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Compiled by	Approved by	Authorised by
William Garnett-Bennett	**Nico Rust**	**Mandla Mthembu**
Senior Consultant	**Corporate Specialist**	**GM : Asset Management**
Generation Draught Plant	**AM ME Draught Plant**	**Mechanical Engineering**
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EXECUTIVE SUMMARY

The Quad Sector Rotating matrix air heaters installed at Medupi and Kusile are complex machines, and inherent to their function of Gas to Air heat-exchange, are subject to severe conditions of erosion.

The organisations Management and Maintenance personnel must have a clear understanding that the execution of Air Heater maintenance needs to be considered as an out of normal task. The effective maintenance of the machine presents a multitude of intricate and interrelated details, and if not correctly managed with the appropriate knowledge and skill levels, it will result in severe plant production losses and stoppages.

Continued operation of the plant, with known deficiencies, such as element blockage, Soot-blower malfunction, sealing failures, etc. will result in the accumulation and exaggeration of damage to components with severe consequences of plant load losses. Any of these deficiencies needs repair on an urgent basis, in order to sustain relative reliability between operational shutdowns.

The effective Management of the Preventative Maintenance Program requires in-depth knowledge of the machine, and processes recommended within this specification.

Periodic evaluation of compliance to planning, processes and engineering analysis is essential to achieve sustainable good performance.

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1. INTRODUCTION

The correct execution of Maintenance on the Quad Sector Rotating matrix type Air Heaters aims at obtaining the best performance and life expectancy of components that are subject to frictional wear and ash erosive wear. Accurate detailed execution of repair Scope strives to ensure that unplanned failures is eliminated in order to ensure effective operation and performance between planned outage intervals.

2. SUPPORTING CLAUSES

2.1 SCOPE

2.1.1 Purpose

This Maintenance Specification stipulates the minimum requirements for inspection and executing repair and preventative maintenance and monitoring performance on the Air Heaters in order to obtain the best operational service between repair intervals.

2.1.2 Applicability

This Specification applies to all Quad Sector Rotating matrix type Air Heaters installed on Eskom fossil-fired Boilers.

Eskom System Engineers and Maintenance Contractors use this specification for proposing and planning of the appropriate maintenance Scope of Work, and for stating minimum requirements for compliance execution to Contractors engaged in Maintenance Contracts.

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] 240-119862281: Air Heater Leakage Guideline.

[2] 240-119862303: Air Heater Fouling Prevention Guideline.

[3] 240-100914307: Regenerative Air heater element pack and preservation storage standard.

[4] 240-106628253: Standard for Welding Requirements on Eskom Plant.

[5] 240-131963944 Draught Plant Preservation Standard

[6] 240-100914307 Regenerative Air Heater Element Packs Storage and Preservation Standard.

[7] OEM recommendation of Sequence for Heating Element Installation.

[8] Station Air Heater washing procedure.

[9] Station Air Heater Fire-fighting procedure.

[10] Station Draught Plant Return to Service procedure.

[11] 240-87694581 Performance Testing of Air Preheaters Standard (Rev 1)

2.2.2 Informative

[12] 240-111508338: Process Control Manual (PCM) for Outage Management

[13] Applicable NDT and wall thickness monitoring standards.

[14] 240-89218264: ID Fan Out of capacity guideline.

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[15] 474-11040: Air Heater fire detection/protection – minimum requirements.

[16] 240-89217730: Standard for Draught Plant Protection functions

2.3 DEFINITIONS

Definition	Description
Rotating matrix	The description of the layout/configuration of the Air Heater type – to obtain regeneration of heat through the element packs via the **rotation** of a shaft/rotor, containing the element packs/**matrix**, which allows rotational exposure of the elements to gas/air flow for regenerative heat exchange.
Regenerative	Regeneration in the heat-exchange context is the mechanism of continuous heat exchanging cycles through the cyclic deposit of heat and extraction of the heat out of the same member.
Capping	The phenomena of the stator to take up a curved or dished shape due to unequal expansion resulting from temperature differences between the top and bottom surfaces.
Entrained-ash	Entrained-ash is the gas and ash “charge” that is captured within the element packs as they transition from the gas stream to air stream during the continuous sealing-off and reversal of the direction of flow during the rotating and re-generative heat-exchange process.
Retained-ash	Retained-ash is the ash contained inside the element pack matrix in quantities over and above the retained-ash, through regenerative cycles and as result of settling in element spaces with low flow distribution or due to element plate design.
Bypass flow	Bypass flow are flow paths created by design or erosion and that does not pass through the intended element pack matrix.
X-Factor	The mathematical manipulation of process temperatures surrounding the element packs in order to assess the machines thermal efficiency.

2.3.1 Disclosure Classification

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

2.4 ABBREVIATIONS

Abbreviation	Description
BOM	Bill of Material
C&I	Control & Instrumentation
CE	Cold End
CIWS	Cast Iron Wear Seals
CW	Cooling Water
FD Fan	Forced Draught Fan
FFFR	Fossil Fuel Firing Regulations
HE	Hot End
HP	High Pressure

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Abbreviation	Description
ID Fan	Induced Draught Fan
KS	Kusile Power Station
MD	Medupi Power Station
NTU	Nephelometric Turbidity Units
PCD	Pitch Circle Diameter
PS	Power Station
QCP	Quality Control Plan
RTS	Return To Service
SOW	Scope of Work
TIR	Total Indicated Run-out

2.5 ROLES AND RESPONSIBILITIES

a) Station System Engineers must be well versed on the content of the Specification and ensure to implement the requirements for the Maintenance program, Outage SOW, and Quality Control.

b) Each Power Station is responsible to implement the minimum requirements described in this Specification and to develop a spares stockholding plan to support the execution of Maintenance work.

c) The Maintenance executing Contractor shall possess of detailed execution procedures and training material to facilitate accurate execution of the stipulated Maintenance repair work.

d) The Eskom Corporate specialist function must execute compliance audits to evaluate the correct implementation and adherence to the requirements of this specification.

2.6 PROCESS FOR MONITORING

Compliance monitoring to this Specification will be via peer reviews and Quality audits.

2.7 RECORDS

Produce the following documentation in line with this Specification;

a) The Eskom Engineer shall develop Scope of Work documentation to guide effective and complete scoping.

b) The Eskom Engineer shall develop the referenced documents recommended in this Specification, pertaining to performance and erosion protection monitoring.

c) Each relevant Power Station shall develop the spares stockholding capability to support the accurate execution of required scope for a specific outage

d) The Maintenance Contractor shall possess instruction documents to guide accurate execution of the detailed tasks in accordance to this guideline.

e) The Maintenance Contractor shall possess/develop Inspection Reporting documentation to facilitate effective and accurate condition Reporting, Analysis and Quality Control of the execution.

f) The Maintenance Contractor shall develop Quality Control documentation to secure effective verification and record keeping of the quality of execution.

g) The Maintenance Contractor shall submit a detailed list with spares requirements based on the requested Scope of Work related to a particular outage.

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3. MAINTENANCE REQUIREMENTS

3.1 AIR HEATER SYSTEMS BREAKDOWN AND DEFINITION

3.1.1 Rotor and Heat Transfer Elements

The rotor structure consisting of a welded matrix of radial- and divisional plates with a depth that accommodates three layers of element packs with incorporated design-reserve depth for element packs. The Rotor hub consists of 34 radial sealing interfaces and 1 divisional interface after ring 3 where an additional radial division in incorporated to the count of 68 up to ring 9.

The Rotor structure mounts on a centrally supported shaft with detachable top extension forming the locating bearing interface.

The surrounding the welded matrix is a circumferential structure forming the axial and circumferential sealing interfaces, and contains hub- and radial sealing interface.

Inserted into the rotor matrix and supported with weld-in steel brackets are the regenerative heat transferring element packs consisting of multiple preformed & profiled plates compressed into a pack-binding structure (basket).

3.1.2 Casing and Ducting

The casing and ducting refers to the ducting and casing around the rotor from the inlet flanges to the outlet flanges on the air and gas paths.

The casing is supported from the boiler-house steel supporting structure, and acts as a supporting structure for the bearings, rotor & element matrix as well as containing the bypass flow of leakages through sealing interfaces.

The external casing uses thermal insulation due to extreme internal operating temperature conditions.

The transition-ducting configuration is suited for the Quad-sector design-concept, with the basic philosophy to separate the gas & airside sectors, while the airside sector incorporates the Primary air heating, with leakages captured inside two adjacent Secondary air sectors.

3.1.3 Drive Mechanism

The Drive mechanism refers to the drive-motor, gearbox & pinion-gear, meshing with a rotor weld-attached pin-rack drive with an ultimate rotational speed on 1.2 rpm.

The gearbox is fitted with an auxiliary drive functionality integral to the gearbox, for (slow-drive) maintenance purposes.

Each Air Heater is fitted with two (100%) continuously engaged drives to improve reliability.

3.1.4 Shaft, Bearings and Lubrication System

The shaft and bearings refers to the main shaft supporting the rotor, thrust/support- and guide bearings with an auxiliary system for oil and shaft cooling.

The thrust bearing positioned in the bottom of the rotor, is a large angular-contact cylindrical roller bearing with uncooled oil bath lubrication. The locating bearing positioned on the top-end of the extended shaft, is a double angular-contact cylindrical roller bearing contained in a water-cooled oil bath.

The top-end of the shaft is fitted with a cooling-cavity to provide circulation of CW through the inserted lance with a rotating pivot facilitating the transfer of CW from a stationery supply to the rotating shaft.

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3.1.5 Rotor Sealing System

The sealing system refers to the axial, circumferential, hub and radial seals installed on the rotor and casing to provide sealing/separation between the rotating and static components for minimisation of leakage between the air and gas flow-paths.

The radial sealing-system consists of auto-adjustable frames/sector plates for the hot-end and manually adjustable frames/sector plates for the cold-end.

Stainless steel expansion joints, spring pins, springs, automatic adjusters and cast iron wear seals form part of the adjustable seal-frame, which is also the contact-interface to the rotor and which is cold-set with the requirement for hot-condition commissioning.

The HE radial sealing frame and the axial seal frame movement is pneumatic-controlled with actuators, while the CE radial and circumferential seal is a cold set static leaf-type seal.

3.1.6 Soot-Blower System

The soot-blower system refers to the external steam lance with a semi-retractable mechanism, and with an internal steam lance, comprising of three vertical branches, each fitted with a cluster of headers/nozzles.

An electrically driven chain-and-sprocket mechanism operates the retractable system. A pilot valve opened by the lance movement admits steam. The external system contains several instruments to report steam condition and movement control.

3.1.7 Fire Detection and Protection Systems

The Detection system consist of temperature measuring clusters of thermocouples in each of the four hot-end sectors and the cold-end gas exit sector, in close vicinity of the element packs.

The Protection system consist of an installed water admission pipework with nozzle matrix - distributing water into all four hot-end sectors. Water drains fitted on the cold-end ducting sectors provides drainage.

3.1.8 Erosion Protection

This aspect on the machine highlights all elements exposed to erosive damage due to ash and high velocity flow. The management of erosion protection elements is covered by detailed drawings/plans and inspection reporting.

3.1.9 Instrumentation

Instrumentation used on the Air Heater, comprising of a rotation sensor, fire detection (temperature) monitoring, lubrication system oil level monitoring and instruments relating to the seal-setting system control.

