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1. INTRODUCTION

Ion Exchange Resins perform one of the most crucial tasks in the production of demineralized (demin) water; which is the removal of unwanted cations and anions. After a while, these resins become exhausted and need to be regenerated in order to perform their function. The Sulphuric Acid Storage and Dilution system is used to regenerate resins within the cation and mixed bed units. The cation and mixed bed segments of the Sulphuric Acid Storage and Dilution system has experienced a significant amount of downtime; due to several failures in the pipework. The reasons for these failures were lack of timeous maintenance and lack of foresight in the current design. These failures have impacted the demin water production as well as compromised the safety of the operating and maintenance staff. The objective of this project was to design a sulphuric acid storage and dilution system that will enable accurate, timeous and safe regeneration of resins in the cation and mixed bed exchangers.

2. SUPPORTING CLAUSES

2.1 SCOPE

This document provides the scope of work for the Sulphuric Acid Storage and Dilution Upgrade project.

2.1.1 Purpose

This document provides the scope for the procurement, commissioning, operation, maintenance and performance testing of the entire engineering Works.

2.1.2 Applicability

This document applies to Duvha Power Station.

2.2 NORMATIVE / INFORMATIVE REFERENCES

2.2.1 Normative

[1] 240-108079430 Power Plant Water Systems Design Guideline

[2] 240-46977703 PCM for Engineering Design

[3] 240-53114002 Engineering Change Management (ECM) Procedure

[4] ISO 9001 Quality Management Systems

2.2.2 Informative

Not Applicable.

2.3 DEFINITIONS

Not Applicable.

2.4 ABBREVIATIONS

Abbreviation	Description
BS	British Standard
Conc.	Concentrated
CPP	Condensate Polishing plant
C&I	Control and Instrumentation
DCS	Distributed Control System
Demin	Demineralized
DFT	Dry Film Thickness
DT	Destructive Testing
ECM	Engineering Change Management
EN	European Standard
EPDM	Ethylene Propylene Diene Monomer
HMI	Human Machine Interface
IWE	Independent Welding Engineer
IWT	Independent Welding Technologist
I/O	Input/Output
NACE	National Association of Corrosion Engineers
NDFT	Nominal Dry Film Thickness
NDT	Non-Destructive Testing
NRV	Non-Return Valve
OEM	Original Equipment Manufacturer
PTFE	Polytetrafluoroethylene
QCP	Quality Control Plan

Abbreviation	Description
QMS	Quality Management System
RP	Responsible Person
SAQCC	South African Qualification and Certification Committee
SIT	Site Integration Testing
WPQR	Welding Procedure Qualification Record
WTP	Water Treatment Plant

2.5 ROLES AND RESPONSIBILITIES

The roles and responsibilities are outlined in the ECM Procedure. [3]

2.6 PROCESS FOR MONITORING

This document is governed by the ECM Procedure. [3]

2.7 RELATED / SUPPORTING DOCUMENTS

382-169338 Duvha Power Station Sulphuric Acid Storage and Dilution System Engineering Management Plan

382-168925 Duvha Power Station Sulphuric Acid Storage and Dilution System Concept Design Report

382-168927 Duvha Power Station Sulphuric Acid Storage and Dilution System Stakeholder Requirements Definition

382-168926 Duvha Power Station Sulphuric Acid Storage and Dilution System Required Operational Capability Report

3. DESIGN

The Contractor must provide the detailed design of the entire scope of the Works.

3.1 DESIGN SPECIFICATIONS

3.1.1 General Requirements

The Contractor's design must:

- Comply with the requirements of the Works Information.
- Be carried out by qualified and experienced personnel.

Prior to submission, the detailed design must be approved by qualified and competent individuals (in the relevant engineering disciplines) who are professionally registered with an internationally recognised engineering body.

3.1.2 Battery Limits

3.1.2.1 Mechanical Battery Limits

The battery limits of the mixed bed segment of the system includes:

- The conc. acid line - from the outlet of the sulphuric acid bulk tanks (10UE51S016) up to (and including) the mixing T (10UE51G016).
- The demin dilution water line - from (not including) the demin dilution water pumps (10UB30D001, 10UB30D002) up to (and including) the mixing T (10UE51G016).
- The dilute acid line – from the mixing T (10UE51G016) right up to (but not including) the three mixed bed ion exchange vessels (10UB11G001, 10UB12G001, 10UB13G001).
- The control air line - from (but not including) the control air common line (10UE51S049) up to (and including) the mixed bed acid batch tank (10UE51G005).

The battery limits of the cation segment of the system includes:

- The conc. acid line - from the outlet valve of the sulphuric acid bulk tanks (10UE51S016) up to (and including) the first mixing T (10UE51G017).
- The demin dilution water line - from (not including) the demin dilution water pumps (10UB30D001, 10UB30D002) up to (and including) the first mixing T (10UE51G017).
- The dilute acid lines – from the first mixing T (10UE51G017), splitting into the two acid lines, right up to (but not including) the three cation ion exchange vessels (10UB11G001, 10UB12G001,

10UB13G001). This is inclusive of the second mixing T (10UB10G001) as well as all the pipework in both lines feeding the top and the bottom of the cation exchange vessels.

- The filtered dilution water line - from (and including) the 65 NB tap-off of the 300 NB filtered water line, up to (and including) the second mixing T (10UB10G001).
- The control air line - from (but not including) the control air common line valve (10UE51S055) up to (and including) the cation acid batch tank (10UE51G006).

The Contractor is not allowed to alter any parts of the plant which are not included in the above lists. For additional clarity on the closely linked systems:

- The Contractor is NOT allowed to alter any part of the CPP A or CPP B segments of the sulphuric acid storage and dilution systems. When work is performed on the acid manifold, the Contractor must ensure that the CPP A and CPP B segments of the system are not affected in any way and that the necessary connections of these segments to the manifold are in place.
- The demin water regen line supplies several other surrounding plants. When work is performed on the demin water line, the Contractor must ensure that the surrounding systems (and the operation thereof) are not affected in any way and that all necessary connections are in place.
- The 300 NB filtered water pipe supplies several other surrounding plants. If any modification is to be made to the 60 NB pipe or the 60 NB tap-off from the 300 NB pipe, the Contractor must ensure that the surrounding systems are not affected in any way.

The Contractor must ensure that the entire sulphuric acid storage and dilution system (especially the mixed bed and the cation segments) is fully functional, fully automated and meets all requirements as set out in the Works Information.

3.1.2.2 C&I Battery Limits

The Contractor is responsible for the C&I design and replacement of all the C&I components of the system outlined in the mechanical battery limits section. The Contractor is to ensure that all the control and instrumentation are standardised with the existing equipment and linked to the WTP DCS.

3.1.2.3 Electrical Battery Limits

The Contractor is responsible for the electrical design (if necessary) of all the segments of the system outlined in the mechanical battery limits section.

3.1.2.4 Civil and Structural Battery Limits

The Contractor is responsible for the civil and structural design (if necessary) of all the segments of the system outlined in the mechanical battery limits section.

3.1.3 Employer's Engineering Design

The Employer's Concept Design investigated three design options for the cation and mixed bed segments of the system: the upgrade of the current system, the pump system and the eductor system. Taking into consideration the key design drivers, the eductor system was selected as the optimal technology for this system. The new systems will replace the current systems.

The systems will make use of direct injection whereby the 98% sulphuric acid will be drawn, via suction, directly from the bulk acid manifold (which draws from the bulk tanks) by the eductor. The proposed systems are shown below:

