definition report

[13] **SA052-R01** Natural draught cooling towers April 2004 performance tests, May 2004

[14] **TRR/P91/021** Arnot Power Station LIFEX Programme performance tests on cooling towers no 2 and 4, Feb 1991

[15] Arnot Power Station cooling tower no 2 performance test, March 1973

[16] **474-11343**: Arnot Power Station-Internal Visual Inspection Report for Northern Cooling Towers Proposed Maintenance Walkways Support Beams.

2.3 DEFINITIONS

Definition	Description
Designer	The *Contractor* may possess the design capability in-house. Where this is not the case, the sub-contracted legal entity with the design capability i.e. the *Designer*, shall demonstrate compliance with the requirement(s) as defined below in Section 6.1.1.

2.3.1 DISCLOSURE CLASSIFICATION

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

2.4 ABBREVIATIONS

Abbreviation & Acronyms	Description

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AIA	Authorised Inspection Authority
BS	British Standard
CAD	Computer-Aided Design
CoE	Centre of Excellence
CW	Cooling Water
EDWL	Engineering Design Work Lead
GNR	Government Notice Regulation
GRP	Glass Reinforced Plastic
HEPA	High efficiency particulate air
ISO	International Organization for Standardization
LDE	Lead Discipline Engineer
OIT	Oxidation Induction Time
PEIC	Production Engineering Integration Coal
PS	Power Station
PVC	Polyvinyl chloride
ROC	Required Operating Capability
SHE	Safety, Health and Environmental
SRD	Stakeholders Requirements Definition
SS	Stainless Steel
UT	Ultrasonic testing

2.5 ROLES AND RESPONSIBILITIES

N/A

2.6 PROCESS FOR MONITORING

N/A

2.7 RELATED/SUPPORTING DOCUMENTS

N/A

3. THE WORKS

3.1 BACKGROUND

The north side consist of 3 cooling towers (towers 1-3). The towers are identical with a height of 122 m and a pond diameter of 90 m. Towers 1-3 are also larger than the southern towers. The asbestos cement distribution pipes (fed from a central diametral duct) are fitted with upward discharging *Ham* sprayers.

These towers were originally designed for the following performance parameters:

Table 1: Original Arnot Cooling Tower performance parameters

Inlet Flow	9.3 m^3/s
Cooling range	12.7 °C
Re-cooled temperature	24.0 °C
Dry bulb temperature	13.9 °C
Relative Humidity	66%

There are no records of the northern towers being re-packed. The towers are currently fitted with the original fill, consisting of polygrid type splash fill at a spacing of 15 ½" (~393mm). The original design was for 10 layers as indicated on drawing 0.41/5152 (see below). Asbestos cement drift eliminators are mounted above the sprayers. The drift eliminators, however, do not cover the entire cross sectional area of the cooling tower. One access door and stairs provide access into the cooling tower shell. Technical details of the cooling tower design are given in the drawings listed in Section 5.

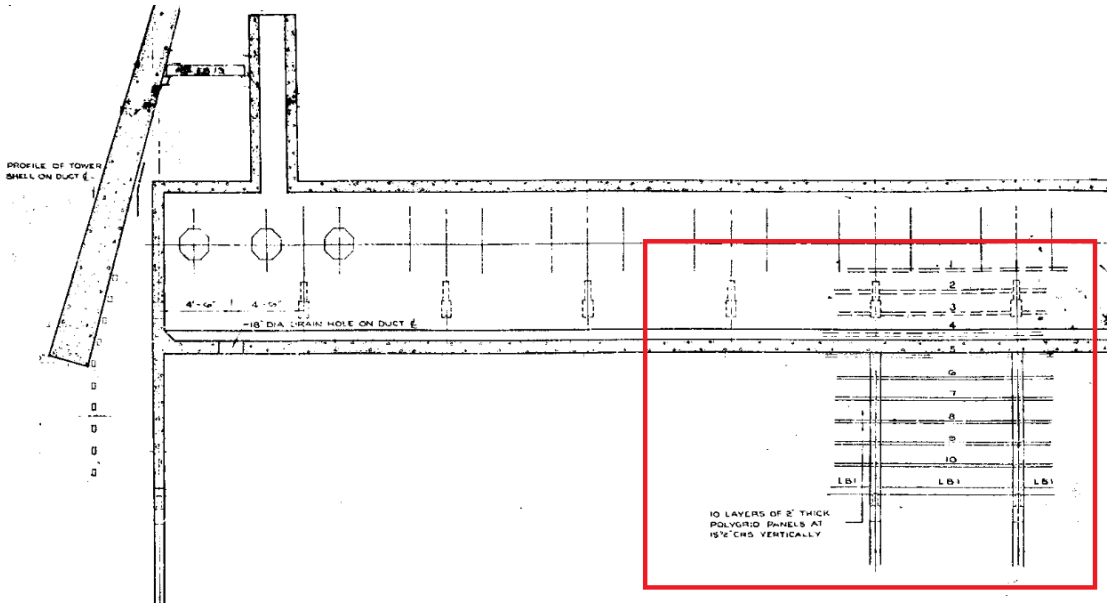

Figure 2: Initial design for north cooling towers (see 0.41/5152)

The cooling towers were completed in 1973 with the re-cooled water temperature being, on average, 2.2°C better than the predicted value (measured on tower 2). Another performance test was carried out 18 years later on tower 2 and the re-cooled water temperature was still lower than the predicted value, however, now only 0.8°C better. The results of the tests are shown in the table below.

