Eskom	Scope of Work	Technology

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CONTENTS

Page

INTRODUCTION

The Ncora Hydro Gen plant is situated in the Eastern Cape as part of the Irrigation works owned by the Dept of water works close to Cala 150km east of Mthatha.

The Plant consists of 3 by mini–Hydro gen Plant rated at 2 by 400kw and I by 1,6MW. The site was built in 1984 as part of the Irrigation scheme and was designed to supply hydro power to the Irrigation works and the associated processing facilities.
The 400kw Hydro plant was manufactured by the UK based Gilkes with U1 Turbine manufactured in 1939 and that was initially installed at 1st Falls by the Municipality.

On the 10/10/2015 @ 00h21 Unit 1 gen 11kV grid breaker tripped on gov oil pressure.
The station is unmanned at night 21h00 to 04h00. On arrival at 04h00 the Operators saw the plant was damaged and proceeded to isolate and report the incident.

The Engineers arrived on Site to investigate the damage early on Monday the 12th and found extensive damage to the Alternator and the Turbine of Gen 1.
The failure of the thrust bearing and damage to the collar caused the runner and the shaft to move axially downstream due to the Turbine thrust.
The shaft was then pulled approx. 50mm along the full length of the plant and the rotor broke the Gen Alternator end bell housing and destroyed the draft Tube mounted thrust pad.
The Plant was then fully stripped to investigate the extent of the damage and Rotek arrived on site to remove the Plant to their Workshops in Germiston.

The renewables Dept requirement is to have the Plant fully refurbished back to its original designed conditions and original status then re-install and commissioned back on site.
This is to facilitate the integration into the existing control systems which include: C&I – HV cabling – Governor – Automatic Voltage Regulator (AVR) and integrated control systems to the other 2 generating units and then finally commissioned to integrate into the existing DX operating systems. (Scada-DC-RTU

1.1 SCOPE

This document covers the high level scope of works for the Restoration of the Ncora Unit 1 Turbine. The Restoration implies the **Inspection**, **Refurbishment, Assembly, Commissioning, and the Supply of Information for the Ncora Unit 1 turbine** and associated shaft with the existing refurbished generator, governor, control equipment and associated auxiliaries.

Once installed the entire Unit will be required to be fully tested and commissioned.

The generator, governor, control equipment and associated auxiliaries falls outside this scope.

1.2 PURPOSE

The purpose of this document is to lay out the extent of the works to be conducted by the *Contractor* to carry out the **Restoration of the Ncora Unit 1 Turbine** in meeting the *Employer's* objective to have a fully refurbished operational Ncora Unit 1 turbine.

The objective is to refurbish the turbine and associated shaft, install the refurbished turbine with the existing refurbished generator, governor, control equipment and associated auxiliaries and test and commission the entire unit.

Refurbishment includes, but is not limited to repair, replace and/or manufacture the turbine components required for the rebuild. Following refurbishment, the *Contractor* shall assemble, test and fully commission (dry and wet) the unit.

The scope of this document covers the provision of the refurbishment, assembly, and commissioning of the damaged 400kW Ncora unit.

The Ncora Power Station is located between Carla and Engcobo on the former Transkei region approx. 120km west of Mthatha in the Eastern Cape, South Africa [GPS co-ords 32 00 37S & 28 53 01.5E.

The Specification defines the scope of supply of all Plant, whether specified in detail or not.

1.3 APPLICABILITY

This document shall apply to Ncora Unit 1 only.

1.4 NORMATIVE/INFORMATIVE REFERENCES

1.4.1 Normative

[1] 240-83539994 Standard for Non-Destructive Testing (NDT) on Eskom Plant

[2] ISO 9712 Non-Destructive Testing Qualification and Certification of personnel

[3] Paint application standard

1.4.2 Informative

[4] ASME Boiler and Pressure Vessel Code VIII Division 1, 2021.

[5] CECT The Design, Manufacture and Erection of Steel Penstocks of Welded Construction for Hydro Electric Installations, 1984.

[6] 240-53113685 Design Review Procedure (latest revision)

1.5 DEFINITIONS

Definition	Description
Turbine	**Hydro turbines** are mechanical devices used in hydroelectric generation plants that transfer the energy from flowing water to a rotating shaft to generate electricity. These turbines basically consist of a spiral case, turbine runner, guide vanes, bearings, and draft tube. These turbines are essential around hydropower - the process of generating power from water.
Employer	Eskom Rotek Industry will be seen as the Employer in this document.