3.2 ROTOR AND HEAT TRANSFER ELEMENTS

3.2.1 Rotor Structure

a) Visually inspect the Air Heater rotor-structure during every 18 monthly outage in order to assess possible cracking and wear-condition. Record findings in order to provide input to future estimates for the repairs. Carry our repairs out during appropriate opportunities. Some rotor-peripheral aspects require monitoring and repair on 18 monthly intervals.
b) To obtain access for the repairs of the rotor structure element pack changes outages are the only planned opportunities available to carry out the work. It is therefore imperative to do frequent assessments of the condition of the rotor in order to identify failure modes & root-causes before pack change outages. Compile appropriate budgets in time for the planned outage.

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c) During a pack change, the main structural welds of the rotor-to-hub plates must be NDT inspected to ensure there are no cracks on these welds on both the hot and cold end. Any cracks need to be repaired during the outage after failure analysis and a repeat NDT performed to confirm repair work.
d) Rotor weld cracking observed during the interim inspections, judged severe may require a decision for urgent out-of-schedule repairs in order to secure the integrity and reliability of the machine.
e) The rotor structural radial- and divisional plates are lined with a weld-on sealing interface – flat-bar radial seals – that forms the flat-surveyed contact interface with the adjustable sealing-system and must be inspected for damage/condition on 18-monthly intervals.
    1) A full-replacement of the radial seal-strips is required during element pack replacements – due to full removal required to facilitate the element pack extraction.
    2) Re-instate damage detected on the radial flat-bar seals through abrasive and/or erosive wear through local cut outs while observing to maintain the required alignment within a 2 mm flatness standard.
    3) Interim damage assessed to require more than 25% cut outs, should prompt for a complete interim replacement, and require a primary root-cause analysis in order to address causal factors.
f) The rotor circumferential HE & CE seal-liner runouts must be checked with every 3 yearly outage during the inspection phase and confirmed to conform to the stipulated standards for flatness & radial dimensions – 3 mm on Radial and 3 mm on Axial TIR – to ensure continued proper sealing during operation.
g) Inspect the rotor circumferential liner during every 18 monthly outage for wear, cracking and erosion. Record the information in the database to allow planning for complete replacements in GO-outages. The general assessment is that the seal-liner may wear up to 10 mm deep where-after repair-intervention is required – expected on three yearly intervals.
    1) As repair method, the circumferential liner may be weld-repaired – due to the prominent wear-groove - to compensate for the re-instatement of the circumferential sealing integrity, while observing acceptable measures for curvature & flatness control as well as the surface definition within a roughness of 6.3 micron.
    2) Repair the sealing surface in a way to provide a smooth circumferential surface that avoids excessive deflective movement for circumferential seals.
    3) Excessive wear-damage and deformation of the sealing surface must prompt for the complete re-lining and redefinition by machining during 12-yearly element pack-change outages. Sealing interfaces compromised in excess of a 50% deviation match this requirement.
h) The Rotor circumferential periphery is further fitted with webbed strips forming the weld-on and pre-set sealing interface with the axial adjustable sealing-system, and must be inspected & repaired throughout the circumference on 3-yearly intervals.
i) The cold setting and commissioning of the axial-sealing ribs noted above is covered in the applicable section for the “Sealing System’ below.

3.2.2 Element Packs, Supports and Condition Monitoring

a) The aspects for monitoring and reporting on the condition of the Element packs, performed on 2 to 3-yearly intervals, are based on the philosophy outage regime that would be manifested by the health of the following indicators:
    1) Element pack **Wear rate** (sampling including location of the element packs sampled).
    2) Element pack **Supports**.
    3) Element pack **Gap sealing**.
    4) Element pack **Blockage manifesting as “Air/Gas flow Pressure drop”**.
    5) **Abnormal** erosive wear or cracking.
b) To determine element pack **Wear Rate extract** samples from each layer in two different rings of two identified element pockets/cavities. Inspect the extracted elements for blockage, split for the removal of one plate pair, re-compressed, and replaced. Engineering analysis the removed plate-pair through mass-loss comparison, modelled with the mass of new plates of same size and profile.

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c) The following cautions are applied during element-sampling:
   1) Never sample the same pocket-elements more than once.
   2) The Engineer to ensure that the sampled plate is representative of a full-plate size.
   3) The Engineer is to inspect the intermediate elements for blockage-condition.
   4) A wear report approaching 30% mass-loss must prompt planning for replacement during the next outage (to occur within a 3 year window), but is also dependent on the life cycle prediction, as a 35% mass-loss is considered as depleted-life. A detailed record of the mass loss must be kept and used as a predictive tool to estimate wear rate and remaining useful life to accurately determine pack change requirements.
   5) Capture all inspection findings and wear rates in an inspection report signed off and accepted by the System Engineer.

d) CAUTION: Element pack lifespan estimation and condition monitoring is ONLY reliable/predictable through normal wear conditions. The unit load-factor must be accurately represented in the analysis, and repeated element pack blockage and prolonged operation with blocked-condition elements must be avoided and must prompt for a more intensive evaluation of the remaining/forecasted life.

e) Element pack **Supports** must be rigorously inspected and any defects found must be repaired or replaced – especially if the unit was subject to prolonged operation with blocked elements and excessive bypass flow. Element Pack supports are to be re-instated to the original design installation.

f) Inspection and reporting must comprise of a layout matrix of rings and segments in order to ensure that 100% of the element supports are covered, reported and repaired where required. It is good practice to plan for full pack support replacement during pack changes that is done in conjunction with rotor repair work.

g) Element pack **Gap-sealing** must be secured in order to counter excessive by-pass flow, in the case of excessive sizing mismatch between the element pack and the stator. **The following aspects are important to manage, if out-of-specification gaps exist on the Hot-end and Cold-end sides:**
   1) The target with element pack sizing and specification should be to avoid any out-of-specification gaps of larger than 6 mm all-round.
   2) The use of a gap-closing mechanism, attached to the element pack surrounding “cage” is preferred for fully boxed packs.
   3) Flat-bar cover-strips of 6mm x 25 mm mild steel can be pre-cut to match the rotor structure, and are weld-attached with 30mm x 100mm space welding method and the strip positioned to overlap with gaps and flush with the elements.
   4) Corner-gaps in excess of 25 mm in size must prompt for a larger cover-strip in the applicable areas based on a target for 75% coverage.

h) Cold-end Element pack **Blocking or fouling** occurs if the element packs are subject to prolonged dew-point conditions during start-up from cold conditions and/or during continuous operation. Exaggeration of blockage is caused through failure or mal-operation of the provided soot-blower cleaning system.

i) System Engineers are to monitor and address/correct this phenomena on the plant by implementing the following management tools:
   1) Implement monthly monitoring, logging, analysis and reporting of Air and Gas pressure drop trends – ensuring that comparisons are made with data relating to similar flow/loading conditions.
   2) Implement monthly monitoring, logging, analysis and reporting of prolonged Air and Gas temperatures that lead to dew-point conditions.
   3) Ensure that dew-point controlling functions are effectively maintained and correctly utilised to avoid/minimise dew-point operation taking into account each stations specific design.
   4) Implement Combined Back-end Temperature trending, alarming and reporting.
   5) Execute a drying process for element-packs prior to returning washed/wet element packs to service. Each Station should develop and approve an acceptable methodology for the drying process, while being cautioned that ash deposition into wet element packs will result in severe plugging or fouling.
   6) Ensure that the mandatory soot-blower sequence is executed on a 2 or 3-times daily routine, with frequency judged on the severity of blockage.

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7) In addition, mandatory monthly walk-down checks are conducted and reported to verify that soot-blower systems are operating in the prescribed manner – with physical witness of traversing/blowing during steam-application.
8) Instil a culture that soot-blower deficiencies are dealt with on urgent basis, as opposed to allowing a malfunctioning system to sit idle for many days without element-pack cleaning/operation.

j) The Soot-blower system's ability to counter severe dew-point blockage is limited, and prolonged failure or non-operation of the Soot-blower system will lead to blockage.
k) High Pressure washing is utilised to clean blocked or fouled packs. Refer to the applicable section dealing with the requirements and controls for "High Pressure Washing" below.
l) Signs of **abnormal erosive wear** and/or cracking of element plates must be inspected, reported and analysed on 18-monthly intervals. Factors contributing to such failures that must be avoided through inspection and repairs are:
   1) Loss of or insufficient compression on element packs.
   2) Soot-blower/system failure (or soot-blower being stuck while in operation) with continuous blowing on localised areas.
   3) Large preference-flow areas through element packs causing flow-induced vibrations and plate-fatigue.

3.2.3 Element Pack Replacement

a) The normal replacement life cycle for element packs in the Eskom fleet of air Heaters is 12 years, while the final Engineering decision for depleted life of the elements is based on the results of inspection assessments as well as the results of the wear-life evaluation detailed above.
b) Caution is accentuated that the norm-rate of element pack wear-life is drastically affected through continued operation with blocked packs, and large bypass deficiencies.
c) Replacements are best executed during Major Overhaul opportunities, providing sufficient duration for Rotor repairs, pack replacements as well as other general repairs coinciding with each individual components repair interval.
d) Aspects of Rotor repairs is accentuated as a requirement during element pack replacements, requiring extensive attention to the following elements:
   1) Rotor structural integrity affected by erosion and cracking of welds due to the continuous operational thermal cycles.
   2) Renewal of element pack supports.
   3) Removal and renewal of Rotor radial and divisional flat-bar sealing strips.
   4) Removal and renewal of element pack bypass-gap cover strips.
   5) Repairs or replacement of the peripheral/circumferential sealing liners requiring in-situ machining to secure the sealing surface to the required specifications.
e) Reference is made to the OEM recommendation for "Sequence for Heating Element Installation", noted in the document reference section above.
f) The re-ordering specification for element packs must be influenced by operational experience, requiring the compilation of a comprehensive specification to control the desired supply-configuration. With reference to the Generation Element pack specification guideline, the important identified aspects applicable for the KS/MD element packs are as follows:
   1) Elevation of the HE elements in order to achieve a closer distance for soot-blower efficiency.
   2) Effective sizing to minimise on bypass gaps with an integrated sealing-strip design.
   3) Fully boxed binding/basket system for ease of size-control and bypass sealing.
   4) Sizing of elements while ensuring that manufacturers are able to sustain the required pack-compression ratio.
   5) A strong consideration for the use of enamelled cold-end elements to counter plugging due to high stratification of exit-gas temperatures.
   6) Retention of the bottom-removal philosophy for Ce element packs.