Table 2: Cooling tower 2 performance for 1973 and 1991

		TOWER NO 4		TOWER NO 2	
		ACCEPTANCE TEST	PRESENT TEST	ACCEPTANCE TEST	PRESENT TEST
Date of test		6-3-74	29-1-91	29-3-73	7-2-91
Period selected		15:15-16:15	16:00-17:00	14:30-15:30	15:30-16:30
Flow to tower	m^3/s	8,85	9,65	9,31	9,12
Inlet water temperature	°C	40,8	42,9	38,4	39,9
Outlet water temperature	°C	28,0	30,4	26,0	28,2
Cooling range	°C	12,8	12,5	12,4	11,7
Dry bulb temperature	°C	24,5	26,9	25,3	27,3
Wet bulb temperature	°C	14,4	18,7	16,9	18,4
Relative humidity	%	35,0	48,0	45,1	44,8
Barometric pressure	kPa	83,2	83,4	83,3	83,3
Wind velocity	m/s	3,2	3,7	Variable	3,2
Predicted water outlet temperature	°C	28,6	30,9	28,2	29,0
Comparison with predicted	°C	0,6 lower	0,5 lower	2,2 lower	0,8 lower

In 2004 another performance test was carried out, this time the test covered all operating towers i.e. all towers except no. 6 which was off due to maintenance. The results, taken form a report by *KP Energy* who conducted the tests, still indicated that the towers performed to satisfactory levels, although not as good as the original performance of 1973. The results of these tests are shown below:

Table 3: Cooling tower 2 performance for 1991 and 2004

		NORTHERN CW SYSTEM	
		Tower 2	Towers 1, 2 & 3
Date of test		02-07-91	26/4/2004
Period selected		15:30 - 16:30	12:00 - 15:33
Flow	m^3/s	9.12	9.12
Inlet hot water temperature	deg C	39.9	38
Outlet cold water temperature	deg C	28.2	24.8
Cooling range	deg K	11.7	13.2
Dry bulb temperature	deg C	27.3	18.9
Wet bulb temperature	deg C	18.4	14.4
Relative humidity	%	44.8	63.6
Barometric pressure	mb	833	837.8
Wind velocity	m/s	3.2	4
Predicted outlet cold water temperature	deg C	28.14	24.8
Comparison with predicted	deg C	0.06	0
TOWER CAPABILITY			
To Original Duty			119.00%
To Northern CW System Duty			119.00%
To Northern Cooling Towers			100.00%

An internal civil visual inspection of the precast concrete support beams was performed on CT's 1-3 in March 2017. Significant scaling was identified during the inspection period on the precast concrete beams; however no evidence of corroding reinforcement was identified as per Arnot Power Station-Internal visual inspection report (474-11343).

3.2 DETAIL DESCRIPTION OF THE *WORKS*

Cooling tower no.2 will be shut down during the Arnot Unit 2 Outage. The outage date is provided in the corresponding NEC document. The off-line outage duration for cooling tower no.2 is 65 days during which time the complete scope of work as detailed in this specification must be completed.

The *Works* consists of the following, applicable for each tower included in the scope of work:

- The design, procurement, transport, installation and commissioning of the new splash fill.
- Removal of the existing polygrid fill and fill supporting wires of each cooling tower.
- Disposal of existing polygrid fill, fill supporting wires and all other debris removed from each cooling tower.
- Inspection and cleaning of the distribution system: All broken or missing distribution pipes are replaced with PVC pipes. All pipes are cleaned with high pressure water on the internal and external surfaces.
- Cleaning of the diametral ducts provided satisfactory tower isolation can be achieved. Any debris/mud in the duct needs to be cleaned by the *Contractor*.
- Inspection of all sprayers: Sprayers which are blocked are removed from the pipe, cleaned and replaced. All broken sprayers are replaced with new ones of the same type and size. If the original sprayers cannot be installed, new saddles are to be strapped on the pipe and the sprayer replaced. See Figure 3 as an example:

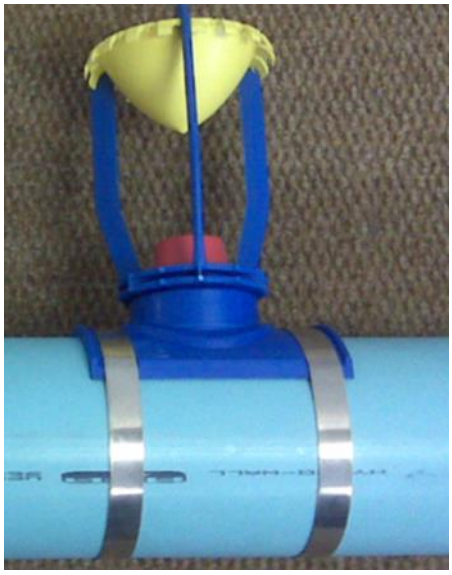

Figure 3: Example of sprayer with strap-on saddle

- Inspection of all end-caps: The existing distribution pipe end-caps are inspected and the condition thereof evaluated for possible refurbishment or replacement. Should the existing end-

caps be unserviceable, new grade 304 stainless steel lever operated end-caps are provided and installed by the *Contractor.* Refer to Figure 4 below:

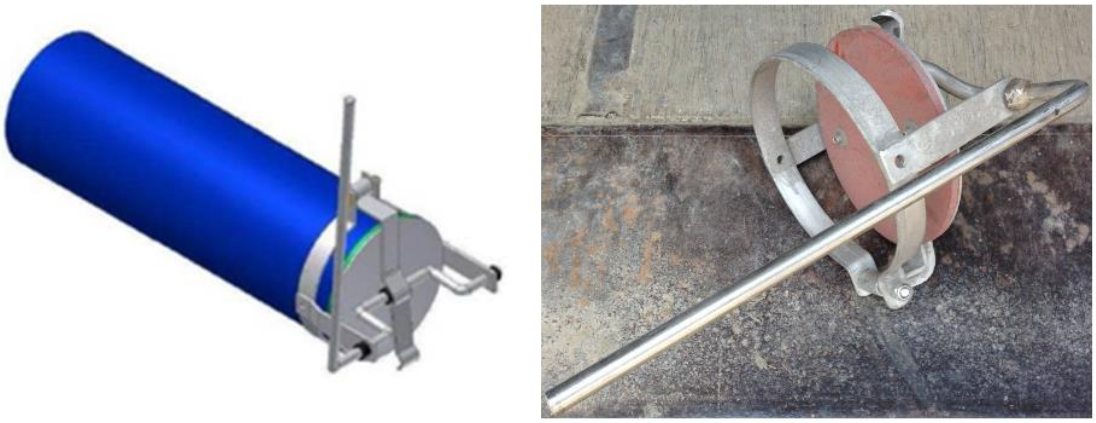

Figure 4: Example of end-cap

- High pressure cleaning of external surfaces of diametral duct and tower shell from the inlet up to 1.5 m above the distribution pipes to remove all scale.
- The establishment of a suitable site based construction management service ensuring the construction is in accordance with the design and specification.
- Where required, existing corroded or unsafe hand rails and steps to be replaced with galvanised or stainless steel.
- The submission of all documentation and drawings and the completion of technical schedules.
- Performance charts signed by the *Designer* predicting the cooling tower performance for the following ranges:

Table 4: Performance chart range

Dry bulb air temperature	5-35 °C
Relative Humidity	10-90% (10% increments)
Water flow rate	70-130% (10% increments)
Cooling Range	7-15 °C (1° intervals)
Cold water temperature	20-35 °C (1° intervals)

These performance curves shall be supplied within two months after the contract date.

The *Contractor* supplies and provides all the constructional plant, temporary works, materials for both temporary and permanent works, labour and supervision, transport to or from the site and in and about the *works* and other things of every kind required for the design, construction and completion of the w*orks*. If applicable, a sub-contracting agreement shall be in place between the *Contractor* and *Designer* for the entire project period.

3.2.1 PERFORMANCE SPECIFICATION

The duty point for each one the north cooling towers no.1, no.2 and no.3 are defined as follows:

Table 5: Performance specifications: Duty point

Circulating water flow rate	9.6 m^3/s
Cooling range	12.7 °C
Cold water temperature	24.0 °C
Atmospheric dry bulb temperature	15.6 °C
Relative humidity	65%
Atmospheric pressure	84 kPa

The main cooling tower dimensions are as follows (all three cooling towers identical):

Table 6: Performance specifications: Cooling tower dimensions

External outlet diameter	60 m
Internal inlet diameter	85.8 m
Shell height	114.3 m
Air opening height	7.9 m
Total height above pond wall	122.2 m (shell height plus the air opening height)
Distribution pipe height above pond wall	10.06 m

3.2.2 FILL REMOVAL AND INSTALLATION METHOD STATEMENT

A preliminary method statement shall be submitted as part of the tender returnables, which should include details regarding the following items/activities:

- High level fill installation method statement:
  - Order of activities.
  - Access control.
  - Details of access arrangements to the fill elevation, working platforms, scaffolding, etc.
  - Safety precautions.
- Procedure for handling asbestos.

3.2.3 FIRE PREVENTION DURING CONSTRUCTION METHOD STATEMENT

Due to the large amount of combustible material which will be handled during this project, the risk of fires is high. The *Contractor* is to provide a preliminary fire prevention strategy during storage of material and during the installation of material in the cooling tower. Please note that no permanent fire detection equipment is installed around cooling tower no.2. Items to be considered:

- Access control
- Fire prevention methodology in laydown area
- Fire prevention methodology during and after installation in cooling tower
- Fire detection
- Equipment to extinguish fire

3.2.4 PERFORMANCE TEST

A performance test for information will be done on tower 2 after the fill replacement is completed. The test will be done by the *Designer*, in accordance with the requirements BS 4485 Part 2 (1988). The *Employer* may do independent measurements during the same time period.