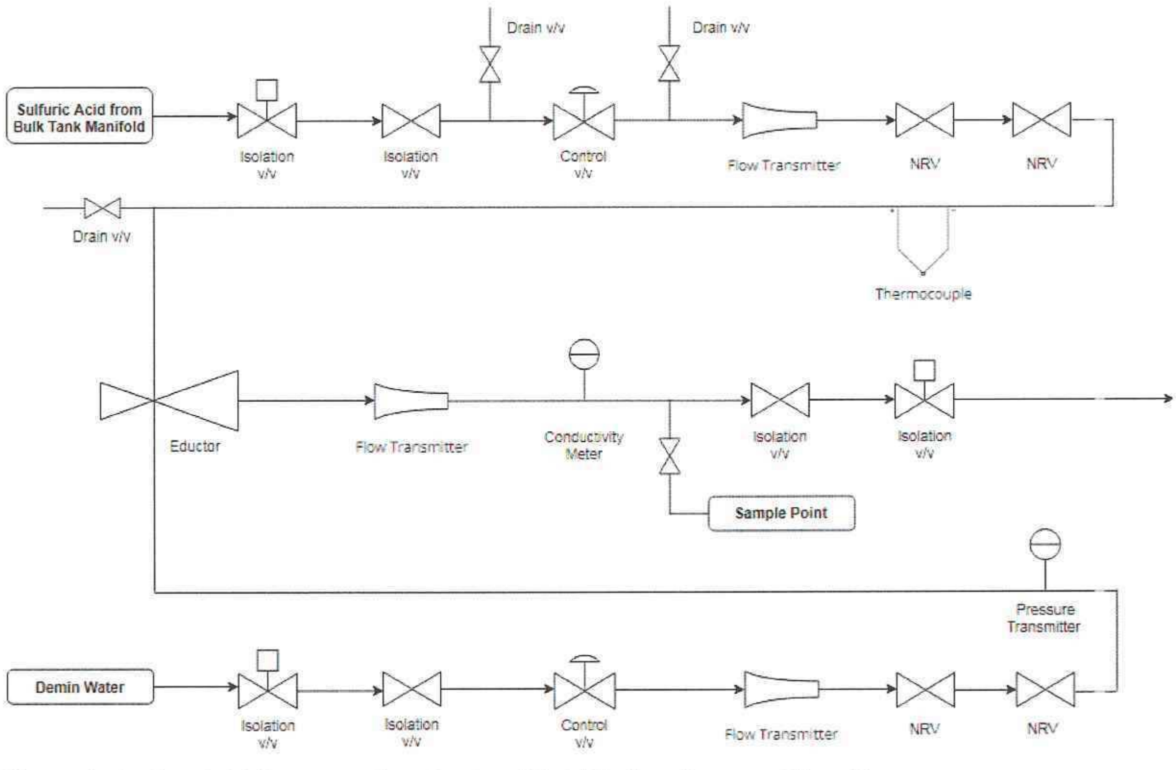

Figure 1: Cation Acid Regeneration System First Dilution Process Flow Diagram

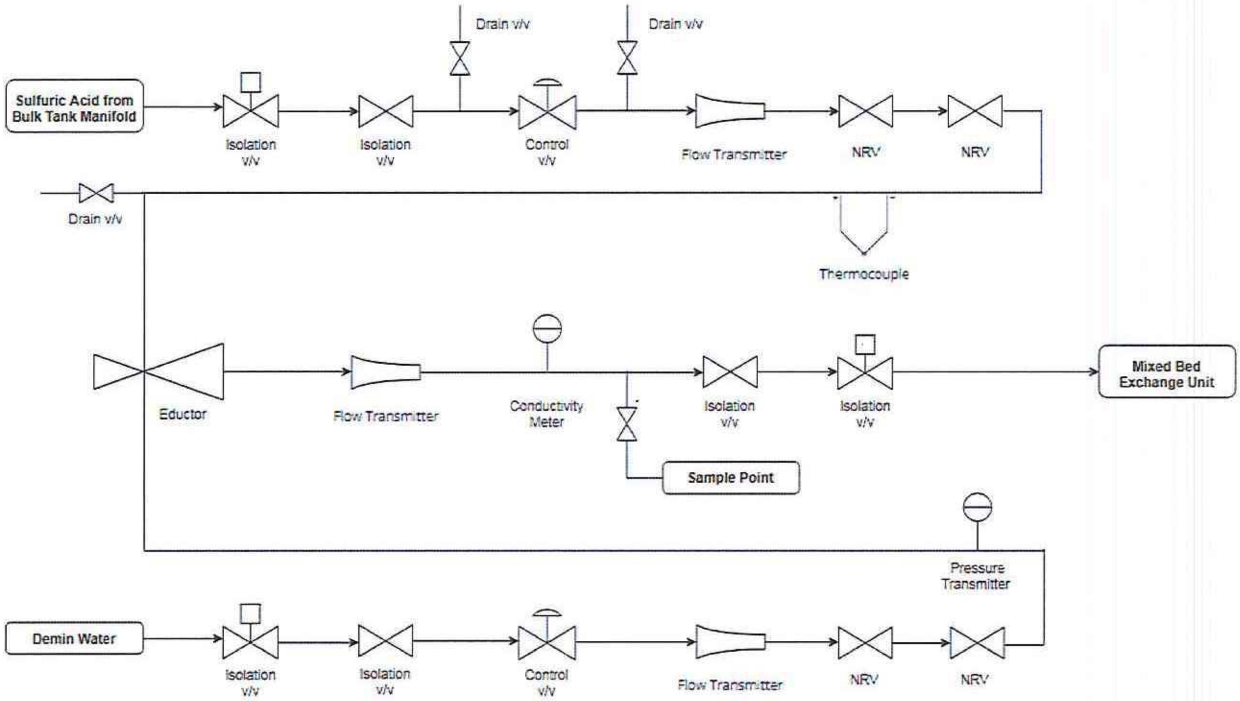

Figure 2: Mixed Bed Acid Regeneration System Process Flow Diagram

The proposed changes are identical for both the cation and the mixed bed hence only one segment will be discussed. The boundaries of the system consists of two isolation valves, one pneumatically actuated and one manual, in order to isolate the system when the system is not in use. The modulating control valve in the acid line regulates the flow of acid to achieve the set-point on the online conductivity meter, which is located after the mixing occurs. The modulating control valve in the demin line will be regulated by a set-point on the flow transmitter in the demin line. The two non-return valves in both the water and the acid lines are to prevent water ingress in the acid line and vice versa. In addition, thermocouples will be placed in the acid line as a protection and will trip the regeneration process if there is an indication of water ingress. Drains are placed frequently along the acid line to ensure there is no stagnation of acid in the system after the regenerations take place. These acid drains will be routed to the effluent launders. The water and acid lines meet at the eductor where they mix. After the eductor there is a sample point which can be used to verify the conductivity meter readings. The drains from the sample lines will also be routed to the effluent launders. After the regeneration takes place, the system will be flushed with water and the drains in the acid lines will be opened. This is to ensure there is no stagnation of acid in the system.

In the mixed bed system, the acid is sent to one of the three mixed bed exchangers after being mixed at the eductor.

In the cation regeneration system, the acid is split into two lines after the first dilution. The one line is sent to the bottom of one of the three cation exchangers and the other line is further diluted (with filtered water) and then sent to the top of the respective exchanger. This is to accommodate for the two different types of resins used in the cation exchangers. The second acid dilution operates using a similar system; by varying flowrates until the set-point on the conductivity meter is reached. This process is an existing process and the design of which will remain the same. All components of the system that is not being redesigned must be replaced. Refer to the diagram below (the diagram is over-simplified for illustration purposes):

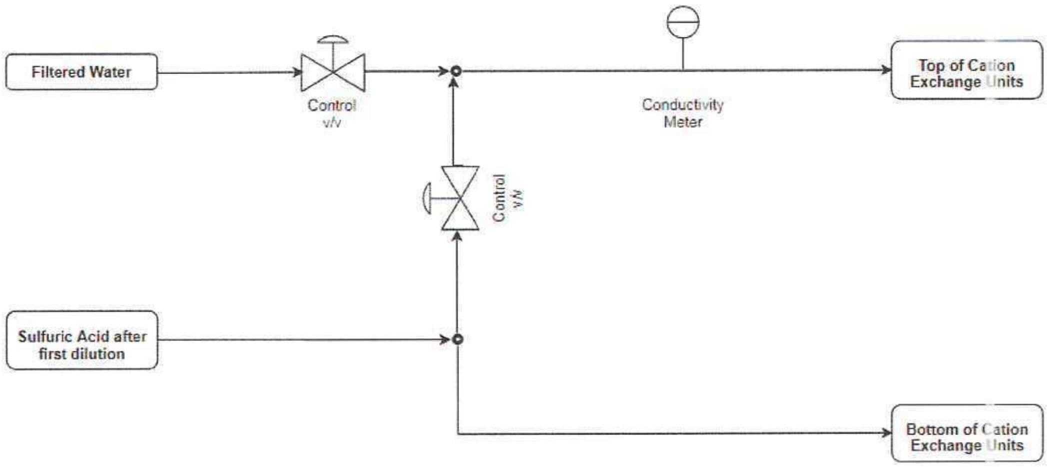

Figure 3: Simplified Cation Acid Regeneration System Second Dilution Process Flow Diagram

Water hammering at the regen station is not advised and will be prevented by installing a slow opening valve before the eductors. All actuated valves in the system are to be pneumatically actuated.

The regeneration methods for both the units are outlined below:

Mixed Bed Exchange Unit - Acid Regeneration

Before the acid injections take place, motive water (demin dilution water) will have to be sent to the eductor. Once the motive water flow has been established, the acid injection can then commence.

The mixed bed exchange unit makes use of strong acid cation resin and strong base anion resin. Sulphuric acid is used to regenerate the strong acid cation resin and this regeneration forms part of this document.

As per the current operation, the mixed bed system supplies 6 % H_2SO_4 at a 10.8 m^3/h flowrate and a conductivity of 234 mS/cm to the respective mixed bed exchangers. It is important to note that these values are the concentrations and flowrates for the system during normal operation; a buffer (5-10%) must be put in place for expandability purposes.

Cation Exchange Unit - Acid Regeneration

Before the acid injections take place, motive water (demin dilution water) will have to be sent to the eductor. Once the motive water flow has been established, the acid injection can then commence.

The cation exchange units at Duvha Power Station make use of weak acid cation resin (Purolite C104DLPlus - 4000 L) at the top of the columns and strong acid cation resin (Purolite C100DL – 10500 L) at the bottom of the columns.

In the current sulphuric acid storage dilution system, the acid is diluted (with demin water) to the concentration required by the strong acid cation resin (bottom of the column). Thereafter, the acid is split into two lines; one for the bottom and one for the top of the column. The top flows are further diluted (with filtered water) to obtain the lower concentrations as required by the weak acid cation resin. The regeneration of both resins take place simultaneously.

The table below illustrates the regeneration process for the cation ion exchange vessel.

Table 1: Illustrating the parameters of the acid flowing into the top and bottom of the Cation exchangers

Step	Where	% H_2SO_4	Flowrate (m^3/h)	Time (min)
Injection A	Top	0.8	21	60
	Bottom	1.8	14.5	
Injection B	Top	1.6	21	60
	Bottom	3.6	14.5	

It is important to note that these values are the concentrations and flowrates for the system during normal operation; a buffer (5-10%) must be put in place for expandability purposes. The system must also be programmed to allow for a double acid injection, which might be required as an abnormal operation. If necessary, this will require injection A and B to be repeated.

3.1.3.1 Operating Concept

The system was designed to be simple from an operational perspective hence the entire process will be automated via the control room. During normal operation, the pneumatically actuated isolation valves will open and close to initiate and stop the regeneration and the manual isolation valves will remain open.

3.1.3.2 Maintenance Concept

This system is essential to the production of demin water hence there should be almost no downtime. For this reason, spare eductors will be kept on hand in the event of failure. For the newly designed segments, the spare parts holding list for each of the two systems includes: two eductors, an acid modulating control valve, a water modulating control valve, a non-return valve for the water line, a non-return valve for the acid line, a flow transmitter (for the demin line) and a conductivity meter on hand. This is only for the newly designed segments of the system.

3.1.3.3 Control and Instrumentation Design

The C&I scope includes:

- Installation of field instruments/equipment that will interface with the WTP Distributed Control System (DCS). All instrumentation must be installed as per OEM requirements to ensure accurate measurements.
- Engineering of the new control philosophy in the WTP Symphony Infi90 DCS.
- Development of new graphics for the preferred option in the WTP 800xa Human Machine Interface.