1.5.1 Disclosure Classification

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

1.6 ABBREVIATIONS

Abbreviation	Description
AM	Asset Management
AVR	Automatic Voltage Regulation
CFD	Computational Fluid Dynamics
CoE	Centre of Excellence
C&I	Control and Instrumentation
DX	Eskom Distribution
ERI	Eskom Rotek Industry
HV	High Voltage
MIV	Main Inlet Valve

Abbreviation	Description
MT	Magnetic Particle Testing
NDT	Non-Destructive Testing
PT	Penetrant Testing
QCP	Quality Control Plan
RE	Reversed Engineered
RT	Radiographic Testing
RT&D	Eskom Research, Testing and Development Department
SP	Service Provider
SoW	Scope of Work
UT	Ultrasonic Testing
3-D	Three dimensional

1.7 ROLES AND RESPONSIBILITIES

- It is the role of the *Employer* to develop the technical content of the scope of work and to conduct reviews (for Acceptance) of all the Turbine Refurbishment *Contractor* submissions in accordance with the Design Review procedure].
- The ERI shall ensure that the TURBINE REFURBISHMENT *CONTRACTOR* that will be appointed has been assessed in accordance with [1] for Eskom approval through the Eskom Material & Plant Integrity CoE and AM (should Eskom decide so at later stages, the assessment by Asset Management may not be mandatory). This assessment must be part of the evaluation strategy.
- It is the role of the TURBINE REFURBISHMENT *CONTRACTOR* to conduct the works in a manner that is aligned with the high level details provided in this document.
- It is the role of the structural and integrity engineers at RT&D to assess the integrity of the plant from results obtained from NDT.
- It is the role of the ERI to ensure that the scope is executed accordingly.

1.8 PROCESS FOR MONITORING

Execution work, including the Works on site, FAT, and other Quality checks at the repair/refurbishment workshops, are to be governed by ERI SHEQ procedures.

2. GENERAL REQUIREMENTS/CONSTRAINTS ON HOW THE *CONTRACTOR* PROVIDES THE WORKS

2.1 GENERAL

1. The Turbine refurbishment *Contractor* is responsible for the supply of services in the following sections of this document according to the applicable codes and standards and the requirements in this document.
2. The *Contractor* is required to adhere to the following in providing the works:
    a. The *Employer*'s safety rules
    b. The *Employer*'s codes of practice
    c. The *Employer*'s Hold and Witness points on the QCP.

3. All the specifications, standards and instructions stated in this document shall be adhered to. Any request for deviations must be submitted to the employee and would be subject to the approval of the *Employer*.
4. The Works shall meet the material specifications and grades, and the minimum material properties stated in the approved Schedules / Specifications. All material certificates for components replaced or manufactured are to be submitted to the *Employer* for approval before refurbishment commences.
5. All components requiring protective coating shall be corrosion protected as specified within the Eskom corrosion protection specification and applied in accordance with the coating manufacturer's approved method.
6. Special tools required for maintenance of the Plant, such as a special fixtures jig to ensure that all flange faces are aligned within tolerance, are to be manufactured and supplied with the works.
7. Update supplied drawings and supply any new developed drawings
8. The *Contractor* shall peruse the supplied drawings and documents and update these documents where required, for the completed refurbishment.
9. Where drawings of components are either incompletely or not supplied at all, the *Contractor* shall source or reverse engineer such components.
10. The fully assembled turbine and spares shall be transported to the *Employer*'s site (Ncora, Hydro Plant site, Mthatha, Eastern Cape). Best practices shall be followed to avoid any damage during transport. Repair and replacement of parts damaged, shall be the *Contractor s* responsibility.
11. Where this document is not clear about the work to be done, it is the Turbine refurbishment *Contractor 's* responsibility to clarify from Eskom's engineering representatives, and the Turbine refurbishment *Contractor* will only act upon confirmation by receipt of an engineering instruction via Eskom's Project Manager. Incorrect work done (where engineering instructions were not issued) will be moved / removed / replaced / changed / reinstalled by the Turbine refurbishment *Contractor* at their cost. The *Contractor* shall do a site inspection to verify all positions and arrangements of equipment on site to be according to the supplied drawings.
12. Safety codes are provided for informative purposes and may be used as a guide.
13. Plant safety regulations shall be adhered to.

2.2 FABRICATION

- The *Contractor* shall carry out the fabrication of components, stress relieving and machining in accordance with acceptable standards.
- The *Contractor* shall deliver all fabricated parts without distortion.

2.3 WELDING PROCEDURES

- The *Contractor* shall submit proposed welding procedures to the *Employer* for approval prior to executing the works. The procedures shall meet BS EN ISO 15614 Part 1 Level standards.
- The *Contractor* performs works that conforms to SANS 3834-2:2006 and BS EN ISO 5817:2014 standards

- The *Contractor* ensures welders have been tested in accordance with BS EN ISO 9606 Part 1 standard
- The *Contractor* shall complete all repair and manufacturing prior to final stress relief. Any machining post stress relief, where necessary, shall be carried out by the *Contractor* .