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3.2.4 Element Pack Washing and Drying

a) Most Air Heaters operated in the South African context are subject to hardened ash on the Cold-End element packs and require high-pressure water washing to dislodge and flush-out hardened ash deposits.
b) It is strongly recommended to follow best practice with scheduling the element pack washing-event upon completion of maintenance work, followed with the start-up and drying process.
c) In these instances, it is good practice to facilitate the “soaking” of blocked elements by means of low-pressure water deposits, prior to executing the High Pressure washing activity.
d) The following aspects are important to manage with the execution of **high pressure washing**:
    1) Over and above the **Required Contractors Procedure** for the control of the high-pressure washing, the Station needs to register and implement a procedure to ensure that the management of water supply, drainage, dirty water disposal and element pack drying, is effectively dealt with. The procedure is to stipulate washing specifications as well as site-specific control-interfaces, such as:
        i. Drainage control points.
        ii. Water disposal control in line with environmental (ZLED – Zero Liquid Emission Discharge) requirements.
        iii. Pressure capacity of High Pressure pumps to be at least 600 Bar.
        iv. Provision of replacement nozzles at sizes ranging from 0.5 to 1 mm.
        v. Rotation and traverse control.
        vi. Criteria for measuring the effectiveness of cleaning.
    2) Hourly monitoring and logging of sustained water pressure at the stations required pressure and healthy nozzle conditions are to be sustained during the HP washing process.
    3) Inspection is to be performed at 24-hour intervals, in order to evaluate cleanliness and to establish focus areas and/or a revised water pressure application. Written record shall be kept of inspections performed, including the water sample test outcomes.
    4) Condition monitoring: Water samples are to be taken for evaluation of exit/waste-water acidity and turbidity. Neutral acidity is considered to be between 6 and 8 pH, and acceptable turbidity gain below 100 NTU is an indication that no further ash-deposits are released to the water.

e) An arrangement is to be made with the executing contractor for the provision and installation of traversing equipment covering the entire heat-exchange surface.
f) The provision of high pressure washing equipment has to comply with the requirements stated in the Eskom washing procedure.
g) Prior to HP-washing, it is vital to ensure that effective sealing and/or screening of plant that could be affected by the water and drainage, has been performed. Affected plant could be:
    1) Cold-end Soot-blower nozzles facing into the down-flushing water/waste.
    2) Immediate area field instruments.
    3) Fans and lubrication systems located below the Air Heaters.

h) CAUTION: As noted above, it is important to screen and prevent the deposit of washing-sludge into the Cold-End soot-blower system nozzles.
i) Post-washing activities, inspections and acceptance criteria for conditions must be stipulated and generally, the typical focus areas to be included are:
    1) Fans and lubrication systems.
    2) Fan casing drain-points.
    3) Ducting compensators that are able to accumulate the down-flow of wastewater.
    4) Downstream ducting pressure tapping points and instrumentation.

j) CAUTION: The effective drying of the element packs after washing is crucial to prevent repeat blockage during start-up, requiring the compilation and testing of a comprehensive procedure. The following aspects are to be considered for the drying procedure:
    1) It is essential to soot blow the boiler prior to shut down.

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2) Further support is rendered to purge the boiler with high velocity airflow during the force-cooling event, before the final shutdown of the draughts, in order to extract the bulk of remaining ash from the boiler.
3) If the Boiler was not washed, extreme caution is required to prevent ash carry-over during the starting of Draught group fans with moderate (<50% MCR) flow velocities.
4) Drip-drying – even after a period of 4 days, this is not deemed an effective method, and should not be the only means of drying used.
5) Cold-air purging with maximised flow of uncontaminated air for a period of 6 hours is a minimum requirement – and must be performed with the air heater rotating.
6) Added heat to cold combustion air – through the use of the Steam Air Pre-heater – can shorten the drying period, and should be utilised whenever possible.
7) Drying should be undertaken with the use of the Air-pass only, thereby avoiding any gas-exit flow, which will mitigate risks of dirty-boiler ash carry-over – thus air will be exhausted via an open flow-path on the boiler bottom ash duct.

a) Additional time allowed for heat-soaking the Elements during boiler warming and using a low-flow draught combined with a single low firing burner level, can shorten the drying cycle to approximately 3 hours.

3.3 CASING, TRANSITION DUCTING AND ACCESS DOORS

3.3.1 Casing and Transition Ducting

a) The Air Heater casing main support structure underneath the support bearing is relatively maintenance free except for a 6-yearly inspection confirmation for signs of visual deficiency on the supporting slide-pads, guides and structure.
b) The rotor casing generally must be inspected on 3-yearly intervals for damage and erosion and repairs carried out accordingly.
   1) Severe erosion-affected areas must prompt for 18-monthly inspection & repair with the philosophy to implement an erosion-protection system, in order to target the facilitation of the 3-year inspection & repair philosophy.
   2) Wear-liner repair and management is detailed in the applicable section for “Erosion” below.
c) The Transition ducting with thermal compensation and ducting guides are an integral part of the Casing and is subject to wear on the HE and CE-sides of the gas-path, requiring visual inspection & reporting on 3-yearly intervals.
d) Remedy/repair of casing-wear is to re-instate the structure-walls by means of the ‘window cut-out’ method, with a like for like material thickness in order to obstruction for flow-turbulence resulting in excessive erosion with resulting ingress/exit-flow over a 3-year period of operation. No overlap patch-repair of air heater casing and ducting is allowed, unless required on a temporary basis to sustain operation.
e) The external casing thermal insulation is of particular importance on the doors and external auxiliary equipment such as drives, shaft seals, & sealing system and requires strict management on documentation to secure the correct re-instatement.
   1) It must be observed that the insulation-design for particular areas require management of the thermal rating, and it is proposed to conduct verification inspections with defined-location thermal imaging.
   2) The re-instatement of insulation on the Primary-sector door requires repeat-management to be covered in RTS documentation.
f) The circumferential casing contains the adjustable Axial seal as well as the fixed Axial ribbed-structure, and is detailed in the applicable section for the “Sealing System” below.
g) The casing contains the shaft-sealing interface, which is detailed under the applicable section for the “Shaft, Bearings and Lubrication” systems below.
h) While the execution of repairs/replacements of thermal Compensators is excluded from the scope of work for the air heater maintenance, it is the responsibility of the Air Heater maintenance contractor

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to inspect, detect and report signs of deficiencies – especially erosion, leakage and possible transfer of thermal expansion forces to the Air Heater casing.

3.3.2 Access Doors

a) Access doors are generally free from damage and erosion but must be managed & inspected during every outage and repaired where required.
   1) Door open/close management must be guided through a Site inspection-preparation requirements guideline. Basically the opening of at least one door for each of the sectors on the HE & CE respectively is required.
   2) Caution is applied on the CE-sectors that access control is required and an extensive scaffolding platform is required for inspections on 3-yearly intervals.
   3) Access for interim Rotor repairs can be facilitated through a gas-side platform only and rotor rotation to facilitate full assessment and repairs.
   4) New packing/seals must be fitted on every outage on the doors that were opened for the specific outage, especially on the pressurised doors.

b) Access doors contain various inspection-ports which require the monitoring for closure of the protection screens for RTs as well as routine inspections and 18-monthly internal cleaning & repair maintenance.

c) Access doors exposed to internal temperatures above 55 degree C is thermally insulated for protection and het retention, and the re-instatement after conclusion of outage work requires the implementation of a QCP verification inspection.

3.4 DRIVE MECHANISM

3.4.1 Main Drive Motor

a) Main drive motors are designed to operate for 12 years, after which it requires a review of the internal condition.

b) As a critical component, thorough motor testing and servicing should be scheduled on 12 year intervals in order to avoid unscheduled failures.

c) The drive should form part of the Power Station Draught Group condition monitoring program and monitored on a monthly basis, using vibration analysis and infrared thermography to identify potential fault conditions or developing failures.

d) The main drive motor is an integral part of the gearbox with a rigid connection to the first reduction gear – thus it contains no coupling. While site separation is discouraged, the removal and transfer of the gear-connection requires special precautions and requirements.

e) Following maintenance intervention on motors, it is compulsory to verify the correct direction of rotation with Mechanical Control personnel as Witness.

f) The main motor is equipped with a manual auxiliary-drive – special tool meshing with a motor-shaft extension requiring management and control for maintenance operation.

g) Continuous rotation must be facilitated with an add-on pneumatic drive mounted in place of the manual sling/lever provided by the maintenance contractor with the added caution to prevent connection damage caused through incorrect connection.

h) IMPORTANT – All rotating “Control” measurements must be done with rotation in the NORMAL direction of rotation.

3.4.2 Main Drive Gearbox

a) The Air Heaters have been fitted with dual drives to improve availability – with both drives meshed for continuous driving.
   1) With one drive designed for a 100% duty, a possible failed drive must be retracted from the simultaneous operation in order to reduce the resistance caused through of the two drive-gearboxes require parallel execution of servicing.

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2) In the case of deficiency or failure of one drive, it is only acceptable to allow meshed idling, for a short period (1 day) – with controlled retraction of the meshed pinion/gearbox as soon as possible
3) Re-meshing of a replacement gearbox may only be performed during a standstill opportunity.

b) The gearboxes are generally designed to operate for 12 years, after which it requires a review with internal inspection, seal replacement and verification of the condition.
c) The maintenance philosophy may not be based on 'run to failure' approach. A 12-year internal inspection and refurbishment interval is strongly recommended and must be executed by a reputable gearbox repair-contractor.
d) It is of utmost importance to sustain consistency of inspections and testing with a repair-contractor, in order to correctly analyse and engineer failure mechanisms, especially when repeated failures on gearboxes are experienced.
e) The service requirement justifies the maintenance and control of replacement gearboxes as rotable spares.
f) Stations need to execute the required condition monitoring checks that will provide the required condition information to inform further scope of work that may be required, such as oil samples, checking for oil leaks, monitoring oil level, and performing vibration monitoring on pre-set periodic intervals.
    1) Daily – observation of oil leakage and oil level and reporting of deficiencies.
        i. It is of utmost importance to adhere to the full oil levels at all times – the horizontal orientation of the box exposes the top gear-pairs without lubrication with only a slight drop in oil level.
    2) Weekly subjective evaluation of vibrations.
    3) Monthly on-line vibration analysis, considering impacts on gear-meshing frequencies.
    4) Two-monthly oil-condition sampling.
    5) Eighteen-monthly inspection on possible signs of oil-leakage from the bottom output-shaft seal.
g) Caution should be made that incorrectly, sampled oil does not detect settled contamination, and gearboxes also do not have an oil circulation filtration system – this creates a situation that requires scheduled OEM-recommended 18-monthly oil replacements.
h) The removal/replacement of a Gearbox must prompt for management of several mounting interfaces such as:
    1) Cleaning the sliding grooves on the base-plate.
    2) Replacement of the bottom sealing O-ring.
    3) Torque-control of the gearbox to base-plate mounting bolts.
    4) Inspection & control of the anti-rotation arm with rubber damper.
    5) Torque-control of the base-plate clamping-bolts.
    6) Correct fitting and tightening of pinion attachment bolts.
    7) Alignment/setting of pinion to pin-rack gap.
i) Thermal insulation around the gearbox requires special attention to prevent excessive temperatures on the gearbox, and allowing for venting of hot air on the rear-side of the gearbox.
j) Control the use of the gearbox for slow motion driving through the motor shaft to prevent meshing damage on the manual drive.

3.4.3 Drive Pinion

a) Pinion wear shall be monitored on-line (subjective report), as well as objective measurement with the use of a gear-profile template and feeler gauge during 18-monthly outage inspection/reports.
b) The expected Pinion wear-life (per wearing side) should be minimum 6-years (@ 6 mm wear depth) – with the service history that must still be confirmed.
c) Reduced wear-life is caused by:
    1) Incorrect meshing conditions (penetration depth).
    2) Incorrect or sub-standard Pin-rack installation.

