Eskom	Technical Specification	Technology

Title: **Technical specification for the Refurbishment of Tutuka Cooling Towers 2, 3, 4 and 5**

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1. INTRODUCTION

Tutuka Power Station is equipped with 6 natural draft evaporative cooling towers which are arranged into East and West common CW circuits, each group of 3 cooling towers are serving 3 turbine units. The cooling towers are fitted with asbestos cement film fill which has been in service since the original commissioning of the station. Cooling tower performance measurements indicate a significant deterioration in thermal performance, which contributes to partial load losses.

This specification is for the removal of all asbestos fill products in on cooling towers 2, 3 4 and 5, the installation of modular fill and maintenance access. In addition the asbestos drift eliminators and distribution system shall be cleaned and repaired as required.

2. SUPPORTING CLAUSES

2.1 SCOPE

The report covers the technical specification for the removal, replacement of the asbestos fill and installation of maintenance access at cooling tower 2, 3, 4 and 5 at Tutuka Power Station. In addition the asbestos drift eliminators and distribution system shall be cleaned and repaired as required

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 and maintenance access. This also includes cleaning of the drift eliminators and distribution pipe system.

2.1.2 APPLICABILITY

This document shall apply to Tutuka Power Station.

2.2 NORMATIVE/INFORMATIVE REFERENCES

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

2.2.1 NORMATIVE

[1] ISO 9001 Quality Management Systems.

[2] ISO 14001 Environmental Management Systems.

[3] OHS Act No.85 of 1993 and the following regulations:

- Construction regulations:2014
- Asbestos regulations:2001
- Noise-induced hearing loss regulations:2003

- Hazardous biological agents regulations:2001
- General safety regulations:2003
- Facilities regulations:2004
- General administrative regulations:2003
- Driven machinery regulations:2015

[4] Compensation for Occupational Injuries and Diseases Act No.130 of 1993

[5] Basic Conditions of Employment Act No.75 of 1997

[6] BS 4485 Part 2: Cooling Tower Performance Testing.

[7] Asbestos regulations :2001 GNR.155 of February 2002

[8] National Environmental Management Act: Waste Act 59 of 2008 - Regulations

- Waste Classification and Management Regulations, 2013
- Regulation for the prohibition of the use, manufacturing, importing and exporting asbestos and asbestos containing materials, 2008
- National Waste Information Regulations, 2012

[9] National Environmental Management Act: Waste Act 59 of 2008 –Norms and Standards

- National Norms and Standards for the assessment of waste for landfill disposal, 2013
- National Norms and Standards for disposal of waste to landfill, 2013
- National Norms and Standards for the remediation of contaminated land and soil quality in the Republic of South Africa, 2014
- National Norms and Standards for the storage of waste, 2013

[10] National Road Traffic Act 93 of 1996 and Regulations

[11] SANS 10228 – Identification and classification of dangerous goods

[12] SANS 10230 – Transportation of dangerous goods – inspection requirements for roads vehicle

[13] SANS 10265 – Labelling of dangerous goods

[14] SANS 10232 -1 – Transportation of dangerous goods – Emergency Information System – Road Transport

[15] SANS 10232 – 3 – Transportation of dangerous goods – Emergency Information – Emergency Response Guides

[16] SANS 10234 -Globally Harmonised System of Classification and Labelling of Chemicals (GHS)

[17] SANS 10160-2: Basis of structural design and actions for buildings and industrial structures Part 2: Self-weight and imposed loads

[18] SANS 1200: Standardized specification for civil engineering construction

[19] SANS 2001: Construction works

[20] ESKPVAAG5 Rev 1: Requirements for the safe processing, storage, removing and handling of Asbestos and Asbestos containing material, equipment and articles

[21] ESKADAA18: The safe processing, storing, removal and handling, of asbestos and asbestos containing material.

[22] 240-123919938: Legionella Control and Management in Water Systems

[23] 240-55864767: Chemistry and Microbiology Standard for Condenser Cooling Water.

[24] 240-61227267 Hot tapping of Cooling Water System Ducts Standard

[25] 240-99527377: Inspection Manual for Civil Works at Eskom's Power Stations

[26] 240-56364545: Structural Design and Engineering Standard

[27] 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

[28] 240-56030508 Cooling Water System Health Care Guideline

[29] Performance Tests on Tower 1 and 4 at Tutuka Power Station, Report Number: 14TFD073-1, 29 October 2014

[30] Tutuka OHS Baseline risk assessment

[31] Contractor SHE Specifications

[32] Tutuka drawings cannot be issued but can be viewed at Tutuka Power Station. The drawings which are available are listed below.

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55357	COMMON PLANT WEST COOLING TOWER SUPPLY & RTURN SYSTEM P&ID

2.3 DEFINITIONS

Definition	Description
Design Report	A detailed design report, compiled and approved by an ECSA Professional Registered Engineer employed by the *Designer*, providing a technical justification, which shall include applicable acceptance criteria, for the *Contractor's* design or analysis. This report shall apply and reference applicable European, South African or US based Standards and Guidelines only. The report shall furthermore make reference to, and provide details of, verifiable references of similar designs done by the *Designer* and case studies in previous contracts performed by the *Designer*.
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 7.1.1 (a-c). In addition the *Designer* shall be responsible for the cooling tower thermal design and structural design of the fill support beams.
Mock-up test	A physical test performed at the *Contractor's* workshop to demonstrate that the *Contractor's* design is sound and design intent is achieved. The test shall simulate the conditions, e.g. temperature, dimensions, forces, pressure, etc., which will be experience in the actual installation. The *Designer* shall be present during the Mock-up tests.
Modular fill	Vertical fluted modular fill which consists of individual polymer fill sheets or grids which are either mechanically, thermally or chemically bonded to form rigid modules. The modules shall be of sufficient rigidity to allow the modules to be simply laid on top of horizontal support beams. The module design shall incorporate adequate bonding points between the sheets such that the modules can be cut during installation to fit tightly at concrete columns and beams. The bonding points shall be distributed evenly across the height and width of the modules. The modular fill geometry and structure shall comply with the requirements detailed in section 4.2:
'P'-Level	Top of the cooling tower pond wall elevation which corresponds to 1 626.2 meters above mean sea level

Range	Difference between the hot inlet, and cold outlet, CW temperature.
Approach	Difference between the cold outlet CW temperature, and wet bulb air temperature.

2.3.1 DISCLOSURE CLASSIFICATION

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

2.4 ABBREVIATIONS

Abbreviation & Acronyms	Description
AMME	Asset Management Mechanical Engineering
BS	British Standard
CAD	Computer-Aided Design
CTI	Cooling Tower Institute
CW	Cooling Water
ECSA	Engineering Council of South Africa
FRP	Fibre Reinforced Plastic
GNR	Government Notice Regulation
GRP	Glass Reinforced Plastic
ISO	International Organization for Standardization
OIT	Oxidation Induction Time
PP	Poly Propylene
ppm	Parts per million
PS	Power Station
PVC	Polyvinyl chloride
P&ID	Process and Flow Diagram
SHE	Safety, Health & Environment
TSS	Total Suspended Solids
US	Unites States of America

2.5 ROLES AND RESPONSIBILITIES

- Contractor will design, manufacture, transport and install as per the works in section 3 of this document
- Eskom to approve and monitor the works

2.6 PROCESS FOR MONITORING

- Tender Returnable Documents
- Approved QCP
- NEC Document
- Technical Specification

2.7 RELATED/SUPPORTING DOCUMENTS

- Refer to section 2.2.1

3. THE *WORKS*

3.1 BACKGROUND

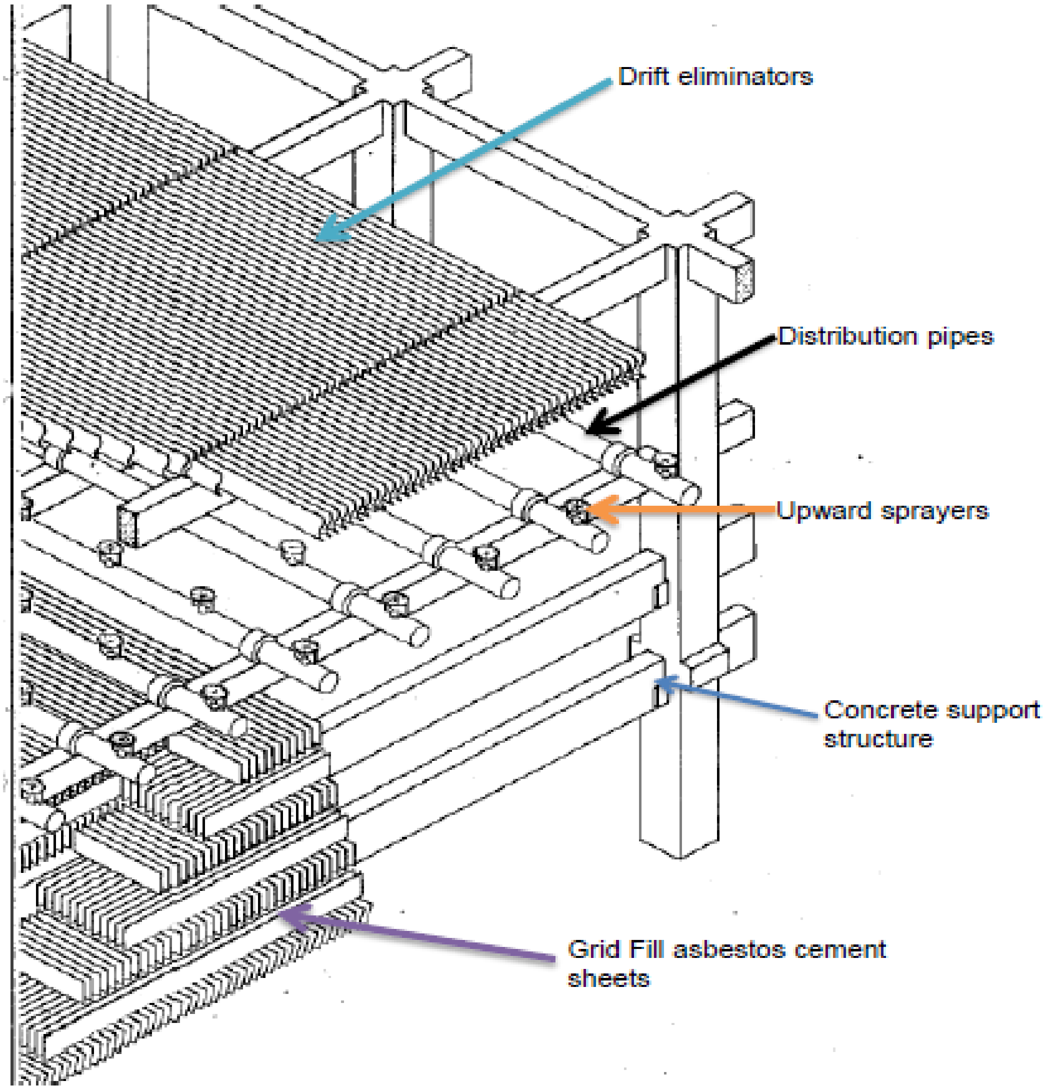


Figure 1: General arrangement inside Tutuka's cooling towers.

Six identical evaporative natural draft cooling towers are installed at Tutuka. Each of these towers is fitted with layers of flat asbestos film fill with the asbestos sheets of alternate layers orientated at 90 degrees to each other, see Figure 1. Each individual fill sheet is 150 mm deep, 4.2 mm thick, with the fill sheets stacked in a vertical orientation on top of each other in 6, 12 and up to a maximum of 18 layers such that the maximum fill depth is 2.7 m deep.

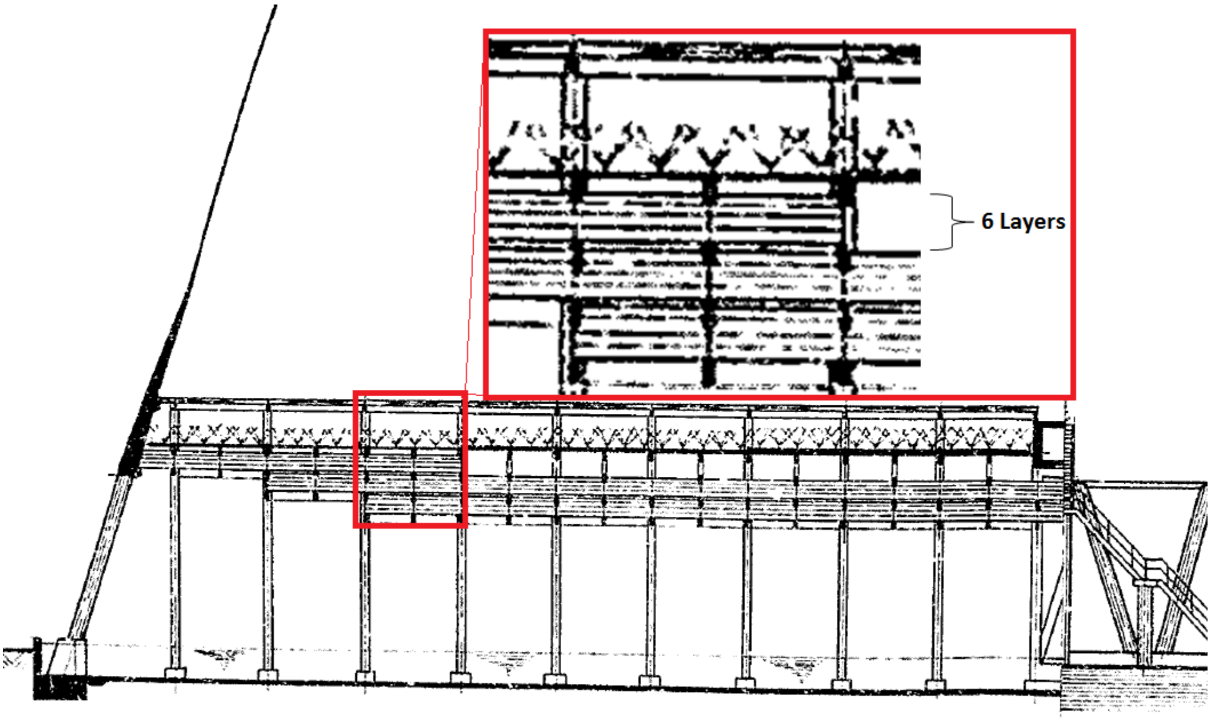


Figure 2: General arrangement of fill layers

Spacers separate the adjacent asbestos sheets from each other. The width of 64% of the spacers in each cooling tower is 11.5 mm while the width of 36% of the spacers is 13.5 mm. The fill is bottom supported on 3 layers of precast concrete beams. The design intent was that the Tutuka fill is of a “see-through” design when viewed from the top, or water flow direction, with the vertical flutes having a free opening of 11.5 mm x 11.5 mm or 13.5 mm x 13.5 mm.