2.4 DESIGN CRITERIA

- The *Contractor* shall provide all design, calculations, and drawings to the *Employer* for approval. The supplied reversed engineered drawings, by the *Employer*, will have limited details regarding tolerances etc. These are to be supplied by the Contractor.

2.5 FACTORY ACCEPTANCE TESTS

- The *Contractor* performs factory testing.
    - The *Contractor* records all relevant dimensions, specifications, and operational parameters of the refurbished turbine components on a check sheet and submits these recordings to the *Employer* for acceptance with the delivery of the U1 turbine assembly. Minimum surface roughness, machining tolerances are supplied in Section 9. Should these not be available, the *Contractor* shall discuss with the *Employer*.
    - The *Contractor* checks the turbine components for structural integrity and weld soundness by means of suitable method/s. The *Contractor* records this on information sheet.
    - Where applicable, the *Contractor* inspects the surface finish and record the condition on the dimensional verification sheet.
    - The *Contractor* checks all dimensions according to the drawings and submits these recordings on the dimensional verification sheet.
    - *The Contractor* inspects the turbine components for indications and submits reports to the *Employer* for acceptance.
    - *The Contractor* inspects the spiral casing and draft tube wall thicknesses and submits reports to the *Employer* for acceptance.
    - *The Contractor checks the spiral casing and draft tube for leaks under pressure test, and records this on an information sheet.*

2.6 TEST CERTIFICATES

- For newly fabricated parts, the *Contractor* shall submit copies of all tests, indicating the results of all tests performed to the *Employer* for acceptance within five (5) calendar days of being performed.

2.7 DIMENSIONS AND TOLERANCES

- The *Contractor* records the exact dimensions of the turbine components provided by the *Employer* prior to the commencement of the work. The *Contractor* indicates all the required dimensions on a drawing or sketch. The *Employer* provides drawings of the turbine components as indicated in Section 10.

- The *Contractor* records all dimensions and tolerances of the finally machined/refurbished turbine components on a suitable check sheet.
- The *Contractor* shall submit a PQP for all quality checks for approval, including details of all significant dimensions before any work commences.

2.8 TURBINE COMPONENTS NDT INSPECTIONS

- All NDT will be in line with all requirements as stipulated in Standard for Non-Destructive Testing (NDT) on Eskom Plant, EN ISO 9712.
- All NDT and inspection personnel must be certified for relevant NDT techniques and levels according to provisions of EN ISO 9712.
- The NDT *Contractor* shall provide individual assessment reports for every NDT conducted detailing the results and shall be submitted to Eskom for acceptance by Eskom NDT Level 3/Materials and Plant Integrity CoE.
- The *Contractor* 's personnel performing the tests are qualified as a Level 2 or better NDE technician as per Eskom Standard ESKASAAA3 and according to latest relevant SANS or ISO standard
- The *Contractor* performs the turbine components Visual inspections as discussed below:
    - The *Contractor* inspects the turbine components to be refurbished prior to commencing any work. The *Contractor* measures the relevant sizes and submits the recorded values to the *Employer* for acceptance within five (5) calendar days after execution of these measurements.
    - The *Contractor* performs inspections during the refurbishment to ensure compliance with specifications.
    - The *Contractor* performs visual inspections under good lighting conditions after the final assembling of the U1 turbine assembly. No dents , scratches or repair defects is allowed.
    - The *Contractor* submits a test report to the *Employer* for acceptance within five (5) days of execution of these inspections.
- The *Contractor* performs Ultrasonic testing (UT) on the turbine components as discussed below:
    - The *Contractor* performs ultrasonic testing to BS EN ISO 1714 and BS EN 12680 standards
    - The *Contractor* performs ultrasonic testing (UT) on the welds and high stress areas of the flywheel, draft tube, Guide vane paddle and spiral casing.
    - The *Contractor* shall provide a wall thickness inspection map for the draft tube, and spiral casing.
    - The *Contractor* submits a test report to the *Employer* for acceptance within five (5) days of execution of these inspections.
    - The *Contractor* repairs all defects.
- The *Contractor* performs Penetrant testing (PT) on welded sections of the turbine components as discussed below:
    - The *Contractor* performs penetrant testing (PT) according to BS EN ISO3452 and BS EN 1371 standards.
    - The *Contractor* performs liquid/ dye penetrant testing (PT) to test for possible surface breaking discontinuities such as hairline cracks, pinholes, and micro surface porosity after machining.
    - The *Contractor* repairs all defects. Refer to Section 8.4.4.

