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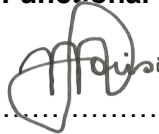
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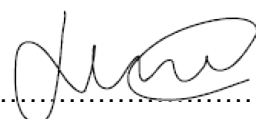
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ABBREVIATIONS & ACRONYMS

Abbreviation	Description
C&I	Control and Instrumentation
COC	Certificate of Compliance
DB	Distribution board
DCS	Distributed control system
ECSA	Engineering Council of South Africa
ECM	Engineering Change Management
EDWL	Engineering Design Work Lead
FMECA	Failure Mode Effects and Criticality Analysis
HAZOP	Hazard and Operability
HMI	Human Machine Interface
LDE	Lead Design Engineer
LPS	Low Pressure Services
MIC	Microbiologically Induced Corrosion
NTU	Nephelometric Turbidity Index
OEM	Original Equipment Manufacturer
OHS Act	Occupational Health and Safety Act
OPEX	Operating Expenditure
P& ID	Process & Instrumentation diagram
PFD	Process Flow Diagram
PLC	Programmable Logic Controller
PSD	Particle Size Distribution
PS	Power Station
PSV	Pressure Safety Valve
RAM	Reliability, Availability and Maintainability
RO	Reverse Osmosis
SDI	Silt Density Index
SOW	Scope of Work(s)
TP	Terminal Point
VDSS	Vendor Document Submission Schedule
SANS	South African National Standard
WTP	Water Treatment Plant

1.1 BACKGROUND

Following the decision to process station effluent water at the Medupi Power station water treatment plant to produce filtered and demineralised water, signs of microbiologically induced corrosion (MIC) are now evident on equipment, pipes and tanks. Refer to Report No: *RTD/ACM/19/240-151882337* and *RTD/ACM/20/240-153955542*.

As the corrosion product from the MIC activity lead to particulate fouling of RO passes 1, stage 1 lead membranes, their production capacity has been reduced by about 37%, and the differential pressures are higher than those recommended by the OEM's due to irreversible fouling. From the engagements with the OEM's, it was deduced that it is a sound engineering practice to install pre-filters upstream of the RO membranes to prevent particulate fouling of the membranes.

This document therefore details the required scope of work for installation of RO1 pre-filters in order to mitigate the risks of particulate fouling of the membranes.

1.2 THE WORKS

The *Works* comprises of the design, procurement, manufacturing, supplying, delivery to site, construction, commissioning, optimising and testing of the pre-filtration system that shall be installed upstream of RO pass 1, to allow for effective and efficient removal of particulate matter in the process stream.

It is envisaged that the RO 1 pre-filtration system will be connected at the marked-up terminal points (TP), illustrated on *Drawing No: 0.84/4674 (P&ID)*, and {*0.84/15836; 0.84/17055; 0.84/19431*} (*Isometric drawings*)

1.2.1 Process designs Information

The water quality of the stream that will be filtered is detailed in Table 1. The water will be taken from the existing filtered water tanks (0 0GDK14 BB001/BB011) and pumped through the proposed filtration system at 798 m³/h ($\pm 5\%$) and 2100 kPa (g), and 40°C (max). The pumps datasheet and curve can be viewed on the process design reference folder. The operating philosophy of the existing system is detailed in document no: *200- 116365*. However, the contractor will be expected to update the operating philosophy and include the proposed modification.

Table 1: Medupi Water Quality

Parameter	Minimum	Maximum	95 th Percentile
Turbidity (NTU)	0.01	3.22	0.18
pH	7.39	9.81	8.56
Conductivity (µS/cm)	1.04	1151.05	913.85
Calcium Hardness as CaCO ₃ (ppm)	0	198.97	128.36
Magnesium Hardness as CaCO ₃ (ppm)	8	96.95	64.55
Total Hardness CaCO ₃ (ppm)	8.06	295.92	192.92
P alkalinity (ppm)	0	21.5	9.38
M alkalinity (ppm)	19.06	5092	81.98
TOC (ppm)	1.26	11.5	7.53
Chlorides (ppm)	5.75	56.326	49.753
Sulphates (ppm)	1.845	468.524	321.971
Nitrates (ppm)	0.01	8.55	0.841
Fluorides (ppm)	0	3.716	1.965
Phosphates (ppm)	0.001	0.741	0.019
Calcium (ppm)	3.54	76.4	51.528
Magnesium (ppm)	1.87	24.026	15.186
Sodium (ppm)	5.04	193.864	133.671
Potassium (ppm)	0.78	17.393	12.392
Barium (ppm)	0.00322	4.36	0.0787
Strontium (ppm)	0.006	0.926	0.18
Manganese (ppm)	0	0.988	0.0705
Silica (ppm)	0	28.6	10
Iron (ppm)	0	0.4567	0.0136
Copper (ppm)	0	0.206	0.0356
Solid Loading (mg/l)	0.051	0.5	0.402
LSI	-2.14	0.06	-0.14