The total number of individual asbestos sheets in each cooling tower is 2.1 million sheets providing a total surface area of 1.55 million m^2 and an approximate mass of 5 194 metric tons of asbestos. This does not include the fouling, sludge and hard scale caught between the sheets which is estimated to be at least 2 500 metric tons. The asbestos sheets are assembled in 150 596 modules, approximately 230 mm wide, with each module tied together with 4 stainless steel or PVC rods. The rods are 6 mm in diameter. In total there are about 101 628 stainless steel rods and 494 232 PVC rods in each cooling tower.

Note that the above is the quantities in the cooling towers as per the status in the Jan 2020. Since then about 60% of the asbestos fill was removed and disposed off. Therefore the **estimated** mass of asbestos fill and fouling in the fill is 2 050 and 1000 metric tons respectively. Originally the asbestos fill sheets were arranged in layers of 6, 12 and 18 layers see Figure 3. Due to clogging (See Figure 4) of the fill that resulted in poor performance of the cooling towers, It was decided to remove the top layers of the fill leaving only 6 layers of the asbestos fill all across the cooling towers see Figure 5.

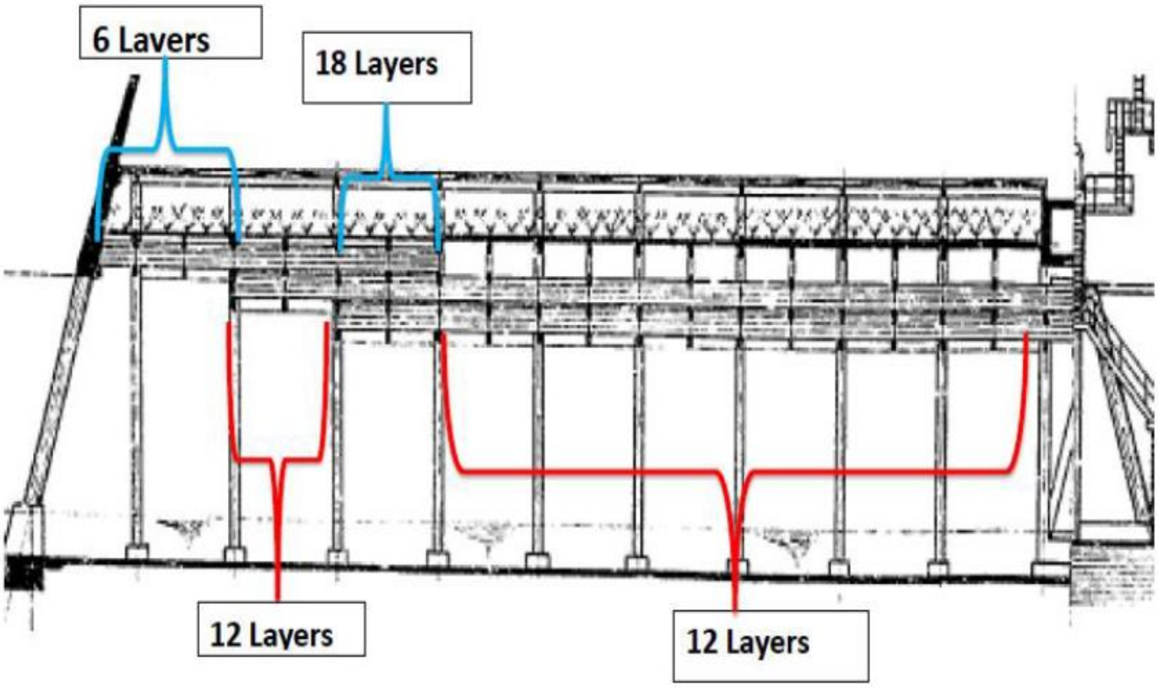


Figure 3: Original cooling tower fill arrangement

Figure 4: Side view of clogged asbestos fill at Tutuka PS

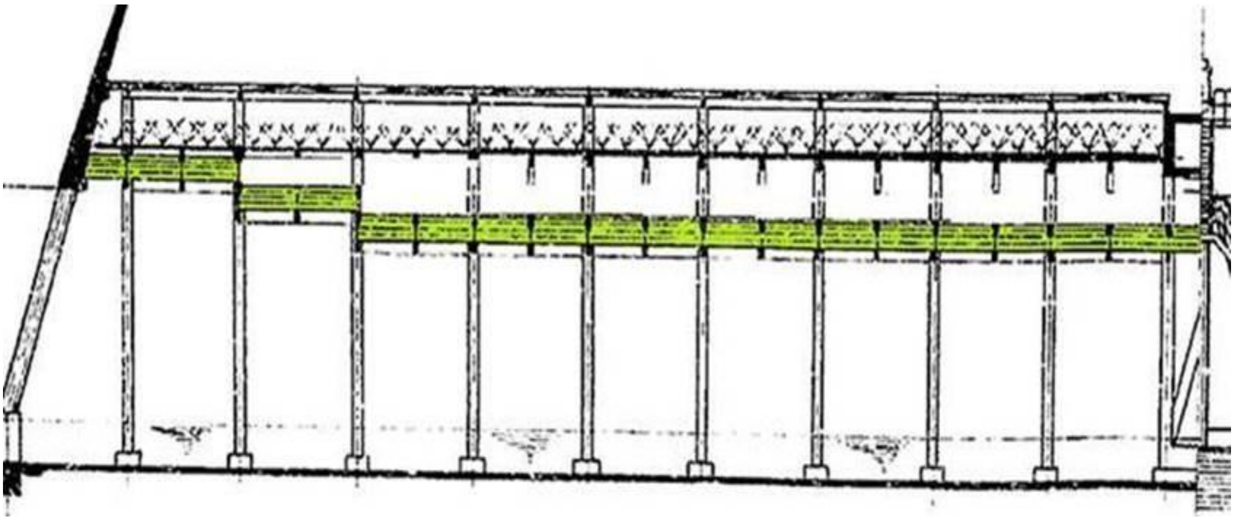


Figure 5: Current cooling tower fill layers

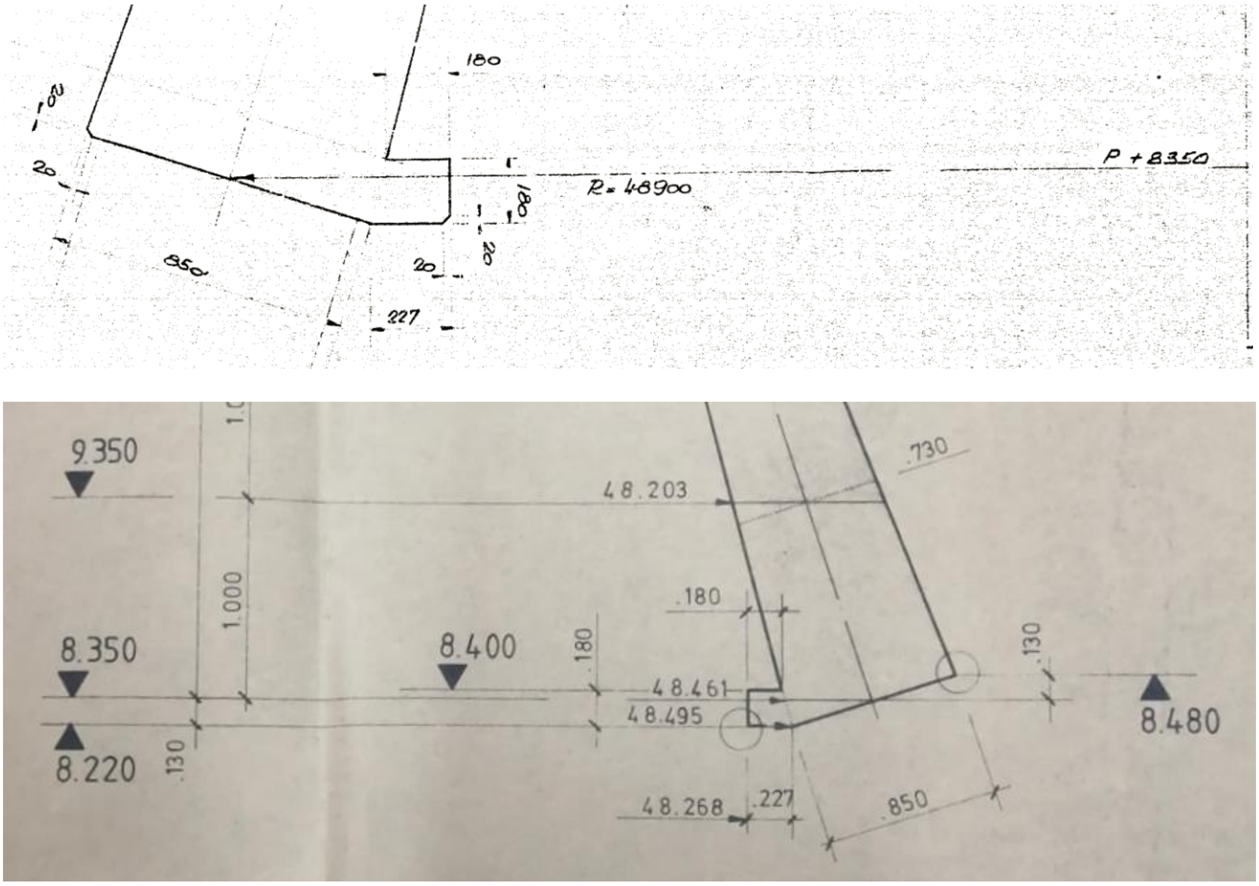


Figure 6: Details of the bottom shell arrangement

Tutuka's cooling towers are all identical with the main dimensions being as follows:

- Tower inlet radius (centre of ring beam) = 48.9m at 8.35m above "P'-level, refer to Figure 6.
- Tower inlet radius (Inner edge) = 48.495-.227=48.268m at 8.22m above 'P'-level, refer to Figure 6.
- Total tower height = 143m above 'P'-level, refer to Figure 8 below.
- Inner outlet radius: 26.875m, refer to Figure 8 below.
- Door details given below in Figure 7.
- Distribution pipe centres are at 1000mm spacing.
- The top elevation of the concrete support structures, relative to the 'P'-level, for the various internal components are as follows:
    - Drift eliminators: 11.7m
    - Distribution pipes: 9.5m
    - Top 6 fill layers: 8.4m
    - Middle 6 fill layers: 7.45m (Refer to note below)
    - Bottom 6 fill layers: 6.5m (Refer to note below)
- Pond diameter: 107.2m
- Height of pond wall: 2.0m
- Pond volume at 240mm below 'P'-Level:15 400m^3

Note: the fill support beams at 7.45 and 6.5m level do not cover the entire cooling tower inlet area. Please refer to Figure 10.

More cooling tower structural details are given in Appendix A.

