Eskom Rotek Industries	SCOPE OF WORK (SOW)	TURBO GEN SERVICES (TGS)

Title: **Supply of Heat Treatment Services.**

Unique Identifier: N/A

Alternative Reference No.: N/A

Area of Applicability: Eskom Rotek Industries SOC Ltd.

Document Type: Scope of Work (SOW)

Revision: 0

Total No. of Pages: 33

Next Review Date: N/A

Classification: Controlled Disclosure

Compiled by:

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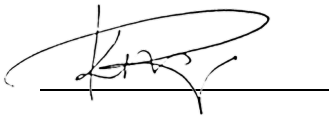
Works Welding Engineer



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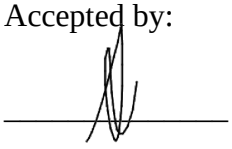
Functional Responsibility:

Accepted by:



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1 Objectives

The objective of this document is to outline the services that are required from Heat treatment company to service the Eskom Rotek Industries (ERI). The contract seeks to ensure that the proposed services required are executed in a planned and structured manner, and that all quality requirements during inspection, refurbishment and final testing are met. This contract should ensure that the project is completed within the specified timeframe, consumables are readily available, and the heat treatment scope is executed efficiently. All scope needs to be executed in a way that supports the project duration.

2 Scope of services

The scope of responsibility includes the supply of heat treatment services such as Pre-heat, Post Weld Heat Treatment (PWHT), Bolt Heating, and Shrink Fitting. The scope will include some or all of the following:

2.1. Conducting Pre-heat,

2.2. Conducting PWHT cycles on various components,

2.3. Conducting Bolt Heating - bolting arc of turn

2.4. Conducting shrink fitting - installation and removal of shrunk on seats

2.5. Supplying of consumables, materials, labour, equipments and,

2.6. Services necessary to provide a reliable, comprehensive, and cost-effective heat treatment service to ERI (TGS, Matla and Rosherville Works).

3 General Requirements

3.1 *Quality*

- Inspections to be carried out in accordance with check sheets and master quality plan provided by ERI in line with the Eskom requirements, which should be compiled from the Scope of Work (SOW) and approved by Engineering (Eskom and ERI TGS). The document must contain all the Product Quality Plans (PQP's) of work that will be done. Inspection values to be recorded for all check sheets. Damaged sustained to components resulting in an out of specification must be manged by a concession obtained from engineering staff. All abnormalities to be recorded and reported with Technical Notifications (TNs).
- All work carried out will be in line with the applicable Eskom or OEM standards. Where nothing exists, IEC, SABS standards and good engineering practise will be followed. This includes but is not limited to the covering of all openings and the use of approved chemicals.
- All quality documents, procedures, check-sheets and PQP to be supplied by ERI TGS

3.2 *Experience of staff*

- The service requested will determine the skill levels and number of specific skills that will be required to execute the service.
- The service provider will work together with the ERI TGS personnel to ensure the KPIs are achieved.
- All staff shall be adequately qualified and competent of performing all work within safe and correct technical specifications.
- Short CV's of all staff, stating qualifications and relevant experience must be provided at least four weeks before commencement of project.

3.3 *Spares and Consumables*

- All spares that would have been pre identified in the pre planning of the project will be sourced and supplied by the respective clients to ERI.
- All consumables that would have been pre identified in the pre planning of the project will be sourced and supplied by the respective service provider.
- The transport of any spares and consumables remains the responsibility of the contractor.

3.4 *Documentation*

- A full-service report will be compiled and provided to TGS, to the ERI TGS standard. The report will contain a high-level description of the work done during the project. It will contain the approved PQP of all work and all related check sheets. All technical notifications will be shown as well. It will contain a section on spares used report.
- PQP to be compiled and presented to Engineering (TGS) for approval before start of project. Report to be accepted by ERI TGS Engineering.

- The supply of new machinery is to be accompanied by a complete operation and maintenance manual which must be reviewed by engineering before any purchase is made.

4 Scope of Work (SOW)

4.1 *Pre – Project Activities*

- Upon receipt of the scope of work, it is the service provider's responsibility to ensure that the scope is clear and executable within the specified durations. The ERI TGS project management will share durations of activities expected to support whole project durations.
- Identify critical spares requirements and incorporate into the scope of works.
- Verify scope execution methods against ERI prescribed methods for inclusion in the scope of work.
- Advice and guide on best practises to hone to meet the project deadlines.
- Active involvement in the compilation of Project Plans in Primavera
- Develop and review project plans for logics and detail as per scope of work for approval

4.2 *Service Provider Service*

Below are the components, pictures and material specifications that will require heat treatment. The list is not limited to the components listed below; however, the list is to illustrate the type of components, set-up and scope that i***s*** expected**,** during the execution stage.