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3) Operating conditions, subjecting the pinion to adverse temperature conditions encountered, especially during Air Heater standstill or Single Draught operating conditions.
4) Operation with OPEN (failed) primary-sector seals – promoting the dumping of hot ash-contaminated air into the bypass area where the pinion is located.
5) Incorrect seal setting with seal-contact increasing drag and driving forces.
6) Incorrect pinion manufacturing specifications.

d) Reduced pinion wear-life shall be reported, investigated, and corrective actions implemented.
e) The Pinion and Pin-rack meshing depth shall be controlled and reported against the prescribed specification (15 mm on pin to pinion-gear root) with all drive pinion change-outs. CAUTION: measurements must be recorded on the maximum Pin-rack radial run-out.
f) The pinion and pin-rack axial alignment shall be controlled and reported against the prescribed specification – this axial set-up of the pinion (which is only “adjustable” during pin-rack replacement interventions) is to provide for the correct centralisation considering the axial thermal expansion due to ‘capping movement’ of the stator and hood assemblies.
g) Pinions are locked in position with bolts and locking plates requiring fitment and torque control after execution the required maintenance tasks.

3.4.4 Drive Pin Rack

a) Pin-rack pin wear shall be monitored off-line (objective report), with the use of a straightedge positioned on unworn surfaces and feeler gauge during 18-monthly outage inspection/reports.
b) The expected Pin-rack wear-life on ONE working-side should be minimum of 6-years (@ 6 mm pin wear-depth) on the driving-side – with the correct service history that must still be confirmed.
c) The OEM recommendation is not to utilise the alternative side due to the risk of pins dislodging – this arrangement must be sustained until reviewed by Eskom Engineering.
d) Reduced wear-life is caused by:
1) Incorrect meshing conditions with Pin-rack installation.
2) Incorrect manufacturing specifications.
3) Operating conditions, subjecting the Pin-rack to adverse temperature conditions encountered, especially during Air Heater standstill with heat-soaking taking place, or excessive operation with open seals or damaged seals on the Primary sector resulting in the leakage of heated & ash-contaminated air into the bypass cavity.
e) Reduced Pin-rack wear-life shall be reported, investigated, and corrective actions implemented.
f) The Pin-rack wear shall be monitored on-line (subjective report), as well as objective measurement with the use of a Vernier calliper during outage inspection/reports. Wear of only the applicable working side is reported.
g) Reduced service life is considered if a wear-measurement of 2.5 mm or more is noted on 3-year inspection cycles.
h) Replacement of Pin-racks must prompt for the control of the following installation parameters:
1) Verified shaft alignment within the stipulated specification.
2) Verified Rotor radial TIR to be within the stipulated specification.
3) For shafts with roller-bearing applications: The Pin-rack radial & axial alignment spacing shall be controlled and adjusted to specification during installation. Radial alignment is adjusted within 3 mm TIR, Axial alignment 5 mm TIR.
4) Inter-segment pin segment spacing/gaps are controlled and reported to specification during installation, at maximum ±0.4 mm from the norm. Inter-segment clamping brackets are used during installation to control the consistency of gaps.
i) The installer is to prove correct alignment before reverting to full weld-attachment of the Pin-rack. The proving of fitment tolerances is to be witnessed by the site system engineer or maintenance QC controller.
j) Pin-rack mounting is to be performed with utmost attention and care, with particular attention being paid to the following:
1) No welding is allowed across and/or near pins.

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2) Full welding all-round on the plate to rack interface is required.
3) Correct weld-fillet size and applied to the prescribed pre- & post heating requirements.
4) Placement position, width and length of the mounting plate to be as stipulated on the applicable drawing – mounting plates are sized to span over two pins.
5) Full top/bottom welding of the mounting plate onto the hood/frame interface is required.
6) The cutting and trimming of the mounting plates to fit a particular position onto the Rotor may be executed on site, while pre-prepared plates are supported to manage the execution program.

k) Pin-rack mounting plates are replaced with each pin rack replacement. Laser cutting or flame cutting of plates is preferred. Guillotine cropping of plates is less desirable as it causes distortion that affect mounting accuracy.

3.5 SHAFT, BEARINGS AND LUBRICATION SYSTEM

3.5.1 Shaft and Alignment

a) The shaft generally requires no maintenance, unless some damage is caused due to bearing failure or shaft seal failure.
b) The checking/verification of the shaft alignment – as a method to detect any possible changes to the operational condition – must be performed and reported on a 3-yearly basis.
   i. The alignment is first verified as a function of axial and radial run-out on the periphery of the rotor.
   ii. Excessive rotor run-outs must prompt for further investigation and a verification of shaft alignment is justified by checking for any deflection in the area of the shaft seal interface area.
   iii. Any investigation into shaft alignment should ensure that all conditions surrounding the top locating bearing is to drawing.
c) Shaft seals inspection must be done during every 18-monthly maintenance intervention and seals must be serviced when required – further details for shaft seals are provided in the section below.
d) Due to the design & layout of the top locating bearing, the shaft is provided with a cooling jacket/facility in the top 0.8 meter length.
e) The cooling water supply pump, supply piping and connecting flexible hoses are required to be monitored for health and operation to secure reliable cooling of the shaft with the following cautions to be applied:
   i. A continuous supply of CW is required to prevent damage to the shaft & top locating bearing.
   ii. The CW supply booster pump must be inspected and monitored on monthly intervals, and serviced on 3-yearly intervals.
   iii. Supply piping must be inspected after maintenance interventions in order to ensure that executed maintenance activities have not interfered with pipework.
   iv. Caution must be applied to ensure that the supply piping flexible is not be clamped to put stress on the movement of the rotating pivot.
f) The “cooling pivot” – a device providing the transfer of CW from the stationery pipes to rotating shaft – contains rotating seals and bearings and must be subject to 3-yearly replacement and servicing, and require management of the following aspects:
   i. Premature failure could be signalled by a leakage tell-tale hole on the body of the pivot.
   ii. Replacement requires the management of several replacement seals.
   iii. Excessive leakage must alarm action, as water ingress into the bearing is possible.
   iv. Refurbishment scope and execution must reside consistently on a qualified source to ensure that the standard of materials/spares and pressure testing in accordance to the applicable norm is maintained.

3.5.2 Locating/Guide Bearing

a) The inspection and condition monitoring of the locating bearing is important to ensure that no adverse condition develops that would cause tilting of the Rotor and effect damage to the shaft seals and rotor sealing system.

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b) The double layer angular contact cylindrical rolling element locating bearings are oil lubricated via an oil bath surrounding which is water cooled by means of cooling coils inside the oil bath housing. The following monitoring activities are required:
   1) Weekly on-line assessment is required to monitor the general condition, oil level and signs of oil or water leakage.
   2) Oil condition sampling must be executed on 3-monthly intervals to identify possible abrasion-wear conditions.
   3) The bearing and internal cooling system is to be inspected for condition and cleanliness on 6-yearly intervals, and the oil sump to be checked for sediments and deposits. It may be required to replace the oil, especially when sediment or metal particles is observed, which may be indicative of bearing damage/failure developing.
      I. It must be cautioned that the opening, inspection and servicing of the bearing oil bath requires the availability of several sealing elements and special bolts & washers – refer to the applicable drawing.
   4) Bearings are subject to compulsory replacement on 12 yearly cycles – recertification and possible re-cycling of the bearings must be implemented to the applicable Eskom standard.
   5) It must be cautioned that ill health of the shaft seal directly below the locating bearing may lead to excessive heat-exposure of the bearing assembly.

c) The removal and re-installation of the locating/guide bearing requires the monitoring of several important aspects:
   1) Controlled blocking/supporting of the rotor in order to stabilise its location while removing the locating bearing.
   2) Inspection and re-torque of the bearing retaining plate bolts to the required specification.
   3) Availability and replacement of O-ring seals.
   4) Verification and reporting of the centralised position and axial movement of the bearing in accordance to the applicable drawing dimensions.
   5) Axial spacing is performed by shimming the axial height of the bearing mounting interface relative to the top casing.

d) It should be noted that several incidents of excessive thermal expansion on shafts have occurred which caused the failure/damage of the shaft top-end taper and keyway, and requiring extensive repairs to the hub (The root-cause for these incidents is yet to be finalised). The recovery from such incident requires cautious planning and preparation of several important aspects as follows:
   1) Assurance of Rotor alignment prior to re-definition of the shaft centreline.
   2) In-situ repairs of the shaft taper – as one possible method of repair.
   3) Availability of the complete locating bearing.
   4) Availability of a complete bearing hub and housing assembly.
   5) Verification and possible repair of the condition of the shaft seals and seal landing on the shaft.
   6) Verification of possible repair of the sealing elements.

3.5.3 Main Support Bearing

a) The inspection and condition monitoring of the support bearing is important to prevent collapse of the bearing that will result in stoppage of the rotor and damage to the rotor and sealing systems.

c) The single layer angular contact tapered rolling element support bearing is oil lubricated via an oil bath surrounding and the condition of the bearing must be managed as detailed below.
   1) Weekly on-line assessment is required to monitor the general condition, oil level and signs of oil leakage.
   2) Oil condition sampling must be executed on 3-monthly intervals to identify possible abrasion-wear conditions.
   3) The bearing system is to be inspected for condition and cleanliness on 6-yearly intervals, and the oil sump to be checked for sediments and deposits. It may be required to replace the oil, especially when sediment or metal particles is observed, which may be indicative of bearing damage/failure developing.

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4) Bearings are subject to compulsory replacement on 12 yearly cycles – recertification and possible re-cycling of the bearings must be implemented to the applicable Eskom standard.
5) It must be cautioned that ill health of the shaft seal directly above the support bearing may lead to excessive heat-exposure of the bearing assembly.

d) The removal and re-installation of the support bearing requires the monitoring of several important aspects:
   1) Controlled blocking/supporting of the rotor in order to stabilise its location while removing the locating bearing.
   2) The use of a special rotor jacking mechanism provided as special tools, requiring the observation of special training and precautions in accordance to the stipulated maintenance procedures.

3.5.4 Shaft Seals

a) Shaft seals are located on each end of the Rotor just above/below each respective bearing, and must be monitored & reported for gap/clearance and tensioning, centralisation and possible shaft damage on 18-monthly intervals.
b) Shaft seal assemblies generally consist of upper and lower clamping rings with an intermediate sealed and floating ring, utilised for centralisation, and that forms the mounting interface for the adjustable sealing interface.
c) The Shaft sealing interface consist of compressible high temperature gland-packing materials, with an adjusting mechanism requiring an applied tension to obtain the required sealing gap.
d) The Gland packing is pre-tensioned and the increased tensioning gap, in accordance to stipulated drawing dimensions, must prompt for replacement and servicing of the seals and packing.
   i. The top shaft seal-tensioning device is set at a gap of 1.4 mm and is allowed to drift up to a dimension of 4.9 mm, whereby re-tensioning of the gland packing must be recommended.
   ii. The bottom shaft seal-tensioning device is set at a gap of 1.0 mm and is allowed to drift up to a dimension of 4.8 mm, whereby the re-tensioning of the gland packing must be recommended.
e) Irrespective of tensioning drift, the shaft seal gland packing tensioning device must be serviced and the gland packing renewed on 6-yeary GO intervals.
   i. Caution must be applied to monitor and report that the spring-pack of all tensioning devices render a pre-tensioned clearance of 6.2 mm.
f) Any signs of damage to the shaft seat must be reported for further assessment – damage in excess of 1 mm should prompt for a proposal to repair the sealing seat.