- The *Contractor* performs Magnetic Particle testing (MT) on turbine components after final machining/refurbishment as discussed below:
    - a) The *Contractor* performs 100% magnetic particle testing (MT) on all turbine components according to BS EN ISO 9934 and BS EN 1369 standards
    - b) The *Contractor* performs (MT) to test for possible surface-breaking discontinuities such as hairline cracks on all welds.
    - c) The *Contractor* repairs all defects.

2.9 TRUTH CHECK

- The *Contractor* performs turbine shaft runouts in accordance with specification
- The *Contractor* will submit runout check sheet for *Employer*'s approval

2.10 WEIGHT MEASUREMENTS AND BALANCING OF THE ROTATING COMPONENTS

- The *Contractor* performs weight measurements of the flywheel, spiral casing, draft tube, front and rear covers, turbine shaft, runner, guide vanes (individual & full set).
- All rotating components shall be balanced as per the appropriate specifications.
- Certificates of weight measurements and balancing shall be provided to the *Employer* prior to re-assembly of the turbine.

2.11 RECTIFICATION OF DEFECTS

- Cracks and linear indications will not be accepted
- Cracks and zones of incomplete fusion or penetration will not be accepted.
- The *Contractor* repairs all defects.
- The *Contractor* repeats the welding and testing process in the event of surface cracks and fabrication undercuts, that have not been accepted by the *Employer*.
- Leaks will not be accepted under a water pressure test.
- Any casting defects exceeding the specified acceptance standards shall be submitted to the *Employer* for consideration and concession

2.12 FINAL INSPECTIONS

- The *Contractor* ensures all welds and joints are free and clear of weld splatter.
- The *Contractor* ensures all edges and corners are free of burrs.
- The *Contractor* ensures all components are free of any other damage.
- The *Contractor* ensures all surface finishes as per as tabled in Section 7.
- The *Contractor* records all measurements, and the measurements must be witnessed by the *Employer*.
- All recorded measurements are submitted to the *Employer* within five (5) calendar days of being performed for acceptance.

3. WORKS INFORMATION

3.1 ASSESSMENT OF EXISTING TURBINE IN TERMS OF REFURBISHMENT

The *Contractor* is required to inspect and assess the Unit 1 turbine and compile an assessment report of what the *Contractor* deems required to be performed to meet the *Employer*'s Objectives with respect to which components require to be repaired, replaced, or manufactured. This report needs to be submitted to the *Employer* for acceptance. Once the report is accepted the *Contractor* needs to proceed to the next phase namely repair, replace, and refurbish.

3.1.1 Repair documentation

The *Contractor* is required to perform a thorough assessment of the existing turbine and associated components and supply the *Employer* with a detailed document stating the following:

- All components selected for repair
- Reasons for selection, including material integrity, etc
- All repair method statements
- All relevant QCPs

3.1.2 Replacement documentation

The *Contractor* is required to perform a thorough assessment of the existing turbine and associated components and supply the *Employer* with a detailed document stating the following:

- All components selected for replacement
- Reasons for selection
- Replacement components to be detailed in accordance with approved specifications
- Any associated designs to be provided
- All relevant QCPs

3.1.3 Manufacturing documentation

The *Contractor* is required to perform a thorough assessment of the existing turbine and associated components and supply the *Employer* with a detailed document stating the following:

- All components selected for manufacture
- Reasons for selection
- Design and manufacturing processes
- All relevant QCPs

3.2 INTEGRATION

- The *Contractor* shall allow for the integration of the refurbished turbine with the other existing systems including but not limited to the generator, governor, control equipment, waterway, and associated auxiliaries.

3.3 WORKS ASSEMBLY

The *Contractor* is required to submit to the *Employer* a detailed re-assembly procedure. All relevant data such as tolerances, torque values, clearances are to be provided.
The *Contractor* is to supply a list of :

- All required lifting equipment
- Special tools

TEST AND COMMISSIONING

- The *Contractor* is required to submit to the *Employer* a detailed re-assembly procedure.
- The *Contractor* shall provide, install, and subsequently remove, any temporary equipment and instruments required to carry out all measurements during the commissioning and site tests.
- Provision at the manufacturing stage for any tappings, fixing lugs, cable glands, pockets, etc, likely to be required for the tests, shall be made by the *Contractor* .
- All commissioning activities shall be fully documented. Method statements and test procedures shall be produced prior to each commissioning activity. They shall be amended to record the actual, rather than envisaged, commissioning process and parameters. All drawings of importance for the tests, and all relevant data, documents, specifications, certificates, and reports shall be made available to the *Contractor* during the tests. Copies of all test results shall be handed over to the *Contractor* as the tests proceed.
- All records shall be assembled into unitised report packages for submission to the *Contractor* . In addition, certain measurements and data are to be presented and discussed in other reports as described in the following clauses:
  The *Contractor* shall provide all test personnel required to carry out commissioning and testing
- Tests that are expected to be performed during site commissioning and performance testing of the pump-turbine include:
  - watering up,
  - bearing heat run,
  - unit overspeed trip test,
  - governor stability,
  - trip and load rejection
  - MIV operation,
  - power output tests,
  - vibration signature,
  - reliability trial.