4.2.1. Rotor Journals– PWHT.

Rotors (LP, IP, HP, BFPT and Generator rotors) are laser welded to build-up the journals to restore the journals to design dimensions (Fig 1). The Heat treatment contractor is expected to set-up and heat treat all welded journal in accordance with the approved PWHT procedure, and without damaging the adjacent components (i.e blades) (Fig. 1).

4.2.1.1. Heat Treatment Procedure

4.2.1.1.1. Typical Material specifications of the rotors: GS-17CrMoV5-11, ST573S, 26NiCrMoV14-5, C30, 34CrNiMo6.

4.2.1.1.2. Typical Filler Material used during welding: 2¼Cr1Mo, NiCrFe.

4.2.1.1.3. Prescribed post-weld heat treatment after weld-build up and cooled in still air to room temperature:

Temperature: 690 °C ± 10 °C

Soak time at temperature: 4 hrs ± 10 min

Heating and cooling rate: 50 °C/hr maximum

4.2.1.2. Thermocouple locations.

4.2.1.2.1. Several thermocouples shall be applied to ensure that the heat-treated area is within the range specified and that undesirable thermal gradient does not occur.

4.2.1.2.2. The number and location of thermocouples shall be sufficient to demonstrate that the requirements of this procedure have been satisfied.

4.2.1.2.3. Use certified / validated thermocouples to control and measure the temperatures of the workpieces.

4.2.1.2.4. Rotek engineer to witness thermocouple locations before and after heat treatment cycle.

4.2.1.2.5. The pads shall be placed such that they permit the temperature control in the heat-treated area with adequate accuracy and temperature uniformity.

4.2.1.2.6. Lagging must be used to limit the heat transfer to other areas of the turbine rotor.

4.2.1.2.7. Calibration of recorder and thermocouples: These should be calibrated at a SANAS approved test house every 6 months (Eskom requirement) for the applicable temperature range (at least from 0 °C up to 800 °C).

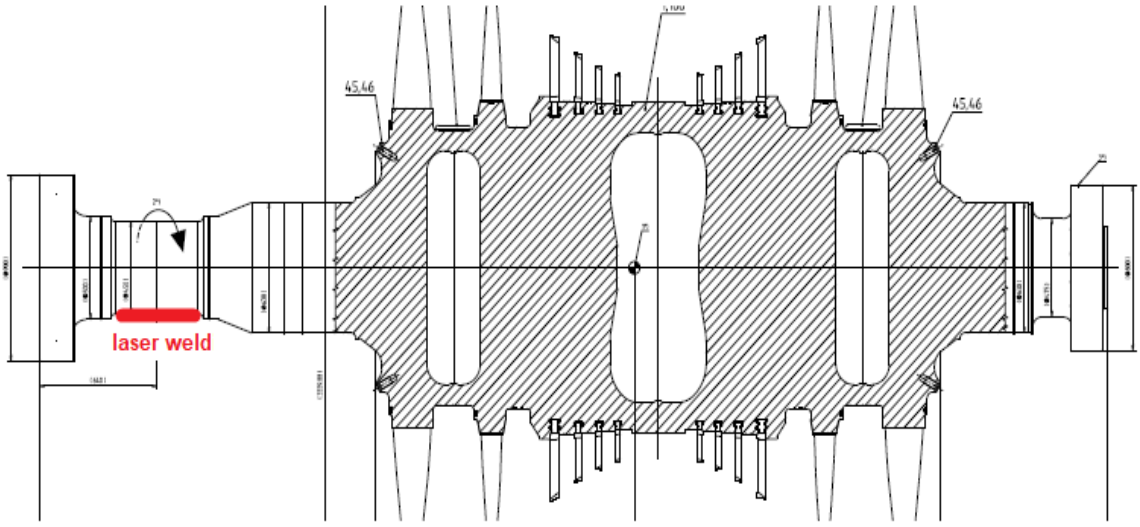

Figure 1: Typical LP Rotor (laser weld journal as indicated in red)

4.2.2. GEC LP1 & LP2 Rotor – PWHT on Welded Tenons.

The rotors are laser welded to build-up the tenons during the understrap replacement (Fig 2a). The Heat treatment contractor is expected to set-up and heat treat all welded (20 off) tenons to the approved PWHT procedure, and without damaging the adjacent components (i.e blades) (Fig. 2b).