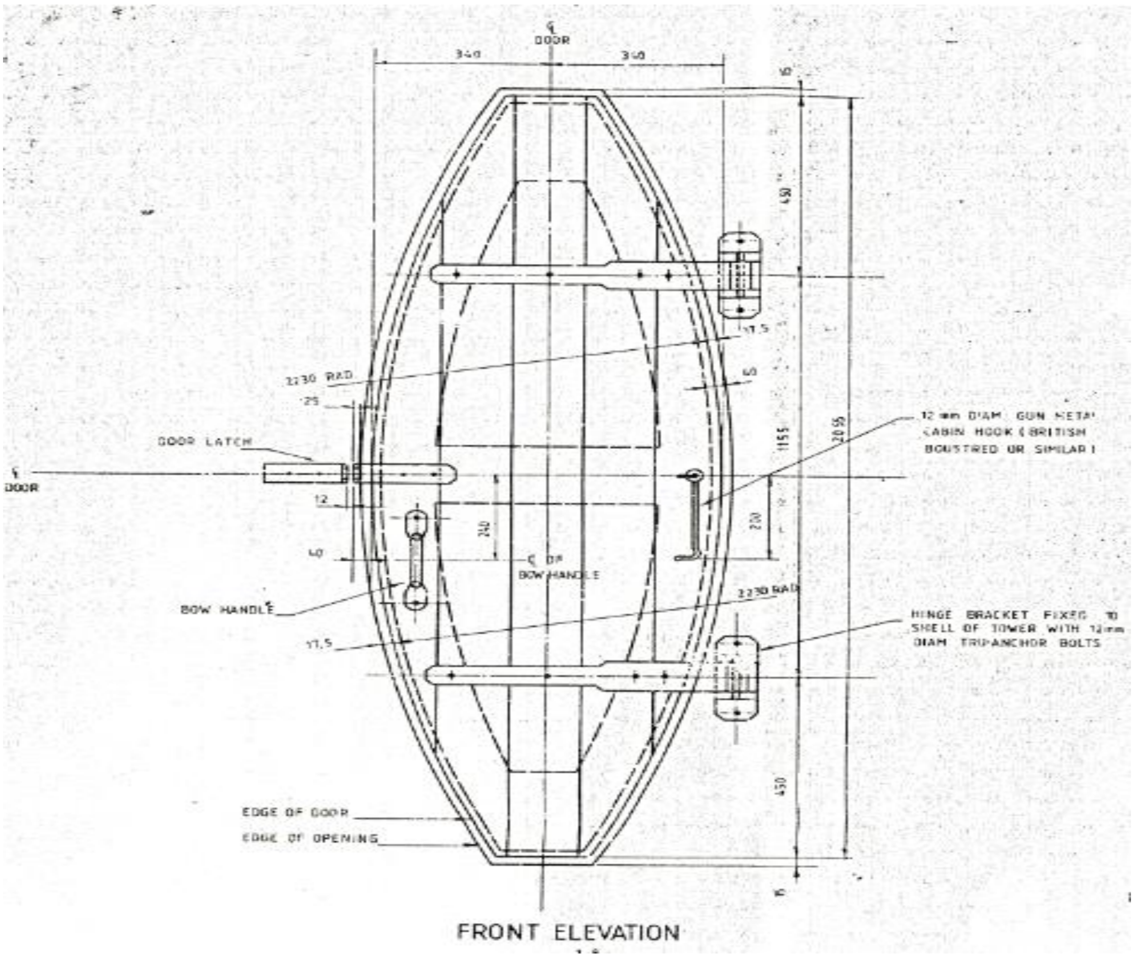


Figure 7: Details of the access door. The bottom of the door is at 11.17 m above 'P'-Level

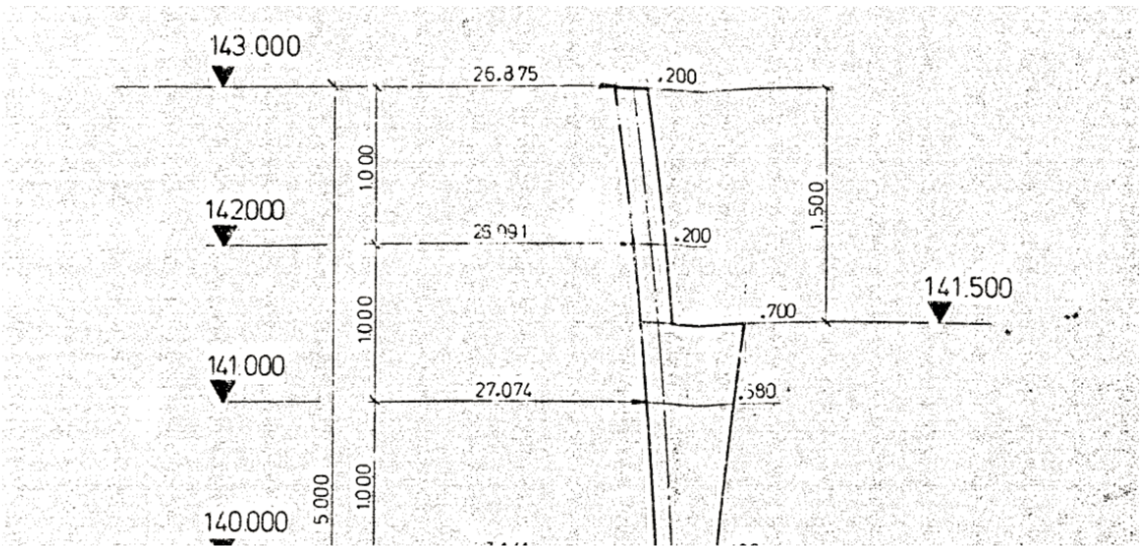


Figure 8: Details for the top of the shell arrangement

3.2 CURRENT STATUS OF THE COOLING TOWER FILL

3.3 SUMMARY OF THE *WORKS*

Due to the performance problems experienced with the existing cooling towers, towers 2, 3, 4 and 5 can only be shut down during a planned outage of a corresponding turbine unit. The scope of work shall be executed and completed in not more than 80 days per tower. No provision for on-line work is provided for.

The key dates for the off-line maintenance period for each cooling tower will be provided in the Contract (NEC) document.

The *Works* for each of the four (4) cooling towers consists of the following:

i. Removal and disposal of all asbestos products and fouling in accordance with the referenced regulations in Section 2.2.

   Note that one contract will be awarded for the refurbishment of all the four (4) cooling towers, however, the work (execution) on the four cooling towers will not be done simultaneously. Only one cooling tower will be work on at a time.

ii. The design, manufacturing, transport, off-loading, installation and commissioning of the new modular fill.

   (**Note**: Total weight of new fill must be compared to the weight of the original designed asbestos fill. If the new fill weight exceeds the weight of the old fill material, structural analysis needs to be done to confirm that the cooling tower can support the new induced loading.)

iii. Cleaning of the distribution pipes, inspection and replacement as required

iv. Acid cleaning of the sprayers, inspection and replacement of sprayers as required.

v. Cleaning of the diametral duct and the cooling tower pond.

vi. Cleaning and visual inspection of cooling tower internal pre-cast concrete beams. If required, repairs of these beams must be done based on the structural inspection.

   Note: All scale to be removed until bare concrete is visible. No loose scale to be present.

vii. The establishment of a suitable site based construction management service ensuring the construction is in accordance with the design and specification.

viii. Existing internal and external handrails replaced with new.

ix. Existing internals cat ladders to be replaced with new.

x. Design, manufacturing and installation of permanent access platform to the inside of the diametrical duct.

xi. Cooling tower performance tests.

xii. Various *Design Reports* and mock-up tests as detailed Section 4.16

xiii. Method statements as detailed in Sections 4.18, 4.19

xiv. The submission of all documentation and drawings and the completion of technical schedules.

xv. Performance charts predicting the cooling tower performance.

xvi. Provision, installation, protection, security and maintenance of electrical cables from the connection point to the Eskom boards to where required by the Contractor. The Contractor shall make provision for a distance of 600 metres.

xvii. Provision and installation of potable water pipes. The contractor shall make provision for distance of 600 meters

xviii. Fencing and security around the Contractors yard and laydown areas as required by the contractor

The *Contractor* supplies and provides all the constructional plant, temporary works, materials for both temporary and permanent works, labour and supervision, transport to and from the site, on- and off-loading, site preparation and rehabilitation in and around the *Works,* and any other means of any kind for the design, construction and completion of the W*orks. A sub-contracting agreement shall be in place between the Contractor and Designer for the entire project period.*

4. DETAIL DESCRIPTION OF THE WORK TO BE PERFORMED BY THE *CONTRACTOR*

4.1 GENERAL

The current performance of Tutuka cooling towers is exceptionally poor, resulting in very high water temperatures. The internal components of the tower as described in this section shall be designed to operate with a water inlet temperature of 48 °C. This temperature shall therefore be used to determine the mechanical characteristics of the polymer and composite components supplied as part of this contract and shall also be used in the *Design Reports*.

The minimum expected ambient temperature experienced at Tutuka during winter is approximately -4 °C to which the tower internal components will be exposed to when the cooling tower is off-line at the time. This temperature is to be considered as the minimum design temperature in the various *Design Reports,* where applicable.

The minimum acceptable material for any metallic components such as bolts, anchor bolts, nuts, wires, pins, valves, etc. installed inside the cooling tower is grade 304 stainless steel. No metallic parts which require corrosion protection, like carbon steel or cast iron, are acceptable.

The *Contractor* shall ensure that the following design principles are incorporated into the design and installation of the new cooling tower internals.

4.1.1 RELIABILITY PHILOSOPHY

The design and installation of the new cooling tower internals shall allow the cooling tower to operate continuously for a minimum period of 12 months before each shut down for basic maintenance as detailed below. The new cooling tower internals will remain in operation for a minimum period of 25 years with little maintenance. The cooling tower shall operate 100% reliably during each 12 month period between maintenance interventions.

4.1.2 MAINTENANCE PHILOSOPHY

After replacing the internals, the cooling tower will only be shut down for a short period, typically 7 days, every 12 months to perform basic cleaning as detailed below. If the *Contractor's* maintenance requirements after fill replacement are different from the list shown below, the *Contractor* shall motivate and document the changes for acceptance by the *Employer*.

- Flushing of distribution pipes by opening end-caps with full water flow through the cooling tower.
- If required, the distribution pipes will be cleaned by high pressure water cleaning, typically 400 bar, with a rotating nozzle traveling the full length of the pipes.
- Inspection of nozzles, cleaning blocked nozzles and replacing broken sprayers.
- Removing debris from the maintenance access platforms and where possible from the top fill layer.
- Removing algae & debris from the top of the drift eliminators. If required the drift eliminators will be cleaned by means of fire water, typically 6 bar. For these activities access is required to the top of the drift eliminators by means of spreader boards.
- Cleaning of the diametral duct and pond.
- Cooling tower pond outlet screens are inspected several times per week and cleaned when required by observing the differential water level across the screen.

Note that once the modular fill is installed, no access is possible to intermediate fill layers. Generally the *Employer* will not make provision to gain access to the bottom fill layer during maintenance periods.

4.1.3 OPERATING PHILOSOPHY

The cooling tower is expected to operate reliably with no manual intervention. Typically a visual, external inspection will be satisfactory, not required more than twice a week. The existing operating procedure, detailed below, shall still be applicable after replacing the cooling tower internals unless changes are recommended by the *Contractor* and is accepted by the *Employer*. As mentioned in the introduction, the cooling towers operate in a common CW circuit. The operating philosophy given below therefore assumes that one cooling tower is isolated while the other two are connected to the same common circuit still in operation. The new modular fill and water distribution system must be self-draining once the main CW inlet valve is closed.

- **Shut down procedure**
  - Close make-up valve if the particular cooling tower is fitted with a make-up point.
  - Close main inlet isolation valve, 3 m diameter butterfly valve, by means of the electrical actuator, closing time approximately 300 seconds.
    Note: If Inlet drain is passing, a pipe is connected from the inlet drain pipe to the centre-well to prevent hot water to flow to the cooling towers.
  - Wait for the cooling tower pond level to drop to 80% before closing the main outlet isolation valve, 3 m diameter butterfly valve, by means of the electrical actuator, closing time approximately 300 seconds.
  - Pond draining, if required is done by means of gravity via a drain valve upstream of the main outlet valve on the cold duct. If not possible an external pump is used to pump water from the relevant cooling tower to the next cooling towers.
- **Operational limits**
  - Normal pond level is between 420 and 240mm below the 'P'-level.
  - Minimum pond level is 560mm below the 'P'-level.
  - CW flow through the cooling tower is not allowed through the tower when the ambient temperature is at or below zero °C without any heat load on the system, i.e. at least one of the 3 turbine units is on load.
  - During partial heat load operation when the ambient temperature is at or below zero °C, full hydraulic load on the tower is maintained and the average cold water temperature is maintained above 10 °C.
- **Start-up procedure**
  - Remove all isolation and ensure that the drain valves on the cold and hot ducts are closed.
  - Open make-up valve if the particular cooling tower is fitted with a make-up point to fill the pond.
  - Crack open the main outlet isolation valve, 3m diameter butterfly valve, by means of the electrical actuator. The cooling tower pond, centre well and the other two cooling towers will start to balance (equalize) each other. Once the cooling tower pond and centre well level settled out, fully open the cooling tower 3m outlet valve.
  - Crack open the cooling tower inlet 3m valve (Hot duct). Once a water flow through the cooling tower is established, open the inlet valve to the cooling tower fully. The total opening time for the 3m valves is estimated to 300 seconds.

4.1.4 DESIGN PHILOSOPHY

The *Contractor* shall design the replacement internals of the cooling tower in accordance with all the requirements of this specification unless specifically agreed to and accepted by the *Employer*. The thermal, hydraulic and mechanical design of the new cooling tower internals shall be designed to operate continuously around the duty point or extremes as follows:

- Design duty point:
  - Design circulating water flow rate: 13.76 m^3/s
  - Cooling range: 15.64 °C
  - Re-cooled water temperature: 19.1 °C, **see note below**
  - Dry bulb temperature: 14.4 °C
  - Wet bulb temperature: 10.39 °C
  - Approach: 8.71 °C
  - Atmospheric pressure: 84 kPa

  Note: The design re-cooled water temperature of 19.1 °C was provided as the guaranteed performance during the original built. However recent calculations indicate that this re-cooled temperature cannot be achieved. A tower performance as expressed in re-cooled water temperature of around 20 °C is most probably more realistic for these cooling towers and duty point.