The filtration system shall be designed to reduce the stream solid loading from about 0.5 mg/l to less than 0.1 mg/l. The intent is to achieve a silt density index (SDI) <3, and turbidity < 0.1 NTU's. Additionally, as the particle size distribution (PSD) showed that about 90% of particles are within the 2 – 5 micron range as illustrated in Figure 1 below, the filter micron size shall not be greater than 2 micron.

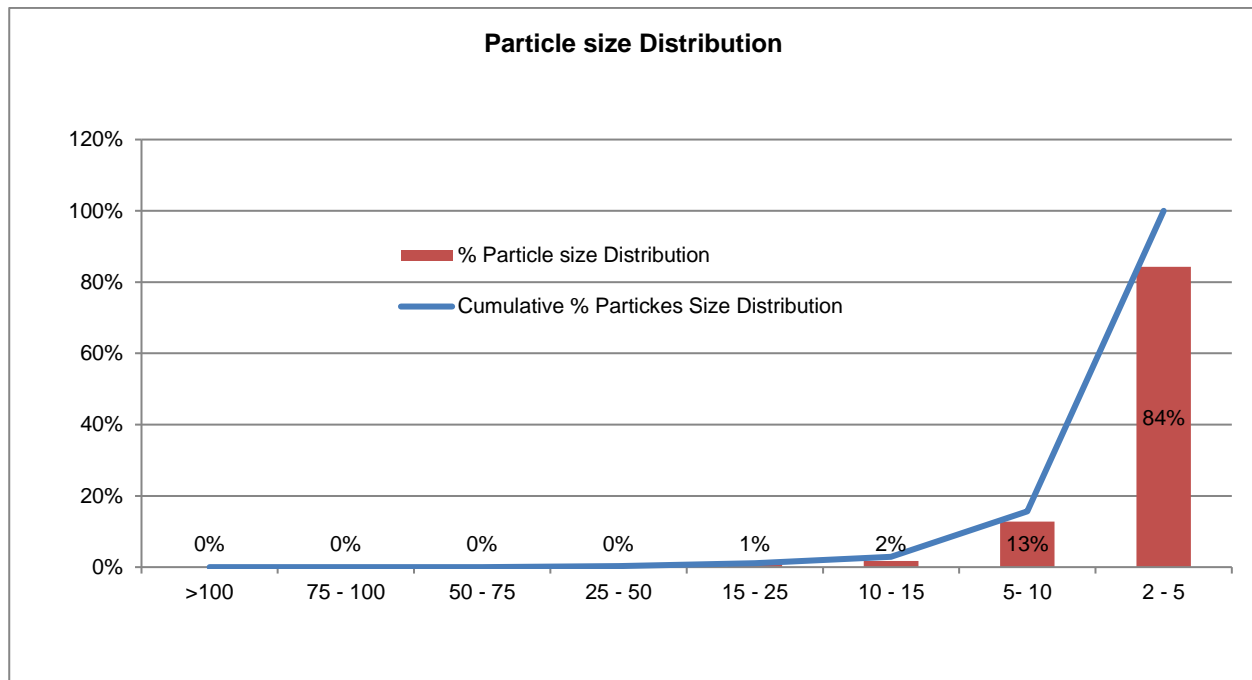


Figure 1: Typical Particle Size distribution of the stream

In order to ensure continuous supply of filtered water for production of demineralised water used for electricity generation, the filtration system shall be designed in such a way that the configuration enables a 3 x 33.3% of the filtration skids in operation, with one on standby. The system configuration shall also be designed in a way that will enable isolation, draining and changing of each of the filter vessels without shutting down the plant. Therefore, operations/maintenance shall be able to take one of the pre-filters out of service and change the filters without affecting production.