4.2.2.1. Heat Treatment Procedure

4.2.2.1.1. Material specification: Blade - FV566 (X12CrNiMoV12-3)

4.2.2.1.2. Filler Material – Inconel 625.

4.2.2.1.3. Prescribed post-weld heat treatment after weld-built tenons cooled in still air to room temperature:

Temperature: 640 °C ± 10 °C

Soak time at temperature: 2 hrs ± 10 min

Heating and cooling rate: 100 °C/hr maximum

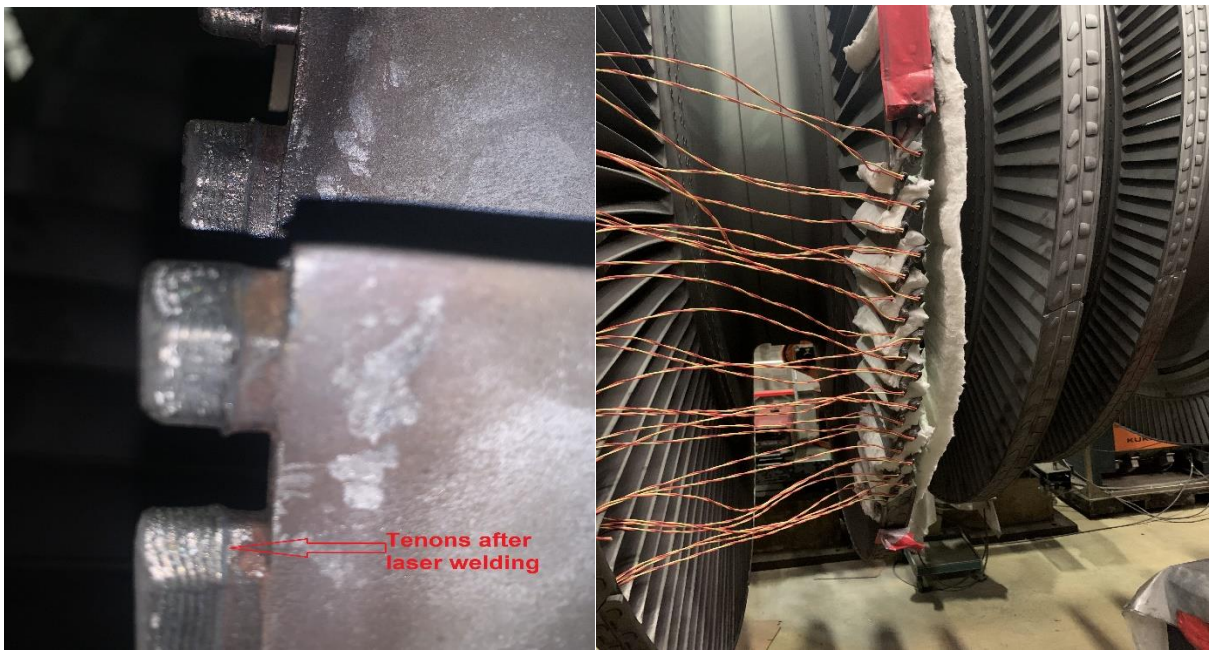

Figure 2: (a). Illustration of Tenons after laser welding, (b). Illustration PWHT set-up

4.2.2.2. Thermocouple locations.

4.2.2.2.1. Several thermocouples shall be applied to ensure that the heat-treated area is within the range specified and that undesirable thermal gradient does not occur.

4.2.2.2.2. The number and location of thermocouples shall be sufficient to demonstrate that the requirements of this procedure have been satisfied (see Fig 3.)

4.2.2.2.3. Use certified / validated thermocouples to control and measure the temperatures of the workpieces. Spot-weld the controlling thermocouple onto the top of the **trailing edge tenon of *each* blade of the repaired packet** (position indicated by * in the picture below).

4.2.2.2.4. During the soaking period, the controlling temperature should be limited to between 630 °C and 650 °C.

4.2.2.2.5. Spot weld a monitoring thermocouple to the top of the leading edge tenon of each blade (position indicated by x) to measure the temperatures thereof. These temperatures should also be limited to between 630 °C and 650 °C. Any deviation outside this range should be reported for evaluation.

4.2.2.2.6. An additional monitoring thermocouple should be used on the trailing edge of each blade as well (position indicated by +). This temperature might not reach 630 °C or might even exceed 650 °C but should be limited to 660 °C. Deviations above 660 °C should be reported.