- Allowable variation in CW flow rate:
  - Maximum flow: 150% of design, i.e. 20.64 m^3/s without overflowing the diametral duct riser
  - Minimum flow: 66% of design, i.e. 9.08 m^3/s without any dry areas in the tower.
- Maximum operational temperature:
  - Water inlet temperature: 48 °C
  - Dry bulb temperature: 35 °C
  - Wet bulb temperature: 20 °C
  - CW flow as per design duty point.
- Minimum temperature the internals are exposed to when the cooling tower is off load is -4 °C.

4.1.5 LINE LISTS AND TIE-IN LISTS

- The cooling tower P&IDs are included in the Common Plant East and West Cooling Tower Supply & Return System P&IDs 0.61 55356 and 0.61 55357 respectively. These drawings are provided for information only since none of the process connections or instruments are affected by or included in the *Works*.
- Process connections to each cooling tower are:

  - Hot CW inlet duct, 3 m diameter, which is connected to the concrete riser and diametral duct.
  - Cold CW outlet connection, 3m diameter, which is connected to the cooling tower pond outlet structure.
  - Make-up connections from the raw water system and clarifiers which dumps water into the cooling tower ponds.
- No electrical supplies or instrumentation are installed to the internals of the cooling of the cooling tower.
  - Only one instrument is installed on the side of the cooling tower ponds which is a level indication/control measurement.

4.1.6 TRANSPORT AND ACCESS REQUIREMENTS

The *Contractor* is responsible for:

- All transport requirements for the *Works*, in accordance with the relevant regulations.
- Providing all loading facilities on site as required. No mobile or fixed cranes or lifting equipment is available around or inside the cooling towers and none will be provided by the Employer.
- Making provision for access to cooling towers during inclement weather when the ground surface can become muddy. No paved or tarred road access is available up to the cooling towers.
- Preparation of lay-down and provision of covered work areas as required and site rehabilitation after completion of contract.
- Preparation on the ground around the cooling tower to allow movements of heavy lifting equipment and trucks. There is no paving, generally the ground around the cooling tower is soft and gets very muddy during rainy seasons or when the adjacent cooling tower is overflowing. This can be done by pouring dolerite or similar and heavy compaction where trucks and lifting equipment will be driving. The employer does not have dolerite site in the vicinity of the station thus the supplier will have responsible to acquire, excavate and transport the dolerite to site.

4.2 FILL

The modular type fill shall comply with the following sets of criteria as a minimum:

- Individual polymer fill sheets shall be mechanically, thermally or chemically bonded to form rigid modules. The modules shall be of sufficient rigidity to allow the modules to be simply laid on top of horizontal support beams without the need to be supported from the sides. The module design shall incorporate adequate bonding points between the sheets such that the modules can be cut during installation to fit tightly concrete columns and beams. The bonding points shall be distributed evenly across the height and width of the modules.

- The individual fill sheets or grids can be either extruded or injection moulded
- Only "see through" (top to bottom) fill modules are allowed. Refer to **Figure 9: Example of fill modules** (non-perforated not allowed)
- All flutes must be in a vertical orientation. Off-sets of the vertical flutes are allowed provided that the flutes remain "see-through".
- Solid, non-perforated sheets, which does not allow water and air to cross over to and from adjacent flutes or sheets, are **not acceptable**. The sheets shall contain no corrugations in the flow direction and have a minimum of 40% of the fill sheet area open, spread over the entire fill sheet height.
- The minimum and maximum dimensions of the flute opening (water inlet) and bottom (water outlet) surface shall comply to one of the following as a minimum:
    - Vertical fluted, no off-set: Minimum 28 mm x 28 mm, Maximum 35 mm x 35 mm.
    - Vertical fluted fill with off-sets: Minimum 38 mm x 38 mm, Maximum 45 mm x 45 mm.
    - Similar to the dimensions of modular fill installed in several Eskom natural draft cooling towers.

Note: It shall be noted that the Employer accepts the risk of fill fouling and therefore the Employer reserve the right to reject any tender which do not comply with the above requirements of the fill. The rationale for allowing only modular fill with the above design characteristics is based on experience gained by the *Employer* in its natural draft cooling tower fleet and results of fouling tests performed by the *Employer*.

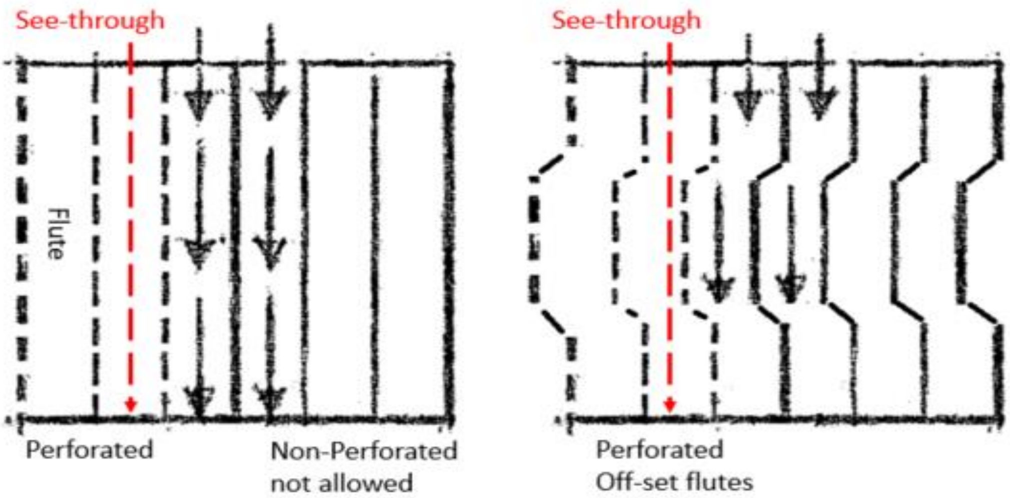


Figure 9: Example of fill modules (non-perforated not allowed)

However, the *Contractor* shall also confirm that the fill offered in the tender was specifically designed to be fouling resistant and can tolerate high levels (≥ 500 ppm) of total suspended solids (TSS) in the cooling water on a continuous basis. The *Contractor* shall provide relevant brochures or technical data sheets confirming that the fill offered can tolerate high levels of suspended solids in the water on a continuous basis. A representative chemical analysis of the cooling water is provided in Appendix A.

Note that the TSS is not measured at Tutuka and is not provided.

The *Contractor* shall determine the minimum volume of fill and therefore the fill depth required per cooling tower to achieve the design duty point as per Section 4.1.4. In addition, the following criteria shall apply:

- The minimum fill volume per cooling tower shall not be less than 11 000 m^3 (i.e. average fill depth of approximately 1.63m) while the following limitations shall apply:
  - The maximum fill depth at any position shall not exceed 2.1m.
  - The minim fill depth at any position shall not be less than 0.9m.
  - The minimum fill depth in the red areas as shown in figure 10 shall be 1.5m. This implies that the new fill support beams will have to be installed below the existing concrete fill support beams in this area which are at 8.4m elevation.
  - The minimum fill depth in the blue areas as shown in figure 10 shall be 1.5m. The fill support concrete beams in this area is at 7.45m elevation
  - The *Designer* shall optimise the distribution of the above given volume of fill across the inlet cross section of the tower to provide the maximum thermal performance.
- The volume of fill installed above the shell air inlet height shall be maximised.
- The fill design shall accommodate access to all sprayers installed in the cooling tower including the at the bottom of the diametral duct

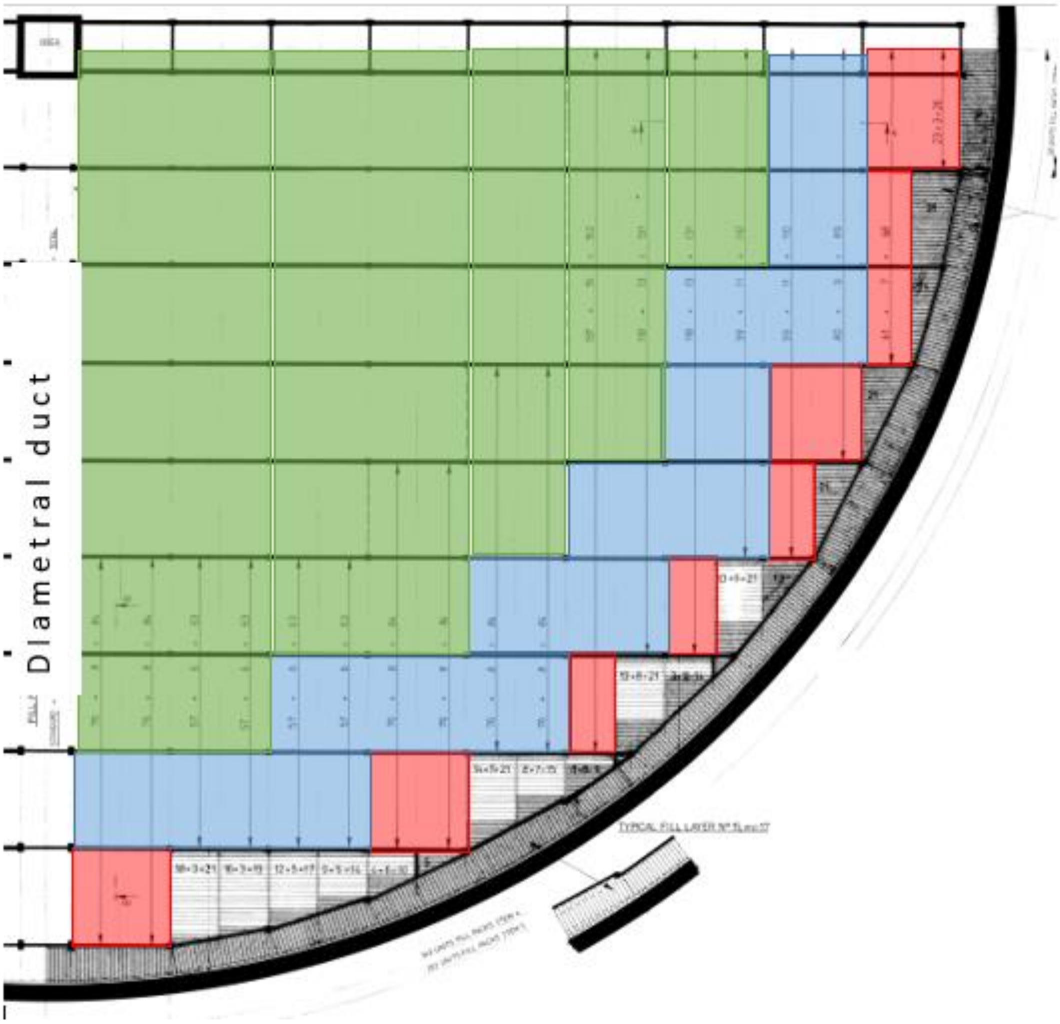


Figure 10: Plan view of the bottom fill support beam elevation: Green = 6.5m, Blue = 7.45m, Red and Grey = 8.4m level.

The fill installation & support structure shall comply with the following:

- The fill modules are to be supported from the existing horizontal concrete beams which are currently being used to support the asbestos fill.
- It is not allowable to use the precast concrete beams carrying the water distribution pipes for any support function of the fill. The *Contractor* shall therefore be responsible, where applicable, to design and construct a permanent fill support structure from suitable and proven FRP (or similar e.g. GRP) material. The fill support beam design shall be done in accordance to the CTI ESG-152 guideline or an alternative internationally accepted cooling tower structural design guideline. The *Contractor* shall provide references of projects where such beams were used in the past. The existing asbestos fill support beams shall support the structural beams for the new fill.

- The *Contractor* shall provide a *Design Report*, which details the design of the fill support structure considering the design load and allowable deflections of the structure members subject to bending moments. The current spacing for the precast beams supporting the asbestos fill is 2.51 m. The design shall cater for a minimum of 100 kg/m^3 of fouling and water mass loaded onto the fill, in addition to the new dry density of the fill. A minimum safety factor of 1.2 shall be applied in the design of the support beams.
- The *Contractor* is responsible for the design and installation of the fill module support structure to eliminate crushing, creep and distortion of the fill modules. The minimum crushing resistance and deflection of the fill modules between the supports shall be demonstrated by a *Mock-up test* described in Section 4.3 to be performed by the *Contractor*. Since the fill modules and fill support beams are inter-dependent, the *Designer* shall be responsible for both the thermal design, mechanical characteristics and properties of the fill modules under operating conditions and design of the fill support beams.
- The *Contractor* shall determine how many fill modules are to be supported on top of each other as well as the orientation between the fill module layers.
- The fill modules shall cover the entire horizontal inlet cross sectional area of the cooling tower.
- The fill modules are cut to fit around support columns and against the tower shell. Any gap of greater than 20 mm is considered as excessive and is to be corrected.
- The gap between adjacent fill modules shall not be more than 20 mm.
- If applicable, the *Contractor* shall propose a methodology to prevent "nesting" of adjacent modules into each other.
- Only virgin PP or PVC material may be used for the entire production of polymer fill modules and no re-ground material is allowed.
- The fill colour shall be black to absorb as much light as possible to prevent algae growth. If black is not possible the Contractor shall provide a justification.
- Requirements for PP fill:
    - The minimal acceptable grade of PP for the fill modules is *Sasol* Polymers grade CPV340 (or equivalent grade or supplier as pre-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 the 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 Employer prefers that the fill modules be moulded or extruded and assembled in **South Africa**, However this will not disqualify suppliers who will manufacture the fil outside South Africa
- The moulded articles shall not contain excessive flash and no short moulded modules or modules containing cold joints are acceptable. All produced modules will be inspected for stress whitening and if found the article is rejected.
- The *Contractor* shall test one of the first fill modules 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 modules manufactured for one cooling tower (a total of 24 tests for the 4 cooling towers). 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.