3.6 ROTOR SEALING SYSTEM

3.6.1 Rotor Radial Seals

a) Radial seals, attached to the Rotor-structure could serve a similar life as for the element packs and must be removed to facilitate element pack replacements
b) All radial seals must be must be inspected during every outage (18 monthly) for damage, wear and erosion and reported accordingly. Repairs must be carried out where required to ensure effective sealing is achieved:
   1) Radial seals are subject to abrasive wear through contact with the sealing interface, which is considered as normal wear. Possible out-of-flatness must be monitored and reported and wear of more than 5 mm should be considered for correction.
   2) Severe abrasive wear caused through abnormal impacts/wear on the sealing-contact area in excess of 3 x 20 mm must be repaired by means of welding.
   3) Cold-end Radial seals are also subject to erosion-wear through element-pack bypass-flow and severe wear must be repaired to prevent a disturbance of the sealing interface, together with actions to address the root-cause of element pack bypass flow.
   4) Sectional cut outs is permitted providing that level-surveys are controlled to achieve a flatness within 2 mm.

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5) Sectional cut outs of more than 50% of the total radial length is not justified, and should prompt for complete replacement.
6) Radial seal flat-bars are weld-attached to the Rotor radial & divisional plates with full fillet-welding on top and 30x130 space-welding on the bottom with cautions not to perform bottom-welding within 100 mm from the corners, in order to simplify removal.

c) It is normal practice to allow for a certain percentage replacement of the seals during interim outages (IR and mini-GO's) while a complete replacement of seals must be planned and executed in conjunction with Element pack changes, during major GO's.

3.6.2 Axial Seals

a) The Axial sector plate – located on the two opposing gas/air sector separations are cold-set and the setting is optimised at 100% MCR operation. Setting is achieved by means of a quantity of 6 fitted spring tensioned adjusters.
b) The Axial sector plate sealing surface must be inspected during every 18-monthly outage for signs of damage, and erosion-wear. Visual inspection is performed from the inner peripheral gaps – especially on the CE gas-sector side, while it must be cautioned that wear could be exaggerated towards the invisible inner width. Visual inspection in the mid-axial areas (between HE & CE) must be accessed via the bypass area.
    1) Extended inspections on the axial seal – retractable axial-seal inspection door with adjustable plunger and stainless steel leaf-type seals – must be executed on 3-yearly intervals for a proper assessment and repair of the axial-plunger.
    2) Wear must be assessed by means of a 250 mm grid of measurements executed with the aid of a straight-edge in the axial orientation and a curved templet in the circumferential direction.
    3) Worn surface revealing a disturbance of curvature of more than 5 mm must be repaired in order to secure reliable operation of the axial-seal with effective sealing.
        i. Sealing surface irregularities must be repaired by welding and proper profiled grind-trimming of the surface.
        ii. Erosive wear rates for the axial sealing surface is unknown, and if found to be severe – requiring 3-yearly weld-repairs, the use of wear-liners must be considered.
        iii. The replacement intervals for the leaf-type plunger seal is unknown and replacement seals should be on standby with 3-yearly outage intervals.
c) The condition of the adjustable axial sealing plunger suspension-rod and leaf-seals must be executed through the provided inspection hatches on 18-monthly intervals.
    1) In the event of consecutive zero-report of defects, the inspection interval may be re-scheduled for 3-yearly intervals.
    2) The requirements for vertical adjustment of the plunger from the suspension rods in accordance to the OEM stipulation, must be observed when replacing the Axial seal assembly.
d) The requirements for cold setting must be observed and verified in accordance to OEM requirements.
e) The requirements for hot setting is detailed in the applicable section for "Seal setting" below.

3.6.3 Circumferential Seals

a) Circumferential seals are constructed of multiple layers of stainless steel leafs (leaf-seals) and are suspended from a housing mounted adjustable frame.
b) The Circumferential seal consist of two layers of overlapping sealing leafs with stiffening backing plates on both sides.
    1) It should be noted that the top & bottom seals are different in size.
    2) A further observation is that the Primary sector circumference is fitted with an expansion sleeve-seal – thus is does not have a circumferential seal.
c) All circumferential seals must be inspected during every 18-monthly outage for damage, wear and erosion and the information recorded on an inspection sheet for future reference and maintenance planning.

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1) Wear limits to be considered for rectification of the sealing gaps, as a rule of thumb is a 10 mm increase on the cold-set gap.

d) It is normal practice to allow for a certain percentage replacement of the seals during interim outages (IN's and IR's) and a complete replacement of seals must be planned during 6-yearly GO's.

e) Repairs – replacement of damaged sections – must be carried out where required to ensure effective sealing and reliable operation of the air heater.
   1) Erosion damage of seals is experienced due to leakage past the axial seals on the gas/air sector separations, requiring on average a replacement of 10% of the circumference.
   2) The Circumferential-seal attachment interface and adjusters in the affected areas may also require to be replaced during interim outages due to erosion damage.

f) The complete replacement of Circumferential-seals must be performed in conjunction with the Rotor circumferential liner repair and the following controls must be implemented:
   1) While the replacement of seals should not require adjustment of the setting devices, the verification of the cold-setting gaps is mandatory.
   2) The Installed leaf-seals must be adjusted in accordance with the specified "cold-setting" gaps as detailed on the relevant OEM drawings and adjusted gaps must be recorded and verified in accordance with QCP requirements.
      i. It should be noted that the cold-set gaps are different between top/bottom as well as between air/gas segments.
      ii. The tolerance on the setting of seal-gaps could be ±2 mm.
   3) Note that the setting devices are locked by means of weld-tacking on the bolts, requiring the replacement of the setting-device bolts, which is verified in accordance to QCP requirements.
   4) A further observation must ensure that the overlaps between sealing plates and backing plates as such that no leakage gaps are evident.

3.6.4 Radial Seals (Sector Plate)

Radial seals provide the sealing interface between all sectors on both the Hot End and Cold End sides and in parallel provides the adjustable sealing interface to the Rotor. The seals generally comprise of the sealing frame – attached to the Air Heater housing by means of an expansion mechanism – and an adjusting mechanism.

3.6.5 Sealing Frames

1) Solid-beam Seal frames – commonly known as sector plates – provide the sealing interface between each respective gas/air sector and must be visually inspected with every outage opportunity for damage and erosion and the information recorded on an inspection sheet for future reference and maintenance planning.
2) The inspection of the sealing frames and the attached expansion sealing interfaces require the removal of cover plates – provided to protect the expansion sleeves.
3) The Sealing frame attachment rods and linkages must be inspected for secure attachment and require recorded verification for each rod in accordance with a QCP intervention.
4) Excessive settlement of ash – layers in excess of 50 mm – on the sealing frame must be reported and cleared.
5) Sealing frames damaged through erosion is abnormal and requires root-cause investigation. The rectification of damage requires the verification of the following norms:
   a) The bolt-on interface for cast iron wear seals must be flat and verified within 2 mm of each meter distance.
   b) The total variation of flatness across the radial length of the frame may not exceed 4 mm.
6) The bolt-on interfaces for the CIWS must be sealed with the use of a high temperature-resistant sealant and require a verification of cleanliness and positive sealing during application.
7) Seal frames are adjusted to stipulated clearances relative to the Rotor during installation. The accurate setting of gaps must be recorded and verified on a QCP intervention.

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8) Prior to the re-fitting of Sealing frame cover plates requires a verification of the conditions noted above and thus require a recorded intervention on the QCP.

3.6.6 Stainless Steel Sleeve Compensator

1) Stainless-steel bellows/sleeve type compensators have been fitted in all areas surrounding the sectors that operate under positive pressure – Secondary sector 1 & 2 radials only and Primary sector all-round.
   i. The Secondary/gas radial sector-plates have been provided with cover-plates on the entire flank of the sector-plates and is required to be removed for inspection & repairs on 3-yearly intervals.
   ii. The Secondary/Primary radial sector-plates have been provided with cover-plates on both sides and is required to be removed for inspection & repairs on 3-yearly intervals.
2) The compensator facilitates movement of the sealing frame, and is sensitive to correct sealing installation, weld-arc damage and particularly erosion damage. The compensator has a reliable expected life of 6 years providing that the correct installation and peripheral component maintenance is thoroughly performed.
3) Seal frame, installation or operational deficiencies could result in the requirement to repair/replace up to 50% of the Primary-sector surrounding on 3-yearly intervals.
4) In the case of repeat failures on short intervals, it is advisable to conduct detailed inspections on visible areas during 18-monthly inspection interventions.
5) Failures must be carefully inspected, analysed and corrective methods proposed in order to re-instate the normal 6-yearly life cycle. Typical failure modes to be identified (and potential repair/remedies) are:
   i. Ash erosion as a result of normal gas-side flow, resulting in the “thinning” of the material. Chronic localised erosion of this type must be treated with an increase of material thickness or flow deflector plates. This failure mode is prone to the Primary sector periphery.
   ii. Localised erosion as a result of installation deficiencies like leakage/cracking. Chronic localised erosion of this type must be treated under emergency by overlapping an add-on insert on the INSIDE of the compensator and sealed with high temperature silicone. Longer opportunities require replacement of the damaged sections.
   iii. Localised erosion as a result of incorrect penetration/overlap on the joints. This is an installation defect and must be addressed/prevented by means of training and quality inspection. Penetration/overlap is required to be a minimum of 30 mm.
   iv. Localised cracking as a result of fatigue cracking due to incorrect cold-setting resulting in excessive “crushing” of compensator sections. This failure mode must be addressed with a review of the seal-frame installation.
6) The compensator is clamped onto the seal frame with a webbing-seal interface:
   i. The clamping L-shaped and flat plate-pairs are re-used with replacement clamping bolts – bolts are weld-tacked to prevent loosening.
   ii. The cutting of clamping-bolts is executed by skilled personnel, and damage to adjacent components is not acceptable.
   iii. The webbing-seal interface is to be properly secured to each respective frame by gluing with contact adhesive.
   iv. Clamping position is secured by pre-determined lugs attached on the stainless-steel sleeves and are retained in accordance to the original design to prevent clamping n a way that may cause cracking or fouling with the movement of the frame.
7) Fitting of the correct joints and lengths to drawing is mandatory in order to reduce the probability of failure.

3.6.7 Cast Iron Wear Seals

1) Wear monitoring and expected wear life of seals is normally in excess of 6 years, providing that seal setting and Operational conditions are correctly optimised/managed.