4.2.2.2.7. The temperatures of the complete workpiece batch must be controlled and recorded for the whole duration of the post-weld heat treatment cycle and time-temperature charts should be provided. The PWHT charts should be signed off by a Rotek and Eskom welding engineer and should be part of the final data pack.

4.2.2.2.8. Rotek engineer to witness thermocouple locations before and after heat treatment cycle.

Figure 3: Required thermocouple positions for the tenon PWHT cycle

4.2.2.3. Equipment.

4.2.2.3.1. Use ceramic resistance heating blankets (75 mm width) to cover 150 mm of the blade from the top of the tenons, down the length of the blade on both the pressure and suction sides.

4.2.2.3.2. The pads shall be placed such that they permit the temperature control in the heat-treated area with adequate accuracy and temperature uniformity.

4.2.2.3.3. Lagging must be used to limit the heat transfer to other areas of the turbine rotor.

4.2.2.3.4. Calibration of recorder and thermocouples: These should be calibrated at a SANAS approved test house every 6 months (Eskom requirement) for the applicable temperature range (at least from 0 °C up to 800 °C).

4.2.3. GEC LP1 & LP2 Rotor – PWHT on Welded Shroud.

The rotors are laser welded to join the shrouds together during the understrap replacement (Fig 4). The Heat treatment contractor is expected to set-up and heat treat all welds (2 off) on shrouds in accordance with the approved PWHT procedure, and without damaging the adjacent components (i.e blades).

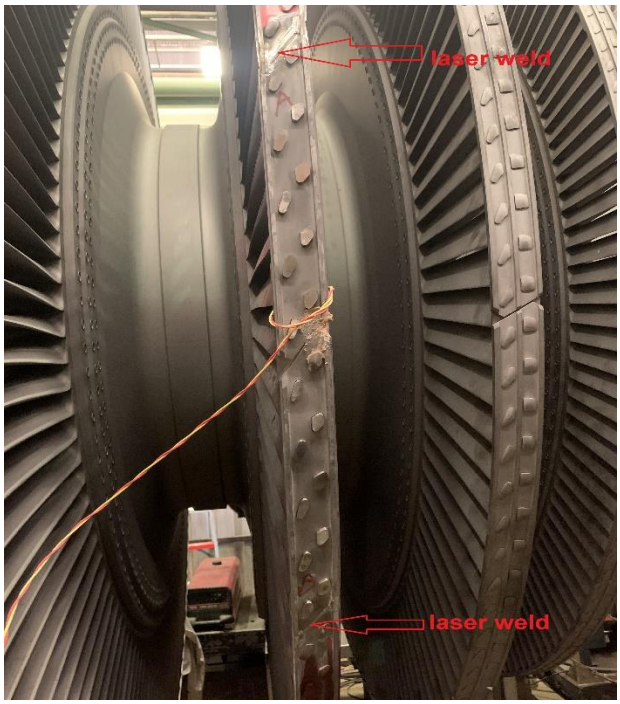

Figure 4: Illustration of laser welding on shroud

4.2.3.1. Heat Treatment Procedure

4.2.3.1.1. Material specification: Blade - FV566 (X12CrNiMoV12-3)

4.2.3.1.2. Filler Material – Low Carbon Martensitic Stainless Steel (410NiMo).

4.2.3.1.3. Prescribed post-weld heat treatment after weld-built tenons cooled in still air to room temperature:

Temperature: 640 °C ± 10 °C

Soak time at temperature: 2 hrs ± 10 min

Heating and cooling rate: 100 °C/hr maximum

4.2.3.2. Thermocouple locations.

4.2.3.2.1. Several thermocouples shall be applied to ensure that the heat-treated area is within the range specified and that undesirable thermal gradient does not occur.

4.2.3.2.2. The number and location of thermocouples shall be sufficient to demonstrate that the requirements of this procedure have been satisfied (see Fig. 5)

4.2.3.2.3. Use certified / validated thermocouples to control and measure the temperatures of the workpieces.

4.2.3.2.4. Spot-weld the **controlling** thermocouple onto the top of the **shroud** as close as possible to the HAZ of the weld (position indicated by * in the picture below).

4.2.3.2.5. During the soaking period, the controlling temperature should be limited to between 630 °C and 650 °C.

4.2.3.2.6. Spot weld a monitoring thermocouple to the shroud castellation (position indicated by **x**) to measure the temperatures thereof. The castellation may also not reach a temperature higher than 650 °C. Any deviation outside this range should be reported for evaluation.

