

 Eskom	Scope of Work	Tutuka Power Station
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Title: **Hydrogen Generating Plant Upgrade Project Scope of Work (Tutuka Power Station)**

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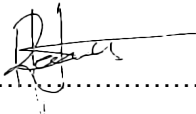

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1. INTRODUCTION

The existing Hydrogen Generating Plant at Tutuka Power Station has been in service since construction of the power station. The plant is aged, maintenance and repair spares are no longer available for purchase, the hydrogen production philosophy of this plant is outdated and no longer conforms to updated national and Eskom hydrogen safety standards. Due to the age of the plant, it has become highly unreliable and requires excessive maintenance and intervention, as a result it does not produce adequate hydrogen required to maintain the receiver levels and the power station will have to procure hydrogen gas in order to have ample hydrogen to supply all the generators.

Tutuka Power Station therefore requires the manufacture and installation of a new hydrogen generating plant, which will ensure that the generator requirements are met at all times. This engineering change will ensure a reliable source of hydrogen production and minimise cost in terms of procuring from hydrogen suppliers, as well as eliminating the risk of unit trips and outage delays due to lack of hydrogen capacity.

The power station requires the following to be met:

- The hydrogen plant capacity shall not be less than the current capacity of 14,4 Nm³/hour.
- Provide the power supply required for the new plant.
- Investigate the location of the current Hydrogen plant to suit the new plant and ensure the building is suitable and complies with required standards.
- Ensure the four receivers are suitable for continued use.
- Ensure the pipework to the units is suitable for continued use.
- Decommission the old hydrogen generating plant.

2. SUPPORTING CLAUSES

2.1 SCOPE

The scope of the requirements set out in this document includes the following:

- Design of a new Hydrogen generating plant.
- Manufacture, supply, installation, and commissioning of a new Hydrogen generating plant.
- Manufacture, supply, installation and commissioning of ancillary components i.e. monitoring panel etc.
- Design of new plinths and platforms if required.
- Modifications to the electrical distribution board.
- Interconnection of the PLC to the C&I DCS.

2.1.1 Purpose

The purpose of these requirements are as follows:

- To ensure safe and reliable Hydrogen production at Tutuka Power Station.
- To ensure that the plant can be maintained and spares availability.
- For long term Hydrogen availability for the duration of operation of Tutuka Power Station.

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2.1.2 Applicability

This document shall apply to the following departments at Tutuka Power Station:

- Electrical Engineering
- C&I Engineering
- Civil Engineering
- Turbine Engineering
- Risk and Assurance Department
- Electrical Maintenance Department
- Project Department
- Finance Department

2.2 NORMATIVE/INFORMATIVE REFERENCES

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

2.2.1 Normative

- [1] 240-56227413: Hydrogen Systems Standard
- [2] OHS Act [85 of 1993]: Occupational Health and Safety Act of South Africa
- [3] ISO 9001 Quality Management Standard
- [4] 240-5635581: Junction Boxes and Cable Termination Standard
- [5] 240-56227443: Control and Power Cables for Power Stations Standard
- [6] 240-56356396: Earthing and Lightning Protection Standard
- [7] 240-89147446: Instrument Piping for Fossil and Hydro Power Plant Standard
- [8] SANS 10142-1: South African National Standard for the Wiring of Premises
- [9] 240-56355843: Pressure Measurement System Installation Standard
- [10] 240-56355888: Temperature Measurement System Installation Standard
- [11] 240-56355754: Field Equipment Installation standard
- [12] SANS 1200: Standardised Specification for Civil Engineering Construction
- [13] SANS 10100: The Structural use of Concrete
- [14] SANS 10160: Basis of Structural Design and actions for Buildings and Industrial Structures
- [15] 240-49230111: HAZOP and Operability Guideline
- [16] 240-56536505: Hazardous Location standard
- [17] 240-49230046: Failure Mode Effects Analysis Guideline
- [18] 240-71432150: Plant Labelling and Equipment Description standard
- [19] SANS 10108: The Classification of Hazardous Locations and the Selection of Apparatus for use in such locations

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- [20] SANS 10140: Identification of Colour Markings (parts 1 to 4)
- [21] SANS 10119: Reduction of Explosion Hazards Presented by Electrical Equipment Segregation Ventilation and Pressurization.
- [22] SANS 1574: Electrical cables – Flexible cords
- [23] SANS 1123: Pipe Flanges
- [24] ISO 11114: Transportable gas cylinders – Compatibility of cylinder and valve material with gas contents
- [25] ISO 16111: Transportable Gas Storage Devices – Hydrogen Absorbed in Reversible Metal Hybride
- [26] ISO 22734-1: Hydrogen Generators using Water Electrolysis Process – Part 1: Industrial and Commercial Applications
- [27] ISO 11625: Gas Cylinders – Safe handling