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2) Seals are generally set and operated in the 'non-contact' mode, leading to the reality that if wear is encountered, there should be a root cause analysis to correct the reasons for wear through the evaluation of several setting and wear features such as:
   i. Cold gaps between seals and Rotor.
   ii. Seal wear.
   iii. Hot End setting gaps
   iv. Rotor flatness – TIR
3) The mapping of the above measurements must point out through analysis how the deficiency was caused and must be corrected through control of re-setting.
4) The re-setting of seal gaps where seals have bedded-in is generally discouraged, as further wear should not incur, while wear beyond acceptable limits justifies correction.
5) Other reasons for wear would be due to erosion and incorrect installation.
   i. Localised erosion on the seals surrounding the high-pressure Secondary sectors would be normal, and may require limited replacement on 3-yearly intervals.
   ii. More severe erosion on the seals surrounding the highly-pressurised Primary sector requires some repair remedy on 3-yearly intervals. Some remedies relating to the severe erosion in this area must be managed with recognition of the following important aspects:
      - Seals MUST be operated through engagement on the 70% MCR, and failure to achieve this condition must be treated as critical requiring immediate remedy.
      - The current tendency of the machine to transfer ash within the element packs through to the Primary sector accelerates the rate of erosion – especially once larger than normal gaps/clearances are created – thus continued operation under such conditions must be avoided.
      - As a temporary measure, hardened wear seals are fitted to the Primary sector periphery – this stipulation requires more detailed management of the correct spares/stock.
      - A peripheral casing liner must be installed and managed in order to prevent rupture of the casing, however it must be cautioned that the liner should not provide a false sense of comfort to persist with incorrect operating practice – accelerated ash particles have the tendency to deflect and transfer erosion further downstream.
   iii. Erosion damage of hub seals should be minimal, providing that the seal-setting is correctly executed & analysed and shaft-seals are correctly set & maintained.
   iv. Erosion damage of other radial seals should be minimal, providing that the seal-setting is correctly executed, and the seal-setting system is functionally applied – Excessive operation below the seal-activation threshold (approx. 70% MCR) results in severe deterioration of the condition of the seals and should be minimised.
   v. Caution must be applied when inspecting seals for thickness and erosion damage – seals often erode more on the inner flat surface, while the outer visible edges appear to be in good condition. Any signs of deeper erosion justifies a requirement to remove the periphery seals for inspection.
6) Seals reaching a wear-condition below 15 mm is to be recommended for replacement. The minimum thickness is determined as a function of:
   i. Reduced thickness and the possibility of incurring further loss of thickness through the next period of operation.
   ii. The threaded attachment integrity with approximately 50% of original thickness should be maintained throughout the operational period.
   iii. Additional caution must be applied to control settings in order to prevent further wear.
   iv. Generally, seals that have bedded-in should not incur further wear, thus requiring some consideration not to change settings.
7) The partial replacement of damaged seals require the control of several important installation features and must be monitored and recorded through mandatory Quality interventions:
   i. New seals added to existing worn seals require a controlled step-down of seal thickness of not more than 3 mm to adjacent seals – this requirement is achieved through the use of previously worn seals of through machining of new seals to the required thickness.

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ii. The Sealing-frame flatness (mounting interface) is to be controlled prior to the fitting of seals, in accordance to norms stipulated under the Sealing frame section.
iii. The CIWS interface with the Seal-frame is adequately sealed with a high temperature sealant.
iv. The correct bolting configuration must be adhered to and must be verified through controlled intervention.
v. CIWS element installation gaps are set to 1 mm, with severe risk of erosion damage if larger gaps are allowed, and must be verified through controlled intervention.
vi. Seals for leading edges are installed with a machined chamfer facing the leading contact surface and must be verified through controlled Quality intervention.

3.6.8 Top Sector Plate Control Devices (Radial Auto Adjustable)

1) The Top Seals are Cold-set to provide a defined gap relative to the stator against a calculated seal-setting schedule, considering the following affected components and parameters that are recorded for inspection:
   i. Seal gap – physical gap between the seal and undamaged/straight stator surface.
   ii. Seal wear – to interpret the effect of previous adjustment and/or operating conditions.
   iii. Adjusting rods with adjusting interfaces correctly configured and locked.
   iv. Adjusting stop-nuts retracted to provide for the setting of appropriate travel & stop positions (allowance for setting-rod travel or to 'seat', which is adjusted during hot setting).
   v. Spring-rod gland – compacted to seal against leakage but allow free-movement of the rod and with a 5 mm available compression adjustment.
   vi. Adjusting nut gag-fork – locked in position after hot setting to prevent setting-nut rotation.

2) The execution of any work on the Setting of springs require a review with both Contractor and Eskom Engineering on the latest configuration of the setting schedule available from the Employer Draught Plant System Engineer.
3) Seal setting rods, springs and nuts could last for the life of the machine, if not damaged by ash-erosion or human intervention. The HE Hub-spring & tension devices have not been found to collapse under normal operating conditions on other Air heaters, but can be scheduled for confirmation on 24 month cycles.
4) Springs/rods and internal connections to the sector plate must be monitored for erosion damage and replaced if evident.
5) Root-cause analysis and remedial action is required when springs/rods are damaged by erosion.
6) All Spring-rods are extended through the Air heater casing and are fitted with a sealing mechanism - the gland-seal packing rings must be maintained as follows:
   i. Inspected for sealing on 18-monthly intervals, with the option to tighten the gland-follower – caution must be applied against over-tightening that will prevent normal movement of the setting-rods.
   ii. Gland-follower tightening must be reviewed in operation on 6-monthly intervals.
   iii. Gland packing must be replaced on 3-yearly intervals to prevent ash-leakage in this area – the seals are configured as individual rings with angle-cut ends.
7) Spring rods must be aligned with protrusion cavities in mounting brackets in order to prevent rubbing-contact that could foul normal movement, and if not correctly installed should be reported.
8) Setting or re-setting of Seals and Rods must be accompanied by an "as-set" recording sheet and require a 100% quality verification.
9) NOTE: It is not standard practice for Seals/springs to be re-adjusted after an operating period. Nut gaps on the spring rods actually blocks the downward movement of the seal frame, thereby preventing any wear more than the bedding-in allowance of 3 mm. Obvious signs of exaggerated wear require further investigation and contributing factors to abnormal wear are as follows:

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i. Incorrect initial setting – not adhering to the setting and verification requirement.
ii. Abnormal operating periods during start-up and Single Draught Capability operation – The Engineer with maintenance team should be sensitive to such occurrences, and take action to monitor and adapt seal frame settings.

10) CAUTION: Any re-setting of seals after an operational period must be approached with appropriate analysis and care:
i. Analysis of wear or failure condition with a written engineering instruction for re-adjustment.
ii. Analysis must incorporate the verification of correct installation of articulation joints, thermal compensator operation, previous nut-gap allowances and abnormal operational conditions.
iii. Normal wear re-adjustment should ONLY require a re-seating allowance – thus a 3 mm re-adjustment of the nut-gaps.
iv. Note: Consistent or repeated wear patterns must be analysed and lead to a review of the Seal-setting schedule. It should however be noted that most abnormal wear conditions are the result of incorrect installation and setting.

3.6.9 Top Sector Plate Control Devices (Hub Fixed)

1) The Top Hub-seals are Cold-set to provide a defined gap relative to the stator against a calculated seal-setting schedule, considering the following affected components and parameters that are recorded for inspection:
i. Seal gap – physical gap between the seal and undamaged/straight stator surface.
ii. Seal wear – to interpret the effect of previous adjustment and/or operating conditions.
iii. Belleville Spring-pack height – measured length excluding the spring seats and with defined packing configuration.
iv. Nut gap and locking mechanism – zero allowance for spring-rod travel or to ‘seat’.

2) The execution of any work on the Setting of springs require a review with both Contractor and Eskom Engineering on the latest configuration of the setting schedule available from the Employer Draught Plant System Engineer.

3) Spring rods must be locked in position to prevent in-operation changes of setting by positive verification of tightened lock-nuts and correctly secured R-clips.

4) All Spring-rods are extended through the Air heater casing and are fitted with a sealing mechanism - the gland-seal packing rings must be maintained as follows:
i. Inspected for sealing on 18-monthly intervals, with the option to tighten the gland-follower – caution must be applied against over-tightening that will prevent normal movement of the setting-rods.
ii. Gland-follower tightening must be reviewed in operation on 6-monthly intervals.
iii. Replaced on 3-yearly intervals to prevent ash-leakage in this area – the seals are configured as individual rings with angle-cut ends.

3.6.10 Bottom Sector Plate Control Devices (Radial & Hub Fixed)

1) The Bottom Seals are set with a large gap between seals and stator with a calculated allowance for the stator to cap “into” the seals to form a tight seal during 100% (MCR) load conditions. The minimum requirements for monitoring of settings are:
i. Spring length (pre-tension) – measured excluding the spring seats.
ii. Seal gap – physical gap between the seal and (undamaged/straight/flat) Rotor surface.
iii. Adjusting rod protruding length with position indicator.
iv. Seal wear – to interpret the effect of previous adjustment and/or operating conditions.

2) The execution of any work on the springs and Setting require a review with Engineering on the latest configuration of the setting schedule.

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3) Seal setting rods and springs could last for the life of the machine, if not damaged by ash-erosion or human error. No CE deficiencies on spring tension have been found under normal operating conditions, but can be scheduled for confirmation on 24 yearly cycles.
4) All other conditions and requirements stipulated under the section for the TOP Springs and Setting-rods above shall apply to the BOTTOM Springs and Setting-rods.

3.6.11 Hot Seal Setting

a) Radial seals Hot End (70% load)
   1) The setting and operational principle applied for seals entail the following:
      i. Settings must be executed and/or verified after each 18-monthly maintenance intervention.
      ii. Cold-settings are executed to position seals in close proximity and readiness of final setting, requiring minimised adjustment with hot-setting.
      iii. Hot-settings facilitates adjusting the seals into close contact with the Rotor sealing interface – with possible/minimised bedding-in of seals, while monitoring minimised increase on motor drive amps.
      iv. Seals are ultimately mechanically retracted to provide a 3 mm contactless gap with the Rotor at 70% load.

   2) The submission and verification of a cold-set adjusting schedule is mandatory before effecting cover-closure and declaring readiness for hot-commissioning, covering the following aspects:
      i. Physical cold-set gaps.
      ii. Control-rod tie-down verification.
      iii. Control rod length adjusting mechanism locked in appropriate manner.
      iv. Control and verification of complete thermal insulation on the HE-setting areas.

   3) Hot setting is executed with proof of an approved procedure detailing and recording all critical steps and controls required for effective control of the task. The procedure shall cover the following aspects as a minimum (and not limited to):
      i. Evidence of previous setting gaps as a norm.
      ii. 24-Hour soaking of the heating elements – recorded times.
      iii. Sequenced lowering of the Sector frame, while considering several iterations surrounding the Primary sector frames.
      iv. Monitoring and recording of the drive-motor amps and unit loading.
      v. 72-Hour monitoring of settings, vibrations and drive-motor amps.
      vi. Controlled verification of applying locking devices.
      vii. Controlled verification of condition and leakage on adjusting-rod gland packing's & followers.
      viii. Controlled verification of setting devices feedback positioners (C&I).
      ix. Repeat testing and verification of movement on each respective adjusting device.
      x. Submission of completed schedule with final gap setting for Engineering evaluation and acceptance.

b) Axial seals (100% load)
   1) The setting and operational principle applied for seals entail the following:
      i. Settings must be executed and/or verified after each 18-monthly maintenance intervention.
      ii. Cold-settings are executed to position seals in close proximity and readiness of final setting, requiring minimised adjustment with hot setting.
      iii. Hot-settings facilitates adjusting the seals into close contact with the Rotor sealing interface – with possible/minimised bedding-in of seals, while monitoring minimised increase on motor drive amps.
      iv. Seals are ultimately mechanically retracted to provide a 3 mm contactless gap with the Rotor at 100% load.
      v. The auto adjustment system is tested to retract the Axial seal frame under emergency shutdown and/or single draught capability conditions.