4.2.3.2.7. An additional monitoring thermocouple should be wedged in (**No spot welding allowed**) between the shroud and the understrap at the second last blade of the packet, to be able to measure the temperature of the understrap. The temperature of the understrap may not exceed 150°C.

4.2.3.2.8. The temperatures of the complete workpiece batch must be controlled and recorded for the whole duration of the post-weld heat treatment cycle and time-temperature charts should be provided. The PWHT charts should be signed off by a Rotek and Eskom welding engineer and should be part of the final data pack.

4.2.3.2.9. Rotek engineer to witness thermocouple locations before and after heat treatment cycle.

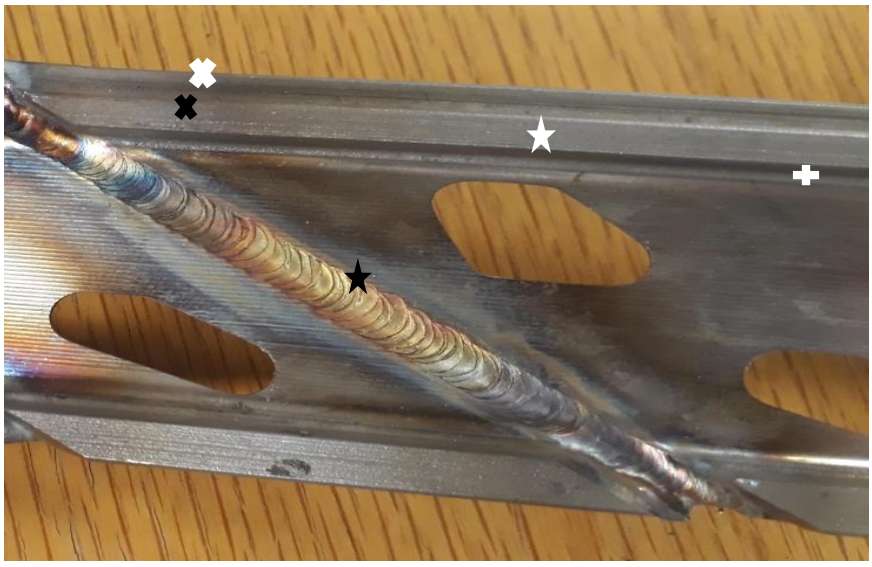

Figure 5: Required thermocouple positions for the shroud PWHT cycle

4.2.3.3. **Equipment.**

4.2.3.3.1. Use a specially prepared ceramic resistance heating blankets (75 mm width) to cover the weld face on top of the shroud.

4.2.3.3.2. The pads shall be placed such that they permit the temperature control in the heat-treated area with adequate accuracy and temperature uniformity.

4.2.3.3.3. Lagging must be used to limit the heat transfer to other areas of the turbine rotor.

4.2.3.3.4. Calibration of recorder and thermocouples: These should be calibrated at a SANAS approved test house every 6 months (Eskom requirement) for the applicable temperature range (at least from 0 °C up to 800 °C).

4.2.4. Steam Chest – PWHT on U-Seal Landing.

The area indicated is red on figure 6 is the U-seal landing and it gets welded, and thereafter requires PWHT.

Figure 6: Illustration od TC locations

4.2.4.1. Heat Treatment Procedure

4.2.4.1.1. Material specification: GS-17CrMoV5-11.

4.2.4.2. Filler Material – E9018-B3.

4.2.4.3. Prescribed post-weld heat treatment after weld-build up cooled in still air to room temperature:

Temperature: 690 °C ± 10 °C

Soak time at temperature: 2 hrs ± 10 min

Heating and cooling rate: 50 °C/hr maximum

4.2.4.1. Thermocouple locations.

4.2.4.1.1. Several thermocouples shall be applied to ensure that the heat-treated area is within the range specified and that undesirable thermal gradient does not occur.

4.2.4.1.2. The number and location of thermocouples shall be sufficient to demonstrate that the requirements of this procedure have been satisfied (see Fig. 6).

4.2.4.1.3. Use certified / validated thermocouples to control and measure the temperatures of the workpieces.

4.2.4.1.4. Rotek engineer to witness thermocouple locations before and after heat treatment cycle.

4.2.4.1.5. The pads shall be placed such that they permit the temperature control in the heat-treated area with adequate accuracy and temperature uniformity.

4.2.4.1.6. Lagging must be used to limit the heat transfer to other areas of the turbine rotor.

4.2.4.1.7. Calibration of recorder and thermocouples: These should be calibrated at a SANAS approved test house every 6 months (Eskom requirement) for the applicable temperature range (at least from 0 °C up to 800 °C).