2.2.2 Informative

- [28] 240-53114002: Engineering Change Management Procedure
- [29] 240-46953552: Plan Technical Effort PCM
- [30] 240-53114026: Project Engineering Change Management Procedure
- [31] 240-53113953: Manage Engineering Accountability Procedure
- [32] 15ENG GEN-1308: Tutuka Power Station Hydrogen Generating plant Upgrade ROC
- [33] 15ENG GEN-2140: Stakeholder Requirements Definition for the Tutuka Power Station Hydrogen Generating Plant Upgrade
- [34] 240-53114186: Document and Records Management
- [35] 240-53113685: Design Review Procedure

2.3 DEFINITIONS

Definition	Description
Contracting strategy	Strategy to define and allocate the scope of supply to work packages / jobs (insourcing and outsourcing) and to select the most appropriate form of contract thereto (Workgroup).
Work Breakdown Structure	In this document, the Work Breakdown Structure (WBS) describes the deliverables that are engineering activities and not physical assets. The WBS will list the required engineering activities. A deliverable-orientated hierarchical decomposition of the work to be executed by the project team to accomplish the project objectives and create the required deliverables. It organises and defines the total scope of the project.
Engineering Work	The application of specific scientific disciplines in the process of developing, designing, maintaining and operating assets with full cognisance of their design limitation in order to improve the lives of people.

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2.3.1 Disclosure Classification

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

2.4 ABBREVIATIONS

Abbreviation	Description
AC	Alternating Current
AKZ	Anlagen Kennzeichnung
BOM	Bill of Materials
C&I	Control and Instrumentation
CD	Compact Disk
DC	Direct Current
DCS	Distributed Control System
DRT	Design Review Team
DVD	Digital Video Display
ECM	Engineering Change Management
EDWL	Engineering Design Work Lead
EMAP	Engineering Management Plan
FMECA	Failure Modes, Effects and Criticality Analysis
H2	Hydrogen
HAZLOC	Hazardous Locations
HAZOP	Hazard and Operability Study
ITP	Inspection and Test Plan
LDE	Lead Design Engineer
MCP	Multiple Cylinder Pack
O2	Oxygen
OEM	Original Equipment Manufacturer
OHS	Occupational Health and Safety
OPCR	Outside Plant Control Room
PER	Pressure Equipment Regulations
P&ID	Piping and Instrumentation Diagram
PLC	Programmable Logic Controller
QA	Quality Assurance
QC	Quality Control
QCP	Quality Control Plant
RACI	Responsible, Accountable, Consulted, Informed
RAM	Reliability, Availability and Maintainability
ROC	Required Operating Capability

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Abbreviation	Description
SANAS	South African Accreditation System
SCCC	Site Change Control Committee
SHEQ	Safety, Health, Environment, Quality
SRD	Stakeholder Requirements Definition

2.5 ROLES AND RESPONSIBILITIES

Engineering Manager - Plant Engineering:

- Review and authorise the Engineering change.

Engineering Design Work Lead (EDWL):

- Develop the Scope of work.
- Develop the Tender Technical evaluation strategy
- Consolidate all LDE inputs and produce the technical effort.
- Compile the ERA and present it to site Investment Committee.

Engineering Line Managers:

- Establish and implement a strategy for design work of his/her discipline.
- Provide technical oversight and resources to support the project.
- Define resource competence for functions related to lead and system engineers needed for the project.
- Manage resources within his/her discipline to meet project staffing level requirements.

Lead Discipline Engineers (LDE):

- Coordination, integration and interfacing of all design related activities and deliverables up to commissioning and handover for his/her discipline.
- Coordination with other LDEs, Consultants, Specialists, Contractors, Suppliers and other Eskom support services such as Commercial, Project Managers, Finance etc.
- Ensure that the plant is designed, constructed and commissioned according to approved designs for his/her discipline.

Maintenance Department

- Provide supervision for execution of the works.
- Ensure that adequate training is provided by the Supplier of the new plant to enable the personnel to perform all required on-load and outage related maintenance.
- Complete commissioning together with the Supplier.
- Accept handover and maintain the plant

Project Manager

- Request a budget for funding the project
- Lead the procurement transport

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- Planning, implementing, monitoring and controlling of all projects related activities close-out/handover.
- Integrating all disciplines
- Project supervision during implementation.

2.6 PROCESS FOR MONITORING

N/A

2.7 RELATED/ SUPPORTING DOCUMENTS

N/A

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3. TECHNICAL SPECIFICATION

The purpose of the Technical Specification is to state the Employer's requirements and provide the Contractor with the necessary information to submit a comprehensive tender in order to replace the existing Hydrogen generating plant with a new system

3.1 DESCRIPTION OF THE SYSTEM

Figure 1 shows an illustration of the Tutuka Power Station Hydrogen production process.