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2) All aspects relating to the preparation as applicable to the cold-set verifications for the radial seals above apply.
3) All aspects relating to the procedural execution as applicable to the hot-set verifications for the radial seals above apply.

c) Radial seals Cold End (100% load)
1) The setting and operational principle applied for seals entail the following:
   i. Settings must be executed and/or verified after each 18-monthly maintenance intervention.
   ii. Cold-settings are executed to position seals in close proximity and readiness of final setting, requiring minimised adjustment with hot setting.
   iii. Hot-settings facilitates adjusting the seals into close contact with the Rotor sealing interface – with possible/minimised bedding-in of seals, while monitoring minimised increase on motor drive amps.
   iv. Seals are ultimately mechanically retracted to provide a 3 mm contactless gap with the Rotor at 100% load.
2) All aspects relating to the preparation as applicable to the cold-set verifications for the radial seals above apply.
3) All aspects relating to the procedural execution as applicable to the hot-set verifications for the radial seals above apply.

d) CAUTION:
1) The continued operation of a unit below the 70% seal-activation threshold must prompt for mitigating mechanisms to avoid severe erosion-damage due to ash-erosion leakages. Typical considerations could be as follows:
   i. Re-commissioning of seals at a lower load threshold – this mitigation requires close Engineered controls, and a re-commissioning when the normal loading is re-instated.
   ii. Severe consequences for delaying the hot-setting operation are similar to the non-engagement consequences as detailed below.
2) Non-engagement of seals with the unit loading above the 70% seal-activation threshold must prompt for emergency action in order to avoid severe erosion-damage due to ash-erosion leakages. Erosion patterns escalate uncontrolled into unprotected areas such as the following:
   i. Peripheral casing – lined and unlined areas.
   ii. Primary sector plate damage requiring replacement of major sections.
   iii. Permanent and costly damage to the Rotor circumferential sealing interfaces.
   iv. Peripheral sleeve compensator – unprotected.
   v. Pin-rack wear due to excessive bypass leakage and accelerated velocities.
   vi. Excessive Hot-Primary heat emissions into the bypass area with definitive effect on pin-rack life.
   vii. Axial seal and sector plate dust cover wear due to accelerated flow towards the lowest point of pressure.
   viii. Circumferential seal wear due to accelerated flow towards the lowest point of pressure.

3.7 SOOT-BLOWER SYSTEM

The soot-blower system is described as a semi-retractable lance, and is installed on both the HE and CE-sides of the heater, inside the gas-sectors. The system requires frequent operational monitoring and maintenance intervention on various levels. The effective operation and care for the soot-blower system is covered under the following aspects:

a) Correct operational application.
b) On-line monitoring.
c) On-line repairs.
d) Off-line maintenance.

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3.7.1 Operational Application

a) The Operator-activation of the Soot-blowing sequence is mandatory on at least a 12-hourly basis, and failure to execute this requirement must be alarmed and treated with emergency response.
b) Failure to activate the Soot-blowing sequence leads to irreversible operational blockage of element packs and ultimate reduction of operational capacity.
c) Severe increase of the Air Heater element pack pressure drop can be countered with an increase of activating the Soot-blowing sequence on 8-hourly basis.
d) The rectification of component failures must be treated as urgent, thus a culture of not experiencing immediate load losses must not lead to the acceptance of deficiencies for extended periods.

3.7.2 On-line Monitoring

a) The effective operation of the soot-blower system must be monitored through weekly inspections and witnessing of operation, covering the following monitoring aspects that are to be recorded and reported to the applicable Supervisor, while any deficiency that affects availability or signs of internal damage that implicates scope of work changes must be elevated to the responsible Air Heater Engineer:
    1) Monitoring of the steam supply pressure reducing station.
    2) Steam supply pressure and temperature conditions.
    3) Operational insertion and retraction movement.
    4) Audible response during blowing.
b) Weekly blowing sequence irregularities must be assessed and reported for analysis to the applicable system Engineer.

3.7.3 On-line Repairs

a) Any deficiency on the external insertion/ retraction drive and steam supply system is repairable while the Air Heater is on load.
b) Detected malfunction or failures must be reported dealt with as urgent repairs.
c) The pipe through casing must also be inspected and repaired to ensure minimal gas leakage.

3.7.4 Off-line Maintenance

a) Comprehensive inspections must be executed during every 18-monthly plant shutdown Inspection, and the pre-planning and availability of spare parts is essential.
b) Internal damage mechanism must each be addressed in accordance with operational conditions, and requires detailed analysis with the view of life-cycle design:
    1) Steam supply operational damage
        i. The nozzles must be inspected on each outage to ensure that they are in good condition. Specific attention must be paid to the cold end nozzles as they face the gas stream directly and are more prone to erosion damage.
        ii. It is recommended to use a “go/no-go” gauge supplied by the maintenance/service provider to do a general inspection of the nozzles in conjunction with a visual inspection to check for concentrated ash or stem erosion.
        iii. Generally wear of nozzles up to 3 mm oversize should prompt for replacement, and depletion of condition before a 6-yearly service interval must prompt the use of replaceable hardened nozzles.
    2) Erosion damage through adjacent plant deficiencies and erosion damage through flow-path exposure justifies similar responses:
        i. The internal lances are subject to erosion and must be covered with adequate erosion protection.
        ii. Root-causes for adverse erosion must be analysed and addressed as first approach to reinstate the intended service life-cycle.
        iii. Erosion wear must be recorded and marked up on a detailed inspection sheet with the purpose of tracking and analysing trends & effectiveness of protection mechanisms.

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iv. Guidelines for the use and fitment of erosion protection elements is detailed in the applicable section for “Erosion protection” below.

3) Operational movement
   i. The external insertion and retraction gear must be lubricated and assess for damage on every 18-monthly inspection interval.
   ii. Sliding damage to the internal transport rail – should be minimal, but progressive signs of wear must be monitored and analysed.
   iii. Slide-path wear in excess of 5 mm should invite a decision to repair, while it must be observed that no rapid step-changes on the flatness of the slide-path is permitted.
   iv. Lance to casing seal – acting like a stuffing box – must be assessed to eliminate air ingress and/or adverse loading on the drive-motor.
4) External steam control pilot valve
   i. Pilot valves must achieve a service life of minimum 6 years, after which it requires a full refurbishment of seat and seals.

c) Replacement repairs.
   1) New installations require the control & recording of nozzle distances from element packs
   2) Nozzle-headers must be engineered for individual replacement.
d) Commissioning.
   1) Every maintenance intervention justifies the testing of movement under cold conditions on 18-monthly intervals, specifically evaluating the following aspects:
      i. Freedom of movement
      ii. Setting of travel distances with control limits
      iii. Alarming conditions

3.8 FIRE DETECTION AND PROTECTION SYSTEMS

3.8.1 Fire Detection System

a) Internal to Air Heater components is the temperature measuring thermocouples with erosion protection shields. These thermocouples require 3-yearly maintenance and inspection.
b) Installed locations must be identified for the potential 3 target monitoring areas:
   1) Flue Gas Inlet
   2) Flue Gas Outlet
   3) Hot Air Outlet
c) The thermocouple protection shields and added erosion protection require specific attention as follows:
   1) Erosion protection design must not be overly elaborate - shielding should allow the thermocouple to sense the heat without significant delay. An up-stream screen with “open” downstream thermocouple shield ensures sufficient exposure.
   2) The length of the erosion/protection tube must be aligned with the standard installation protrusion in order to ensure maximum wear-life for the probe.
d) Systems with “local” temperature indications are monitored for functionality of measurement accuracy and alarm-activating relays should be tested on 18-monthly intervals.
e) In terms of Air Heater Fire Protection requirements of the FFFR, the Unit start-up temperature deviations must be incorporated into alarming functions and requires intensive monitoring during start-up.

3.8.2 Fire-Fighting Water Supply Piping

a) The Fire-fighting water supply system (incorporating the “deluge valves”) up to the Air Heater casing is maintained by “other” contractors/maintenance service providers, but it remains the responsibility of the Air Heater maintenance team to ensure correct functionality is tested and declared before returning the air heater to service.
b) External water supply pressure control and isolation valves are subject to failure (leakage) and such incidents occurring during Unit/Air Heater operation can go undetected. The fitting of a leakage tell-

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tale valve – downstream from the main valves – is recommended, and is to be monitored during operation on a daily basis (and condition recorded on the operating daily check sheets).

c) Internal water supply piping is guided through the ducting and must be inspected for erosion, and suitably protected if erosion is evident.

3.8.3 Fire Water Nozzles

a) Air Heaters are generally fitted with a distribution network across the element matrix with nozzle-placement which will effect coverage of the entire surface with spray-water when the system is activated.
b) It is important to inspect the system for erosion, blocked nozzles and damage during every outage.
c) In situations where the water-supply network was ruptured through erosion, a thorough flushing control procedure must be executed.
d) Erosion patterns must be recorded and added to the Air heater Data Book to ensure planning for material can be done for future outages.

3.8.4 Casing Drainage for Fire-Fighting Water

a) All Air Heaters must be fitted with bottom transition duct drainage points, which require evaluation of function and cleanliness during outages:
    1) Air-side drains admit water into ducts and fan casings, which are required to be tested and maintained during 3-yearly outages in order to secure correct functioning with on-line activation
    2) Gas-side drains must be evaluated for tendencies to block during operation and action plans must be developed to keep drains clear in order to prevent drainage failure with water carry-over into the ash-removal plant if/when fire-water is activated during operation.
    3) Emergency drains are installed, requiring maintenance & testing during 3-yearly outage interventions.

b) Observation of a tendency of these drains to block must be reported, to initiate a process for rectifying the design.

c) It is recommend that the water must be directed to the FFP basement area which has a dedicated ash-removal design as the washing water is very muddy and should not be ducted into the Stations drains systems.

3.8.5 Fire-Fighting System Hardware Testing

a) Functional testing of the Air heater Fire-fighting system is mandatory and is executed during element pack washing events. In cases where air heater washing is not planned/done, minimum 6 yearly testing must be scheduled.
b) During testing, the following aspects are specifically verified:
    1) Internal inspection for missed points of wetting.
    2) Function testing of isolating valves to ensure that that they fully isolate. This is done manually
    3) Correct functioning of pressure controlling “deluge” valves.
    4) Verification of nozzle function and cleanliness.
    5) Verification of drainage system function (if not tested though the execution of water washing).
c) Compulsory system testing must be scheduled as part of Outage SOW.

3.8.6 Fire-Fighting Procedure and System

a) Each individual Power Station must possess a dedicated Fire-fighting procedure, identifying the required reporting, management and activating points.
b) Maintenance crews are to familiarise themselves with the content, specifically on reporting requirements and water-activating points.

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3.9 EROSION PROTECTION

3.9.1 Identification and Control of Erosion Areas

a) Erosion protection is one of the most important maintenance aspects on Air Heaters, with a continuous effort required to improve and expand the list and design of protection areas.
b) Inspection of all areas subject to erosion is facilitated through a detailed check-sheet. This check sheet is used to capture the exact recording of the existing wear-condition and effectiveness of protecting elements, and replacement recommendations are made and executed in accordance to recordings.
c) Visual inspection is executed on erosion areas during the initial walk-through assessment, with a follow-up ultrasonic thickness verification where applicable, in order to table a complete scope of work during the Outage Scope review meeting.

3.9.2 Minimum Reference List of Known Repair Areas

a) Transition ducting Gas inlet & outlet areas with a focus on points with flow-direction changes.
b) Transition ducting periphery for Hot Secondary & Primary sector air outlet areas, with a focus on points with flow-direction changes and particularly above sector plates of rotational leading edges.
c) Transition ducting roof for Hot Secondary & Primary sector air outlet areas, with specific focus above sector plates of rotational leading edges (HE sides).
d) Primary sector seal-frame on HE sides.
e) Periphery casing especially surrounding the Primary sector.
f) Periphery sleeve compensator surrounding the Primary sector.
g) Axial seal plunger with interfacing sector plate sealing area.
h) Sector plate ends with dust-protection plates for all ends on HE & CE sides.
i) Element pack supports damaged through element pack bypass leakage on CE sides.
j) Rotor radial seals damaged through element pack bypass leakage on CE-side.
k) Soot-blower lances in flue gas HE & CE sides.
l) Fire protection piping and nozzles.
m) Fire detection thermocouples.
n) Air Heater leakage monitoring instruments.