All test instruments are supplied, calibrated and installed by the *Contractor*.

The *Designer* shall compile a test procedure which shall be submitted to the *Employer* for comments and acceptance, 6 months after the c*ontract date*. The following measurements shall be done as a minimum:

Table 7: Minimum measurements for performance test

Parameter	BS 4485 section	Number of measurements
Wind velocity	5.1	1
Inlet air dry bulb temperatures	5.2	4
Inlet air wet bulb temperatures	5.2	4
CW inlet temperatures	5.3	2
CW outlet temperatures measured in outlet structure	5.3	8

CW flow rate*	5.4.1.1 and 5.4.2.2	1

*The CW flow will be measured with a single velocity traverse from the top of the pipe using the stub in the meter pit to cooling tower 2. The stub for the traverse to be installed by others.

The *Designer* shall document the test methodology, test results and comparison of the measured performance with the supplied performance curve and submit the report to the *Employer* no more than one month after the performance test date.

3.2.5 COMMISSIONING

The *Contractor* attends the start-up of cooling tower no.2 after fill replacement.

4. WORK TO BE PERFORMED BY THE *CONTRACTOR*

4.1 FILL

The minimum acceptable material for any metallic components such as bolts, anchor bolts, nuts, pins, etc. installed inside the cooling tower is grade 304 stainless steel. Handrails or steps inside cooling tower no.2, which need replacement, are grade 304 stainless steel or galvanised steel.

The *Employer's* expectation is that the new cooling tower fill will remain in operation for a minimum period of 25 years with little maintenance.

The new fill shall comprise of horizontal layers of suspended splash type fill. The horizontal layers should comprise of individual fill elements installed in a horizontal orientation. Each element shall be supported by four (4) support brackets.

Fill elements will be rigidly secured against vertical and lateral movement, particularly at the tower periphery and at the lower levels of the fill. As a minimum the fill should be stabilized at the bottom layer and at one intermediate layer of the fill which is installed below the bottom of the shell by means of horizontal wires or similar constraints.

The **fill elements** are to be suspended by vertical support wires with the following requirements:

- Minimum acceptable material for the support wires - grade 304.
- Minimum acceptable support wire diameter - 4 mm.
- The *Contractor* shall submit 3 random samples of the support wires (per cooling tower) to a SANAS accredited laboratory for chemical analysis and comparison to a recognised (European or US) material standard for the specified material. The 3 samples shall be selected from different batches and labelled in the presence of the *Employer* as soon as the material arrives on site at the beginning of the project.
- Support wires shall be of the interlocking type, i.e. separate wires shall be installed between each fill layer. No bolts, screws, spacers, clamps, etc. are allowed to secure support brackets onto the support wires. Continuous wires where the fill layers are separated by spacers are not acceptable.
- The connection details of the support wires to the concrete structure are designed to eliminate a stress concentration which may result in fatigue related failures of the wires.

- If exiting hooks in the cooling tower fill support structure is worn, they shall not be used. The *Contractor* proposes an alternative method for acceptance by the Employer. It is not allowable to use any other of the existing concrete beams in the cooling tower to suspend the fill from, other than the beams which are currently used. The Contractor shall provide a report to the Employer proving that the pre-cast beams in the tower is not exposed to more loads or moments than the current loads.
- All support wires shall be vertical from the top anchor point to the lowest fill layer. If the size of the new fill elements does not correspond to the existing support structure in cooling tower no.2, the *Contractor* shall add additional support beams or anchors to ensure that all support wires are vertical. Support beams shall be either grade 304 stainless steel or GRP. The maximum deflection in the centre of beams shall not exceed 0.5% of the length of the beam after fill installation.
- Each support wire assembly, i.e. interlocking wires and support brackets, shall be designed to carry a minimum load of 120 kg without any sign of deformation.
- The support brackets for the fill elements are to be supported on the connection point of the support wires.

Requirements for the individual **splash elements** and **support brackets** are as follows:

- Each element will be supported on each one of the four corners.
- Support brackets interlocks with the fill elements with a minimum of two interlocking prongs at each interface point, e.g. assuming that each bracket will support the 4 corners of the elements, the bracket shall have 8 prongs as a minimum.
- The fill elements cover the entire horizontal inlet cross sectional area of cooling tower no.2 and the elements are cut to fit around support columns and against the tower shell.
- Any gap of greater than 50 mm is considered as excessive and is to be corrected.
- The interlocking arrangement between the fill elements and brackets shall be such that the connection cannot become undone by normal forces imposed on the fill, e.g. wind, water, moderate ice, etc. No cable ties, wires, etc. are allowed to connect fill elements to support brackets.
- If fill elements are cut, the element shall still be supported by at least 4 support brackets on the 4 corners of the element. The *Contractor* provides a detailed description and drawing in the tender, detailing the support bracket to fill element attachment arrangement on a corner where the fill element will be cut. It is **only** allowable to use polypropylene cable ties (with a minimum width of 6 mm) to secure fill elements to the support brackets on positions where the fill element will be cut.
- The maximum cantilever length of any part of the fill element shall be 25% of the element side length i.e. the maximum unsupported length of a fill element is 25% of the element side length.
- Nylon cable ties are not allowable.
- It is not allowable to use wires to tie fill elements to each other or to support brackets.
- Fill elements shall be flat. The maximum natural deflection of the elements shall be less than 10 mm, measured on any position of the element when the element if placed on flat surface.
- Only virgin polypropylene (PP) material may be used for the entire production of polymer fill elements and support brackets and no re-ground material is allowed.
- The minimal acceptable grade of polypropylene for the fill elements is Sasol Polymers grade CPV340 or equivalent grade or supplier as approved by the *Employer*. In addition to the base