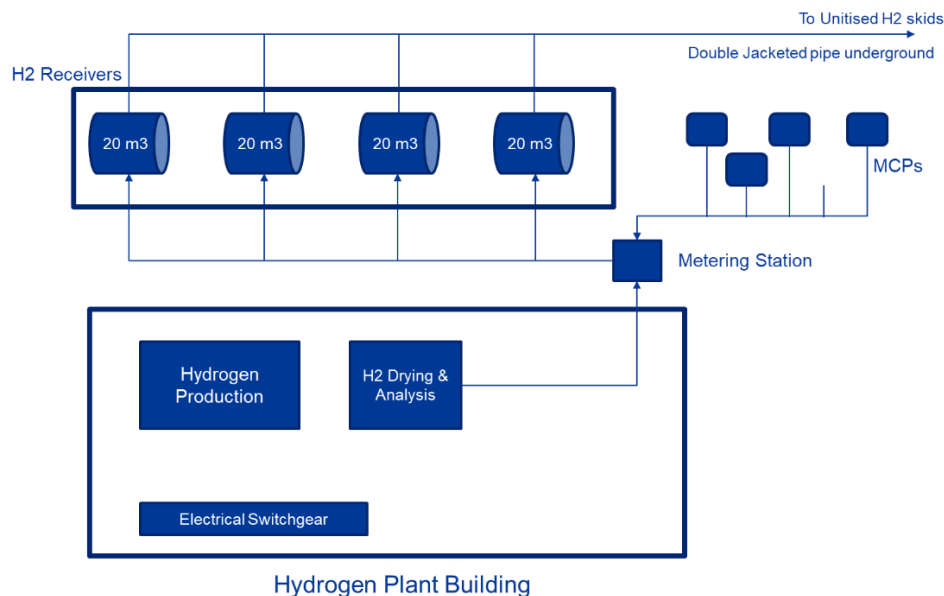


Figure 1: Hydrogen Generation Process

3.1.1 Existing System

The existing hydrogen generating plant at Tutuka Power Station is capable of producing 14,4 m³/h of hydrogen a maximum production rate. The hydrogen plant consists of the following components:

- **Rectifier system**

The rectifier receives 380V, 3 phase, 50Hz power supply from the 380V H2 Generating plant and lighting board. This rectifier converts this AC power to 14.8V, 5 720 A DC power which is then supplied to the electrolytic cells. The DC power output from the rectifier is controlled by means of a saturable reactor.

- **Electrolytic cells**

The hydrogen plant has 6 electrolytic cells which are electrically connected in series. DC power from the positive terminal of the rectifier is supplied to the cells and returns to the negative terminal of the rectifier. Hydrogen and oxygen gases are produced inside the cells at a rate of 0.45 m³ of hydrogen and 0.22 m³ of oxygen per 1 kAh. At maximum production

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of 5 720 A, the 6 cells are able to produce 14,4 m³/h of hydrogen and 7,2 m³/h of oxygen. Both gases are produced inside the cells and are separated by asbestos diaphragm bags, the hydrogen is collected inside the bags while the oxygen is outside. The oxygen is then vented out to atmosphere while the hydrogen is collected to be stored inside the bulk storage receivers.

- **Demineralised Water Storage Tank**

The process plant uses demineralised water, which is consumed through the electrolysis process. This water needs to be continuously replenished and the feedrate is controlled by a float valve mounted on each individual cell. At full production, the six cells require approximately 13 litres of feedwater per hour. The electrolytic cells produce a lot of heat during the process and are cooled by water which flows through a cooling jacket on each cell. This water supply is stored in the water storage tank

- **Gas Purity Metering Equipment**

The gas purity metering equipment is made up of analysers which monitor the purity of the hydrogen produced in the plant. If the hydrogen purity drops below 99,5% the air-operated valves automatically switch over and vent the hydrogen to atmosphere. Furthermore if the analyser is switched off, the valves automatically switch over to vent.

- **Gas Holder**

The hydrogen gas from the electrolytic cells is collected in a 2.5m³ low pressure gas holder which has level switches used for starting and stopping the compressors.

- **Compressors**

Two low pressure compressors compress the hydrogen, from the gas holder, from atmospheric pressure to 2 760 kPa, which is then stored in the bulk storage receivers.

- **Hydrogen Dryer**

A dessicant type hydrogen dryer maintains the hydrogen dew point temperature below -50°C.

- **Hydrogen Bulk Storage Receivers**

Tutuka Power Station has 4 bulk storage receivers, each 20 m³ and rated at a pressure of 2 750 kPa. The receivers are located inside a bund wall next the Hydrogen plant building.