The following instruments will be installed in the newly designed segments of the system:

- Differential pressure transmitters across all non-return valves to ensure that it is easy to detect when they are clogged. There will be a total of 8 Differential Pressure transmitters: 4 for the cation acid regeneration system and 4 for the mixed bed regeneration system.
- 2 conductivity analysers to be used for valve position control in the acid lines.
- 2 pressure transmitters to monitor the pressure in the demin lines.
- A total of 16 proximity switches to ensure that all manual isolation valve positions are available in the control room; 8 proximity switches for open limits and 8 for the closed limits.
- 4 valve positioners; one for each modulating control valve.
- A total of 6 flow transmitters i.e.: 2 for acid lines, 2 for demin water lines and 2 flow transmitters after the eductors. The 2 flow transmitters in the demin line will be used to control the control valves in the demin lines.
- 2 thermocouples to be used as a protection to trip the system if water ingress occurs in the acid line.

3.1.3.4 Electrical Design

No electrical design was performed by Eskom as it was not deemed necessary in the concept design phase. All electrical design work and components are to be performed, supplied and installed by the Contractor; if these are deemed necessary in the Contractor's detailed design.

3.1.3.5 Civil and Structural Design

No civil and structural design was performed by Eskom as it was not deemed necessary in the concept design phase. All civil and structural design work and components are to be performed, supplied and installed by the Contractor; if these are deemed necessary in the Contractor's detailed design.

3.1.4 Functional and Performance Requirements

The mixed bed and cation segments of the system must:

- Incur minimal operator intervention.
- The entire system must include the following modes of operation: automatic, remote manual, local manual and local maintenance. Note: the standard mode of operation is to be automatic.
- Meet the operational concentrations and flowrates as set out in the Employer's Engineering Design section of this technical specification. These operational concentrations and flowrates must be achieved at the entrance into the relevant ion exchange vessels. The design must also include a buffer for resin expandability purposes and possible future efficiency losses.
- The Contractor must perform hydraulic designs and other calculations/tests to determine the suitability of the current system with the newly designed segments. If the existing system is found suitable, all the components in the system upstream and downstream of the newly designed segments must be replaced. If not suitable, the Contractor will be responsible for the modification of the existing system. The entire system must be functioning optimally (including the CPP A and CPP B portions) before handover takes place. This hydraulic study must be performed as a tender returnable. This is so that the cost is inclusive of all modifications and replacements of components in the system.
- The design must include the safety and corrosion prevention mechanisms as stipulated in the Employer's Engineering Design (i.e. draining and flushing of lines after regeneration, NRVs in the acid and water lines, thermocouples to detect ingress, etc.). The Contractor may implement additional mechanisms to enhance the safety, reliability and longevity of the system.

- Notify the operator, by means of alarms in the control room, if there is an indication of water ingress in the acid line. The system must be tripped and the regeneration process halted if there is a clear indication of the ingress.

3.1.5 System Architecture

The system architecture (mainly component sizing and ratings) for some of the components in the existing system is provided in the table below. The Contractor must evaluate whether these existing components are suitable for their design. For the components that do not fall within the battery limits, the Contractor must design the system such that these components are suitable.

Table 2: Illustrating the parameters of the current system.

Component	Description
Pipes – Conc. Acid	The acid manifold is an 80 NB pipe with 25 NB tap-offs. Each segment of the system (cation, mixed bed and CPP) taps off from the manifold. The eductor system can draw conc. acid from this manifold using the 25NB tap-off. (Contractor to verify if suitable)
Pipes – Demin Dilution Water (1st dilution)	100 NB pipe from the demin dilution pumps becoming an 80 NB pipe before feeding the cation and mixed bed segments. The mixed bed segment taps off with a 50 NB pipe and the cation segment taps off with a 65 NB pipe. The cation line further reduces to 40 NB before the mixing T. (Contractor to verify if suitable)
Pipes – Filtered Dilution Water (2nd dilution) – Only for Cation segment	65NB reducing to 50NB pipe before mixing with the acid line. (Contractor to verify if suitable)
Pipes – Dilute Acid	100 NB pipes after the acid dilution, reducing to 50 NB and then becoming 80 NB before the mixed bed ion exchange vessels. (Contractor to verify if suitable) In the cation segment, the pipework after the first dilution but before the split is 65 NB. After the split, the pipes going to the bottom of the vessel is 65 NB and the pipe going towards the top is 50NB. The pipe going to the top of the vessels becomes 65 NB and then meets with a 50 NB filtered water

	line. After the join, the pipe is 80 NB going to the top of the cation exchangers. (Contractor to verify if suitable)
Control Air Supply	The air pressure in the WTP is 400 kPa.

The system architecture for the newly designed segments and the segments of the system which will be replaced is provided in the table below:

Table 3: Illustrating the design parameters for the major components of the newly designed system.

Component	**Description**
Pipes – Conc. Acid Line	The pipework from (and including) the bulk acid manifold up to the respective eductors are to be made of 316L Stainless Steel. The pipes from the NRVs up to the respective eductors must be made of 316L Stainless Steel and must be PTFE-lined. All pipes must be seamless and flanged.
Pipes – Demin Dilution Water Line	The dilution water line up to the respective eductors must be made using Carbon Steel, lined with vulcanised butyl rubber.
Pipes – Dilute Acid Line	The pipework after the respective eductors must be made of 316L Stainless Steel and must be PTFE-lined for at least a length of 2 meters. (starting from the eductors) The pipework must be seamless and flanged.
Pipes – Filtered Water Line	The filtered water pipework right up to the second mixing point in the cation segment must be made using Carbon Steel. The pipe must either be galvanized, coated or lined with vulcanised butyl rubber. The Contractor is to select the most economical option.
Valves – Conc. Acid Line	From the bulk acid manifold up to the respective eductors (in the proposed system). All valves should preferably be ball valves.

	All valve bodies and trims must be constructed with 316L Stainless Steel and have PTFE seats and seals. All control actuators shall have a positioner installed that is loop powered with visual indication of the valve position. All actuated valves must be pneumatically actuated. The control valves and isolation valves must fail in the closed position. The drain valves must fail in open position. The actuator body and internals must be constructed from Stainless Steel.
Valves – Dilution Water Lines (Demin and Filtered)	The demin dilution water lines going towards the first dilution points (cation and mixed bed). The filtered dilution water line going towards the second dilution point in the cation segment of the system. All valve bodies and trims must be constructed with 316L Stainless Steel and have natural rubber or EPDM seats and seals. All control actuators shall have a positioner installed that is loop powered with visual indication of the valve position. All actuated valves must be pneumatically actuated. In the demin dilution line, the control valve must be also be a slow opening valve. This is to prevent water hammer in the system. The duration of the valve opening must be determined by the pressure in the system. The valve must be programmed as such. The control valves and isolation valves must fail in the closed position. The Actuator body and internals must be constructed from Stainless Steel.
Valves – NRVs	All NRVs should be piston or ball check valves. All valve bodies and trims must be constructed with 316L Stainless Steel. For the conc. acid line, the NRVs must have

	PTFE seats and seals. For the demin water line, the NRVs must have natural rubber or EPDM seats and seals.
Valves – Dilute Acid Line	After the first dilution points to the respective ion exchange units. All valves should preferably be ball valves. All valve bodies must be constructed with 316L Stainless Steel and have PTFE seats and seals. The isolation valves must fail in the closed position.
Cation Acid Eductor	The inlet fluids are demin water and 98% H_2SO_4. The outlet fluid is up to 3.6% H_2SO_4 during normal operation. The Cation acid eductor must be made of PTFE-lined 316L Stainless Steel or 904L Stainless Steel.
Mixed Bed Acid Eductor	The inlet fluids are demin water and 98% H_2SO_4. The outlet fluid is up to 6% H_2SO_4 during normal operation. The Cation acid eductor must be made of PTFE-lined 316L Stainless Steel or 904L Stainless Steel.
Cation Acid Conductivity meters	The conductivity meter for the first dilution should be able to accurately measure in the range of 0-190 mS/cm. The conductivity meter for the second dilution should be able to accurately measure in the range of 0-100 mS/cm. Both conductivity meters must be constructed from 316L Stainless Steel. The analysers that will be supplied must have been tested, evaluated, and approved by Eskom Research, Testing and Development. If not evaluated, the analysers should be made available for evaluation for a period of at-least 6 weeks. The evaluation should be complete before the tender closing date. Proof must be submitted that all of the proposed analysers have been tested, evaluated, and approved by Eskom Research, Testing and Development.

	The analyser shall have one analogue output, and one alarm output. The analyser shall be 24V two wire loop powered.
Mixed Bed Acid Conductivity meter	The conductivity meter should be able to accurately measure in the range of 0-280 mS/cm and must be constructed from 316L Stainless Steel The analysers that will be supplied must have been tested, evaluated, and approved by Eskom Research, Testing and Development. If not evaluated, the analysers should be made available for evaluation for a period of at least 6 weeks. The evaluation should be complete before the tender closing date. Proof must be submitted that all of the proposed analysers have been tested, evaluated, and approved by Eskom Research, Testing and Development. The analyser shall have one analogue output, and one alarm output. The analyser shall be 24V two wire loop powered.
Flow Transmitters – Demin Line	In the demin lines for the both the cation and mixed bed eductor systems, the flow transmitters will be used to control the demin modulating control valves. The Contractor must ensure that the type of flowmeter installed will be able to detect the flows of demin water. All flowmeters shall have a local display and a remote display
Instrumentation – General	All instrumentation must be constructed from 316L Stainless Steel and must be installed as per the OEM requirements. All instrumentation (and associated components) must be sufficiently resistant to the concentrations of acid that it will typically be exposed to.

3.1.6 Life Expectancy

The design should last for the remaining useful lifespan of Duvha Power Station (10 years), subject to periodic maintenance.

3.2 CONTRACTOR'S ENGINEERING DESIGN SCOPE

The Contractor will be responsible for the design, manufacture, procurement, factory acceptance, testing, delivery to site, off-loading, installation, site testing and commissioning of all plant and material required for ensuring a fully functional system.