As there system is high pressure, double isolation on the inlet and outlet of each filtration train shall be considered for safety of the personnel, in case of passing valves. To protect the vessels from over pressurisation in case of pumping against a closed discharge, each filter vessel inlet shall be fitted with a flow meter, and a no flow alarm. Alternatively, a two out of three pressure transmitter voting system can be considered. The signal from the flow meters or pressure transmitters shall be used to stop the pumps/ isolate the filter vessel with closed discharge. For standardization purposes,

the valves shall be pneumatic valves, with limit switches to enable viewing of the valve status from the HMI.

In addition to the above, a mechanical device such as a pressure safety valve (PSV) shall be installed to protect the vessels. The set pressure of the PSV shall be determined as recommended by API 520/521/526.

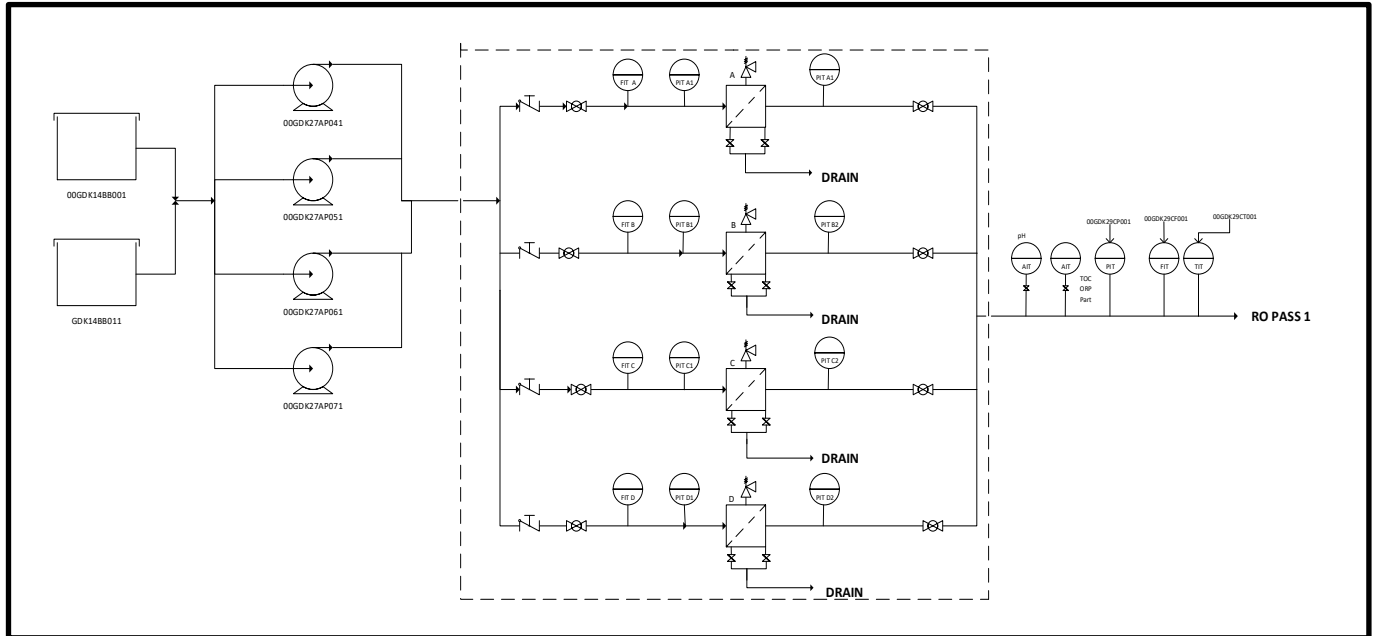


Figure 2: The proposed Filtration process flow diagram

To mitigate the risks associated with RO 1 operations, the allowable pressure drop across the filtration skids shall not be greater than 100 kPa. However, the contractor is expected to do hydraulic calculations, and run ROSA/WAVE software to determine the acceptable pressure drop that will not affect the performance of the RO system. The contractor is expected to submit both the hydraulic calculations/model and ROSA/ WAVE model results that shows that the performance of the RO pre-filters will not be affected by the selected allowable pressure drop.