3.1.2 System Upgrade Overview

The upgraded system would need to ensure that the primary purpose of the hydrogen generating plant is accomplished. The upgraded system will include:

- A reliable and modern plant design to allow for:
 - a. Adequate routine maintenance.

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- b. Optimal operating without the need for continuous Operator intervention.
- c. Availability of maintenance and repair spares.
- d. Ensure a plant that is safe and without harm to people and other plants

3.2 EMPLOYER'S DESIGN REQUIREMENTS

3.2.1 Employer's design

- The *Employer* will make existing plant interface information available to the *Contractor*. The *Employer* supplies AKZ codes to the *Contractor* for completion.

3.2.2 Parts of the works that the Contractor designs

- The *Contractor* provides all the design services for the works, including design of the plant, material used as well as their layouts, all interfaces and additional cabling requirements. These will include but will not be limited to the general arrangement of all equipment, single lines, cable terminations
- The *Contractor's* designs interfaces with the demineralised water supply to the hydrogen plant, the hydrogen supply to the units and the connection to the C&I DCS.

3.2.3 Design phases

The Contractor performs the following designs

- Detailed design

The detailed design package shall consist of:

- The final drawings (electrical, mechanical and C&I) of the complete hydrogen plant and all its ancillary equipment
- General layout drawings
- Single line diagram of the solution
- Terminations schedules
- Manuals
- All specifications of the proposed equipment to be used
- A complete factory acceptance testing procedure
- A complete on-site inspection check list
- A disassembly and assembly method statement
- A complete cold commissioning procedure
- A complete site acceptance procedure
- A complete hot commissioning procedure

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3.2.4 Use of the Contractors design

The *Employer* may use the *Contractor's* design for any purpose in relation to the Hydrogen Generation plant at the *Employer's* installation.

3.3 SYSTEM DESCRIPTION

3.3.1 Philosophies

Hydrogen is produced, dried, analysed and compressed inside the Hydrogen production plant building. The hydrogen gas is then stored in the bulk storage vessels that are located on the outside of the building, while oxygen, as a by-product of the electrolysis process, is vented to atmosphere. From the storage vessels, the hydrogen gas is supplied to each of the 6 unitised hydrogen skids at a constant pressure of 600kPa via the common hydrogen manifold.

The hydrogen plant also has back-up MCPs (multiple cylinder packs). These usually consist of 5 skids, with each skid consisting of 12 hydrogen filled gas cylinders. The pressure of the generated hydrogen gas is monitored at the metering station. In the event that the hydrogen supply pressure were to drop below 600 kPa, the metering station sends a communication to an actuated valve which will activate the supply from the MCPs. This will increase the hydrogen pressure back up to 600 kPa.

Hydrogen purity analysis is carried out both at the generating plant and at the unitised hydrogen skids. In the event that the hydrogen purity were to drop below 99.5%, the gas will not be permitted to enter the system. The generating plant will automatically blow off this gas and restarted the generating process.

3.3.2 Operating philosophy

3.3.2.1 Hydrogen Plant Operating Philosophy

The operation of the plant shall be fully automatic, with system start/stop initiated from the Local control station which is connected to the PLC of the generating plant and interface to the employers OPCR for monitoring and alarming. Local/remote selection shall be done at one location in the plant. The control system for the receiver filling and that of the generating plant shall be integrated to optimise the life of the cell stack and to ensure safe plant operation.

The hydrogen generating plant shall vent produced hydrogen with purity below 99.5% and initiate a trip if the oxygen content is greater than 1%. Following the trip, the plant will depressurise and an automatic nitrogen purge shall be initiated following a safety trip. In order to ensure safe plant operation of pressurised electrolyzers it is required that at minimum production and maximum pressure all contamination must stabilise after approximately 30 minutes. Under no circumstances shall it be allowed that the contamination of the hydrogen with oxygen to exceed 1% measured directly after the cell stack. This monitoring shall be repeated at maximum production and pressure. The hydrogen production plant shall comply with all requirements stated in 240-56227413: Hydrogen Systems Standard.

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3.3.2.2 Receiver Operating Philosophy

The receivers shall be fill in the following sequence:

- Fill the first receiver when the hydrogen generating plant is at maximum capacity until the first receiver is entirely full.
- Reduce the generating capacity to 12 Nm³ then fill the next fullest receiver to its capacity.
- Reduce the generating capacity to 8 Nm³ and fill the third receiver.
- Reduce the generating capacity to 6 Nm³ and fill the last receiver.

This filling philosophy is used in order to maximise the cell stack's life, by minimising the stop/start operations of the generating unit. When hydrogen is used from a receiver and the pressure gets to 500kPa, the outlet solenoid form the receiver shall be closed. If the pressure drops below 460kPa, an alarm should be initiated in the control room.