3.2.1 Sulphuric Acid Storage and Dilution Upgrade Requirements

The Contractor is required to carry out the entire design required for the Works. The Contractor's design calculations, decisions, drawings and other documents must be reviewed and signed off by competent individuals who are qualified in the respective disciplines and who are professionally registered.

The Contractor assumes full responsibility to ensure that the Works complies with all requirements of the Works Information and any other governing laws or codes. Compliance of the Works does not relieve the contractor of this responsibility.

3.2.2 Scope of Work

The scope of work describes all the major activities and materials that fall within the scope of the Contractor. It is the responsibility of the Contractor to ensure that all the activities are carried out and all equipment and material is supplied to complete the Works in every aspect.

1. The Works comprises of the following:
    - Detailed design
    - Manufacture and Procurement
    - Factory and Acceptance tests
    - Delivery to and offloading at site.
    - Installation
    - Manufacture and Installation of Labels (as per Eskom Standard)
    - Corrosion Protection
    - Commissioning and testing
    - Quality management for all activities

- Safety and plant signage
- Storage on site
- HAZOP Study

2. All plant, material and equipment are required to be designed for operation in a Water Treatment Plant (specifically for sulphuric acid and demin water applications) with minimum requirements for maintenance interventions.

3. It is not the intention of this scope of work to describe in detail all the activities the Contractor is required to carry out, nor to describe in detail everything to be supplied by the Contractor.

4. The Contractor provides the entire Works as defined in section 3.2 of the Technical Specification Information except where explicitly stated otherwise.

5. The Contractor designs according to the requirements of the Employer's design stated in section 3.1 of the Technical Specification. It is the duty of the Contractor to deviate from the Employer's engineering design if the Contractor believes that these decisions will result in the optimal functioning of the system. The Contractor will be held liable for any negligence in this regard. The Contractor is required to gain approval from the Employer with regards to these decisions and to support each decision with sound reasoning, logic and/or calculations.

6. Prior to submission, the final design should be approved by an ECSA registered professional engineer or technologist, in the relevant engineering discipline.

7. The Contractor's design is required to be reviewed and accepted by the Employer before any implementation of the work begins. The Contractor must submit the initial design within 1 month of the contract award.

Due to the complex nature of the tie-ins required into the system, the simplified diagram below demonstrates the major sections within the system and will be used to explain what is required of the Contractor for each segment of the system.

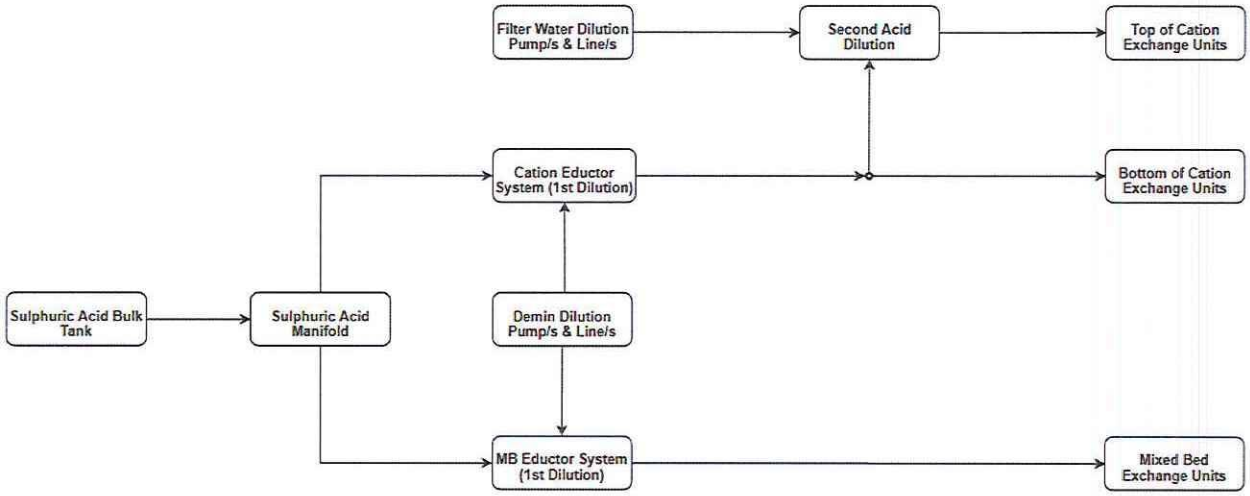

Figure 4: Simplified Cation and Mixed Bed Acid Regeneration System

In reference to the diagram above, the Contractor is required to design the cation and mixed bed eductor systems. The Contractor is also required to evaluate and perform the necessary calculations and assessments (hydraulic designs etc.) on the existing systems (rest of the diagram above) to determine if these systems are suitable for the cation and mixed bed eductor systems. The Contractor must design the newly designed segments so that there are minimal (if not none) changes required to the existing systems. If there are no design changes required to these surrounding systems, the Contractor must replace all the components of the remaining segments of the system so that there is a complete system which is fully automated, fully functional and meets all the functional and performance requirements.

If it is necessary that changes be made to the surrounding systems, according to the assessments and calculations performed by the Contractor, the Contractor will be responsible for these modifications. If any modifications are to be made to these systems, these modifications must not interfere with the operation and functioning of any other related system. Special emphasis is placed on the sulphuric acid manifold, the demin dilution water line and the control air common line as these pipes feed to the CPP A and CPP B segments of the system. Special emphasis is also placed on the filtered water pipework as this feeds other parts of the WTP.

The Contractor will be held liable for the modifications as well as the complete functioning (including full automation) of the entire mixed bed and cation sulphuric acid storage and dilution system (refer to Battery Limits section). From these surrounding systems in the figure above (and in accordance with the Battery Limits section), whatever is not modified by the Contractor must be replaced by the Contractor as per the current design and drawings. This includes all components in the current system as per the current design and drawings.

The second dilution in the cation segment of the system has not been automated for some time due to non-functioning and/or obsolete valves. If the sizing of this segment of the system is found to be suitable in the Contractor's design, the Contractor must ensure that all pipework, valves, instrumentation and other components of the system are replaced as per the current design. The entire system (redesigned and replaced segments) must be linked to the DCS and must be fully automated. The Contractor is also required to standardise the valves and instrumentation with the rest of the system, where possible.

3.2.3 Project Implementation Requirements

The implementation of this project must coincide with the project which aims to resolve the uneven floor in the WTP. The mixed bed and cation eductor systems should only be installed once the floor where the systems will be installed on is repaired.

3.2.4 Operating, Control and Maintenance Philosophy

The Contractor must submit a detailed operating and control philosophy to the Project Manager for review prior to construction.

The Contractor must submit a detailed maintenance philosophy, including a preventative maintenance strategy for the modified parts of the plant prior to handover. The Contractor must ensure that Eskom has all the critical spares (and in the required quantities) on hand prior to handover of the system to Eskom.

3.2.5 General Design and Manufacturing Process Constraints

The Contractor is fully responsible for the delivery, offloading and storage of all plant, equipment and materials required for the Works. The Employer reserves the right to carry out checks on any equipment and materials for the Works that have been delivered to site.

The Contractor is fully responsible for the installation of all mechanical, civil, electrical, control and instrumentation components, equipment and material as required for the Works.

The Contractor is responsible for the complete optimisation of the Works in order to meet the minimum requirements and specifications set out in the Employer's Engineering design.

3.3 MECHANICAL INTERFACES

The mechanical interfaces into the existing systems are as follows:

- The eductor systems must connect to the current system from the tap-offs on the bulk acid manifold.

- The eductor systems must reconnect to the current system after the first conductivity meter of the current system. In the cation system, this is before the acid line splits into the two lines going to the top and the bottom of the cation exchange units.

The upgrades must be performed in a manner that minimises plant downtime and does not interfere with the regeneration schedule. If there is any disruption to the regeneration schedule, the Contractor will be responsible (at the Contractor's expense) for ensuring that all affected resins are restored to a suitable state whereby demin production may continue. This is to be performed hastily. The Contractor will be held liable for any delays in this regard.

The parts of the system upstream and downstream from the interfaces into the existing system must be replaced (and, if necessary, modified) so that the entire system performs optimally and as required. It is the duty of the Contractor to ensure that the newly design segments of the system tie-in with the existing system. The Contractor will be held liable if the system on the whole does not function as required.

3.3.1 Eductor Requirements

The Contractor is responsible for all aspects regarding the eductors in the system; including manufacturing, procurement, testing, installation, commissioning etc. The contractor must provide in-depth specifications and detailed manufacturing drawings of the eductors in order for Eskom to be able to procure these pieces of equipment from other manufacturers after the defect period and guarantee period has elapsed. The Contractor must also ensure that the eductors are supported and does not endure excessive stresses of any nature. The Contractor must take into consideration the specifications outlined in the System Architecture section.

The Contractor must take the following into consideration:

- The eductor must be custom designed to perfectly suit the needs of the respective segments. All details regarding the design of the eductors are to be supplied to Eskom.
- The installation of the eductors should allow for ease of maintenance. If any of the eductors are to fail, they should be easily replaceable. This is so that the system can be restored to full working order in the shortest possible time.
- The eductor should be able to suction acid from the bulk acid manifold; even when the bulk acid tanks are low. The bulk acid tanks supply the acid manifold by gravity, hence the eductor should have adequate suction (in all steps of the regeneration processes) to be able to draw acid from the manifold. The minimum operational level of the bulk tanks is 20% of the total working volume.
- The Contractor must submit hydraulic designs for each of the eductors.

3.3.2 Valve Requirements

The Contractor is responsible for all aspects regarding the valves in the system; including manufacturing, procurement, testing, installation, commissioning etc. The Contractor must ensure that all actuated valves are pneumatically actuated and that they interface with the control air system at the station. The Contractor must take into consideration the specifications outlined in the System Architecture section.