Note: The purpose of the OIT tests is to keep the results as a reference, which can be used as a baseline for 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.

- Requirements for PVC fill:
  - The *Contractor* shall specify their proven PVC formulation to ensure that the life expectancy of the fill will be achieved.

- During the fill Installation, it is not allowed to cut the fill modules inside the cooling tower. The fragments from cutting might enter the fill already installed which will results in blocking the already installed fill modules, this will also have the possibility of blocking the condenser tubes once the cooling tower is in operation.

Note: The following fill materials will **not be acceptable**:

  - Asbestos cement
  - Fibre cement
  - Metallic fills
  - Non-modular or traditional splash fills

4.3 FILL MODULE MOCK-UP TESTS

The *Contractor* shall carry out 2 *Mock-up tests* to demonstrate the mechanical characteristics of the fill as part of the design review. For both tests an upfront test procedure and method statement shall be provided during the tender stage. A final report for both tests shall be included as part of the documentation package as per Section 4.13.8. The tests are as follows:

4.3.1 TEST 1: LOCALISED, FOOT TRAFFIC MOCK-UP TEST AT AMBIENT CONDITIONS

This test is to be read in conjunction with the maintenance access options detailed in section 4.7.

Purpose: Demonstrate by means of a *Mock-up test,* at atmospheric temperature, no localised crushing or distortion of the fill module if a human with a mass of at least 90 kg walking repeatedly on top of the fill modules or on the open grid floor panels laid directly on top of the fill modules as detailed in 4.7. The fill module(s) shall be arranged as per the final design and layout of the fill replacement including support beams at correct spacing.

Acceptance criteria: No localised crushing or distortion of the fill modules during the test. Whether this test is successful or not is the sole discretion of the *Employer*.

4.3.2 TEST 2: A 7-DAY, CONTINUOUS FILL CRUSHING MOCK-UP TEST

Purpose: Fill crushing *Mock-up test* to demonstrate the mechanical characteristics and properties of the fill modules under operating conditions. The *Contractor* shall be responsible for executing the design, manufacturing and testing. A proposed process flow diagram is provided below:

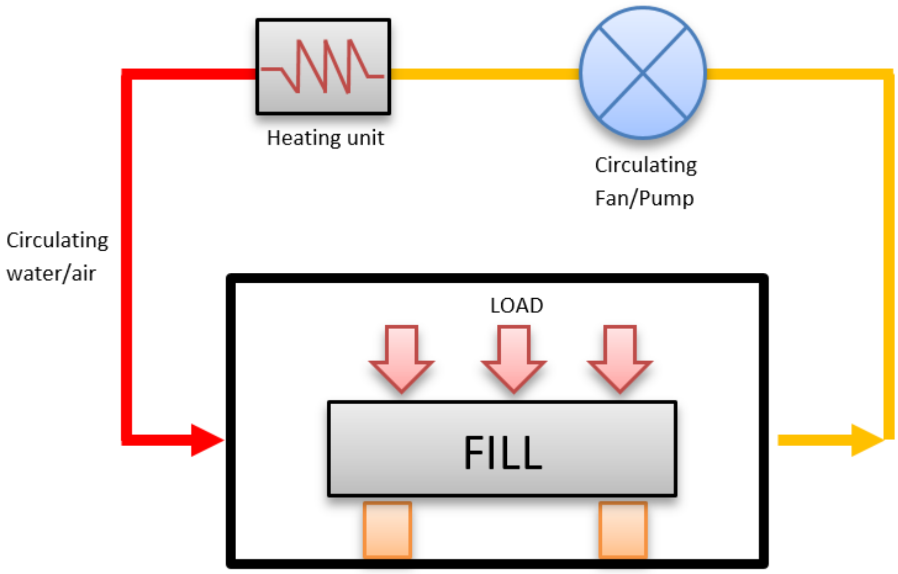


Figure 11: Proposed fill module crushing *Mock-up test* process flow diagram

The *Mock-up test* facility shall meet the following requirements:

- Referring to Figure 11 above, the *Contractor* shall design and construct a test rig to analyze the deflection of the proposed fill module by circulating air or water at a constant temperature of 45 °C for a period of 7 days.
- The fill in the test rig shall be representative of the maximum number of fill modules supported on top of each other on a set of support beams. Thus the additional load of 100 kg/m^3 shall be calculated based on the entire volume of fill, i.e. all layers, supported on a set of support beam.
- The *Contractor* shall investigate the most suitable method to apply additional load of up to 100 kg/m^3 (uniformly distributed on top of the fill module).
- Water/air temperature control range ±1degC of set point (i.e. max 2°C variation allowable).
- The fill displacement/creep to be measured and recorded at regular intervals, typically 4 times daily, positioned midway between the supports (as depicted above) at the top and bottom of the fill during the 7 day period.
- Test rig dimensions shall accommodate fill module, support structure and additional weight detailed above.
- The air/water shall be circulated to ensure uniform temperature. In the case of a water system the water shall be distributed uniformly to wet the entire fill section.
- At least 2 thermocouples (air) and 2 thermocouples (water) shall be located in different locations of test rig to present an average of the chamber temperature.

- The chamber shall reach a stable temperature within 1 hour of starting the heating unit from ambient temperature (25°C).
- The temperature shall be measured every 5 min (as a minimum) for a 7 day period. The temperature data for the 7 day period shall be made available to the *Employer* at request.
- In case of air being circulating, protection shall be in place in case of over temperature with alarm.
- The front panel of the chamber shall contain a transparent window such that the module can be viewed during the test period.
- The test rig shall have a removable section/panel for easy access to the fill, installation and removal of fill and instrumentation.
- The test shall be carried out at a location of the *Contractor's* choice within a 100km range from Johannesburg.

Acceptance criteria:

- No localised crushing of the fill module is acceptable at the support position.
- The fill module shall maintain its overall shape, i.e. shall not distort significantly.
- The max deflection at midway between the supports is 20mm.

If these are not met the *Contractor* shall either (1) modify the support structure or (2) modify the fill modules or (3) change the fill material and design (different fill) or (4) all of the previous options until acceptance criteria is met and repeat Test 1 and Test 2 of Section 4.3. All cost and delays caused by this is for the *Contractors* account.

4.4 DIAMETRAL DUCT AND POND

The following maintenance activities are required for the diametral ducts:

- All diametral duct sprayers to be removed (downward sprayers, underneath the duct).
- All debris and sludge to be cleaned manually from the duct (internal) and removed by means of buckets or vacuum outside the cooling tower. **Note!** No sludge or debris shall be thrown down the risers.
- HP-clean (400 bar and above at a flow rate of 40l/min) the internal and external surfaces of the diametral duct. This includes the removal of flakes and sludge. The HP nozzle to be used for cleaning of the diametral duct surfaces shall be a zero degree non-rotating nozzle, i.e. the jet shall be a solid forward projecting jet. **Acceptance criteria:** All scales to be removed until bare concrete.
- Removal of fallen algae and sludge from the top of the diametral ducts which are used as walkways.

- Diametral duct sprayers (downwards sprayers) to be cleaned (preferably acid clean) and replaced after the distribution pipes and diametral duct are cleaned. All damaged or missing diametral duct sprayers shall be replaced with new sprayers.
- Install 110mm in diameter and 300 mm long PVC stand pipes on all diametral duct sprayers inside the diametral duct to prevent debris from blocking the sprayers. **Acceptance criteria:** All sprayers to be clean as visible from the diametral duct floor.
- Sludge and debris is to be removed from the pond by the *Contractor* and dispose off (usually at the ash dump site, ±7km away from the station). Bobcats (or similar), brooms, spades and squeegees to be used for removing sludge from the ponds. **Acceptance criteria:** No mud layers (>5mm deep) or loose debris/particles (>10mm in diameter/length) anywhere on the pond floor.
- The approximate volume of sludge in pond and ducts is less than 25% of the total pond volume. If the sludge is not contaminated with asbestos it can be dumped on one of the ash dams. If contaminated the *Contractor* shall dispose of it in accordance with the asbestos regulations, however sludge contamination with asbestos must be avoided at all cost.
- Replace the asbestos vent pipes on top of the diametral ducts with similar diameter and length PVC vent pipes

4.5 WATER DISTRIBUTION, SPRAYERS AND END-CAPS

The distribution pipes and sprayers shall not be replaced as a whole. The pipes and sprayers shall be cleaned and repaired as detailed below. The existing piping is made from asbestos cement.

Distribution pipe cleaning and maintenance activities shall be done in a systematic way and the *Contractor* shall not be allowed to work in the entire cooling tower simultaneously in a hap-hazard manner. After Contract award the *Contractor* shall provide a method statement to the *Employer* for acceptance detailing the following as a minimum **per tower**:

- Provision to replace 200 broken or missing sprayers
- Equipment used for cleaning the pipes
- Method for cleaning of pipes
- Method how sprayers will be cleaned and protected if high pressure water is used for cleaning pipes. Due to hard scaling on the sprayers, acid soaking and rising with water is preferred.
- Description for repairing and/or replacement broken pipes. **NB!** Should any of the distribution pipes require replacing, only PVC or 304 SS pipes will be accepted
- Details for replacement sprayers

- Details for replacement end-caps, The *Contractor* shall make provision to replace about 50 end-caps per tower.
- Descriptions on how pipe cleaning activities will interface with fill replacement.
- Schedule for cleaning pipes. It is recommended that the pipes are groups in e.g. 5/10 sections and the schedule to indicate when each section will be ready for final inspection. Please **note** that pipe cleaning to be completed before the new fill is installed in a particular section.

Acceptance criteria for pipes and sprayers: No loose debris in the pipes and all spray nozzles clean and free of scaling.

4.6 DRIFT ELIMINATORS

The drift eliminators shall not be replaced as a whole but maintenance as part of the fill replacement is required. The existing drift eliminators are made from asbestos cement.

Cleaning shall be carried out from below with water (±6 bar). If cleaning from above is required, a length of walkway plank 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 minimum two DE 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 DE support beams. **Acceptance criteria:** No visible sludge/mud/algae between DE panel profiles

The *contractor* to supply and replace all broken asbestos DE's with UV stabilised PVC drift eliminators. The new DEs shall meet the following specification:

- The current support beam spacing is 2.51 m. If additional support beams are required these shall be of Grade 304 Stainless Steel or GRP. The support beams shall be designed to support at least 5 times the weight of the new drift eliminators.
- 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 the air temperature the DE will experience at the maximum operating point as per Section 4.1.4. Only DE profiles with a proven track record shall be used (similar to the "big six" type profiles currently in the existing tower).
- The new drift eliminators shall be made out of individual profiles and spacers assembled into modules (see below).
- The minimum technical requirements for the modules shall be:
  - Maximum profile spacing of 55 mm
  - Non-"see through" design
  - Minimum profile depth of 150 mm

- If a polymer material is used for the manufacturing, only new or virgin material is allowed.
- Provision to replace 50 m^2 of broken or fallen drift eliminators.

4.7 MAINTENANCE ACCESS

Depending on the proposed fill and its mechanical characteristics, additional maintenance access to the end-caps and sprayers shall be provided. After the fill replacement, the *Employer* requires unrestricted access to the tower internals for maintenance personnel without the need for spreader boards etc. The following 3 possibilities are foreseen:

Option 1: The fill is robust and safe enough to tolerate foot traffic to serve as maintenance access.

Option 2: A permanent, open grid maintenance access platform is laid directly on top of the top fill modules i.e. the open grid floor panels are used as a type of spreader board.

Option 3: Permanent open grid maintenance access is supported on its own dedicated support beams, i.e. the open grid floor panels are not in contact with the fill.

> **Note**: If the *Contractor* proposes Option 1 and fails test 1 of section 4.3.1 and is forced to install a maintenance platform, i.e. Option 2 or even Option 3, all additional costs involved is for the *Contractor*.

Currently, Tutuka uses scaffolding to gain access into the two sections of the diametral duct via the riser. The *contractor* shall design, manufacture and install permanent and safe maintenance access steps and platform as required to both sections of the diametral duct. Preferable the Riser access must be made of GRP material. Care must be taken to ensure the access platform does not restrict the flow of water into the distribution pipes.

Since the entire horizontal cross sectional area of the cooling tower is covered in modular fill, no handrails and kick plates are required. In the case where open grid floor panels (option 2 & 3) are used, the minimum width is 600 mm. If required, floor panel material is GRP and shall have an open structure allowing free flow of water and air and incorporate slip resistant features. If applicable, individual floor panels are positively fixed to the support structure (option 3) to eliminate the possibility of the panels slipping off support beams.