3.4 DESCRIPTION OF THE WORKS

3.4.1 Mechanical Plant Requirements

The hydrogen production shall be designed to produce 15Nm³/h at a pressure of 2,7 MPa with no external compression. The hydrogen purity shall be no less than 99.5% by volume and the dew point no less than -50°C at 101.4 kPa. Four bulk hydrogen storage vessels, each with a storage capacity of 20 m³, are currently installed on site and are being used for hydrogen storage before being dispensed to the units. The hydrogen should be supplied at a constant pressure of 600kPa to the unitised hydrogen skids in each of the 6 units at Tutuka Power Station.

The hydrogen production unit, metering station and the control system shall be located inside the existing Hydrogen production plant building and it shall be equipped with hydrogen fire and hydrogen leak detection devices.

The dew point analysers, as well as the hydrogen and oxygen purity measuring devices shall be integrated into the hydrogen generating plant.

Key design requirements for the hydrogen generating plant are:

- Safe operation shall be assured at all times.
- It shall be simple and reliable.
- Measuring equipment and analysers must be installed to identify the production of a potentially explosive mixture and prevent it from being stored.

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- An automatic, unattended operation, insensitive to power interruptions. In the event of a power interruption, the plant shall revert to a safe condition, depressurised and purged with nitrogen.
- The control system must be insensitive to power interruptions and after reboot will be able to continue with producing hydrogen without requiring the reinstallation of software.
- Data recording shall be integrated to the plant with a minimum of 30 days of storage.

3.4.1.1 Functional Requirements

The hydrogen plant shall be capable of producing hydrogen gas at a rate of 15Nm/h at a purity of 99.9% and a pressure of 600kPa. Hydrogen shall be stored in the bulk storage receivers. The operation of the plant shall be fully automatic with the signals passed from the generating plant to the outside plant control room.

The new hydrogen plant together with all its ancillary equipment as will be designed and provided under this contract shall operate effectively for at least 15 years.

3.4.1.2 Piping Systems Requirements

All piping, whether existing or new, shall comply with the requirements stated in 240-56227413: Hydrogen Systems Standard.

3.4.1.3 Pressure Test Requirements

The hydrogen supply piping shall be pressure tested to determine if there are any leaks. The following shall apply:

- Pressure test procedure shall be submitted to and approved by the employer before pressure tests can take place. Pressure test results shall be included in the data books.
- Two pressure gauges shall be used for the pressure test.
- All pressure gauge shall have valid calibration certificates prepared by a SANAS accredited pressure laboratory for all locally manufactured items. The maximum validity of the calibration certificates shall be 6 months.
- Proper venting shall take place and all air pockets shall be vented. Method statements for all works shall be provided.
- The pressure inside the equipment under test shall be increased to a value of the specified test pressure as defined by the code. Thereafter, the pressure shall be increased in steps of approximately 10% per minute of the specified test pressure until the full test pressure is

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reached. The piping system shall be held at the test pressure for a period of at least 30 minutes.

- After the test has been completed a pressure test certificate shall be issued which shall be included in the data books.

3.4.2 Control and Instrumentation Requirements

3.4.2.1 Scope of Work

The assumption is that the C&I (instruments, local indication and field Input/Output controller) would be supplied by the OEM as an integrated component of the Hydrogen production unit.

An operator interface is required at the outside plant control room for the H2 plant to display and archive the H2 plant status, alarms, events and to provide operating functions (i.e. acknowledging alarms, starting and shutting down H2 plant systems from the control room).

The outside plant Yokogawa C&I upgrade project has installed the hardware for a network interface to the H2. The installation also includes a fibre optic communication cable open ended at the H2 plant for future use when the H2 plant is upgraded to a microprocessor based system.

The following scope of work is required to complete the Yokogawa interface once the H2 plant is upgraded:

- Installation of fibre optic converting hardware at the H2 plant (fibre optic patch panel and network switch)
- Network protocol converter module installation at the H2 plant to provide the communication protocol compatible to the new H2 controller (Profibus, Modbus etc.)
- Configuration and commissioning of the interface data on the H2 controller and Yokogawa DCS system.
- Configuration and commissioning of a Yokogawa graphical display at the control room

Configuration of the Yokogawa ExaQuantum (plant information management system) to archive the H2 plant data.

3.4.2.2 Junction Boxes

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 shall be rated IP65. All junction boxes shall comply to 240-56355581 : Junction Boxes and Cable termination standard.

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3.4.3 Electrical requirements

3.4.3.1 Electrical System Overview

The existing hydrogen generating plant is supplied from the 380V Hydrogen plant and Lighting Distribution Board, which is fed from the 380V Distribution Board 2. The new plant will get its supply from the same 380V Hydrogen Plant and Lighting Distribution board. It is assumed that the isolator capacity will be sufficient to supply the power requirements of the new plant.