In order to provide an indication of the differential pressure across the filter vessels, the filter vessels shall be equipped with a differential pressure indicator that will be connected to the DCS. The control systems shall be configured to provide an alarm to alert the operators, and also to close an inlet valve and outlet valve of a vessel that have high differential pressure. The standby vessel shall be automatically put in-service following a start-up sequence, should one of the vessels be automatically isolated.

To minimize Opex costs, the contractor target change-over frequency of the filters shall not be more than once a week.

As it is evident from Table 1 that the water is aggressive, and the fact that external corrosion is possible in the identified area of installation, the contractor shall protect the vessel materials of construction against corrosion.

At the end of the process design phase, the contractor is expected to deliver the following updated documentation:

- Process Flow diagram (PFD)
- Piping and Instrumentation diagrams (P&ID's)
- Equipment datasheets
- Valve lists
- Instrument schedule
- Control Narrative
- Operating philosophy
- Power requirements of equipment and instrumentation
- Design calculations
- Hydraulic Model input file and results
- HAZOP study report
- FMECA study report
- Reliability, Availability and Maintainability (RAM) study Report

The applicable guidelines for the above mentioned deliverables are listed in Table 2, in Appendix A

1.2.2 Mechanical design Information

Specific to the works, Mechanical Engineering works will include design of the filter vessels, piping and piping accessories, pipe supports, instrument tubing (impulse lines), and pressure relief device(s).

The pressure vessels shall be designed to comply with the ASME VIII code, and shall be horizontally orientated. The filter elements shall be changeable from opening the davit arm that one can swing after loosening the holding bolts.

The vessel thickness shall take into consideration a corrosion allowance of 3mm/year, and the fact that the life of plant is expected to be at least 50 years. For ease of transportation and rigging, the vessel shall be fitted with at least two lifting lugs of not less than 20 mm thickness, and a support bracket. As a minimum, the vessels shall be fitted with a vent and a drain valve. The vessel nozzles/flanges shall be designed to comply with EN 1092-1 (former BS4504), whereas the piping and piping accessories shall comply with ANSI/ASME B31.1 design code, and impulse piping shall comply with document no: 240-89147446. Figure 3 below provides a general arrangement of the envisaged filter vessel.