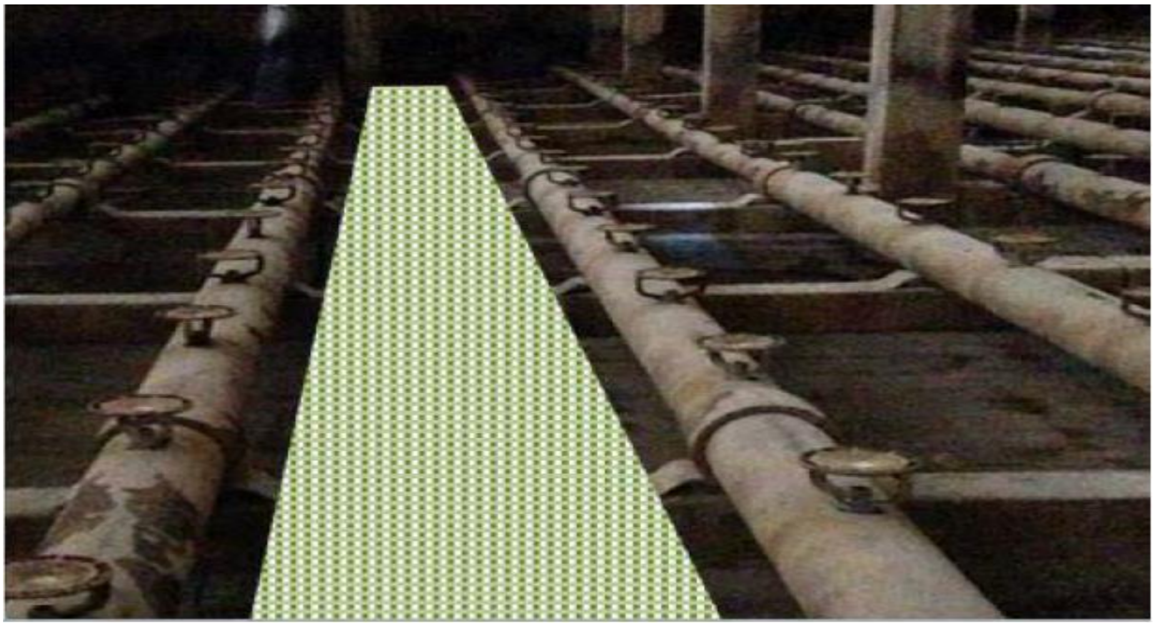


Figure 12: Example of Maintenance access between Distribution pipes

As a minimum the floor platform should cover the following areas:

- On both sides of every distribution pipe for the full length of each pipe (see Figure 12).
- Around the inside perimeter of the shell.
- Below the diametral duct to reach the downward sprayers.

The *Contractor* shall demonstrate the suitability of the proposed option by the test as detailed Section 4.3.

Note: The walk-way should have minimum spaces between the distribution pipe and the walking platform to prevent workers from falling (safety), preferably a gap of 50mm. The walkway must be safe and properly secured to protection of the modular fill in case workers fall or drop tools whiles working in the cooling tower.

4.8 CIVIL

The *Contractor* shall on a continuous basis inspect the internal concrete structure of the cooling tower while the fill is being removed. If any structural defects are noticed, the *Contractor* shall notify the *Employer* together with a proposal for repair and/or replacement as required. If accepted by the *Employer*, the repair/replacement will be done by the *Contractor*. **Please note** that the civil inspection cannot be done as a once-off activity once all of the asbestos fill is removed, but must be done on a continuous basis once removal of fill has started. This requirement is important to avoid surprises and lengthy programme delays after all asbestos fill is removed if accepted by the *Employer*, the repair/replacement will be done by the *Contractor*

The existing precast concrete beams in the cooling tower shall not be loaded in excess of the imposed as-built loads considering the weight of the original internal components (as no actual design loading information is available). The *Contractor* shall provide the *Employer* with a structural *Design Report* to verify that none of the existing concrete beams will be subject to higher loads compared to the original as-built loads imposed on the beams.

If required structural test such as hammer testing must be performed to ensure sound structural integrity of the existing structures. The Scope covers all the concrete structures internal and external of the cooling tower excluding the shell but including the Riser, concrete Inlet duct, diametral duct, Pond, support Beams, etc.

Note:

1. During the internals replacement of 2 (Cooling tower 1 and 6)cooling towers at Tutuka, structural damages that needed to be repaired were found due to the extra fouling weight hence it is expected that the structure will definitely require some repairs.
2. All precast concrete beams will be HP cleaned until bare concrete to expose any structural damage.
3. The structural/civil inspection and method statement shall be conducted by the same person/team who is ECSA registered Professional Engineer specializing in reinforced concrete design and repair.

4.9 HANDRAILS AND STEPS

Corroded, damaged or broken handrails, grating and steps inside the cooling tower shell shall be replaced with stainless steel material or GRP.

The external handrails on the access stair case must be replaced and painted accordingly to the applicable SANS Standard.

4.10 COMMISSIONING

The *Contractor* shall be present during the commissioning of the cooling tower.

4.11 PERFORMANCE TESTS

The *Designer* shall perform a minimum of 4 performance tests on the first tower on which the modular fill replacement is completed. The test will be done by the *Designer*, in accordance with the requirements of BS 4485 Part 2 (1988). The *Employer* may do independent measurements during the same time period. The purpose of the performance tests is to measure and record the performance of the tower for various ambient conditions and heat loads. The tests will be conducted over a time period of 4 months from the time the tower refurbishment is completed and the cooling tower commissioned.

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 2: 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 5.4.2.3	1

*The CW flow will be measured by using the permanent sharp edge flow orifice installed in the hot duct towards cooling tower 4. During the original acceptance tests the flow was calculated from the differential pressure measurement across the orifice by means of BS 1042: 1964.

The *Designer* shall document the test methodology, test results and updated performance curves and submit the report and updated curves to the *Employer* no more than one month after the 4 month test period. All test instruments are supplied, calibrated and installed by the *Contractor* with valid calibration certificates available and submitted as part of final report for all instruments.

4.12 COOLING TOWER PERFORMANCE CHARTS

The *Designer* shall produce performance chart(s) for the cooling tower within the following ranges.

Table 3: Performance chart ranges

Dry bulb air temperature	5-35 °C
Relative Humidity	10-90% (10% increments)

Water flow rate	70-130% (10% increments)
Cooling Range	7-20 °C (1° intervals)
Cold water temperature	12-32 °C (1° intervals)

These design performance curves shall be supplied within four months after the *Contract Date*. These charts shall be updated by the *Designer* once the performance tests after modular fill replacements are completed. The update of these charts will include the *test* results and the updated charts will be adjusted as required to correspond to the "as tested" performance of the cooling tower.

4.13 DOCUMENTATION REQUIREMENTS AND CONFIGURATION MANAGEMENT

4.13.1 GENERAL

- All documents supplied by the *Contractor* shall be subject to Eskom's acceptance and approval.
- The *Contractor* shall include the *Employer*'s drawing number in the drawing title block. Drawing numbers will be assigned by the *Employer* as drawings are developed.
- All documents, correspondence, certificates and all wording on drawings shall be in English. The *Employer* will not undertake any translation, and any errors or misunderstandings made by the *Contractor* or his sub-contractor and their agents and officers shall be deemed to be the responsibility of the *Contractor*.

4.13.2 DOCUMENTATION IDENTIFICATION

- The *Contractor* is required to submit the completed Vendor Document Submission Schedule (VDSS) as per agreed dates to the delegated Eskom Representative.
- Eskom will pre-allocate document numbers on the VDSS and send back to the *Contractor* through the delegated Eskom Representative.
- The *Contractor's* VDSS shall indicate the format of documents to be submitted.

4.13.3 DOCUMENTS SUBMISSION

- All project documents must be submitted to the delegated Eskom Representative with a transmittal note according to Project / Plant Specific Technical Documents and Records Management Work Instruction (240-76992014).
- In order to portray a consistent image it is important that all documents used within the project follow the same standards of layout, style and formatting as described in the Work Instruction.
- The *Contractor* is required to submit documents in electronic and hard copies and both copies must be delivered to the Eskom Representative with a transmittal note.

- In addition, the *Contractor* shall be provided with the following standards which must be adhered to:
  - Project / Plant Specific Technical Documents and Records Management Work Instruction (240-76992014).
  - Project Documentation Deliverable Requirement Specification (240-65459834).
  - Technical Documentation Classification and Designation Standard (240-54179170).
  - Documentation Management Review and Handover Procedure for Gx Coal Projects (240-66920003).

4.13.4 REQUIREMENTS FOR DRAWINGS

The *Contractor* provides drawings for the *Works*:

- The creation, issuing and control of all Engineering Drawings will be in accordance to the latest revision of the Engineering drawing Standard (240-86973501).
- Drawings issued to Eskom will be a minimum of a hardcopy and an electronic copy, and must also be editable. The *Contractor* is required to submit electronic drawings in Micro Station (DGN) format, and scanned drawings in pdf format.
- No drawings in TIFF, AUTOCAD or any other electronic format will be accepted.
- Drawings issued to Eskom may not be “Right Protected” or encrypted.
- The *Employer* reserves the right to use these drawings to meet other contractual obligations.
- The *Contractor* shall provide the drawings to provide a record of the complete design and construction of the plant. All drawings shall be approved by the *Designer.* These drawings must include the following:
  - General arrangement (side and plan views) of cooling tower internals showing the relevant elevations.
  - Fill element details and support wires and brackets.
  - Details of support of modified fill elements.
  - Fill support beams and structure details.
  - Distribution pipe plan view, pipe details, and support arrangements.
  - Plan view of sprayers indicating nozzle sizes.
  - Plan view of drift eliminator arrangement and support beams.
  - Maintenance access arrangements and details.
  - End-cap details.
- All Drawings must be submitted for approval by the *Employer*.

- All original drawings shall be subject to approval by the *Employer*. After acceptance, the *Contractor* shall also issue the *Employer* with all drawings in electronic PDF as well as original electronic format. This procedure shall apply to all subsequent revisions.
- All drawings will have a revision block with the exact reason for the revision.

4.13.5 PLANT CODIFICATION

Not applicable since the cooling tower internals are not coded.

4.13.6 PLANT LABELLING

Not Applicable since the cooling tower internals are not labeled.

4.13.7 MANUAL REQUIREMENTS

- Operating and maintenance manuals shall be provided. The instruction manuals are required to give technical information of the new fill replacement and cover aspects related to operation and maintenance and include as a minimum:
  - A description of the new cooling tower fill.
  - Drawing numbers of the drawings listed in section 4.13.4. This list shall also contain the Employer's numbers.
  - Recommended maintenance intervals and maintenance activities.
  - Fire prevention requirements during maintenance activities.
  - Permissible operating conditions.
  - Operating & Maintenance guidance.
  - Performance curves.
  - List of suggested spares for stock keeping (if applicable).

4.13.8 DOCUMENTATION PACKAGE

The *Contractor* shall provide 2 hard copies of the documentation package as well as 1 electronic copy. The documentation package shall contain the following as a minimum:

- List of contents of documentation package.
- Drawings and technical datasheets
- Operating & maintenance manual.
- Completed QCPs.
- Bill of materials with material specifications.
- All *Design Review* reports and *Mock-up test* procedures and results.
- Copies of all NCRs with close out proof.

4.14 DESIGN REVIEW

The *Contractor* shall submit a complete design package to the *Employer* for acceptance, three months after the *Contract Date*. The design shall be accepted by the *Employer* before any material is ordered or site work commence. The design shall include the following:

- Drawings as detailed in 4.13.4.
- Formulation of master batch.
- *Mock-up tests* as detailed in Section 4.3.
- *Access Platform and Steps as detailed in section 4.7 and 4.9*
- *Design Reports* as detailed in Section 4.16. The *Designer* shall be available for a desk-top review of these documents if requested by the *Employer.*
- Proof of asbestos *Plan of Work* submitted to approved asbestos inspection authority.
- Final fire detection and prevention philosophy to be implemented during the project as detailed in Section 4.19.
- Final asbestos removal and disposal method statement addressing risks and relevant regulations and requirements of Section 4.18.

The Employer has the right to call a monthly site meeting if required for the entire duration of the project. Both the *Contractor* and *Designer* shall attend these meetings.

4.15 TESTS DURING MANUFACTURING

- OIT tests as per requirements in Section 4.

4.16 DESIGN REPORTS TO BE SUBMITTED

- Fill support structure – Section 4.2
- Access Platform and Steps- Section 4.7 and 4.9
- Civil – Section 4.8

4.17 ISOLATION

An existing cooling tower inlet drain valve, positioned on the downstream side of the 3m inlet isolation valve, can be used to assist in case the main isolation valve passes after isolation. In the unlikely event that the single drain valve is not enough to provide complete isolation, the *Contractor* provide an optional price to install a 300mm drainage point in the valve pit downstream of the main isolation valve. If necessary, the drainage point to be installed as per the hot tapping standard [24], if the drain point cannot be used. If required by the *Employer* the water drained from the hot duct by means of the newly installed drain shall be piped to the CW centre well in the pump house.

An existing cooling tower inlet drain valve, positioned on the downstream side of the 3m inlet isolation valve, can be used to assist in case the main isolation valve passes after isolation. However the amount of water passing around either the inlet or outlet 3 m isolation valve cannot be guaranteed or predicted. To cater for challenges that may arise when trying to isolate a cooling tower the *Contractor* shall provide the following optional prises.