4. MECHANICAL TURBINE GENERAL DATA/DESIGN/MANUFACTURING

The runner, stay-vanes, guide-vanes, draft tube, and spiral is viewed as one integrated design. The CFD and or other design processes would have to be integrated. All these parts have a structural design aspect and a flow dynamic aspect. The individual parts will be discussed. This Section is included as a guideline for the *Contractor* should their review of the plant require the repair/manufacturing of new parts.

4.1 RUNNER

The pump-turbine runner shall either be manufactured from a single mono block cast material item or alternatively as a fabricated welded design consisting of individually cast crown, band, and blades, welded together, or forged.

For the design of small turbine runners, 3-D CFD analysis, by an approved numerical method performed on the runner to attain optimal flow conditions through the runner blade passages, is seen as the preferable tool for the Ncora turbine runners. 3-D CFD analysis replaces the need for model testing.

The entire runner shall be of a material suitable for the operating conditions at Ncora. The material choice shall be presented to the *Employer* for approval. The *Employer*'s preference are materials of a type which can be repaired by welding satisfactorily at Site without the need for complex requirements other than local heat treatment.

All surfaces exposed to the flow shall be ground to accurate template forms or CNC machined to obtain even and smooth surfaces without depressions, projections, or other defects liable to affect the performance or cause premature wear. The surface finish and surface waviness shall be as per Section 9.

The runner shall be designed to operate safely at steady state runaway speed for at least 15 minutes. It shall possess a minimum factor of safety at the maximum runaway speed based on the international standards covering the design of hydro turbine runners.

Sealing surfaces matching the rings on the spiral case front and end covers shall be manufactured as integral parts of the crown and band of the runner.

The completed runner shall be non-destructively tested (a minimum of PT and UT).
The complete runner shall preferably be dynamically balanced in two planes, or at least as per ISO 1940 Grade 2.5, at the manufacturer's factory before despatch.

The Ncora runner design is at least 40 years. The *Contractor* may offer a comparable, suitable runner for the conditions at Ncora, which shall be fully integrated into the existing turbine system

4.2 TURBINE SHAFT

The turbine shaft shall be manufactured, forged or cast in one piece from carbon steel with minimum mechanical properties as stated in the Schedules.

The wetted part of the shaft shall be protected against corrosion.

The shaft shall be free from visible defects or imperfections and no forging/casting shall be used until it has been subjected to a full ultrasonic examination by the *Contractor* .

The shaft shall be suitably machined and finished over its entire length. Bearing surfaces, the target surfaces of vibration monitoring equipment, and surfaces to be used in the checking of alignment, shall be machined to appropriate finishes and tolerances

Machining tolerances, and mechanical and electrical runout shall be minimised on all these locations by the appropriate use of machining, grinding, and rolling techniques.

The shaft must be subjected to NDT (a minimum of PT and UT) and balanced after completion of the mechanical works.

4.3 FLYWHEEL

The flywheel shall be manufactured from either cast or forged steel. It shall be of the solid disc type with a hub and wheel. The flywheel shall be assembled onto the shaft using the appropriate key fixation and tolerance design for such assemblies.

4.4 SHAFT SEAL

The sealing arrangements on the turbine shaft shall be of the radial mechanical type and shall employ renewable elements. Presently the current design is a gland packing with a stuffing box. The *Contractor* may offer a comparable, suitable shaft seal for the conditions at Ncora, which shall be fully integrated into the existing turbine system. Special attention shall be paid to durability and minimum wear, and it is required that the wearing part shall be able to operate without attention for a minimum of five years. The design shall nevertheless permit easy inspection and maintenance, without disturbing the guide bearing. A visual wear indicator shall be accessible during routine inspections.

Provision shall be made for drawing off leakage water, containing it local to the shaft seal, and gravity draining it by a closed pipework system. Arrangements shall be made so that the leakage flow can be monitored, and seal wear indicated, as an aid to maintenance and as a measure of the shaft seal performance.

The seal shall be continuously supplied with filtered water at a pressure sufficient to prevent any grit, silt, or other foreign matter from entering.