3.4.3.2 Electrical Scope of Work

The Electrical scope for this project is to provide the bulk power supply as will be required for the new Hydrogen generating plant. The electrical requirements of the new plant will be limited to capacity of supply from the 380V Distribution Board and the cables from the 380 Distribution Board to the 380V Hydrogen Plant and Lighting Distribution board. This project will not include and replacements or removal of equipment upstream of the 380V Hydrogen plant and Lighting Distribution board.

The Employers scope of work:

- The employer shall provide the bulk power supply required to power the entire H2 production plant, and all ancillaries which form part of the production process as required to fulfil the requirements in this specification. The upgrade of the hydrogen plant is limited to the maximum capacity of the existing 380V Hydrogen plant and Lighting Distribution Board.
- For the 380V Hydrogen Gen Plant Board Switchgear Schedule, refer to drawing number 0.61/15537
- The Employer shall review the designs as issued by the Contractor and upon agreement with all requirements, the Employer shall accept the designs for manufacture.

The Contractors scope of work shall include but not limited to:

- The Detailed design of the electrical portion of the plant, shall size all cables, circuit breakers and other electrical reticulation equipment according to the requirements of the hydrogen generating plant.
- Manufacturing, construction, testing and commissioning of the electrical plant for the hydrogen plant.
- Adherence and compliance to the Generation Plant Safety Regulations for all Electrical works.

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- Design, manufacture, construction, testing, installation and commissioning of the Distribution board based on the power requirement and approved switchgear schedule for the hydrogen plant including small power and lighting installation requirements.
- Provide the Certificate of Compliance (CoC) for the Electrical installation.
- Lighting and small power designs shall be in accordance with 240-56227413: Hydrogen Systems Standard.
- Termination of the bulk power supply cables from the Distribution board to all Electrical power consumers that form part of the hydrogen plant installation.

3.4.4 Civil and Structural Requirements

3.4.4.1 Civil and Structural Scope of Work

Tutuka Power station is equipped with a hydrogen generating plant building which currently houses the existing hydrogen plant, this plant will be decommissioned and the equipment will be removed. The new equipment is smaller, more efficient and weighs less therefore the existing Cell bank Foundation and Plinth will be sufficient for commissioning the new equipment, the existing cell bank is already equipped with drainage points therefore there is no additional drainage points required. The Multiple Cylinder Packs will be placed outside of the building as a safety measure. The existing foundation and plinth will be sufficient to house the new, compact equipment therefore there will be no requirement to strengthen the foundation. The Contractor shall perform a structural assessment of the existing building and submit to the Employer for review and acceptance.

3.4.5 Spares and Maintenance Requirements

A detailed maintenance programme for a 20 year life span shall be submitted to the Employer as part of the Detailed design submission. It shall consist of the component list, model numbers and technical description including details of critical spares. A spare cell stack shall be supplied at the cost of the Contractor during the warranty period with the option to purchase by the Employer at the end of the warranty period.

3.4.6 Safety Requirements

The Contractor shall adhere to and comply with the latest revision of the Eskom Generation Plant Safety Regulations as well as the Occupational Health and Safety (OHS) Act of South Africa and to the specific regulations relating to all works they will be involved in performing.

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3.4.7 Training Requirements

Training together with all associated training manuals (including special tools) for the operation and maintenance of the plant shall be provided by the Contractor for effective and efficient operations.

3.4.8 Reliability, Availability and Maintainability

The Hydrogen plant shall be designed, manufactured and assembled such that the availability of the individual sub-systems is 99.99% or greater over the design life of the plant. The Contractor shall perform RAM (Reliability, Availability and Maintainability) studies on all major areas of Plant that form part of the Works.

The RAM studies shall be done in accordance with requirements as stipulated in the Eskom RAM Guideline: 240-52844017. The objectives of the studies are to achieve the following:

- Predicting the availability and Throughput of each sub-system
- Predicting the availability and Throughput of the complete system
- Performing redundancy studies on the systems
- Using the above studies to optimise the system spares holding

3.4.9 Technical Risk Assessments

3.4.9.1 Hazardous and Operability Study (HAZOP)

The Contractor carries out a formal Hazard and Operability Study. These studies shall be done in accordance with the requirements as stipulated in the Eskom HAZOP Guideline: 240-49230111. The HAZOP study is conducted by the Contractor and submitted to the Employer's design team for review and acceptance.

3.4.9.2 Failure Mode Effects and Criticality Analysis (FMECA)

The Contractor carries out a formal Failure Mode Effects and Criticality Analysis. These studies shall be done in accordance with the requirements as stipulated in the Eskom FMECA Guideline: 240-49230046. The Contractor makes a presentation of the FMECA report to the Employer's design team for review and acceptance.