- Drain the pond by pumping the pond volume by means of a portable pump to the adjacent cooling tower pond. The duration for this activity to be indicated on the *Contractors* programme. Draining should not be more than 2 days.
- Install an approximately 100 m long, 300 mm drainage pipe from the drain point to the centre well in the pump house. The water will drain by gravity to the centre well. Preferably an HDPE pipe can be used as the CW water might be corrosive
- In a case were both options are not successful install an additional line of minimum 300 mm drainage point & isolation valve in the valve pit downstream of the main isolation valve. The drainage point to be installed as per the hot tapping standard.

4.18 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:

- Asbestos removal from installed position, including methodology and required equipment.
- Asbestos transport methodology between cooling tower and temporary laydown site.
- Asbestos transport methodology from temporary laydown site to disposal site.
- Asbestos containment, suppression (which includes pond water decontamination philosophy if applicable) and local area contamination monitoring.
- Asbestos personnel protection philosophy.
- The pre-identified waste site for asbestos disposal.
- Civil inspection method statement
- Re-work prevention
- Fill, drift eliminator and piping installation method:
  - Order of activities.
  - Access.
  - Safety precautions.

4.19 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 the cooling towers. 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

5. 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:

- National Environmental Management Act: Waste Act 59 of 2008 and Regulations
- National Road Traffic Act 93 of 1996 and Regulations
- Asbestos Regulations :2001
- Construction Regulations:2014
- Driven Machinery Regulations:2015
- All Acts, Regulations, Standards and Guidelines as mentioned in the "*Normative"* Section of this document. The most recently updated revisions of these documents shall be adhered to.
- The new internal document for plant safety regulation.
- Main entrance door to be locked in the open position.

5.1 ASBESTOS

The existing fill, 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 towers 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 the *Employer* in advanced and the informal internal auditing of the ultimate fate of the waste will be conducted by *Employer*.

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 the direction of the Occupational Hygiene Practitioner at Tutuka subjected to asbestos handling procedures, as stipulated in Eskom procedure ESKPVAAG5 and the waste management procedure 32-245.

5.2 LEGIONELLA

The cooling water system (cooling tower) provides a conducive environment for the formation, growth and infectious mode of legionella. The table below shows the low to high risk categories of legionella count in cooling water.

Table 4: Legionella counts and guidelines

Counts (CFU/L)	Guidelines
1 — 10 000	No additional action is necessary. Keep on with normal control activities (acceptable).
10 000 ---100 000	Shows evidence of poor control. Investigate your dosing system (poor)
>100 000	Take urgent action to reduce levels of contamination (very poor)
Although industrial cooling systems limits are set out as above the aim should be to achieve less than a 100cfu/L. This should be the ultimate goal.	

The Legionella Control and Management in Water System Standard (240-123919938) shall be observed by all parties involved in the cooling tower project.

The following monitoring process shall be used by Eskom to evaluate the Legionella risk:

- A detailed risk assessment of the CW system will be conducted by an external to Eskom assessor, certified to evaluate the risk of legionnaire's infection to personnel. Microbiologists can assist with the recommendations of the external assessors.
- There must be documented proof of continued improvement in the water quality management.
- Cooling water samples will be submitted to a ISO 11731 accredited laboratory on a quarterly basis and must be analysed according to the ISO 11731 method (for normal counts).

It is imperative that all personnel entering any part of the cooling tower which may contain Legionella must wear a P3 filter in half face mask or a 3M Aura Particulate Respirator 9332+ covering both the nose and mouth.

Although the Legionella are quite prolific in the cooling water system, they only become problematic if aspirated (breathed) into the lungs. For this to occur the water has to be in fine droplets as is the case in spray cooling or humidifying. Due to the fact that Legionella is often found in biofilms, the fact that the system has been drained does not minimise the risk. In fact it may increase, as the humidity within the system will allow the water present to be present in droplet form.

6. WORK TO BE PERFORMED BY THE *EMPLOYER*

- Take cooling tower out of operation for a maximum period of 80 days to allow replacement of fill, this also includes the washing and repairs of drift eliminators and water distribution system and installation of maintenance access.
- Treat cooling water for Legionella and produce test results to *Contractor*.
- Make provision for lay down area adjacent to the cooling tower and access to the cooling towers.
- Provide source of water and electricity supplies.
- Provide opportunity for site inspection inside a cooling tower during tender clarification meeting(s).
- Please note that no compressed air is available on site for use by the *Contractor*.
- All Scaffolding will be provided by the Power Station. Requirements to be arranged 3 days in advance with the *Employer*.
- Drain the pond however the *contractor* to assist in case the gravity draining is not possible.

7. TENDER RETURNABLES

7.1 GATE KEEPERS

7.1.1	Only *Contractors* with the design capability and proven track record for either natural draught or mechanical draught evaporative cooling tower thermal and structural design 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 verifiable design experience shall demonstrate compliance with the requirement(s) as defined below in Section 7.1.1 (a-c). The *Contractor* shall provide: • verifiable proof of design experience e.g. contractual documentation, certificate of completion 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, distribution system, drift eliminators, 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
7.1.2	*Contractor* or his *subcontractor* provides valid certification as Registered Asbestos Contractors.	

7.2 TENDER RETURABLES FOR TECHNICAL EVALUATION

The following will be used to score the tender returnables to evaluate if the *contractor* is cable to satisfy this Technical specification

7.2.1. Exclusions or qualification to this technical specification. If no exclusions or qualifications are provided, an explicit statement to this effect must be clearly made in the tender by the *Contractor*.

7.2.2. Preliminary method statements as detailed in Sections 4.18 and 4.19.

7.2.3. Tower performance, expressed in the re-cooled water temperature and evaporation rate for the water flow rate, range, atmospheric conditions and tower geometry provided in Section 4.1, i.e. the duty point.

7.2.4. Technical details of the fill modules containing the following as a minimum:

- Method of joining different sheets to each other to form a module, e.g. chemical, mechanical, fusion, etc.
- Number of contact points between adjacent sheets per square meter
- Module dimensions, length, width and depth.
- Maximum debris diameter (mm) which can pass through the fill.
- Maximum continuous operating TSS (ppm).
- Maximum water inlet temperature (°C).
- Specific weight, kg/m^3
- Photos/sketch of fill module:
  - From both sides (to show perforations).
  - Viewed directly from the top to show "see-through" characteristic.
  - Viewed from the top with a ruler or scale to show the dimensions of the openings.
- Life expectance of the fill
- Fill module material, formulation. In the case of PP the Contractor shall also specify dosage percentage of the master batch.
- Maximum water pressure for cleaning

7.2.5. High level drawing(s) of fill to be installed into the cooling tower showing the fill dimensions to meet the design duty point. If the *Contractor*'s design includes different fill depths for different areas of the inlet cross section of the cooling tower, details for each fill depth shall be indicated on the drawing

7.2.6. The total fill volume (m^3) to be installed in each cooling tower.

7.2.7 Typical drawing(s) of the support beams and arrangements for the fill i.e. width of supports and spacing of support beams. In addition, clarify whether each fill layer will be individually supported or how many layers will be carried by the bottom fill layer. If more than one set of support beams are used, details of each set to be provided.

7.2.8. Statement where the fill elements will be moulded or extruded.

7.2.9. A clear statement that the outage work will be completed in not more than 80 day period.

7.2.10. Programme indicating the off site design and manufacturing and on site work for the completion for the *Works* as detailed in this specification.

7.2.11. Replacement sprayer, drift eliminator and end-cap data sheets which include basic dimensions and verifiable reference list of existing installations.

7.2.12. Working platform arrangement (Option 1, 2 or 3), material and dimensions (if applicable). If no working platform will be installed, i.e. fill will serve as a working platform, a specific statement to be made.

7.2.13. Statement that the fill offered by the *Contractor* can tolerate levels of TSS in excess of 500 ppm on continuous basis together with brochures or technical data sheets of the specific fill stating this information.

7.2.14. Verifiable reference list of the particular fill being installed and in operation since 2014, i.e. a minimum of 6 years operational experience, for either natural - or mechanical draft cooling towers (minimum plot area size 60 m^2). The reference list shall contain the year of installation, country, client and details of the application.

7.2.15. List of sub-contractors that will be used during the contract.

7.2.16. List of items, e.g. material, components, raw material, products, that will be imported into South Africa for the completion of this project.

8. TENDER EVALUATION FORM

8.1 GATEKEEPERS

Section	Criteria	Yes / No
7.1.1	Only contractors complying with one or more of the requirements in Section 7.1.1 will be considered.	
7.1.2	*Contractor* provides valid certification as Registered Asbestos Contractors.	

Contractors who do not comply with both of the gate keepers will not be considered for further technical evaluation.

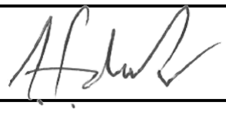
8.2 TECHNICAL EVALUATION

Minimum score of 70% required			**Score**			
Scope Section	**Criteria**	**Weight, %**	**0**	**2**	**4**	**5**
1	Exclusions or qualification to technical specification detailed in Sections 3 to 5	60	Deficient or non-responsive	Unacceptable risks or omissions in accordance with the requirements of section 3 to 5 of the Technical Specification	Acceptable risks	Fully compliant and no technical risks
2	Preliminary method statement as per the requirements of Section 4.18.	25	Deficient or non-responsive	Unacceptable risks or omissions in accordance with the requirements of section 4.18 of the Technical Specification	Acceptable risks	Fully compliant and no technical risks
3	Preliminary method statement as per the requirements of Section 4.19.	15	Deficient or non-responsive	Unacceptable risks or omissions in accordance with the requirements of section 4.19 of the Technical Specification	Acceptable risks	Fully compliant and no technical risks

Note: A minimum total of 70 % is required in this section for further consideration. The tenderer is to ensure that all the evaluation criteria are submitted as stated with the tender application.

9. AUTHORISATION

This document has been seen and accepted by:

Name & Surname	Designation	Signature
Francois du Preez	AMME: Condensing and Feedheating	

10. REVISIONS

Date	Rev.	Compiler	Remarks
April 2021	5	FdP	First draft

11. DEVELOPMENT TEAM

Francois du Preez

Nathi Mabaso

12. ACKNOWLEDGEMENTS

APPENDIX A: COOLING TOWER DETAILS

1.2 Technical Description

The plant description is subdivided into the sections civil work and internal equipment.

1.2.1 Civil Work

The cooling tower consists of the following items

- tower shell
- shell support columns
- foundation ring
- piled foundation
- water inlet
- central riser
- distribution channel
- stack support system
- cold water pond
- cold water outlet

The tower shell has a hyperbolic shape with a minimum wall thickness of 200 mm. Above the throat the shell has been built in a slightly convergent shape. In order to enlarge the stiffness of the shell edges the lower and upper portions of the shell have been increased in thickness. Both faces of the shell are reinforced in two directions. The concrete cover to all reinforcement in the shell is minimum 35 mm on the inside face and minimum 40 mm on the outside face. The characteristic strength of the concrete, which is class B, was taken as 30 MPa at 28 days after mixing for the shell design.

A total of 72 diagonal columns supports the tower shell. The columns have a circular cross-section with a diameter of 760 mm and consist of reinforced concrete of class A with a minimum strength of 32 MPa at 28 days after mixing. The concrete cover to all reinforcement is minimum 40 mm. The feet of two single diagonal columns are combined in one common plinth, which transfers the loads into the foundation.

The foundation ring is a continuous uniform and annular reinforced concrete structure. It acts in two different functions. Firstly it serves as a common pile cap for the 36 augered piles. Secondly its function is to act as a tension member loaded by radial loads, as the rake of the piles is different from the base angle of the shell. The ring beam has been constructed in reinforced concrete of class C with a minimum strength of 20 MPa at 28 days after mixing. The concrete cover for the ringbeam is minimum 75 mm.

The ring foundation beam of the cooling tower is founded on augered piles of 1500 mm diameter. The piles are arranged in a rake of 1:4 radially outwards with a reinforced concrete characteristic strength of minimum 25 MPa. The concrete cover is minimum 75 mm. All piles have been drilled so far below normal refusal level, that the pile socket length is at least 1000 mm.

The hot water inlet with a square cross-section of 2600 mm x 2600 mm is located above the pond floor.

It rests on 500 mm high footings thus leaving between the bottom of the inlet channel and the top of the pond floor a clear space of 500 mm height. The concrete used is of class B with a 28 days strength of minimum 32 MPa. The concrete cover to all reinforcement is minimum 35 mm. Two expansion joints allow longitudinal movements of the inlet due to temperature variations.

The riser located in the center of the tower has a clear cross-section of 2600 mm x 2600 mm. It consists of concrete class B with a 28 days strength of 32 MPa. The reinforcement cover is minimum 35 mm. At the elevation 'P'-level plus 9 500 mm (equal 1 635,7 m a.m.s.l.) the inlet openings for the rectangular distribution duct have been located.

The horizontal distribution channel has the clear dimensions height x width equal to 1650 mm x 2290 mm. The side walls contain the flared inlets for the water distribution piping. The bottom of the duct has drain openings, whereas the roof slab is equipped with wall sleeves for vent pipes. The distribution duct rests on support frames. The concrete quality used for the distribution duct is of class B with a 28 days strength of 32 MPa. The concrete cover is minimum 35 mm.