The Contractor must take the following into consideration:

- The valves should minimise pressure-drop in the open position.
- All valves must be lockable.
- The installation of the valves should allow for ease of maintenance. (valves should be flanged)
- The actuated valves should be pneumatically actuated. As outlined in the C&I design of the Concept design, certain valves should have positioners and limit switches. All automatic valves should also have provision to be controlled manually.
- Valves should, as far as possible, be standardised with other valves on the plant/system. Valves should also be interchangeable with one another, where possible.
- The Contractor must ensure that the temperature and pressure ratings of the valves are suitable for their respective environments within the system.
- The Contractor must provide a valve schedule with the design to be approved by the Project Manager for acceptance prior to commencement of the Works. Details of the valves along with their actuators must be provided to Eskom. The Contractor must also provide a recommended list of spares, maintenance procedures as well as assembly and disassembly procedures.
- All valves and brackets must be in accordance with ISO 5211 part–turn actuator attachments standards.
- As a minimum, all valves must adhere to BS EN 12516 or ASME B16.34 design codes.

3.3.3 Pipework Requirements

The Contractor is responsible for all aspects of the system pipework; including manufacturing, modification, procurement, testing, installation, commissioning etc. The Contractor must also ensure that pipework is supported and that any segment of the pipework does not endure excessive stresses of any nature. The design of the pipework should allow for ease of maintenance of the system. The Contractor must take into consideration the specifications outlined in the System Architecture section.

The Contractor verifies the integrity of all pipework and takes into the following into consideration:

- The piping is in accordance with '240-123801640 Standard for Low Pressure Pipelines'.
- The piping is sized to minimize pressure drop.
- The piping allows for ease of maintenance. (pipework should be flanged unless otherwise stated)
- Flange covers should be installed on all flanges.
- The Contractor must submit the piping data sheets and complete design to the Project Manager for acceptance prior to commencement of the Works.
- The Contractor must ensure that all pipework is colour-coded and labelled in accordance with SANS 1091: National colour standards of paint and SANS 10140: Identification colour markings.
- The Contractor must ensure that the pipework and other components installed by them does not interfere, restrict access or damage any other pipework or existing equipment in the plant.
- The Contractor must ensure that the temperature and pressure ratings of the pipework are suitable for the system and for the respective environments within the system.
- All material must be accompanied by material certificates. (BS EN 10204 3.1 or ASME BPVC section 2)
- Mechanisms must be put in place to prevent galvanic corrosion where the Carbon Steel meets Stainless Steel.

3.3.4 Welding Requirements

All welding and fabrication related activities are to be performed in accordance with the BS EN welding specifications and the latest versions of '240-106628253 Standard for Welding Requirements on Eskom Plant' and '240-123801640 Standard for Low Pressure Pipelines'.

3.3.4.1 Basic Requirements

The welding procedure qualification for welds should be in accordance with the welding standard incorporated into the relevant design and construction code. Mixing of different codes is not permitted.

A welding procedure specification, Welder Qualification Records and a valid Welding Procedure Qualification Record (WPQR) must be approved by a registered Independent Welding Engineer or Technologist (IWE or IWT) and submitted to Eskom for approval by an Eskom welding engineer/technologist. The IWE or IWT must possess the minimum qualifications as defined in 240-106628253. The WPQR must be accompanied by test coupon parent material certification, consumable material certification, destructive and non-destructive test results (DT and NDT) and heat treatment charts.

Welders and welding operators must possess the minimum qualifications outlined by the relevant construction code or engineering specification.

100% NDT must be performed on all welding.

For all butt welds and fillet welds, penetrant testing must be performed. Radiographic or ultrasonic testing must also be performed on all butt welds.

3.3.4.2 Additional Requirements

And Eskom welding engineer or technologist must approve the welding documents used for fabrication. Welding and testing (destructive and non-destructive) must be overseen by an Approved Inspection Authority. Mechanical tests conducted during the welding procedure qualification must be performed at an accredited test laboratory and conforming to the requirements of ISO/IEC 17025.

The Contractor must submit Quality Control Plans (QCPs) to the Project Manager for acceptance before commencement of the work.

Acceptance for defects on metallic welds must be evaluated according to Level B as described in BS EN ISO 5817. These levels will be determined before the work starts.

NDT must be performed by an independent entity from the welding operation to ensure unbiased inspection. The company that will perform the welding must have ISO 3834 Part 2 certification as a minimum. NDT on welds must be performed according to the requirements of the relevant design and construction codes, applicable engineering and/or product specifications and Eskom standard 240-83539994. All technicians performing NDT must be Eskom approved or employed by an Eskom approved company.

3.3.5 Internal Corrosion Protection Requirements

'240-101712128 Standard for the Internal Corrosion Protection of Water Systems, Chemical Tanks and Vessels and Associated Piping with Linings' will apply for the internal corrosion protection of all process and piping equipment of the plant. This standard applies to plant and equipment exposed to aqueous and chemical immersion conditions. This standard focuses on the use of organic linings as a means of corrosion protection for mild steel substrates exposed to aqueous or chemical immersion conditions.

Corrosion aspects of materials that are inherently 'corrosion resistant' such as brasses, bronzes, copper, aluminium, nickel alloys, high grade steels, specialised alloys, stainless steels, special plastics (FRP, GRP), specialised polymer and elastomeric materials etc. which would be selected for specific applications and special components or parts of a component are not considered in the above mentioned document. Typical examples for application would include component castings, valves, pumps, motors, strainers, hoses, plastic tanks and piping, plastic and polymer lining systems, rubber and other elastomeric materials for seals and seats, gasket materials etc.

Special applications and other materials of construction i.e. brick, mortars and concrete for general construction as well as for specialised applications such as for immersion, high temperature exposure, chemical attacks etc. will also be considered. These materials are prone to degradation by a variety of mechanisms and will require the same attention as prescribed below.

In all these cases the Contractor is required to consider and select the correct materials (grades, types thereof) with due consideration of all corrosion, degradation or deterioration related aspects for the applicable environment and possible variations for these environments. Furthermore, the material selection process will also consider the following potential corrosion impacts:

- Design aspects and corrosion allowances.
- All manufacturing processes such as casting, forming, welding, heat treatment processes, cutting, machining, surface pickling and passivation, surface polishing, corrosion protection by coating systems (surface preparation and application) etc.
- All required and suitably adequate tests and NDT methods for the determination and quantification of defects and flaws during and post manufacturing.
- All storage and preservation measures to be employed during periods of transportation and construction phases.
- Suitability and applicability of greases, inhibitor systems to prevent corrosion and to ensure that these methods do not induce any corrosion.
- Installation, assembly and construction processes which could have an impact on corrosion.

For the above factors, the Contractor must propose and list all relevant and applicable internationally recognised standards, test methods and procedures. The Contractor must also consider the relevant points above for all plant areas for specific material, specific applications and specific applications.

3.3.5.1 Rubber Lining of Demin Water Pipes

Please refer to GAM/MAT/21/185.

3.3.5.2 PTFE Lining of Eductor and Surrounding Pipework

Please refer to GAM/MAT/21/185 for pipework. PTFE lining of eductors are a standard practice.

3.3.6 External Corrosion Protection of Process and Piping Equipment

'240-106365693 Standard for the External Corrosion Protection of Plant, Equipment and Associated Piping with Coatings' will apply for the external corrosion protection of all process and piping equipment of the plant. This standard applies to general plant and equipment exposed to atmospheric conditions and the external surfaces of buried piping.

3.3.6.1 Corrosion Protection of Structural Steel

Please refer to GAM/MAT/21/181.

3.3.7 General Requirements

- The Contractor must provide detailed specifications and material certificates for all components which are being designed, modified or replaced. The Contractor also guarantees that the materials used are of appropriate quality for the respective fluid which they will be in contact with. During material selection, the Contractor must also make provisions for likely exposure of the respective material to other fluids (e.g. acid ingress in the water line and vice versa).
- The Contractor must perform a pressure surge analysis to verify that the pipes and other components are designed to withstand any pressure transients which may lead to abnormal pressure surges within the system.

3.4 WASTE MANAGEMENT

All pipe offcuts and scrap metal should be sent by the Contractor for recycling, unless otherwise specified by Eskom. It is the responsibility of the contractor to ensure that all acid and water spills are routed to the effluent sump. The Contractor is responsible for the ethical and environmentally conscious disposal of any waste generated by the Contractor.

3.5 CIVIL SCOPE OF WORK

3.5.1 Pipe Route

The Contractor must evaluate whether support structures are required for the newly designed and the replaced segments of the system. If required, the Contractor will be responsible for the design, manufacture, procurement, factory acceptance, testing, delivery to site, off-loading, installation, site testing and commissioning of these civil supports.

3.6 C&I SCOPE OF WORK

This section should be read in conjunction with section 3.2 and 3.3. The C&I scope includes:

- Installation of field instruments/equipment that will interface with the WTP Distributed Control System (DCS).
- Design and Engineering of the new operating and control philosophy (section 3.2 and 3.3) in the WTP Symphony Infi90 DCS. Development of new graphics in the WTP 800xa Human Machine Interface (HMI).

3.6.1 C&I Specification

The contractor shall supply, install and commission all instruments for the entire system (newly designed and segments of the system which needs to be replaced). The following instruments are for the newly designed segments of the system:

- Differential pressure transmitters across all non-return valves to ensure that it is easy to detect when they are clogged. There will be a total of 8 Differential Pressure transmitters: 4 for the cation acid regeneration system and 4 for the mixed bed regeneration system.
- 2 conductivity analysers to be used for valve position control in the acid lines.
- 2 pressure transmitters to monitor the pressure in the demin lines.
- A total of 16 proximity switches to ensure that all manual isolation valve positions are available in the control room: 8 proximity switches for open limits and 8 for the closed limits.
- 4 valve positioners; one for each modulating control valve.
- A total of 6 flowmeters (flow transmitters) i.e.: 2 for acid lines, 2 for demin water lines and 2 flowmeters after the eductors. The 2 flow transmitters in the demin line will be used to control the control valves in the demin lines.
- 2 thermocouples to be used as a protection to trip the system if water ingress occurs in the acid line.

The Contractor shall design, engineer, supply, install and commission the following:

- The control philosophy as per sections above.
- Engineer the logics in the ABB Infi90 DCS as per the requirements.
- The sequences and interlocks to be checked, verified and/or modified as per all the process control requirements before commissioning.