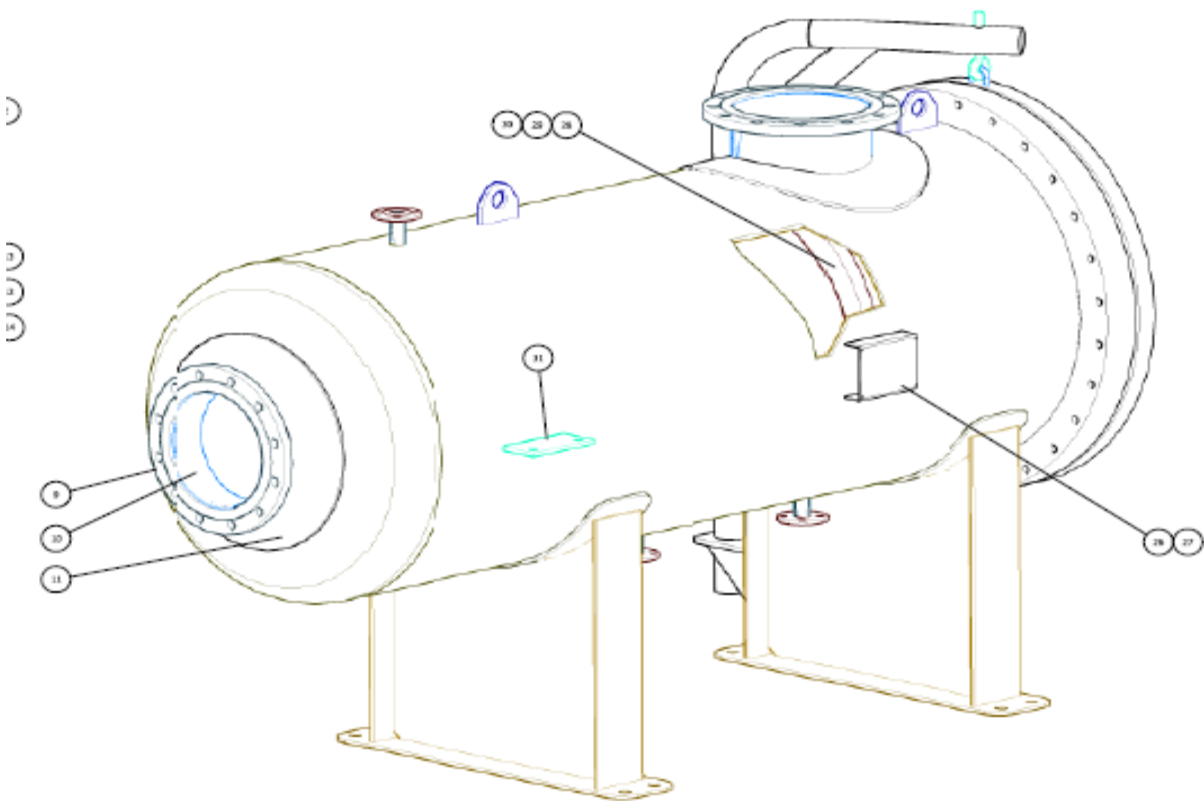


Figure 3: Typical Envisaged Filter Vessel

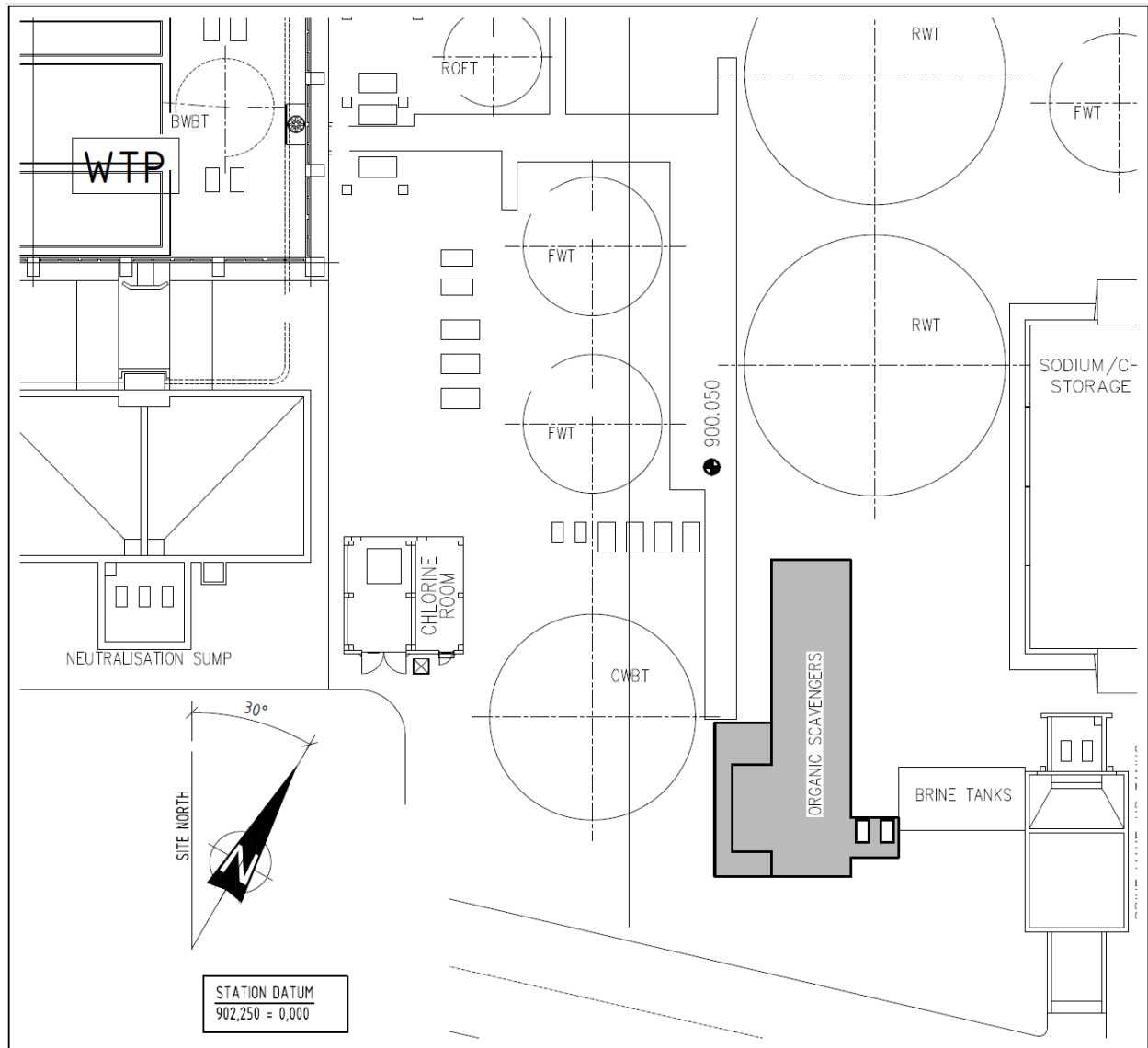
At the end of the mechanical design, the contractor is expected to submit:

- Vessel design Calculations
- Models input files and results (depressurization, vibration, stress analysis studies)
- Vessel GA drawing with nozzle sizes, and vessel design conditions,
- Equipment and pipe layout plans (GA's)
- Isometric drawings
- Corrosion protection plans

To aid the development of the 3D model for the works, the Medupi Plant zero datum drawing no: 0.84-364 shall be used as a reference. The applicable guidelines for the above mentioned deliverables are listed in Table 3 in Appendix A

1.2.3 Civil & Structural design Information

The area identified to place the filtration system was originally earmarked for the Organic scavengers. This area comprises of 2 pump plinths and a large reinforced concrete slab, refer to extract below from drawing 0.84/13033 Sheet 1 Rev 04.



LOCALITY PLAN

Figure 4: Locality Plan of Area to be used for Filtration system (Drawing 0.84/13033, Sheet 1)

(The contractor to review the available area above and provide best fit layout of required equipment)

The pump plinths were designed for 8kN (SLS) load each and the reinforced concrete slab for a uniform distributed load of 25kPa (SLS).

The Contractor shall be responsible for all civil designs, the construction/fabrication thereof and professional engineering certification specific to the required works, this will include, but not limited to:

- Any supporting infrastructure and/or plinths required for vessels, tanks, pipes, C&I and Electrical Equipment etc.
- All grouting requirements
- Assessment of loads to be imposed on existing concrete structures as well as any design changes on the existing structures if required.
- Assessment and acceptance (with modifications if required) of the existing concrete slab and plinths, as per drawing 0.84/13033 Sheet 1 Rev 04.

The works shall be designed and constructed for a 50 year plant life cycle.

1.2.3.1 Requirements

1. The Contractor shall perform acceptance tests, if required, in order to certify the existing works pertaining to the support of the required pre-filter system.
2. The Contractor's ECSA registered engineer shall become professionally responsible for the existing base and any additions required to support the required pre-filter system.
3. The *Contractor* shall take full professional accountability for all of the Works in their scope and shall provide the following for review and acceptance:
 - Consolidated detailed design report signed by a Professional Civil Engineer which as a minimum includes:
 - As-built Survey results, outcomes of Geotechnical investigation (if deemed necessary), design criteria/parameters, specifications and standards used, loadings, assumptions, calculations results including detailed design calculations, design models (where applicable), sources of information and any record of other information associated with the completed Works.
 - Detailed drawings for construction. Drawings shall be submitted in native CAD – and PDF formats.
 - Detailed models (where applicable) and calculations pertaining to the design shall be submitted in PDF as well as native format.
 - Professional engineering certificate, signed by an ECSA registered professional once construction work is completed.
4. The *Contractor's* registered engineer shall provide services to the employer in accordance with the construction regulations and ECSA code of conduct and Guidelines.