The cooling tower internals support system consists of single beams, multiple beams, columns and frames. All the support elements are precast. One layer of single beams, arranged on top of the columns and frames at level 'P' + 11 700 mm, serves as a support for the drift eliminator. The multiple beams support the water distribution piping at level 'P' + 9 500 mm and heat exchanger fill at level 'P' + 8 400 mm and at level 'P' + 7 450 mm. Every second multiple beam rests on single beams transferring its loads to columns or frame legs. The layer of single beams at level 'P' + 6 500 mm supports the lower six layers of fill. The whole system is horizontally stabilized by frames acting in two directions, namely parallel and perpendicular to the inlet duct. One group of frames is located under the hot water distribution duct and the second group stands upon the inlet duct respectively along the extension of the inlet duct axis on the pond floor. The concrete used for all the precast structural members is of class A1 with a strength of 32 MPa at 28 days after mixing. The concrete cover to all reinforcement is minimum 20 mm. The columns and frame legs have cast-in corbels, on which the beams rest. The beams and columns are arranged in such a way, that the free span length for all internals (drift eliminator, water distribution piping, and fill sheets) is 2 510 mm.

The loads of the fill supporting columns and of the inlet duct are directly transmitted to the mudstone by mass concrete footings provided under the pond floor. The holes for the column footings were augered down to the level of competent material and immediately filled with concrete. This procedure ensures a minimal settlement below the columns.

Four wind screens have been provided in order to reduce losses of cooling water by drift out of the air inlet and to assure a uniform airflow through the heat exchanger fill during strong winds. The screens are located in the tower radially at ninety degree intervals. They extend vertically from the lower edge of the packing to the pond water level. Laterally they project from the pond edge to the tower center for a distance of one quarter of the pond diameter. The screens consist of precast concrete elements fastened to the legs of the support frames. For balancing the pressure within the cooling tower, openings are provided between the individual wind screen elements allowing the air to pass between neighbouring tower sectors and to avoid a dead space on the leeward side of the vertical wind screen.

The cold water pond side wall is located outside the shell column plinths. The depth of the pond is 2000 mm below 'P'-level; the thickness of the side wall is 200 mm. Beneath the pond floor a 75 mm thick layer of blinding concrete of class E has been provided. The thickness of the pond floor is 175 mm. For the entire pond concrete of the class B with a 28 days strength of 32 MPa has been used. The thickness of the concrete cover over the reinforcement is minimum 30 mm for the pond floor and minimum 35 mm for the pond wall. The pond floor is separated from the foundation ring by a water bar type no. CBR 190, whereas a galvanized iron water bar has been provided for the working joint between pond wall and shell foundation ring. Between the outlet structurr and the ring beam a rubber water stop has been arranged.

The outlet, which has been designed and constructed under a separate contract, is 19 500 mm wide. The total width is subdivided by piers and walls into 4 openings with clear widths of about 4 500 mm. For the piers, internal walls, curbs and walkway slab concrete of class C1 with 28 days strength of 20 MPa has been selected. The concrete cover to all reinforcement is minimum 35 mm. The construction joints of the external walls and slabs were equipped with galvanized iron water stops.

1.2.2 Internal Equipment

The cooling tower internal equipment includes

- heat exchanger fill
- water distribution system
- drift eliminators
- access facilities

The material of the film packing, which is used to increase the heat transfer between the circulating water and the air flowing through the tower, is asbestos cement complying with S.A.B.S. 685. The fill system consists of flat sheets, which are arranged in several layers within the lower portion of the shell. In order to produce a combination of film and splash heat transfer, alternate layers of fill have been installed at right angles. The individual fill sheets (length x height x thickness equal to 2500 mm x 150 mm x 4,2 mm) are assembled into fill packs.

A system of rods and plastic spacers holds the fill sheets in both vertical and horizontal alignment. The entire fill system is supported by reinforced concrete beams.

The inlet duct enters the tower above the foundation ring beam. It feeds the central riser, out of which the water flows into the distribution ducts. Horizontal asbestos cement distribution pipes which comply with S.A.B.S. 286, feed the cooling water to the spray nozzles screwed directly into the pipes. The tower spray system consists of a multiplicity of plastic sprayers located at uniformly spaced intervals above the entire fill area. The sprayers are arranged to spray the hot water in an upward direction. The upward directed spray system creates a long spray dwell time for each water droplet. The heat rejection achieved in the spray zone is considerably higher than for a down-spraying system. The sprayer breaks the cooling water jet into a spray pattern of uniformly sized droplets. The uniform break-up of the water creates a very large surface to volume ratio. This feature results in a significant overall evaporative heat transfer in the spray zone. The sprayers are arranged in a square pattern. The pitch distances produce an overlapping of the individual sprays. This arrangement and the upspray of uniformly sized droplets create a very even water distribution above the fill. The overall result is a maximum heat transfer efficiency within the fill system. As the sprayers are mounted on top of the distribution pipes, any accumulated silt deposits on the bottom of the pipes and not in the nozzles. The silt accumulation in the pipes can be flushed by momentarily opening of butterfly valves, which are located at the end of each distribution pipe and have to be manually operated. This operation can be performed during normal tower operation.

As the riser extends sufficiently above the horizontal distribution ducts, 150 percent of the normal circulation water flow can be accommodated without overflowing of the riser. In addition the riser dampens pressure surges, which may occur during operational transients. The horizontal distribution ducts are provided with downward spraying nozzles. They are attached to the bottom of the ducts thus avoiding settlement of silt and allowing all water to drain out of the distribution system, when the water flow is shut-off. Venting during start-up and shut-down of the system is allowed by vent pipes in the roof of the ducts.

The drift eliminator is located 2 000 mm above the water distribution system. It rests on a layer of precast concrete beams at about 11 500 mm above 'P'-level. This arrangement leads to very uniform velocities through the drift eliminator, which is important for achieving low drift rates. The drift eliminator consists of 6 mm thick corrugated asbestos cement sheets, which comply with S.A.B.S. 685. Between the corrugated sheets the air flow direction is changed (three times) and inertially the water droplets are separated from the air flow. The droplets captured by the drift eliminator return to the fill system by gravity. The individual corrugated sheets are assembled into panels by means of plastic spacers and threaded non-corrodbile rods.

WARNING:

It is not permitted to walk on the drift eliminators!

A stairway outside the cooling tower leads to an access door permitting entrance to the tower at the height 'P'-level plus 11 170 mm, which is the top of the hot water distribution duct. The top of the distribution duct serves as a regular walkway. As the end flush valves of the distribution piping are located at the shell circumference at the elevation 'P'-level + 9 500 mm, the maintenance personnel have to descend from the top of the hot water distribution channel down to the top of the fill at the elevation 'P'-level plus 9 300 mm. For each quarter of the tower a hatch door has been provided in the drift eliminators. With the help of permanent ladders of hot dip galvanized steel an operator can easily step down on to the top of the fill for inspection and maintenance work. The course of a normal inspection walk is from the access ladder to and along the pipe end flush valves. Those areas of the fill, on which regular inspection walking takes place, have been equipped with grates of hot dip galvanized steel. The steel grids ensure that the live loads are sufficiently spread so that the heat exchanger sheets are not damaged. For maintenance work of the sprayers the workmen have to walk on top of the multiple beams or directly on top of the fill. In this case the workmen have to wear soft rubber-soled or canvas shoes to avoid any possible damage to the sheeting.

2. OPERATING INSTRUCTIONS

The cooling system is a wet natural draught cooling tower which rejects the heat by bringing the circulating cooling water into direct contact with the air flowing through the tower. Most of the cooling is produced by evaporation of water or exchange of mass between cooling water and air. Only a minor portion of the heat transfer is the result of convection, which causes a heat flow from the medium with higher temperature to the medium with lower temperature. Under certain conditions the convective portion of the process can be zero or even act in the reverse direction.

2.1 Pre-start Checks

Before starting-up the cooling tower the following requirements must be fulfilled:

- The cold water pond must generally be filled with water up to the normal operating level, which is 'P'-level minus 250 mm. The absolute minimum water depth is about 600 mm corresponding to a water level of 'P'-level minus 1 400 mm. For smaller water depths the cooling water pumps may run dry.

- Within the cooling tower the end flush valves of the distribution piping must be closed.

- The make-up water supply must be ready for operation.

- The blow-down system must be ready for operation.

CAUTION:

No tower operation without sufficient water in the tower pond!

APPENDIX B: REPRESENTATIVE CW CHEMISTRY

Take note that TSS is not measured on site, and in addition note that the CW chemistry at Tutuka exceeds some of the limits detailed in [23].

Date	Calcium (mg/l as CaCO3)	CCPP	Chlorides (mg/l)	copper (mg/l)	Iron (mg/l)	Potassium (mg/l)	Conductivity (µS/cm)	M-alk (mg/l as CaCO3)	Magnesium (mg/l as CaCO3)	Sodium (mg/l)	P-alk (mg/l as CaCO3)	pH	PO4 (mg/l)	Silica (mg/l)	Sulphates (mg/l)	TOC (mg/l)	Turbidity (NTU)
2019/01/02	315	88	1498	0.09	0.27	152	14340	216	2205	2519	20.5	8.9	0.80	15.5	4300		9.4
2019/01/03	231	102	1647	0.09	0.27	173	15053	226	2725	1135	20.5	8.8	0.80	16.8	3280		9.2
2019/01/04	257	62	1658	0.10	0.37	162	14845	223	2126	2492	21.2	8.8	0.80	16.2	25220	45.1	10.4
2019/01/05	328	67	1862	0.09	0.32	186	15538	212	2279	2608	16.5	8.7	0.80	16.9	6940		10.3
2019/01/06	601	77	1847	0.11	0.36	185	16287	213	2381	2737	16.4	8.7	0.80	16.3	26420	42.7	9.2
2019/01/07	262	121	1768	0.06	0.06	192	13929	206	2719	2852	18.3	8.8	0.70	19.1	4090		13.8
2019/01/08	370	92	1738	0.09	0.25	184	15230	211	2967	1932	16.6	8.8	0.80	16.7	4180		9.5
2019/01/09	397	70	1458	0.09	0.43	160	13809	194	2101	2304	11.8	8.6	0.80	17.7	3170		18.6
2019/01/10	318	76	1322	0.15	0.36	153	12284	190	2202	2306	12.3	8.7	0.70	18.2	23060	43.3	11.4
2019/01/11	257	85	1398	0.09	0.22	157	13697	191	2187	2363	13.7	8.7	0.80	16.5	29090		8.5
2019/01/12	794	74	1386	0.08	0.21	158	13234	201	2333	2508	12.1	8.6	0.80	17.3	7418		9.5
2019/01/13	313	71	1307	0.08	0.25	156	13101	207	2303	2568	10.1	8.6	0.70	19.7	6115	38.9	7.3
2019/01/14	251	87	1368	0.08	0.23	145	13470	211	1906	2151	17.6	8.8	0.70	17.3	5882		8.4
2019/01/15	269	91	1356	0.08	0.34	142	13485	211	2041	2280	17.3	8.7	0.80	17.9	6968		12.5
2019/01/16	492	57	1414	0.08	0.32	164	14119	175	2243	2831	10.8	8.6	0.80	21.4	8399	38.4	10.2
2019/01/17	349	83	1479	0.07	0.62	177	14627	173	1314	2909	12.6	8.7	0.80	11.2	7958		8.3
2019/01/18	967	72	1495	0.07	0.41	141	13810	175	906	2494	10.9	8.6	0.80	12.6	6185		13.7
2019/01/19	397	97	1459	0.05	0.21	209	14206	184	1864	2989	12.6	8.7	0.01	11.6	7651	37.5	8.3
2019/01/20	357	95	1640	0.08	0.35	141	14619	185	999	2642	15.8	8.8	0.80	11.8	6601		12.6
2019/01/21	484	107	1970	0.01	0.05	251	19593	183	2384	4702	13.4	8.7	0.01	12.0	9187	22.6	5.2
2019/01/22	438	72	1790	0.01	0.07	218	17424	274	2008	4450	17.8	8.7	0.01	11.8	10350		7.2
Average	**402**	**83**	**1565**	**0.08**	**0.284**	**172**	**14605**	**203**	**2104**	**2656**	**15.2**	**8.7**	**0.67**	**15.9**	**10117**	**38.4**	**10.2**
Specification	**200-500**	**30**	**<400**	**Not specified**	**Not specified**	**Not specified**	**4000**	**80-120**	**Magnesium X Silica=<25000**	**<500**	**7.5**	**8.1-8.6**	**0.5**	**<150**	**1000**	**ALAR**	**100**

mg/l=milligrams per liter
CaCO3= Calcium Carbonate
CCPP= Calcium Carbonate Precipitation Potential
µS/cm=micro siemens per centimeter
M-alk=Methyl orange alkalinity
P-alk=Phenolphtalein alkalinity
PO4-Orthophosphates
TOC=Total Organic Carbon
NTU=Nephelometric Turbidity Units

	Calcium (mg/l as CaCO3)	CCPP	Chlorides (mg/l)	Sulphates (mg/l)	Conductivity (µS/cm)	M-alk (mg/l as CaCO3)	Magnesium (mg/l as CaCO3)	Sodium (mg/l)	Turbidity (NTU)	P-alk (mg/l as CaCO3)	pH	PO4 (mg/l)	Silica (mg/l)	TOC (mg/l)	copper (mg/l)	Iron (mg/l)	Potassium (mg/l)
Average	402	83	1565	10117	14605	203	2104	2656	10.2	15.2	8.71	0.67	15.9	38.4	0.079	0.284	172
Site Specifications	500	30	400	1000	4000	120	2500	500	100	7.5	8.6	0.5	150	ALARA	-	-	-

ALARA=As Low as Reasonable Achievable