- Updating of the HMI graphics and engineering as per the new philosophy stipulated in section 3.2 and 3.3.
- Updating of the station historian (Visual Automation).
- Field instrumentation for the plant as per the Instrument Schedule.
- New tapping points for additional instrumentation.
- Cabling, racking and power distribution.
- Junction boxes

3.6.1.1 Field Equipment Requirements

- All instrumentation shall be provided with a nametag/plate, the contractor must comply with the ENS0002 Duvha Power Station AKZX Plant Location Coding Manual
- All instrumentation must use either 24V for binary feedback or 4-20mA, 2-wire for analogue feedback.
- All additional signals to be trended on the station historian.
- Cabling (including termination) from the field devices to junction boxes and to WTP DCS.

All field equipment & installations comply with the following Eskom Standards:

- 240-56355535: Process Calibration Equipment Standard
- 240-56355754: Field Instrument Installation Standard
- 240-56355815: Field Instrument Installation Standard for Junction Boxes and Cable Termination.
- 240-56355843 Pressure Measurement Systems Installation Standard.
- 240-56227443 Requirements for Control and Power Cables for Power stations Standard
- ENS0002 Duvha Power Station AKZX Plant Location Coding Manual

The Contractor to ensure that field installation inclusive of instrumentation, junction boxes, cabling and racking shall be properly labelled with permanent labels that will not be effortlessly removed. Field device labels must be made of stainless steel, text on labelling be engraved as per the as per ENS0002 Duvha Power Station AKZX Plant Location Coding Manual whilst also adhering to SANS 10108 Hazardous area classifications.

The equipment layout is such that when mechanical work is performed, no C&I equipment is damaged. Where harsh environmental conditions are not avoidable, the field equipment is designed for operation in that environment must be used (i.e. all field equipment is selected according to the environment in which they will operate in).

3.6.1.2 Transmitters

All transmitters supplied as part of the Works are compatible with the relevant primary measuring element. All transmitters have built in diagnostics that constantly monitor and alarm any faults on transmitter. The transmitter and its installation position are labelled such that if the transmitter is removed the label is still visible in the plant. The labels are provided as per the labelling requirements defined ENS0002 Duvha Power Station AKZX Plant Location Coding Manual.

Transmitters are suited and adequate to fulfil the following function and accuracy requirements:

- All digital transmitters have built in local digital indicators that can be programmed to indicate the range and specified engineering units for the process.
- All transmitters conform to a minimum accuracy of span of 0.05%. All transmitters are supplied with a drift free guarantee period of 10 years or better
- It is ensured that the installation of the transmitters: allow for the environmental conditions, allow for safe and easy access (for maintenance and calibration) and allow for the removal of equipment for maintenance in the vicinity of the transducer.

3.6.1.3 Valves

Binary Isolating Valves

As per the control philosophy, the contractor must ensure that all the binary isolating valves will have the capability of being operated from the control room as well as manually locally in the via a local control station. There will a total of 6 binary isolating valves (3 for cation acid regeneration system and 3 for the mixed bed regeneration system). The table below shows the minimum number of I/O's for each valve.

Table 4: Illustrating the minimum amount of I/O's for each valve

Number	I/O Name	I/O Type
1	FEEDBACK OPEN	DI
2	FEEDBACK CLOSED	DI
3	OPEN PUSHBUTTON	DI
4	CLOSE PUSHBUTTON	DI

5	REMOTE SELECTED	DI
6	LOCAL SELECTED	DI
7	ALARM ACKNOWLEDGE	DI
8	LAMP TEST PUSH BUTTON	DI
9	COMMAND OPEN	DO
10	COMMAND CLOSE	DO

Control Valve

As per the control philosophy, the contractor will install 4 control valves (2 for cation acid regeneration system and 2 for the mixed bed regeneration system). Below is the I/O count for each control valve.

Table 5: Illustrating the I/O count for each control valve

Number	I/O Name	I/O Type
1	VALVE POSITION FEEDBACK	AI
2	VALVE SETPOINT	AO

Pneumatic Actuators for the Control valves

- The Contractor supplies, installs and commissions the pneumatic positioners.
- All connections between the pneumatic actuators, air supplies and positioners are implemented with flexible nylon tubes with a 2 MPa rating and are provided by the Contractor.
- The linkages and couplings installed on the actuators do not change the control characteristics of the pneumatic valves.
- All linkages for the positioner are provided by the Contractor.
- The Contractor must make use of ABB TZID positioners for standardisation purposes.

Manual Hand Isolating Valves

As per the control philosophy, the contractor will supply, install and commission 6 hand isolating valves (3 for cation acid regeneration system and 3 for the mixed bed regeneration system). Each hand isolating valve position (open or closed) shall be indicated in the WTP control room through the use of proximity switches. The table below shows the IO count for each valve.

Table 6: Illustrating the I/O count for each control valve

Number	I/O Name	I/O Type
1	FEEDBACK Open	DI
2	FEEDBACK CLOSED	DI

3.6.1.4 Cabling & Racking (Cable Installation and Routing)

All Cable Installation and instrumentation cables, shall be flame retardant low smoke type, and comply with the Eskom Standard 240-56227443: Requirements for Control and Power Cables for Power Stations Standards. Instrument cabling to be installed with due respect for safety, reliability, access, maintenance, environmental conditions and best practices. All cabling must be suitably protected against mechanical damage, chemicals, dust build-up and heat.

The Contractor to take note of the following for cabling design:

- Instrument cabling defined as cabling between field instrumentation and junction boxes.
- Power supply cabling is defined as being cabling required to power field equipment.
- Cables shall only be terminated in instruments, junction boxes. No intermediate cable joints are permitted.
- Cables connected to instruments are installed with a loop of cable to provide sufficient slack for remaking the cable connection if the instrument is removed and to allow for removing the instrument without electrical disconnection.
- Instrument cables are routed separately from electrical power cables and crossovers that bring signal and power cables into close proximity are made at right angles.
- The routes for power supply cabling and the racking are of a consistent and integrated design taking into account different cabling and racking routes for common modes of failure, and the redundancy concepts of the mechanical plant design.
- The Contractor provides 20% spare installed capacity in all multi-core cables, rounded up.

- UVG cable and Field/Trunk Cable installations will be used to transfer signals from the field equipment to the WTP DCS. The Contractor to comply with the Eskom Standard 240-56355815: Field Instrument Installation Standard for Junction Boxes and Cable Termination.

3.6.1.5 Junction Box

New junction boxes are to be provided to terminate all instrumentation. Junction boxes shall be properly labelled with permanent labels that will not be effortlessly removed and to also have enclosure material of 3CR12 stainless steel grade or higher and will be powder coated using RAL7035. Junction boxes are rated IP 65. The contractor to comply with the Eskom standard 240-56355815: Junction Boxes and Cable Termination.

3.6.1.6 Documentation Requirements

The contractor shall supply the following Control and Instrumentation documentation:

- Detail electrical hook-up drawings (including instrument loop drawings)
- Detail mechanical hook-up drawings for instrumentation
- Signal and alarm list
- Equipment list
- Standard equipment operating manuals
- Equipment data sheets
- Maintenance manuals and procedures
- Updated HMI graphic files
- Updated DCS database
- Updated network configuration diagram
- KP (remote IO) panel internal equipment layout, configuration and wiring
- Cable schedules and termination schedules
- Junction boxes GA and internal layout drawings
- Field device calibration certificates
- Cold and Hot commissioning procedures and test reports
- Testing procedures

- Quality Control Plans
- System functional, and performance specifications.
- Communications and control system network(s) based on the current design showing the expected changes of the plant I/O expansion.
- Process control and monitoring system equipment allocation & distribution.
- Operator interface including all operating philosophies from the WTP HMI.
- Operating displays and navigation.
- HMI and peripheral devices functional distribution.
- Interfacing and communication specifications.
- Interfacing to field equipment.
- All hardware and software interfaces.
- Detail control and operating philosophies.
- Design to match functional, performance criteria both for the process control and monitoring system as well the plant processes.
- Cabinet and cubicle layouts Junction box designs and locations.
- Alarm/event handling.
- Power supplies specifications, allocation and distribution,
- Quality assurance and quality control measures and methodologies.
- Design methodologies & procedures.
- Sample documents of the factory acceptance testing (FAT), installation and commissioning procedures, Site integration testing (SIT), Site acceptance testing (SAT) both of the process control and monitoring system functions and performance as well as the plant processes operating and performance, operational testing.
- Sample synopsis documents of engineering, maintenance and operating documentation.
- Sample documents of engineering, maintenance and operating training manuals.
- Project phasing, resources to meet availability requirements.
- Switch over strategies and roll out/ commissioning methodologies.

3.6.1.7 Requirements for Engineering, Installation, Commissioning and Testing

During the engineering phase the Contractor performs plant investigation to verify and clarify scope, documentation provided by the Employer and the location of equipment. The installation of the relevant equipment does not begin until the design documentation has been accepted by the Project Manager. Quality inspections and tests are carried out by the Contractor and Employer's representative after installation to prove the compliance of the installation with the technical specification and the detailed engineering design documentation. The installation is only considered complete once the quality inspections and tests for the installation concerned have been accepted by the Project Manager. The Contractor is required to perform cold commissioning activities which include field equipment loop checks and WTP DCS interface. Site Integration Testing (SIT) is performed by Contractor to ensure all interfaces have been implemented and comply with the requirements of the technical specification and design documentation. The test includes full testing of the logic/program, mechanical and visual inspection of the equipment (including wiring in the panel), plant coding, signal descriptions, HMI graphics, etc. The test is witnessed by the Employer's representatives.

3.6.1.8 ABB Infi90 DCS and 800xa HMI Mandatory Requirement

Duvha WTP plant uses the ABB Infi90 DCS which is a unique control system as well as the 800xA HMI. The contractor must be an authorised installer of the ABB Infi90 DCS and 800xA HMI and this must be proven by providing a letter from the OEM (ABB), alternatively, the contractor must provide a letter from the OEM (ABB) stating that ABB will be subcontracted and will be responsible for the execution of the Infi90 DCS and 800xA HMI should the company secure the contract. The Infi90 DCS scope does not include pulling of cables and installation of field equipment. It is only for the Engineering on the WTP DCS and development of new graphics.