3.4.9.3 Hazardous Location Study (HAZLOC)

The Contractor carries out a formal Hazardous Location study according to the Eskom Hazardous Location standard: 240-56536505. This study shall include the hydrogen plant and all parts of the

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works. The Contractor makes a presentation of the HAZLOC report to the Employer's design team prior to handover of the signed report.

All equipment installed as part of the works shall comply to the requirements of the HAZLOC zone to which they are installed.

4. QUALITY MANAGEMENT

4.1 GENERAL

- The Contractor shall at all times adhere to the South African Environment Protection Act, the waste management code of practice and the South African Occupational Health and Safety Act No. 85 of 1993, the regulations promulgated thereunder and Eskom Safety, Health, Environment and Quality (SHEQ) Policy 32-727 for all works.
- Submit a comprehensive method statement of the entire works to the Project Manager for acceptance prior to the start of the works.
- Submit a project specific safety file to the Employer for comments/ acceptance.
- Submit a detailed level 3 schedule for the works to the Employer for acceptance after contract award.
- Take all necessary precautions to ensure that none of the existing plant that is not in the scope of work is damaged during demolition.
- The Contractor disposes of all rubble at a waste disposal site to be approved by the Employer. The waste disposal site is selected to suit the classification of the materials to be disposed of. Certificates of disposal are required to be submitted to the Employer.
- Store salvaged components elevated off the ground to protect from ingress of dust and rainwater, etc.
- Manage his own access to the working areas and the site.
- Manage his activities on site to ensure that no interference takes place between his work and that of others.
- Complete Contract Activities Daily Reports.

4.2 QUALITY REQUIREMENTS

- The contractor submits a fully detailed Quality Control Plan (QCP) for acceptance within four weeks of the Contract Date.
- The Contractor is responsible for defining the level of QA/QC intervention points or inspection to be imposed on his subcontractors and suppliers of material in the QCPs. This level is based on the criticality of equipment and be submitted to the Project Manager for acceptance.
- The Contractor submits on a monthly basis, the following QA returns:
 - A register of defects with those older than 30 days being flagged and an explanation attached.
 - A register of non-conformance reports

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- Monthly Project Quality Report
- Monthly updated site and pre-site programmes
- Inspection dates
- Site acceptance dates
- Inspection completed/ outstanding

5. SYSTEM INTEGRATION REQUIREMENTS

5.1 DRAWING REQUIREMENTS

The creation and control of all Engineering Drawings shall be in accordance with the latest revision of the Engineering Drawing Standard – Common requirements: 240-86973501. The Contractor shall provide detailed “As Required” arrangement/ dimensional drawings for each part of work to be done. No work will commence without approval of these drawings approved by the Engineering representative of the Employer.

After the works have been completed, detailed “As-built” drawings shall be provided by the Contractor. The “As-built” drawings are subject to the Employer’s Engineering representative comments and approval. All drawings shall indicate new installation/ modified parts as well as adequate existing pipework to which the items are connected. This shall be done in sufficient detail to easily identify the location of the installation.

All drawings shall contain the following as a minimum:

- Description of components with AKZ number,
- Layout of the pipework with dimensions and angles,
- Bill of materials (BOM) for all components traceable to the layout. BOMs should include size, schematic, pressure rating or class, material, quantity etc.
- Design and operating pressures and temperatures,
- Pressure Test requirements and pressures
- Design code
- All drawing revisions must be provided as paper copies in original (in all cases at least A3) size as well as in .pdf format

To aid in the production of the drawings, the Contractor may request copies of P&ID drawings and the equipment’s original drawings from the Employers Library where possible. The availability of current plant drawings cannot be guaranteed.

All required drawings shall be prepared in accordance with the requirements as specified in 240-86973501: Engineering Drawing Office and Engineering Drawing standard. A drawing register, (Master Document List with document titles, document revision, status, transmittal details and project phase) which records the drawings information shall be maintained by the Contractor.

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Drawings to be prepared include, and are not limited to the following:

- Equipment drawings,
- Equipment lists,
- Isometric drawings and P&IDs,
- Original Equipment Manufacturers (OEM) manuals and part catalogues,
- Set point and parameter lists,
- Three dimensional drawings requirements – DGN model.

5.1.1 Drawing Format and Layout

The creation, issuing and control of all Engineering Drawings will be in accordance with the latest revision of 240-86973501: Engineering Drawing Common Requirements Standard. Drawings issued to Eskom will be a minimum of one hardcopy and an electronic copy. All Contractors are required to submit electronic drawings in Micro Station (DGN) format, and scanned drawings in .pdf format. No drawings in TIFF, AUTOCAD or any other electronic format will be accepted. Drawings issued to Eskom may not be “Right Protected” or encrypted.