Auxiliaries, Water Supply

The shaft seal water, if required, shall be furnished via a pipe connection from a source supply, which shall be discussed between the *Contractor* and *Employer*.

The *Contractor* shall be responsible for providing all filtration devices, valves, pipework, instrumentation, and fittings. Valves, pipework, instrumentation, and fittings shall comply with the General Technical Specification document, which will be supplied on request.

The *Contractor* shall supply two self-cleaning duplex-type filter.

4.5 JOURNAL AND THRUST BEARINGS

The present journal bearing design shall be re-engineered should the journal bearing be required to be replaced or manufactured. The thrust bearing and associated housing were severely damaged in the incident and needs to be re-engineered and manufactured. Employer can supply samples of the journal bearings and name of the Company that has worked on the thrust and journal bearings.

4.6 SPIRAL CASE

The spiral casing shall be designed for both the highest operating pressure, the highest transient pressure and the long term fatigue stresses expected for turbine operating duty. It shall be manufactured out of welded carbon steel or cast steel.

The spiral casing shall feature a flange at the upstream end of the intake piece to mount the dismantling joint assembly located downstream of the main inlet valve.

The material specification and the thickness of the steel plate at the inlet shall be as stated in the Schedules. The design shall include 2 mm corrosion allowance.

The external surface of the spiral casing shall be protected by a suitable corrosion protection. The internal painting of the spiral casing shall be in accordance with the requirements of the Works Information/Schedules.

In assessing the usage of the spiral casing, the *Contractor* shall undertake a fully comprehensive mechanical integrity analysis, including assessment of fatigue life, of the spiral casing based on maximum permitted critical crack size for the material using an approved theory.

All welds shall be inspected in the *Contractor 's* factory at which time the *Contractor* may wish to carry out a pressure test.

4.7 SPIRAL CAGE/CASE FRONT END COVER ASSEMBLY

This component as well as the rear end cover assembly, Section 4.8, house the thrust bearing assembly. The Contractor will need to either visit site or the

Employer's Works to ascertain the work required in the refurbishment of the Spiral cage. The *Contractor* shall most likely be required to design a special fixture/jig to ensure the holes for front & rear end covers, runner, spiral casing, front, and rear plate are on the same PCD, and holes centres are aligned to within 0,05mm.

4.8 SPIRAL CAGE/CASE REAR END COVER ASSEMBLY

4.9 GUIDE VANES AND BUSHES

The guide vanes shall be manufactured, cast in one piece with their stems, or forged, in an acceptable steel, approved by the *Employer*.

The hydraulic profile of the guide vanes shall be such as to ensure minimal losses within the tolerances specified in Section 9. As for the turbine runner, it is preferable that the profile is developed using computational fluid dynamics (CFD) analyses of the guide vane and stay vane profiles to ensure smooth inflow conditions to the runner.

The guide vane and runner inlet profile shall be optimised using CFD, and the results documented.

All surfaces exposed to the flow shall be ground to accurate template forms or CNC machined to obtain even and smooth surfaces without depressions, projections, or other defects liable to affect the performance or cause premature wear. The surface finish and surface waviness shall be as per Section 9.

The guide vanes shall be adequately supported on the top and bottom stems by substantial renewable bushes. The stems shall be equipped with either greased bushes with reliable water-to-grease sealing system or self-lubricating greaseless bushes suitable for this application and reliability.

No grease shall be released into the waterway. An automatic greasing system shall be provided. This system shall consist of a central grease reservoir, distribution system, and tubes to individual bushes. The distribution system shall provide adjustable, controlled, discrete release of grease to each bush. The distribution system shall indicate if there is a blockage in an individual supply.

Seals designed to keep water out and grease in shall be provided in the bearing bushes of the top and bottom stems where these pass through the front and rear end covers. The seals shall be packed with water resisting rubber sealing rings or other approved packing, which shall be readily renewable.

NDT is required after manufacturing.

4.10 REGULATING APPARATUS

The regulating ring shall be made from carbon steel.

The design of the whole regulating apparatus shall be such that non-linearity of the guide vane opening and closing is minimized.

If not available, hydraulic forces acting on displaced and adjacent guide vanes shall be determined from model tests.

The primary protection system to prevent guide vanes breaking and stalling, should a foreign object become lodged between adjacent guide vanes, shall consist of shear pins. The *Contractor* shall also install a friction device system mounted at the upper stem, or some similar device, to stop an unrestrained guide vane flapping following a shear pin break.

All bushes and bearings shall be of the greased type with reliable seals and be designed to minimize backlash. An automatic greasing system shall be provided. Self-lubricating greaseless bearings and bushes, with supporting information on design, suitability for this application and reliability, may be offered as an option.