material components, ultra violet stabilisers, anti-oxidants, leach prevention agents and carbon black should be added to extend to life of the material. These additions are referred to as the master batch.

- The *Contractor* specifies the formulation and dosage percentage of the master batch in sufficient detail as part of the tender to allow an independent review of the proposed material.
- The base material of the master batch shall be virgin PP.
- The fill elements shall be moulded in South Africa.
- The moulded articles shall not contain excessive flash and no short moulded elements are acceptable. All produced elements will be inspected for stress whitening and if found the article is rejected.
- The physical properties of at least one packing element out of every batch will be tested by means of an impact test at room temperature. During a typical impact test the packing element will be subjected to a falling weight of 2.5 kg from a distance of 1.5 meters while being supported at the designed positions. The fill element shall suffer no permanent damage as a result of test.
- The *Contractor* shall test one of the first fill elements made from each material batch for Oxidation Induction Time (OIT) analysis using a Differential Scanning Calorimeter (DSC). These tests shall be done in South Africa by an industry recognised test facility. Tests shall be performed in accordance with ASME D3895-14. A report must be provided with sufficient information to allow future tests to be replicated in the future with reasonable accuracy. A minimum of 6 OIT tests shall be done for the fill elements manufactured for one cooling tower. The report as a minimum shall contain the following information.
    - Calibration details of the DSC
    - Grade of Nitrogen and Oxygen used
    - Individual flow rates of Nitrogen and Oxygen
    - Material, dimensions and average mass of the sample pans used.
    - Mass of polymer samples used
    - Temperature selected for isothermal test runs
    - Settling time after melting and before changeover to Oxygen.
    - Pressure inside the testing equipment.
    - The determined Oxidation Induction Time (OIT)
- The minimum acceptable OIT is 20 minutes

The purpose of the OIT tests is to keep the results as a reference which can be used as a baseline to future tests on deteriorated material. To this end, the raw data used to determine the OIT must be supplied in a suitable electronic format (e.g. CSV) with appropriate headings and units to allow the OIT to be independently verified at a future date. It is advised that a suitable isothermal temperature be chosen for the particular polymer such that oxidation is not observed too quickly, allowing sufficient resolution for comparison with future tests on degraded samples

- The maximum length for any of the four element sides is 1.2 metre.
- The minimum frontal surface area (viewed from the top) of each fill element is 15%.

The minimum number of fill layers to be installed in each cooling tower is 10 layers. Note: the minimum number of fill layers to be installed is a function of the frontal area of each fill element. Refer to Table 8 below. Each fill layer is to cover the entire horizontal inlet cross sectional area of a cooling tower, i.e. no steps in fill layers allowed.

Table 8: Number of fill layers to fill surface area function

Range of fill element surface area, %	Minimum number of fill layers
15 - 15.5	14
15.5 - 17	13
17 - 18.5	12
18.5 - 20	11
> 20	10

- The vertical distance between each fill layer shall not be less than 390 mm. The *Employer* acknowledges that fill layers will extend to below the inlet edge of the shell.
- The following fill materials will not be acceptable:
    - Asbestos cement
    - Fibre cement
    - PVC
    - Metallic fills

4.2 DIAMETRIC DUCT

Solid scaffolding platform to be erected on the floor level (inside diametric duct) of the diametric duct on top of the risers, i.e. to create a walkway between the adjacent ducts. All debris and sludge to be cleaned manually inform the ducts (internal) and dumped on the pond floor through the maintenance openings in the duct floor. The pond will be cleaned after cleaning the diametric ducts. HP-clean (400 bar and above at a flow rate of 45 l/min) the internals of the all diametric ducts. This includes the removal of flakes and sludge. Debris shall not be dumped down the risers or on top of the fill. **Acceptance criteria**: All scale to be removed from the internal surface of the diametric duct.

4.3 WATER DISTRIBUTION SYSTEM

For the repair of broken or damaged asbestos cement distribution piping, PVC pressure piping class 6 or better (nominal bore not less than 150 mm) is to be used. Details of couplings and reducers shall be submitted to the *Employer* for acceptance.

The use of Asbestos and Fibre Cement products is not allowed.

Each distribution pipe must be cleaned with a high pressure lance travelling the full length of the pipe. A lance with a high pressure spray head can be inserted from the diametric duct (when tower is isolated) or from holes where sprayers have been removed (at regular intervals). A pump discharge pressure of between 400 and 450 bar with a flow rate of 45 l/minute shall be maintained during cleaning. Criteria for acceptance are defined as: no loose debris visible for the entire length of the pipe and all scale are removed from the internal pipe surface.