5. The *Contractor* shall submit as-built data and drawings of the completed works upon handover.
As-built drawings shall be submitted in PDF and native CAD formats.

All civil construction works to be performed in accordance with Medupi concrete specification, 84CIVL053 and according to Medupi Project processes.

Any discrepancy or ambiguity between the *Employer's* Specifications or requirements shall immediately be brought to the attention of the Project Manager for clarification.

The relevant civil drawings as well as the stability certificate are listed in Table 4 while the applicable guidelines for the above mentioned deliverables are listed in Table 5 in Appendix A

1.2.4 Control & Instrumentation design information

Specific to the works, Control and Instrumentation engineering design will be responsible for:

- Designing, procurement and installation of all field instrumentation,
- Providing designs for powering of all field instrumentation,
- Making available designs for connecting of field instrumentation signals to the DCS,
- Updating and providing designs for incorporation of control logics into the existing DCS system,
- Designing, procurement and installation of junction boxes or use the existing ones that were used for scavenger plant since there will be not scavenger plant no more.
- Designing, procurement and installation of trunk cable from the junction box to the DCS cubicles.
- Designing, procurement and installation of the instrument cables from the required instrument to the junction boxes.

The KKS of the junction box with available space is *+0 0UGD10 GA540* and the truck cable is *00CSE7259UGCE*.

The above KKS might change because the existing JB signals and instruments are currently assigned to the function group of the Organic scavenger instead of RO Prefilter

The applicable guidelines for the above mentioned deliverables are listed in Table 6 in Appendix A

1.2.5 Configuration and Document management

The following documents shall be used by the contractor as guidelines for document submittals, record management, design reviews, and change management.

1.3 QUALITY MANAGEMENT

1.3.1.1 Quality Management System

The contractor shall be ISO 9001:2015 compliant and shall apply the following Eskom quality standard 200-1689 rev 4 (Contractor Quality Management specification) and 240-105658000 (Supplier Quality Management Specification)

1.4 COMMISSIONING

The Contractor shall be responsible for commissioning (including flushing), and performance testing of all systems supplied (and interfacing systems should it be necessary) and will compile and submit the following documentation as stipulated in documents *200-16714*

1.5 AUTHORISATION

This document has been seen and accepted by:

Name & Surname	Designation
Msondezi Polisi	Medupi chemical Lead Design Engineer
Kgaugelo Shebe	C& I Lead Design Engineer
Tumelo Chauke	Control & Instrumentation Engineer
Marius Van Niekerk	Civil Engineer
Willie Beetge	Medupi Civil Lead Design Engineer
Chuma Mketo	Medupi Configuration Lead Design Engineer
Lihle Cingo	Configuration management Engineer
Prince Lepota	Acting GMR 2.1 GCD
Philip Steyn	Medupi Project EDWL
Ludwig Louw	Integration LDE
Moses Sinobolo	BOP Quality
Brian Ramathaga	BOP Commissioning

1.6 REVISIONS

Date	Rev.	Compiler	Remarks
May 2020	01	P.Mamathoni	Inclusion of PSD and Solid loading and Updating of the document
October 2019	00	J. Pillay	Compiled the draft document

1.7 DEVELOPMENT TEAM

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

- Msondezi Polisi

1.8 ACKNOWLEDGEMENT

- Sello Senama
- Jerushan Pillay

APPENDIX A

Table 2 : Process Design Deliverables Guidelines and Standards

	Number	Name
Eskom	240-86973501	Engineering Drawing Standard – Common Requirements
Eskom	240-93576498	KKS Coding Standard
Eskom	240-71432150	Plant Labelling Standard
Eskom	240-109607332	Eskom Plant Labelling Abbreviation Standard
Eskom	240-49230111	Hazard and Operability (HAZOP) Studies
Eskom	240-49230046	Failure Mode Effects and Criticality Analysis (FMECA)
Eskom	240-52844017	System Reliability, Availability and Maintainability Analysis Guideline
Eskom	240-72249423	Instrument Schedule
Eskom	240-61379755	Drive and Actuator Schedule
Eskom	240-72344339	Virtual signal list
Eskom	240-72346360	Load Schedules for UPS Supply