4.2.5. HP Steam Inlet Pipe.

The area indicated is red on figure 7 is weld built joining the inlet stub to the steam chest. PWHT is required afterwards.

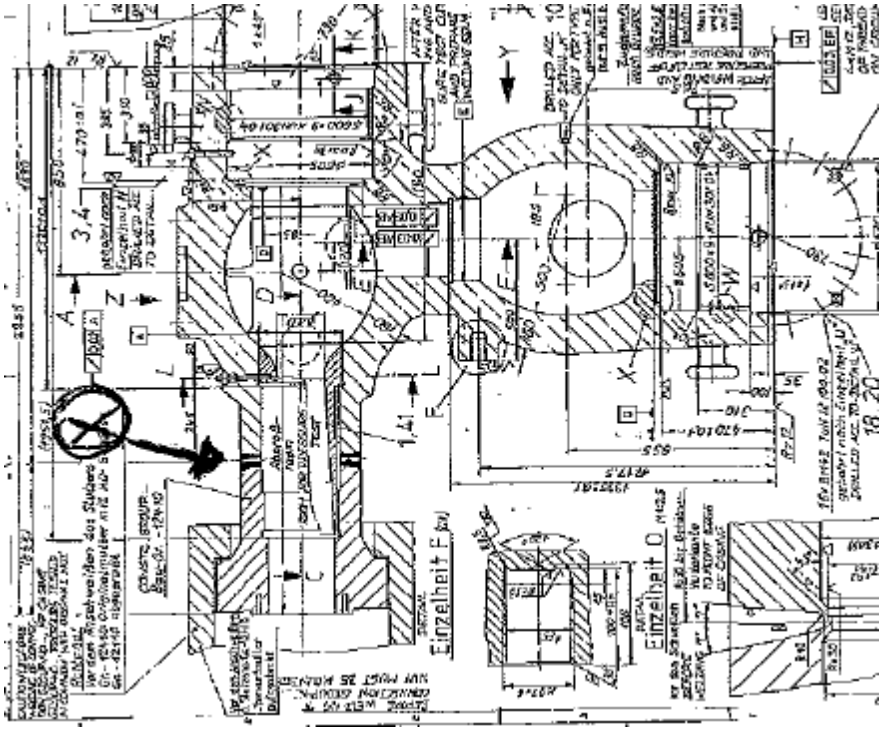

Figure 7: Illustration of Steam inlet pipe

4.2.5.1. Heat Treatment Procedure

4.2.5.1.1. Material specification: GS-17CrMoV5-11.
4.2.5.1.2. Filler Material – E9018-B3.
4.2.5.1.3. Prescribed post-weld heat treatment after weld-build up cooled in still air to room temperature:

Temperature: 690 °C ± 10 °C
Soak time at temperature: 2 hrs ± 10 min
Heating and cooling rate: 50 °C/hr maximum

4.2.5.2. Thermocouple locations.

5.2.5.2.1. Several thermocouples shall be applied to ensure that the heat-treated area is within the range specified and that undesirable thermal gradient does not occur.
5.2.5.2.2. The number and location of thermocouples shall be sufficient to demonstrate that the requirements of this procedure have been satisfied (see Fig. 7).
5.2.5.2.3. Use certified / validated thermocouples to control and measure the temperatures of the workpieces.
5.2.5.2.4. Rotek engineer to witness thermocouple locations before and after heat treatment cycle.
5.2.5.2.5. The pads shall be placed such that they permit the temperature control in the heat-treated area with adequate accuracy and temperature uniformity.
5.2.5.2.6. Lagging must be used to limit the heat transfer to other areas of the turbine rotor.
5.2.5.2.7. Calibration of recorder and thermocouples: These should be calibrated at a SANAS approved test house every 6 months (Eskom requirement) for the applicable temperature range (at least from 0 °C up to 800 °C).

4.2.6. **Heating application for installation and removal of shrunk on seats and bolting**

4.2.6.1. **For seat replacement varies sites**

Wrap the chest of the valve on the seat area (range of OD 170mm to 1000m)

Heat until seat is removed (+/- 300 degrees Celsius)

4.2.6.2. For replacement of the seat varies sites

Wrap the chest of the valve on the seat area (range of OD 170mm to 1000m)

Heat until seat is installed (+/- 300 degrees Celsius)

4.2.6.3. For removal of valve modules/inserts

Wrap the chest of the valve on the seat area (OD 170mm to 1000m)

Heat until seat is removed (+/- 300 degrees Celsius)

Wrap HP valve chest and induction heat to assist in removal of the retaining nut.