4.4 SPRAYERS

Sprayers which show no sign of damage and are clean will remain as is. Where it is necessary to replace any broken sprayers, the same type and size as the original will be installed by the *Contractor*. Refer to Figure 3. After cleaning the distribution pipes, blocked sprayers should be cleaned and replaced.

4.5 END-CAPS

End-caps shall be of grade 304 stainless steel. Where required, new lever operated end-caps (see Figure 4) must be fitted to the end of relevant distribution pipework for flushing purposes. The end-caps must be of proven design and shall withstand a water head of at least 5 m in the closed position. The end-caps shall be of robust construction; the minimum design requirement is that the end-cap can withstand an open or closing torque of 75 Nm (lever minimum length being 250 mm) without any sign of permanent deformation.

4.6 DRIFT ELIMINATORS

The Drift Eliminators will be cleaned with water (typically 6 bar). All fallen algae must be removed to avoid it falling through on top of the fill on a regular basis. In addition, when cleaning is done all flakes and excessive sludge will be removed. The Contractor must do the cleaning from below. When the cleaning from above, a length of walkway with a minimum width of 800 mm must be in place. Each walkway plank length will be long enough that it will be supported on two Drift Eliminator support beams. Only one person will be allowed on one section of walkway. When more than one walkway is erected, they must not rest on the same Drift Eliminator support beams. Replacement of broken asbestos Drift Eliminators to be replaced with PVC drift eliminators. Include additional supports if required The contractor shall supply a drawing of the drift eliminators used indicating the material and dimensions of the drift eliminators as well as maximum supporting beam span to avoid sagging or deformation at a continuous temperature of 45 °C. In addition a verifiable reference list of where the drift eliminators were used in past to be supplied as part of the tender.

4.7 POND AND OUTLET SCREENS

Sludge and debris are to be removed from the pond by the Contractor and dumped on a designated site area that will be predetermined by the Station. All dumped debris should be removed by the Contractor. The floor of the pond is then to be swept with brooms to remove all loose debris. The contractor must ensure that debris is not collected/ dumped to the outlet screens. Pond outlet screens to be cleaned and repaired where necessary. All screens shall be removed from position and the outlet structure floor shall be cleaned before replacing the screens. **Acceptance criteria**: No debris visible in pond or screen outlet.

4.8 HP CLEANING OF EXTERNAL SURFACES

HP cleaning of external surfaces includes the diametric duct, distribution pipes and tower shell (from inlet up to 1.5 m above the distribution pipes) with the purpose to remove all scale.

All of the above surfaces to be cleaned by HP lances. Pump discharge pressure of between 400 and 450 bar with a flow rate of 45 l/minute shall be maintained during cleaning. Criteria for acceptance are defined as: no loose debris or adherent scale remain.

4.9 HOT & COLD DUCTS

Brooms, Rubber squeegees, Plastic egg lifters, Industrial type bags, Plastic buckets are to be used instead to clean the floor and duct walls. No HP cleaning (water jet), metal tools, spades, etc. or scaffolding to be used inside the ducts. Only loose scale is to be removed on the duct walls. Any adherent scale is to be left as is. Access ladders into the ducts are to be fitted with plastic or rubber feet to prevent damaging the ducts' inner surface. All debris and loose scale to be removed from inside the ducts. **Acceptance criteria**: Complete removal of loose scale from the duct wall. Any adherent scale is to be left as is so as not to remove the paint.

4.10 DRAWINGS

The *Contractor* provides drawings for the *Works*, conforming to *Project Manager's* standards.

It is a requirement for this project that all drawings, be produced by the *Contractor* on a CAD system. The preferred CAD system being "Bentley" system (Distributed by Intergraph) "Microstation" SE Version 7 or 8 ("Microstation - DGN" format only) are handed over to the *Employer* on completion of each section of the *Works.* All drawings shall be signed by the *Designer.*

4.11 OPERATION AND MAINTENANCE MANUALS

The *Contractor* provides three sets of operation and maintenance manuals for the *Works* six months after the Contract Date. As a minimum the manuals contain details of the following:

- A description of the cooling tower fill.
- Design conditions.
- Materials.
- Maintenance instructions and periodicity.
- Recommended operating practices and constraints in particular to minimize ice formation during low ambient temperature conditions.
- Recommended maintenance intervals and maintenance activities.
- Maximum cooling water flow rates.

Performance curves according to requirements in

- Table 4.

4.12 DESIGN REVIEW

The *Contractor* shall submit a complete design package to the *Employer* for acceptance, 1 month after the *Contract Date*. The *Designer* shall attend the design review meetings. The design shall be accepted by the *Employer* before site work commence. The design shall include the following:

- General arrangement drawing(s) of new fill installation.
- Detailed fire prevention method statement.
- Detailed drawings of fill element and support bracket.
- Detailed drawings of fill installation, indicating positions where fill elements need to be modified to accommodate support beams etc.
- Detailed drawings of how modified fill elements will be supported.
- Replacement end-cap details.
- Details of new fill support beams (if required).