3.7 ELECTRICAL SCOPE OF WORK

Not Applicable.

3.8 DESIGN REVIEW

- The initial design documentation must be submitted to the Project Manager within 1 month after the Contract Date. The design will have to be approved by the relevant Eskom engineering committee.
- All design work must signed off and approved by the applicable Professional Engineer (mechanical, electronic, electrical, chemical, civil etc.) responsible for its preparation before being submitted to the Project Manager.

- The Contractor must submit detailed Technical Data Sheets of all equipment used for the Works to the Project Manager as part of the design.
- Acceptance of the design by the Project Manager does not relieve the Contractor of any liability for their design and drawings.

3.8.1 HAZOP Study

The Contractor must conduct a HAZOP study with the participation of Eskom representatives before the design is finalized as well as before the construction and commissioning of the system. In addition, the HAZOP report must be reviewed by Eskom.

3.9 PROCEDURE FOR SUBMISSION AND ACCEPTANCE OF CONTRACTOR'S DESIGN

The Contractor must establish a document tracking system to record the dates for the supply and receipt of all design drawings, calculations, requests for information and design documentation.

The Contractor is to supply the following documentation as the minimum requirements before any manufacturing, construction or commissioning commences:

- Document submission schedule
- Drawing submission schedule
- Complete detailed design file
- Functional Specifications
- Line Sizing Calculations and Material Selection
- Final isometric and general arrangements illustrating pipe dimensions, pipeline layouts and showing pipe supports
- General Arrangement Drawing of System and boundaries
- Piping and Instrument Diagrams
- Piping and flow diagrams
- Manufacturing diagrams for all equipment
- Component material datasheets
- Constructability Assessment
- Quality Manual
- Quality Control Procedures
- Quality Control Plan and Inspection and Test Plan
- Method Statements
- Commissioning procedures

- Assembly procedures
- Technical, Operation and Maintenance Manuals of all plant equipment
- Operating and Control Philosophies
- Chemical Safety Data Sheets and Safe Handling Procedures
- Maintenance Philosophy
- Water and sulphuric acid balance across the plant
- Eductor design calculations, drawings and detailed specifications
- Piping design calculations, drawings and material of construction
- System curves, eductor curves and pump curves (if necessary)
- Hydraulic calculations
- Pipe Schedule
- Valve schedule
- Instrument schedule
- Drive and Actuator Schedules
- Mechanical Hook-up diagrams
- Software drawings
- Alarm list
- Functional Distribution (Allocation of field devices to I/O)
- Detailed I/O List and Channel Assignments
- C&I cable schedules
- C&I termination schedules
- Cable installation and loop check sheets
- Instrument datasheets
- Instrument calibration certificates
- Drive configuration reports
- Valve datasheet
- Parts list for all components
- Critical Spares List
- Welding Procedure Specifications
- Welding Procedure Qualification Record
- Operating, Maintenance and Engineering Training Manuals

3.10 TESTING AND INSPECTIONS

The Contractor must prepare a detailed Quality Testing and Inspection Plan that must be reviewed and accepted by Eskom.

3.10.1 System Performance Testing and Commissioning

Testing and Commissioning of the system must, at minimum, include the following:

- The services of skilled Engineers to supervise the testing and commissioning of the system.
- All management, supervision, labour, tools, instruments, test apparatus, calibration equipment and any other equipment and facilities that may be required.

The operating and maintenance manuals must be submitted for acceptance by an Eskom representative at least 2 weeks before commissioning of the system.

The commissioning of the Works is to be performed by the Contractor as well as suitable Eskom representatives. The Contractor must submit a commissioning programme to the Project Manager for acceptance at least 2 weeks prior to the commissioning of the system.

Before plant and equipment is put in service, the Contractor certifies that the plant and equipment are in a suitable and safe condition. The Contractor must also ensure that the plant is free of contaminants prior to commissioning.

In the event that that there is any component (or the system on the whole) of the mixed bed and cation segments of the system (and any other modifications made by the contractor) that is not functioning correctly or not meeting the required targets, the Contractor is responsible for determining the cause of the malfunction as well as the repair/replacement thereof; at the expense of the Contractor.

3.10.2 Reliability

Since the cation and mixed bed acid regeneration systems are critical and there are no backups for these systems, the new systems should be extremely reliable. The design should include features to prolong the lifespan and ensure there is a high reliability of the components within the system and the system on the whole.

3.10.3 Availability

The system must have an availability of greater than 95%. Essential spare parts are to be kept on hand to ensure that if any failures occur, the system will be returned to service as soon as possible. (refer to Employer's Engineering Design for the critical spares list) The spare parts holding list for the other segments of the system which will be redesigned/replaced will be at the discretion of the Employer.

3.11 OTHER REQUIREMENTS OF THE CONTRACTOR'S DESIGN

3.11.1 Physical Characteristics

The Contractor is to ensure that all components installed are consistent and standardised, where possible, with existing plant components. The equipment should be protected from corrosion (acid induced and other) and external ingress.

3.12 USE OF CONTRACTOR'S DESIGN

When completed, the design in its entirety will become the property of Eskom.

3.13 EQUIPMENT REQUIRED TO BE INCLUDED

The Contractor must submit a project Inspection and Test Plan for all equipment included in the scope. The Contractor must only use ISO 9001 accredited suppliers for the equipment used in this project. The ISO 9001 certification should be supplied with the delivery documentation. Failure to do so will result in rejection of the equipment by Eskom. The Contractor should specify which pieces of equipment are of a proprietary nature; where standard documentation and certificates of conformity are the only forms of certification. If any components are to be manufactured, the Contractor must ensure that the manufacturer is ISO 9001 certified. The Contractor must supply Inspection and Test Plans for each phase of the project and submit to Eskom for review and approval.

3.14 AS-BUILT DRAWINGS, OPERATING MANUALS AND MAINTENANCE SCHEDULES

All drawings to be created using Eskom templates to be supplied by the Employer. Drawings to be developed as per requirements set in 240-86973501 Engineering Drawings Standard. As-built drawings, operating manuals and maintenance schedules must be available to Eskom before the commissioning process has begun. Once completed, all drawings, reports and other documentation for the Works are to become the property of Eskom.

3.15 TECHNICAL, OPERATING AND MAINTENANCE MANUALS

The Contractor must provide technical, operating and maintenance manuals that are prepared by experienced and qualified personnel. The maintenance manuals must state the maintenance requirements for all components of the redesigned and replaced segments of the system. The technical manuals must contain detailed information regarding the make, model, type, material of construction and other specifications for all the equipment.

3.16 PLANT AND MATERIALS

3.16.1 Quality

The Contractor is required to submit a comprehensive Quality Management System (QMS) for all phases of the project. This QMS must comply with the requirements of 240-105658000. The Contractor and all of the Contractor's suppliers must hold a compliance certificate for their QMS to the requirements of ISO 9001:2015. The Employer reserves the right to conduct any audits in this regard.

Documents are to be submitted for review by the Employer after the Contract Date and before commencement of work.

The Contractor must submit a detailed Quality Manual and Quality Control Plan which will be reviewed and accepted/rejected by Eskom.

3.16.2 Plant and Materials Provided 'Free Issue' by the Employer

No free issue plant and materials will be available. All plant and materials are to be provided by the Contractor.

3.16.3 Contractor's Procurement of Plant and Materials

The Contractor is responsible for all procurement of materials required for the construction, installation and commissioning of the Works. The Contractor must:

- Ensure that all equipment and materials are inspected. The Contractor must also inform the Project Manager to arrange for the Eskom representatives to inspect the equipment and materials before it is delivered to Site.
- Ensure that all the relevant factory tests are conducted on the equipment and that these tests are witnessed by both the Contractor as well as Eskom representatives.
- Submit calibration certificates to the Project Manager for all equipment used for testing.

3.16.4 Spares and Consumables

The Contractor will provide all the critical spares for the plant as part of the Works. (refer to Employer's Engineering Design for the critical spares list)

Prior to handover of the plant, the Contractor must ensure that Eskom has all the critical spares (as per the critical spares list) on hand.

3.17 TESTS AND INSPECTIONS BEFORE DELIVERY

Eskom and its representatives will carry out inspections at their own discretion. All inspections and testing are to be performed in accordance with the QCP developed by the Contractor and accepted by Eskom and its representatives. A factory release inspection does not release the Contractor from their obligations.

3.18 CONTRACTOR'S EQUIPMENT

The Contractor is liable for all plant and equipment under their control. Eskom will not take responsibility for any loss or damage to the plant and/or equipment of the Contractor.

4. CONSTRUCTION

4.1 TEMPORARY WORKS, SITE SERVICES AND CONSTRUCTION CONSTRAINTS

4.1.1 Employer's Site Entry and Security Control, Permits and Site Regulations

All the Contractor's employees are to attend a mandatory site safety induction course before they are allowed to work on site. It is the responsibility of the Contractor to ensure that all of their staff has attended the induction. The Contractor must compile their own safety file which has to be approved by Eskom's safety officer. This file must be approved before the Contractor may attend the safety induction course.

The Contractor must provide a list of all employees, along with the dates and times of arrival, at least 2 days prior to arrival on site.

All individuals entering Duvha Power Station will be subject to alcohol testing daily. No person found to be intoxicated will be admitted on the premises. All Covid-19 protocols must be followed by all individuals prior to entering and throughout their entire duration on Site. It is the responsibility of the Contractor to ensure that their staff is compliant.

4.1.2 Restrictions to Access on Site, Roads, Walkways and Barricades

All vehicles must comply with the Road Traffic Act. Vehicle inspections will be conducted daily; check sheets should be kept at the Contractor's offices.

4.1.3 Site Procedures and Regulations

4.1.3.1 Permit to Work System

- No work can be carried out without a valid 'Permit to Work'.
- The Contractor must appoint a responsible person who must ensure that all possible sources of danger are mitigated.
- The Contractor must provide a facility to lock valves, switchgear and other equipment in accordance with the permit to work system.