4.2.6.4. For removal of bolting

Wrap the HP inlet nut as per procedure

Heat HP inlet nuts for unthreading and treading of the nuts as per procedure

4.2.6.5. For removal of HP and IP strainer

The Kendal units consist of 4 off High pressure and 4 off intermediate pressure strainers.

The following is the scope of work for the removal of strainers from the chest:

Wrap the strainer chest (range of OD 300 to 1000mm)

Heat strainer chest to assist in the removal of the strainer. Heat until (+/- 300 degrees Celsius)

4.2.7. **Equipment**

4.2.7.1. Fully calibrated Recorders, with 12 Points of measurement and a continuous strip chart.

4.2.7.2. Calibration of recorder and thermocouples: These should be calibrated at a SANAS approved test house every 6 months (Eskom requirement) for the applicable temperature range (at least from 0 °C up to 800 °C).

4.2.7.3. All thermocouples required, including compensating cables to attach to the recorders.

4.2.7.4. Each circuit of heating elements shall be controlled either by a contactor or suitable solid state switching circuit. In turn this circuit shall be controlled by one of the following: Semi – automatic control using a combination of a set – point controller.

An automatic pre – set programmer control unit to automatically control the heat treatment throughout its cycle. (NB. The operator shall be present throughout the heat treatment cycle.)

4.2.7.5. Thermocouples shall be made from nickel – chromium – aluminium wire. A certificate of conformance may be made available for each reel of wire utilised and shall indicate a tolerance of less ± 0.75% throughout the temperature 400ºC - 800ºC.

4.2.7.6. Thermocouples shall be attached by means of the direct wire capacitance discharge method. The gaps between the two wires shall exceed 6mm. Care shall be taken to ensure that the two wires do not touch each other.

4.2.7.7. Where possible thermocouples shall be located under the heating pad.

4.2.7.8. The thermocouple to component cable connections shall be a minimum of 0.5 meters from the heated zone.

4.2.7.9. Following each heat treatment cycle, at least 150mm wire measured from the hot zone shall be discarded. After each application has been preformed, the area shall be sanded or filed to remove all irregularities.

4.2.7.10. 2 KVA complete machines (heaters).

4.2.7.11. 25 mm thick Lagging blanket (insulation wool).

4.2.8. **Documentation.**

4.2.8.1. Equipment calibration certificates shall be verified by Rotek engineer before work commence.

4.2.8.2. Rotek engineer to witness thermocouple locations before and after heat treatment cycle.

4.2.8.3. Upon completion, heat treatment chart that was generated by the recorder to be submitted to form part of the heat treatment package. The following information shall be referenced on the chart:

(i). Rotek PQP number
(ii). Heating and Cooling Rate
(iii). Chart Speed
(iv). Soaking Time
(v). TC number and their respective colours.
(vi). Job description and Order number

5 Minimum qualification requirements

Resources assigned to the project are to comply with the minimum qualification requirements below:

Heat Treatment Operators	• At least 3 years relevant experience. • Formal training from accredited institution. • Verification of equipment calibration. • Set up of heat treatment equipment. • Attachment of thermocouples in accordance with the approved procedure. • Execution of heat treatment in accordance with the approved procedure. • Record and report all deviation from the heat treatment chart. • Compilation of all records pertinent to the heat treatment process. • Execute heat treatment activities in accordance with Eskom's standard.
Supervisors	• At least 5 years relevant experience. • Formal training from accredited institution. • Verification of equipment calibration. • Set up of heat treatment equipment. • Attachment of thermocouples in accordance with the approved procedure. • Execution of heat treatment in accordance with the approved procedure. • Record and report all deviation from the heat treatment chart. • Compilation of all records pertinent to the heat treatment process. • Execute heat treatment activities in accordance with Eskom's standard.

6 SHEQ REQUIREMENTS

All service providers are expected to comply with, but not limited to the following:

- Compliance with the Occupational Health and Safety Act 85 of 1993 is compulsory.