5.2 DOCUMENT MANAGEMENT

5.2.1 General Requirements

The Contractor shall include the Employer’s drawing number in the drawing title block. This requirement only applies to design drawings developed by the Contractor and his sub-contractors. It shall not apply to drawings developed by manufacturers for equipment and materials such as valves, instruments, etc. Drawings numbers shall be assigned by the Employer as drawings are developed.

The project name shall be listed on all drawings, including manufacturers’ drawings. A separate sheet may be attached to the submittal if needed to adequately list all tag numbers associated with the drawings such as valves or instruments which may have numerous tag numbers associated with it.

The language on all documentation shall be English. The units of measure shall be metric. The Contractor retains project design calculations and information for the entire design life of the plant and provides these to the Employer on prior written notice at any time, notwithstanding the expiry or termination of the contract.

5.2.2 Documentation Requirements

All documents supplied by the contractor shall be subject to the Employer’s approval. Documents such as QCPs, method statements and other documents impacting the works shall be approved by the Employer prior to commencement of the Works.

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Each revision of a document or drawings shall be accompanied with a list of the comments made by the Employers representative on the previous revision if applicable, and the response/ corrective action taken by the Contractor. Changes shall be recorded in a revision table contained on/ in each drawing/document.

Documents and drawings shall indicate the Employer's drawing number as allocated by the Employer. The Contractor may have his own internal document or drawing number of the document or drawing, but where reference is made among documents or drawings, the Employer's number shall be used.

The Contractor shall complete a data book for all work done during manufacturing, construction and commissioning; containing the following as a minimum if applicable:

- Scope of work
- Approved "As built" drawings
- Design calculations
- Approved QCP/ ITP
- Inspection reports
- Pipe ovality reports if applicable
- As built isometric drawings and P&ID drawings
- Material summary that gives full traceability between components used, drawings and material certificates
- All material certificates for pipes, fittings and all components used
- Pressure test certificates
- Calibration certificates for all gauges used during pressure testing
- Procedure for pressure testing
- The manufacturers/repairers certificate as defined in the PER or 2009
- Operating philosophy including all alarm and trip values
- Parts catalogue
- Maintenance manual
- Storage, packing and transportation instructions

5.2.3 Document Management

All documents supplied by the Contractor shall be subject to the Employer's approval. The language of all documents shall be in English. The Contractor shall include the Employer's drawing number in the title block. This requirement only applies to documents developed by the Contractor and his sub-contractors. Document numbers will be assigned by the Employer as documents are developed. All documentation shall be controlled and managed in accordance with the Project/ Plant Specific Technical Document and Records Management procedure: 240-53114186.

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5.2.4 Document Submission

All project documents must be submitted to the delegated Employer representative with a transmittal note according to Project/ Plant Specific Technical Documents and Records Management Work Instruction: 240-76992014. In order to portray a consistent image it is important that all documents used within the project follow the same standards of layout, style and formatting as described in the Work Instruction.

The Contractor is required to submit documents as electronic and hard copies and both copies must be delivered to the Eskom representative with a transmittal note.

In addition, the Contractor shall be provided with the following standards which must be adhered to:

- Documentation Management Review and Handover Procedure: 240-65459834
- Project Documentation Deliverable Requirement Specification: 240-65459834
- Technical Documentation Classification and Designation Standard: 240-5417919170

5.2.5 Email submission

The Contractor submits all documentation to the Employers Representative in the following media platform:

- Electronic copies are submitted to Eskom Documentation Centre. The email subject as a minimum has the following: (Station_Project Name_Discipline_Subject). Electronic copies that are too large for email are delivered on CD/DVD, large file transfer protocol and/or hard drives to the Project Documentation Centre. In a case where CD has been submitted, a notification email, with the transmittal note attached, is sent to the project generic email address. The Representative is copied on the email as well.
- Hard copies are submitted to the Employers Representative accompanied by a Transmittal note.

5.2.6 Engineering Change Management

All design change management shall be performed in accordance to the latest revision of the Eskom Project Engineering Change Management Procedure: 240-53114026 and the Employer shall ensure that Contractor is provided with the latest revisions of this procedure. Any uncertainty regarding this procedure should be clarified with the Employer. All design reviews will be conducted according to the Design Review Procedure: 240-53113685.

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6. AUTHORISATION

This document has been seen and accepted by:

Name & Surname	Designation
Ntombifuthi Ngcobo	Engineering Manager
Ryan Hector	Electrical Engineering Manager
Lungelo Memela	Project Manager (Act)
Sandile Thabethe	Electrical Maintenance Manager
Kebebe Moiloa	Programme Manager (Act)

7. REVISIONS

Date	Rev.	Compiler	Remarks
June 2022	1	Lucas Thobejane	Final report

8. DEVELOPMENT TEAM

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

- Lucas Thobejane

9. ACKNOWLEDGEMENTS

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