In addition the *Contractor* shall demonstrate the following one month after contract award:

- Support wire assembly load test at the *Contractor's* workshop. The load test shall be done on the entire support wire as installed, i.e. all fill layers. The *Contractor* will demonstrate that the support wire assembly can support a load of 120 kg without any sign of deformation. A further test will be done to determine the load that will cause failure of the support wire assembly.

4.13 TESTS DURING MANUFACTURING

- OIT tests as per requirements in Section 4.1.
- Fill element impact tests as per requirements in Section 4.1.
- Fill element flatness test as per Section 4.1. Test to be done on weekly basis during manufacturing of fill elements. The batch number and test date will be included on the test records.
- End-cap valve open/close torque test as per Section 4.5.

5. WORK TO BE PERFORMED BY THE *EMPLOYER*

- Treat cooling water for Legionella and produce test results to *Contractor*.
- Provide access to site.
- Provide a lay down area adjacent to the cooling tower.
- Provide access to the cooling tower.
- Provide water and electricity supplies.
- Provide the following drawings:
    - **0.41/1830** Cooling Stack, Typical details of Construction
    - **0.41/3346** Shell Setting Out Details
    - **0.41/5152** Diametral duct General Arrangement

- **0.41/5513** Precast Stack Elements
- **0.41/5514** Layout of Lower Stack Beams and Bearers
- **0.41/5520** Precast Stack Elements
- **0.41/6227** Peripheral Precast Elements
- **0.41/7128** Distribution System GA
- **0.41/7129** Sprayers

6. TENDER RETURNABLES

6.1 GATE KEEPERS

6.1.1 Only *Contractors* with the design capability and proven track record for either natural draught or mechanical draught evaporative cooling tower design, construction and installation will be considered for this contract. The *Contractor* may possess the design capability in-house. Where this is not the case, the sub-contracted entity with the design capability shall demonstrate compliance with the requirement(s) as defined below in paragraphs (a-c).

The *Contractor* shall provide

- verifiable proof of design experience (e.g. contractual documentation, certificate of completion, etc.) requirements (if a reference is an Eskom contract the verifiable proof is not required) and,
- the description of the project, details of the client and the construction date,

which demonstrates compliance with one or more of the following:

a. Design and construction of at least one natural draft evaporative cooling tower, with a thermal capacity of at least 400MW, since 1995.

b. Design and construction of at least one field erected mechanical draft evaporative cooling tower, with a minimum heat transfer area of 350 m^2, since 1995. The cooling tower may consist of more than one cell but shall be done as a single project/contract.

c. Design and construction for a complete cooling tower internals (including fill, performance guarantees and performance test) replacement project for at least one natural draft evaporative cooling tower, with a thermal capacity of at least 400 MW, since 1995. Note that patch/partial repairs to the fill, distribution system and drift eliminators will not be considered.

6.1.2 *Contractor* provides valid certification as Registered Asbestos Contractors.

6.2 TENDER RETURABLES FOR TECHNICAL EVALUATION

A minimum score of 70% is required for acceptance.

6.2.1	Exclusions or qualification to this technical specification. If no exclusions or qualifications are provided, an explicit statement to this effect must be made in the tender by the Contractor.
6.2.2	Fill support wire diameter and material.
6.2.3	A detailed description and drawing/photo detailing the support bracket to fill element attachment arrangement attachment on a corner where the fill element is cut.
6.2.4	Tower performance, expressed in the re-cooled water temperature, for the water flow rate, range, atmospheric conditions and tower geometry provided in Section 3.2.1.
6.2.5	The Contractor completes Table 9 and Table 10 as part of the tender.
6.2.6	Fill element material, formulation and dosage percentage of the master batch.
6.2.7	Dimensions of fill element (length and width).
6.2.8	The minimum frontal surface area percentage (viewed from the top) of each fill element.
6.2.9	The total number of fill layers to be installed.
6.2.10	Number of fill layers installed above the bottom of the tower shell
6.2.11	Statement whether the fill elements and support brackets will be moulded in South Africa
6.2.12	Programme indicating the off site design and manufacturing and on site work for the completion for the *Works* as detailed in this specification.
6.2.13	Clear statement whether the outage work will be completed within the 65 day outage period.
6.2.14	Replacement sprayer material, drawing showing different parts and verifiable sprayer reference list.
6.2.15	End-cap material details (including material) including basic drawing with dimensions.
6.2.16	Evidence of sub-contracting intent between the *Contractor* and *Designer* to be submitted (if applicable). As part of the returnable, this agreement shall clearly define which parts of the scope of work are sub-contracted. If not applicable, i.e. *Contractor* and *Designer* is the same entity, a specific statement to be made.
6.2.17	List of all sub-contractors

Table 9: HP pumps Inventory

HP pump #[1]	Make & Model of pump	Pressure rating or range, bar[2]	Flow range, l/min
1			
2			
3			
4			
5			
6			

[1] The Contractor shall provide a minimum of 3 HP pumps for cleaning the distribution pipes and diametral duct.