Mechanical end stops shall prevent the guide vanes over-opening and fouling the runner but must also not damage the guide vane heads. The system proposed shall be such that any displaced guide vane can be quickly reset, and any expendable parts replaced without the need for prolonged dismantling or adjustment.

In order that the best possible seal can be achieved with the guide vanes closed, and to compensate for any wear or deformation, the vanes shall be capable of individual adjustment in relation to each other by appropriate means.

Two double-acting oil servomotors for operation of guide vanes shall be provided attached to adjustable sole plates, or an acceptable alternative design. Forces shall be transferred to surrounding concrete. The forces shall be equally distributed between the two servomotors in normal operation.

The servomotor shall be of seamless fabricated steel body construction designed to withstand the maximum possible oil pressure during the governor operation. The servomotor shall be provided with two oil drainage points, bleed points, bleed couplings for air bleeding, and connections for pressure measurement.

The servomotor cylinders shall be designed such that each cylinder takes half load. However, each cylinder shall be designed to carry any unbalanced load if this is possible during operation. The *Contractor* shall provide a piston rod of suitable material to provide good running characteristics, seal life, and corrosion resistance. The piston seals shall be self-lubricated low friction type.

The servomotor pistons shall be arranged so that at either end of their stroke the velocity of the moving parts is decreased to avoid slamming, the cushioning effect being obtained by means of orifices or other devices arranged for adjustment on Site.

The servomotors shall be provided with direct mechanical stops adjustable by hand, whereby the opening travel of the guide vanes can be limited without affecting their closing travel.

Suitable conveniently operated mechanical locking systems shall also be provided on the servomotors or regulating ring to maintain the guide vanes firmly in the fully open or fully closed position even against full oil pressure in the servomotor cylinders. These systems are for maintenance purposes and shall not interfere with the closing movement of the guide vanes under normal condition.

When sizing the guide vane servomotors normal operation, runaway and transient conditions shall be considered together with the hydraulic torque data collected during the pump-turbine model tests. Mechanical friction should also be included. The servomotors shall have ample reserve capacity available, when the oil pressure is at its lowest permissible value, to overcome the highest resistance forces occurring under any possible conditions of either normal or emergency operation.

The servomotors shall be pressure tested in the manufacturer's factory to assess internal and external leakage, rubbing of seals, any sticking effects, and forces at opening & closing.

4.11 DRAFT TUBE

The draft tube is a welded carbon steel plate structure which exits into the draft tube extension piece which is embedded in concrete. If the runner is manufactured from stainless steel, then the upper portion of the cone should have a stainless steel overlay of minimum acceptable length.
The draft tube shall consist of cone, bolted to the bottom cover, elbow and draft tube extension piece. The extension piece shall connect to the draft tube extension tunnel steel liner.

4.12 OVERSPEED DEVICES

Two independent electrical overspeed devices shall be supplied. These are provided as part of the Generator supply.
Two independent non-contact speed sensing systems shall be provided for:

- direction sensing,
- speed sensing,
- creep sensing, and
- overspeed protection with separate paths so that one sensor sends a signal to the governor and the other sensor to the unit control system

No mechanical overspeed device shall be supplied.

5. WORK TO BE PERFORMED BY THE *EMPLOYER* FOR THE WORKS

5.1 Scope of work

The *works* include the following:

5.1.1 Inspection

- The *Employer* shall review and evaluate the QCP from the *Contractor* , by including intervention points.
- The *Employer* shall review and evaluate weld procedure specifications and supporting procedure qualification records
- The *Employer* may perform visual inspection of the *works* at the site of the *Contractor* while the fabrication, machining, inspection, and testing by the *Contractor* are executed.
- The *Employer* perform visual inspection with the delivery of the U1 turbine at the *Employer*'s site (Ncora Hydro Plant Site, Mthatha, Eastern Cape).
- The *Employer* may provide check sheets for recording data by the *Contractor* where it is deemed necessary and critical during installation.
- The *Contractor* must provide detailed maintenance and operating manuals for the machinery.

5.1.2 Storage of the turbine

- The *Employer* stores the turbine shaft assembly in a safe area on the *Employer*'s plant (Ncora Hydro Plant Site, Mthatha Eastern Cape) after delivery by the *Contractor* .