- Adherence to Quality Management System Policies, Procedures and related requirements of ISO 9001.
- Adherence to Occupational Health and Safety Policies, Procedures and related requirements of the OHSAS 18001.
- Adherence to environmental aspects, related impacts and legal requirements associated with work activities in accordance with ISO 14001.
- Adherence to Life Saving Rules.
- Compliance with the Eskom Plant Safety Regulations.
- Only authorised documents and processes are to be used in the execution of duties.
- Continuously seek methods for improvements from a process, quality and safety perspective.
- Obey all instructions.
- Familiarize with:
    - The applicable work instructions and procedures in place.
    - Safe working conditions and procedures.
    - All legal and contractual requirements.
    - Discipline and integrity.
- Compliance to all ERI Work Instructions, processes, procedures, and standards
- Adherence to ERI's disciplinary code or practice.
- Set example to co-workers and others.
- Participate in Risk Assessments.
- Responsible for own safety.
- Responsible for Personal Protective Equipment issued.
- Execute duties promptly and safely.
- Safeguard tools and safety equipment issued.
- Keep good relationship with all personnel.
- Compile a HIRA for each and every activity that needs to be performed.
- Ensure the activities are carried out following a Works Instructions and Procedure.
- Adhere to clean condition policy where required.
- All activities to be carried out as per the documented processes and comply with the requirements of ISO and OHSAS certification
- Service provider to comply to Eskom PPE (Personal Protective Equipment) Policy with regards to issuing of PPE to resources
- Proper use of PPE to be followed
- Ensure that tools and equipment are stored correctly in a safe place.

7 KEY DELIVERABLES

The following deliverables are to be met by the service provider:

During the servicing of equipment duration:

- No customer complaints
- Compliance to all ERI Work Instructions, processes, procedures, and standards
- No SHEQ incidents
- Milestones to be provided and to be achieved on time, or earlier

8 PROCEDURE ADHERENCE REQUIREMENTS

The ERI TGS Quality Management System consists of various procedures and processes that are utilized to manage and control the level of quality of maintenance activities during an outage to an acceptable standard. These procedures and processes are employed during the planning and execution of maintenance activities with a focus of meeting the customer's requirements and enhancing their satisfaction. These procedures shall be adhered to by the service provider and will be made available on request by the service provider.

- Execution and Control of All Site Work (240-137025973)
- Quality Control
- PQP Workflow Assessment and Tracking for Outages (F-198)
- Technical Notification Work Instruction (240-94067868)
- Standard for Welding requirements on Eskom Plant (240-106628253)
- Control of Blanks and Foreign Material Exclusion Covers (T-03)
- Rotor Lockable Components Inspections (E-67)
- Hydraulic Equipment Specifications, Operation and Maintenance Requirements (F-465)
- Compilation of Service Reports and Data Books (F-737)
- Lifting Machines and Lifting Tackle Safe Working Practices (E-19)
- Management and Control of Tools in a Tool Store or a Container (240-125904456)
- Correcting of Checksheets Engineering Instruction (X-1384391-033)
- Project Management Product/Process Quality Plan (240-130329202)
- Control of Non-Conforming Product/Service, Corrective and Preventive Action (240-103649507)
- Business Management System Audit (240-94027195)
- Coding of Business Management System Documentation (240-94027233)
- Development and Management of the Product/Process Quality Plan for Outages (240-142892057)
- Generator Clean Conditions Requirements Work Instruction (240-56178527)

- Turbo Gen Services - Outage Quality Control Cabin240-142894278)
- Turbo Gen Services Rework Work Instruction (240-147200671)
- Flogging procedure(E-60)
- Safe operation of electrical equipment (TT-A-01)
- Plant Safety Regulations

9 Key Performance Indicators

The performance of the contractor will be evaluated on the KPIs in the table below:

Objective	**Key Performance Indicator**	**Measure**	**Unit of Measure**	**Source of Evidence**
Safety Sustainability	LTI Free days	LTI Free days	Days	To be provided by supplier
Due Date Performance	Due Date Performance	Average contracted days	Days	To be provided by supplier
Reduce the Number of Rework Incidents	No of Rework Incidents	Number of Rework Incidents	Nr	To be provided by supplier
Reduce the Rework Duration	Rework Duration (Days additional to planned outage duration)	Number of Days Rework Duration Impacts Outage Due Date	Days	To be provided by supplier
No of Legal & Environmental Contraventions	No of Legal & Environmental Contraventions	Number of contraventions	Nr	To be provided by supplier
Zero Fatalities Excl 3rd party at fault	Zero Fatalities Excl 3rd party at fault	Number of fatalities	Nr	To be provided by supplier

- The service provider will be responsible for the successful completion of the scope
- After each application has been performed, the area shall be sanded or filed to remove all irregularities.
- The NDT personal must be able to conduct NDT after the scope is completed (i.e. TC wires must be removed and the surface polished to a smooth surface)
- Any defects that are noted after the scope execution will be corrected by the service provider at own cost.