Table 3 : Mechanical Design Deliverables Guidelines and Standards

	Number	Name
SANS	347	Categorization and conformity assessment criteria for all pressure equipment
ASME	VIII	Boiler and Pressure vessel code
SANS	10140-3	Identification colour markings of pipelines
EN	1092-1	Flange standard
Eskom	240-86973501	Engineering Drawing Standard – Common Requirements
Eskom	240-56364545	Structural Design And Engineering Standard
SANS	10143	Building Drawing Practice
Eskom	240-101712128	Standard for the Internal Corrosion Protection of Water Systems, Chemical Tanks and Vessels and Associated Piping with Linings
Eskom	240-106365693	Standard for the External Corrosion Protection of Plant, Equipment and Associated Piping with Coatings
Eskom	240-49230111	Hazard and Operability (HAZOP) Studies
Eskom	240-49230046	Failure Mode Effects and Criticality Analysis (FMECA)
Eskom	240-52844017	System Reliability, Availability and Maintainability Analysis Guideline

Table 4: Relevant Civil Drawings and Stability Certificate

Document Title	Document Number
WTP Area Organic Scavengers Concrete layout	0.84/13033-Sheet 01
WTP Area Organic Scavengers Reinforcement Layout and Detail	0.84/13034-Sheet 01
WTP Area Organic Scavengers Reinforcement Layout and Detail	0.84/13034-Sheet 02
Structural Stability Certificate of WTP-Organic Scavenger	200-213520

Table 5: Civil and Structural Codes and Standards

	Code	Description
Eskom	240-86973501	Engineering Drawing Standard – Common Requirements
Eskom	240-56364545	Structural Design And Engineering Standard
Eskom	240-107981296	Constructability Assessment Guideline
Eskom	240-57127953	Execution of Site Preparations and Earthworks Standard
Eskom	240-57127951	Standard for the Execution of Site Investigations
Eskom	84CIVL053	Medupi Power Station Specification for Structural Concrete
Eskom	SSZ_45-17	Medupi Power Station Corrosion Protection Specification

Table 6: C&I Specific Minimum Standards and Guidelines

Type	Number	Name
Eskom	240-56227443	Requirements for control and power cables for power stations
Eskom	240-56355466	Alarm Management System Standard
Eskom	240-56355729	Plant Control Modes Guideline
Eskom	240-52844017	System Reliability, Availability and Maintainability Analysis Guideline
Eskom	240-56355754	Field Instrument Installation Standard
Eskom	240-56355815	Junction Boxes and Cable Termination Standard
Eskom	240-56355843	Pressure Measurement Systems Installation Standard
Eskom	240-49230046	Failure Mode and Effects Analysis Guideline
Eskom	240-49230111	HAZOP Analysis Guideline
IEC	IEC 62381	Automation systems in the process industry - Factory acceptance test (FAT), site acceptance test (SAT), and site integration test (SIT)
SANS	10142 – Part 1	The Wiring of Premises Part 1: Low-voltage installations.
Eskom	240-72249423	Instrument Schedule
Eskom	240-61379755	Drive and Actuator Schedule
Eskom	240-72344339	Virtual signal list
Eskom	240-72346360	Load Schedules for UPS Supply

Type	Number	Name
Eskom	240-72346591	C&I Defects Check sheet
Eskom	00 UG10GA 540	JB Schedule
Eskom	240-72350241	Panel Interface List
Eskom	240-56355815	Field Instrument Installation Standard for Junction Boxes and Cable Termination
Eskom	240-56355754	Field Equipment Installation Standard
Eskom	240-56355535	Process Calibration Equipment Standard

Table 7: Configuration Management Codes and Standards

	Code	Description
Eskom	240-85521112	Vendor Document Submittal Schedule
Eskom	240-65459834	Project Documentation Deliverable Requirement Specification
Eskom	240-53114186	Project/Plant Specific Technical Document and Records Management Procedure
Eskom	240-54179170	Technical Documentation Classification and Designation Standard
Eskom	240-53113685	Design Review Procedure
Eskom	240-53114026	Project Engineering Change Management Procedure
Eskom	240-66920003	Documentation Management Review and Handover Procedure for Gx Coal Projects