6. COMPONENTS NOT INCLUDED IN THE WORKS

The following components are not included in the refurbishment scope of works:

- Generator
- C&I
- Governor
- Penstock
- MIV
- Mechanical and Electrical Auxiliary equipment

The *Contractor* shall ensure that all turbine plant is integrated with the existing plant

7. SPECIFICATIONS AND STANDARDS

The *Contractor* adheres to the following in providing the items to be supplied:

- BS EN ISO 15614 Part 1 Level 2, Welding procedure qualification
- SANS 3834-2:2006, Quality management for fusion welding of metallic materials Part2: comprehensive quality requirements
- BS EN ISO 5817:2014, Welding-Fusion-welded joints in steel
- BS EN ISO 9606 Part 1, Qualification, testing of welders
- BS EN ISO 9934-1:2016 NDT (MPI) Magnetic particle inspection standard,

- BS EN ISO3452-1:2013 NDP (PT), penetrant inspection standard or latest versions.
- BS EN ISO 1714 latest revision, Ultrasonic Testing of welded joints
- Linear imperfections exceeding 5mm will not be accepted
- Wearing ring material must be of Nickel aluminium bronze meeting ASTM B148-grade 955 standard or latest equivalent.
- Paint specification
- The flange faces must be square to the axis
- Holes PCDs and pitch distance to be maintained to within 0.05 mm.
- The machining surface finish must be at least Ra 0,8µm.
- The surface waviness and roughness of the turbine shall be as per the requirements of IEC 60193 sub-clause 2.2.3 and the extra guide vane requirements below.

Surface waviness		
runner areas subject to cavitation	X/U ≤ 0.01	
other runner areas	X/U ≤ 0.02	
guide vane in flow direction	X/U ≤ 0.01	extra requirement
guide vane in non-flow direction	X/U ≤ 0.015	extra requirement
Surface roughness		
runner internals	Ra ≤ 3.2 µm	
guide vanes, guide vane passageway	Ra ≤ 6.3 µm	extra requirement
stay ring, spiral and draft tube cone	Ra ≤ 12.5 µm	

Table 1. Surface waviness and roughness requirements.

8. DOCUMENTATION

The *Contractor* is to supply all relevant documentation pertaining to the refurbishment of the Ncora U1 turbine. This would include a full set of design drawings, as built drawings, check sheets, commissioning procedures and reports. The *Employer* shall supply RE drawings and associated documents where available.
A high level schedule to be provided on Tender with a detailed schedule on awarding that includes hold points and witness testing by client.

9. EXISTING INFORMATION

- Drawings associated with this specification can be found in Section 10. Most of these drawings have been produced by 3-D Scanning.
- The *Employer* has compiled an evaluation list of the turbine components expected to be refurbished. This list is supplied as a guideline. The *Contractor* can add components requiring refurbishment provided reasons are provided, for the *Employer*'s acceptance.

- The *Employer* has compiled an evaluation list of the turbine components expected to be manufactured. This list is supplied as a guideline. The *Contractor* can add components requiring manufacturing provided reasons are provided, for the *Employer*'s acceptance.
- Summary of Hydraulic Data:

Rated turbine output	400	kW
Overload turbine output	Unknown	kW
Rated net head	Unknown	?
Maximum static head, normal operation	42.0	m
Minimum static head, normal operation	36.0	m
Synchronous speed	1000	rev/min

The water level range and live storage capacities associated with the upper reservoir is between 38m & 40m (2m) with storage capacity of 600 000 cubic meters. Reservoir is supplied with a constant inflow of 6cumecs via a canal from the Ncora DWS main dam.

10. DRAWINGS

11. QUALITY MANAGEMENT

The *Contractor* is required to provide the *Employer* with a Quality Control Plan (QCP)

12. BASIS FOR TURBINE REFURBISHMENT

The Turbine Refurbishment *Contractor* shall provide Eskom with an organogram and CVs of all personnel. Where the nominated *Contractor* is not yet an Eskom authorised *Contractor* , a factory assessment of the potential *CONTRACTOR* will be conducted to determine compliance to Eskom standards. This is mandatory for contract award. All key personnel are to be dedicated to the Project for its entire duration and shall not be changed without Eskom's prior approval. Further basis can be sought from [1].

13. LIABILITY

The *Contractor* needs to take note that review and acceptance of any document or drawing by Eskom in no way relieves the *Contractor* of their liability for the works. The *Contractor* remains liable for all works conducted as per this SoW.

14. AUTHORISATION

This document has been seen and accepted by:

Name & Surname	**Designation**
Basil Barnes	Project Manager for the works,
Derrick Boltt	
Deva Moodley	
Akash Rambharos	

15. REVISIONS

Date	**Rev.**	**Compiler**	**Remarks**
Jan 2023	1	D. Johnson	Document required to obtain the services of an external Turbine Refurbishment *CONTRACTOR*

16. DEVELOPMENT TEAM

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

Basil Barnes

Derrick Boltt

Deva Moodley

Akash Rambharos

17. ACKNOWLEDGEMENTS

Coert Venter

Desigan Padayachee