4.1.3.2 Permitry

- The Contractor verifies that the respective system being worked on is drained, isolated and is safe to work on by means of the issue and acceptance of a Permit to Work by the Responsible Person (RP) and that all workers are signed on to the RP's Worker's Register.

- Eskom will provide the Responsible Person/s.

4.1.3.3 Local Safety Procedures

The Contractor must abide by all Local Safety Procedures, available from Eskom on request.

4.1.3.4 Incidents

In accordance with '32-136 Safety, Health and Environmental Requirements for Contractors', all incidents must be investigated by the Contractor and reported to Eskom within 24 hours of the incident occurring. The Contractor is advised to have a first aid station on site. Eskom's medical centre will be available to the Contractor on request and at a fee.

4.1.3.5 Safety

The design, manufacture and installation of equipment are to comply with SABS and all other local by-laws. All safety devices are to be installed to prevent damage to personnel, equipment and property and are to be tested by the Contractor. The Contractor must testify that these safety devices are in proper working order, in the form of inspection reports. Test certificates from accredited laboratories are required to confirm the fire hazard ratings for all equipment and materials. In accordance with '32-136 Safety, Health and Environmental Requirements for Contractors', fire prevention and protection must be adhered to.

4.1.3.6 Inspection of Equipment

- The Contractor's equipment will be inspected by a suitable Eskom employee upon arrival on site.
- Where applicable, copies of all test certificates and maintenance records are to accompany the Contractor's equipment. Non-compliance will result in Eskom removing the equipment in question, from site.

4.1.3.7 Documentation

In accordance with '32-136 Safety, Health and Environmental Requirements for Contractors', the Contractor must keep copies of the following documentation on site:

- All site accident report forms.
- Minutes of health and safety meetings held on site.
- Inspection reports produced by the Accident Prevention Officer.

4.1.4 Contractor's Equipment

The Contractor must:

- Provide all equipment that is required to complete the Works.
- The Contractor's equipment must not impair the operation of or access to the rest of the sulphuric acid storage and dilution system or any system within the WTP.
- The Contractor must provide storage for their equipment and/or materials.

All equipment used by the Contractor must be comply with the Occupational Health and Safety Act safety standards and must be in a safe and good working condition. Eskom has the right to stop use of any equipment by the Contractor if it deemed by Eskom to not comply with the aforementioned.

The Contractor must supply a list of tools and equipment before entering the Site. This will be checked by Eskom. Any tools or equipment not mentioned on this list will become the property of Eskom. On completion of the project, the Contractor may only remove tools and equipment with the permission of Eskom and after completion and approval of the necessary documentation.

4.1.5 Equipment Provided by the Employer

Not Applicable.

4.1.6 Site Services and Facilities

4.1.6.1 Supply of electricity

Eskom will provide electricity required for the completion of the Works. It is the duty of the Contractor to provide the necessary equipment and manpower to pull electricity from the nearest electrical outlet. Eskom does not guarantee the quality and duration of power supply. The Contractor is to make the necessary arrangements, at their own expense, in the event that that there is no power supply from Eskom for whatever reason. No claim of any nature and/or reason for delay of the Works will be considered regarding the aforementioned.

4.1.6.2 Sanitation

Eskom will allocate a sanitary facility to be used by the Contractor. The Contractor will abide by the rules set by Eskom regarding these facilities.

4.1.6.3 Potable Water

Eskom will provide potable water for use by the Contractor if required. It is the duty of the Contractor to pull potable water to the location where they require it.

4.1.6.4 First Aid and Fire Fighting

In case of emergencies, the Contractor may call upon first aid or firefighting resources at Duvha Power Station. It is recommended that the Contractor also provides these facilities to the best of their ability. Eskom will not be held liable for any loss, injury or death of the Contractor's employees. The Contractor will be held liable for any damage to Eskom property and/or injury or death to Eskom employees due to negligence on the part of the contractor.

4.1.7 Facilities Provided by the Contractor

4.1.7.1 Security

The Contractor is responsible for providing the necessary security for the protection of the Works and their equipment at all times. All persons entering the site are required to pass through the main access gate and must possess temporary access permits to the Site. The Contractor must request Eskom to provide these temporary permits.

No firearms, weapons, alcohol, illegal substances and cameras (including cell phones with cameras) are permitted on Site.

4.2 COMPLETION, TESTING, COMMISSIONING AND CORRECTION OF DEFECTS

4.2.1 Work to be Done by the Completion Date

All work and documentation, except those listed below, must be completed by the Contractor before the Completion Date of the Works. The Project Manager cannot certify that the work is complete until all work and documentation (except those listed below) has been done and the work is free of defects.

- As built drawings of the Works – Completion date is within 14 days of completion of the Works.

4.2.2 Use of the Works before Completion has been Certified

Not Applicable.

4.2.3 Commissioning

Refer to section 3.10.1.

4.2.4 Start-up Procedures Required to put the Work into Operation

The plant is to only be put in operation after the safety clearance and functional testing of all systems.

4.2.5 Takeover Procedures

Handover of plant will be initiated only after the system has successfully completed all functional tests.

4.2.6 Training and Technology Transfer

All operating and maintenance requirements must be included in the training manuals. The contractor must provide training on operating and maintaining the system (in all scenarios) to the Eskom operators and maintenance staff. The operator must also provide training on the system to the engineering staff.

4.2.7 Defect Period

The defect period will commence as soon as handover takes place and will last for a period of 52 weeks from the date of handover. During this defect period, the Contractor is responsible for the repair of any fundamental flaw in the system (or the operation thereof). The Contractor is also responsible for the repair of the system if the system is not performing as set out in this document.

4.2.8 Guarantee Period

According to point 4.13 (b) in 240-106365693, the Contractor guarantees that all work (goods and service) is be free from defects. The duration of the guarantee period of any component is defined by the OEM of that component. The guarantee period begins after the official handover process of the plant has been completed. The Contractor must provide a further guarantee on the entire system if any repairs are required during the initial guarantee period. This further guarantee will commence once the repair work on the system has been completed.

4.2.9 Limited Access Register (LAR)

- The Limited Access Register (LAR) is a register used by the Eskom personnel who are in charge of the plant. It is used to maintain control over the individuals in the plant as well as activities taking place on the plant that are not covered by the Plant Safety Regulation and Operating Regulations for High Voltage Systems.
- Activities that are carried out under LAR must require a permit, must be performed by skilled personnel without any risk of production loss and must be completed in less than 24 hours.
- Activities that are carried out under LAR must not endanger any individual in the plant and must not require any plant isolations.
- The Project Manager or Supervisor will accompany the Contractor for the first instance of working under the LAR of the specific plant area. Thereafter, the Contractor is expected to know and abide the rules and regulations which are set out.

- Any individual who wishes to perform any activity on the plant under the LAR must inform the person in charge of the plant. This involves the verbal communication as well as the signing of the LAR book. Once the activity has been completed, the person in charge of the plant must be verbally notified and the LAR book must be signed.

5. STANDARDS AND SPECIFICATIONS

The Contractor is required to adhere to the following standards and procedures while executing the Works.

5.1 CIVIL AND STRUCTURAL STANDARDS

- SANS 10400 Application of the National Building Regulations
- SANS 10400 Application of the National Building Regulations
- GAM/MAT/21/146: Corrosion Protection Specification – Duvha Power Station - Water Treatment Plant Acid Regeneration Bays – Acid Proof Tiling
- GAM/MAT/21/181: Corrosion Protection Specification – Duvha Power Station - Sulphuric Acid Storage and Dilution System Structural Steel Work and Plinths
- GAM/MAT/21/185: Corrosion Protection Specification – Duvha Power Station: Water Treatment Plant Acid Regeneration Piping – Rubber Lined.
- GAM/MAT/21/189: Corrosion Protection Specification - Duvha Power Station Water Treatment Plant Corrosion Protection of Effluent Channels by Thermoplastic Sheeting.

5.2 MECHANICAL STANDARDS

- 32-632 Requirements for Non-Destructive Testing (NDT) on Eskom Plant
- 240-56241933 Control of Plant Construction, Repair and Maintenance Welding Activities
- 240-56355225 Welding of High Pressure, Temperature Tube and pipework
- 240-56246601 Personnel and Entities Performing Welding Related Special Processes on the Employer's Plant
- SANS 1091 National colour standards of paint
- SANS 10140 Identification colour markings
- 240-123801640 Standard for Low Pressure Pipelines
- 240-106628253 Standard for Welding Requirements on Eskom Plant
- 240-150642762 Generation Plant Safety Regulations
- GAM/MAT/21/185: Corrosion Protection Specification – Duvha Power Station: Water Treatment Plant Acid Regeneration Piping – Rubber Lined

5.3 CHEMISTRY STANDARDS

- 240-55864792 Chemistry standard for once through boilers above 16MPa
- 240-88257914 Chemistry Guideline for Demineralised Water Production Using Ion Exchange Resins

5.4 OTHER STANDARDS

- ENS0002 Duvha Power Station AKZX Plant Location Coding Manual
- 240-71432150 Plant Labelling Standard
- Occupational Health and Safety, Act Number 85 of 1993
- 240-49230111 Hazard and Operability Analysis (HAZOP) Guideline (Rev 1)
- 240-30008949 Safety, Health and Environmental Specifications for Contractors
- 240-105658000 Supplier Quality Management Specification (QM 58)
- 240-28463367 SHE Organization
- 240-62196227 Life Saving Rules
- 240-101712128 Standard for the Internal Corrosion Protection of Water Systems, Chemical Tanks and Vessels and Associated Piping with Linings
- 240-106365693 Standard for the External Corrosion Protection of Plant, Equipment and Associated Piping with Coatings

6. AUTHORISATION

This document has been seen and accepted by:

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7. REVISIONS

Date	Rev.	Compiler	Remarks
September 2021	0	Y Moola	First Draft
November 2021	1	Y Moola	Review

8. DEVELOPMENT TEAM

The following people were involved in the development of this document:

- Yaaseen Moola
- Lethukuthula Ndwandwe (C&I Scope of Work)

9. ACKNOWLEDGEMENTS

- Sumayyah Sulliman
- Jacqueline Kotze
- Andile Makhubo