[2] Each pump shall 350 to 400 bar (at the pump outlet) at the pump discharge with a flow rate of 45 l/minute

Table 10: HP Hose Inventory

HP hose #[3]	Hose internal diameter, mm[4]	Hose external diameter, mm[4]	Maximum working pressure, bar	Hose length, m
1				
2				
3				
4				
5				
6				

[3] The Contractor shall provide a minimum of 3 HP hoses for cleaning the distribution pipes and diametral duct

[4] The minimum internal hose diameter shall be 10 mm

7. TENDER EVALUATION

7.1 GATEKEEPERS

Section	Criteria	Yes / No
6.1.1	Only contractors complying with one or more of the requirements in Section 6.1.1 will be considered.	
6.1.2	*Contractor* provides valid certification as Registered Asbestos Contractors.	

7.2 TECHNICAL EVALUATION

Minimum score of 70% required			**Score**			
Scope Section	**Criteria**	**Weight, %**	**0**	**2**	**4**	**5**
3 and 4	Exclusions or qualification to technical specification detailed in Sections 3 and 4.	60	Deficient or non-responsive	Unacceptable risks, refer to section 7.3.	Acceptable risks	Fully compliant and no technical risks
3.2.2 and 3.2.3.	Preliminary method statements as per the requirements of Sections3.2.2 and 3.2.3.	40	Deficient or non-responsive	Unacceptable risks or omissions in accordance with the requirements of sections 3.2.2 and 3.2.3..	Acceptable risks	Fully compliant and no technical risks

7.3 FORESEEN UNACCEPTABLE TECHNICAL RISKS

Risk	Description
1	Contractor has Inadequate Evaporative Cooling Tower Design experience.
2	Contractor has Invalid or no certification as Registered Asbestos Contractor.
4	Number of splash fill layers less than that specified in Table 8.
5	The following not provided: A clear statement whether the outage work will be completed within a 65 day off-line maintenance period.
6	Fill support wire diameter is less than or fill support wire material is inferior to that specified.
7	OIT for fill material less than 20 minutes.
8	Fill elements and support brackets not moulded in South Africa.
9	Inadequate fill element to support bracket attachment where fill element is cut.
10	The failure strength of the support wire assembly is less than the minimum specified.
11	Less HP pumps and HP hoses are supplied as specified or do not meet specifications

8. SAFETY, HEALTH AND ENVIRONMENTAL (SHE) MANAGEMENT

The process needs to be monitored according to risk identification and the management of the total scope of SHE risks including focus on scaffolding, working at heights, etc.

The *Contractor* provides a comprehensive plan for access control.

The *Contractor* complies with:

- The new internal document for Plant safety regulation.
- Main entrance door to be locked in the open position.

8.1 ASBESTOS

The existing drift eliminators and distribution pipes are manufactured from asbestos cement. This project is therefore subject to the handling of asbestos. Removal of these components from the cooling tower may only be carried out by contractors who have the necessary registration with the Department of Labour as Registered Asbestos Contractors.

The appointed *Contractor* needs to comply with the OHS Act 85 of 1993 and more specifically the Asbestos Regulations, GNR 155 of 10 Feb 2002. The pre-identified waste site for disposal will be communicated to Arnot in advanced and the internal, informal, auditing of the ultimate fate of the waste will be conducted by Arnot.

Asbestos Regulations must be adhered to including:

- Asbestos plan drawn up by an accredited Approved Inspection Authority (AIA).
- Asbestos training for all personnel handling asbestos cement components as well as all those working in the dirty area.
- Demarcation of the site into clean and dirty (asbestos contaminated) areas.
- Provision of decontamination hot water shower units.
- Monthly air sampling and reporting by the AIA.
- Transport and disposal of the asbestos cement waste at a certified disposal facility including the provision of Safe Disposal Certificates.

The process will be under direction of the Occupational Hygiene Practitioner at Arnot subjected to asbestos handling procedures, as stipulated in Eskom procedure 32-303 and the waste management procedure 32-245.

9. LEGIONELLA

The conditions prevalent in Eskom's cooling water systems are highly favourable for Legionella contamination. These include temperatures between 20 and 50°C, potential stagnant or low flow areas and raw water inflow supplying nutrients. When the system has been drained, the risk may increase as the humidity and the amount of water droplets in the surrounding air will increase.

To minimize the above-mentioned risk, the following precautionary steps shall be taken during the refurbishment of Arnot Cooling Tower no.2:

- Laboratory test regarding legionella disease must be obtained from Arnot Chemical Services Department. Latest test results must be communicated before cooling tower entrance.
- If personnel have to enter any part of the plant which may contain Legionella it is imperative that HEPA filters be worn over both the nose and mouth.

10. AUTHORISATION

This document has been seen and accepted by:

Name & Surname	Designation
Claude Chetty	Plant EDWL: Arnot Power Station
Francois du Preez	Corporate Consultant
Thandekani Ngcobo	System Engineer: Arnot Power Station

11. REVISIONS

Date	Rev.	Compiler	Remarks
July 2017	1	OPH Augustyn	First draft
April 2020	2	AF du Preez	Revised scope
January 2021		T. Ngcobo	Revised scope.

12. DEVELOPMENT TEAM

13. ACKNOWLEDGEMENTS