3.9.3 Repair of Eroded Areas

a) The design of protection elements must have the goal to prevent erosion of structural elements or other components, for a minimum 3-year outage interval period, and where possible (and more desirable) to enable wear protection that protect elements for the full period between major 6-yearly Outage interventions.
b) The designed/proven repair methods and recommended materials are documented on drawings for each power station air heater design. The following design/selection aspects are considered:
    1) Flow-directional installation, and where multi-directional (turbulent) flow is encountered, the use of a side/flanking plate is recommended.
    2) The protection element selection is installed close to the protected member with maximum 20% size overlap (e.g. a 100 mm diameter pipe has 120 mm wide protection element).
    3) The use of inverted channel-iron sections is preferred, for offering partial flank protection.
    4) Large diameter members protected with flat-plates are subject to “eddies-flow” and protected members may get damaged anyway with rapid depletion of width.
    5) High erosion rates are countered with the use of thicker materials – an alternative would be to rather use exotic materials to ensure that the desired wear-life can be achieved.
    6) Overlay (patch) repairs are used where repeatable erosion patterns occur, this would be required in areas where frequently replaceable protection layers will provide the most feasible solution.
    7) Insert (window) repairs are used when the original structure was damaged, either through slow undetected erosion or failure due to delayed repairs of the overlay protection layers.

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8) As far as possible – erosion caused due to bypass-leakage should not only be addressed through protection elements installation, but also through performing root-cause analysis to eliminate causal factors.

c) Drawings will list the type and maximum quantity of materials required.

d) Attachment and weld-quality is of utmost importance, as detached elements can result in major damage to plant. The following aspects are to be considered:
   1) Weld quality is managed to the required standard and a Weld Procedure Statement shall be in place for all repair work performed. Weld quantity is established to prevent detachment through erosion.
   2) Direct welding onto protected members is preferred with weld-position such that the welds are not subject to erosion.
   3) Welds are to be positioned in such a way so as not to overly complicate removal/replacement of protection elements.
   4) For relatively large piping members (>120 mm), the use of 30x30 mm angle-iron supporting brackets is recommended.
   5) For attachment onto complex materials – such as the Soot-blowing system – the use of clamp-on designs is preferred.

e) The protection elements do not consist of multiple (loose) plates attached with space-welding – continuous elements/plates are used or joined with full-penetration welds, This is a strategy deployed to reduce the risk of dislodged eroded sections causing damage to the Air Heater internals.

3.10 INSTRUMENTATION

Reference should be made to the Draught Plant “Minimum Protection Requirements” applicable to Air Heaters.

The purpose of listing the critical instrumentation is to:

a) Compile a Draught Plant RTS (Return to Service) procedure covering critical instrument verifications to ensure reliability.

b) Guide the Operating and Maintenance Engineers regarding the purpose and application of the provided instrumentation.

Air Heater maintenance personnel are required to comply to the test and verification requirements for air heater instrumentation to ensure the accurate functioning of all control and protection instrumentation. Instrumentation plays a vital role in assisting the system engineer to monitor the condition and do performance assessment of the air heater.

3.10.1 Process and Protection Instrumentation

a) Oxygen content control – While this measurement falls outside of the Air Heater scope, it is an important field instrument to verify and maintain, as it is used in conjunction with the outlet Oxygen increase measurement to report on Air Heater leakage. Incorrect oxygen measurement can cause critical boiler failures or costly increase to Fan power-consumption and is always used in conjunction with pressure-drop analysis.

b) Rotation failure measurement must be verified for suitable protection and stable performance, as the heavy mechanical maintenance works can damage critical field instrumentation installed on the rotating elements.

c) Fire detection thermocouples – erosion protection details were stipulated with re-commissioning to verify correct installation, protection and operational functionality is achieved.

d) Lubrication system pressure/flow/temperature indications must be operational at all times – inherent critical verification is required during recommissioning. This is vital to prevent spurious trips or possible component damage.

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e) Dew-point control is dependent on condition monitoring temperature instrumentation. Erosion protection and accuracy verification is important – incorrect dew-point control and faulty instrumentation presents no direct load loss, but is a “silent killer” as moisture results in air Heater blockages resulting in major load loss costs.

3.10.2 Condition Monitoring Instrumentation

a. Motor drive amps – This is the most important monitoring aspect for seal setting and emerging problems, thus verification of operation is critical. Increases in current is generally indicative of increased friction at seal surfaces or motor electrical/failure conditions.

b. Temperature indicating process parameters – are important indicators to flag possible upstream process variations that affect Air Heater performance. The temperatures are also used for back-end temperature (dew point) process control.

c. Pressure indicating process parameters – are important for the sole purpose of element pack health monitoring and trending and flags other deficiencies and/or planned maintenance requirements. Continued operation with blocked element packs causes major life-affecting damage to element packs and air heater rotor structure and must be avoided.

d. Outlet oxygen measurement – This is for the verification of “on-line” leakage, and affects analysis of root-cause for process changes that may be required to address the problem.

4. SPARES AND MANAGEMENT OF SPARES BOM

a) Management of Spares requires the dedicated effort to continual improvement the accuracy and extent of the details, in order to secure effective execution of maintenance strategy for the air heaters.

b) Spares lists are to be structured in accordance to plant layout (as per approved plant breakdown structure) and headings.

c) Spares availability cannot be measured and managed on main items alone. The success of Spares management lies in the provision of accurate details and availability of each spare-able item.

d) Due to the unpredictability of scope on high-wear plant equipment and components, resulting from operational changes, prolonged operational periods, and the inter-related effect of failures, spares-holding and bills of material must be complete – meaning for the maximum scope applicable to the scheduled outage. Partial stock-availability will result in partial repairs, with a spiralling decline in performance, and increased unreliability.

e) The System Engineer is responsible to ensure that a consolidated list of spares is available, with continuous improvement of content.

f) The Maintenance Contractor is responsible to contribute towards the population of the spares list, and to confirm the spares BOM, after evaluating the Outage/Repair Scope of work submission.

5. INSPECTION AND TESTING

5.1 ONLINE INSPECTION

5.1.1 Plant-walk Down Verification

The plant aspects to be monitored with daily/weekly plant walks are important – reporting from these on-line inspections will flag failures, detect early signs of failure/deteriorating plant health and the monitoring of changing process conditions that may warrant remedial action.

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Recording of observations is made and reported to Maintenance personnel, and load-affecting deficiencies identified are elevated to the System Engineer. The following are key aspects to be included in on-line inspections:

a) Abnormal/Excessive noise or external leakage is observed and noted.
   1) Steam leaks during soot blowing is clearly audible.
   2) Increase in low-frequency vibrations should prompt for further investigation
   3) Air heater seal related issues (Seal rubbing noises or internal “thumping” noises) are clearly audible and should be a prompt for further investigation.

b) Motor drive-amps should be recorded/monitored on a daily basis, and reported should any abnormal variation/deviation from design base specification be observed.

c) Lubrication system health in terms of oil/grease levels, filter maintenance, fault alarms and leakages are monitored and reported.

d) Soot-blower function and steam feed conditions are monitored while soot blowing is in operation in accordance to stipulations in the applicable section on Soot-blowers above.

e) Drive system vibrations are not specifically monitored on any on-line system, but subjective observation should be made, and abnormal noise or vibration noted at the drive system should be reported to the system engineer for further investigation or request for detailed vibration analysis.

f) Pinion and Pin-rack wear is subjectively observed and reported as an input to Outage SOW planning.

5.1.2 Operational Assessment and Incidents

Some machines are adversely affected when exposed to process abnormalities or system operating parameter excursions.

The purpose of elevating the importance for awareness of operational incidents is that it provides knowledge for root-cause analysis and informs decision-making on changes that may be required to address operational, maintenance and design deficiencies.

Inspections are also aimed at identifying, recording and reporting of incidents that affect plant health.

a) Operational assessment and trend identification
   1) Blockage and flow imbalance – trend identification will assist with balancing high velocity erosion and temperature imbalance, which affects the downstream gas-cleaning plant performance.
   2) Blockage and temperature imbalance – identification will assist with managing adverse effects to the elements as well as downstream gas-cleaning plant. Blockage results in an irreversible upward spiralling of plant damage if left unchecked.
   3) Element pack wear – trending is important for optimal replacement scheduling in line with financial and outage planning requirements, without adversely affecting plant performance.
   4) All of the above aspects are early identifiers of deteriorating performance and risk of failures and the effects will be evident with the engineering trending of the machines heat-exchange “X-factor”. Refer to the provided definition.
   5) Start-up Fire – most incidents arise during the start-up of the air heater and therefor justify intensive observation and monitoring of alarm tools for flagging the risk. In most cases, the fuel source is provided from lubrication system failures, adjacent plant, or process failures (eg. fuel oil carry-over, and PF carry-over).

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b) Operational incidents

1) Single draught operation – The logging of conditions arising from this mode of operation can result in changing the thermal behaviour of the machine with severe consequences for increased seal wear.

2) Air Heater Soot-blower failures – Early identification limits operational effects. Blocked element conditions arising from this failure mode can be counter-acted with a temporary review and adjustment of the soot-blowing cycles.

3) Boiler Soot-blower failures – Early identification limits adverse seal-wearing conditions. Flue gas temperature excursions are reported for rectification by other responsible personnel.

4) Continued dew-point operation – Early identification limits slowly emerging performance degradation, and management is critical as the rectification often lies with personnel responsible for adjacent plant, unaware of failure on their plant.

5.1.3 Contractors Documentation

a) On-load plant walk down/inspection documentation is developed and made available, containing effective reporting mechanisms for trending, and flagging of anomalies of critical failures.

b) Report format, layout and content is approved for use by the Eskom Engineer, and is subject to practicality changes and learning points.

c) A comprehensive written report is issued on weekly basis, with verbal reporting on a daily basis of urgent anomalies.

d) Records are retained for the duration of the contract and handed over to Eskom at termination of the contract.

e) A formal inspection documentation management system shall be put in place for the duration of the contract where all on-load/online and outage inspection records and information are managed. A full electronic set of this information shall be hand over to Eskom at termination of contract.

5.2 OUTAGE CONDITION AND SOW INSPECTION DOCUMENTATION

5.2.1 Preventative Replacement SOW

a) The Employer System Engineer compiles and submits the basic Outage Scope of Work, based on known life cycles and maintenance intervention requirements of individual components, as stipulated in the applicable sections of this document.

b) The Contractor Engineer reviews the Scope of Work, and proposes additions to the Scope of Work. This would be based on observed defects reported during the operational period, as well as omitted Scope of Work from previous outage interventions.

c) It needs to be noted that any Scope of Work for components which is primarily subject to an erosive wear mechanism can only provide an 80% accurate reflection of the real/final scope, thus requiring some verification and update of the actual scope after the initial inspection phase.

5.2.2 Compulsory Inspection/Assessment

a) The purpose of this inspection is to assess the real condition of the Air Heater and to confirm the actual Outage Scope of Work.

1) The Contractor's key experienced personnel conducts and reports on the inspection(s) performed.

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2) The initial visual walk-through inspection is performed with the involvement of the Employer's Engineer (as a minimum).

3) The Inspection content is tailored and defined for each specific outage type, eg. all the stipulated measurements cannot be scheduled for a limited-duration shut-down opportunity, and outage duration would be a key determinant of the scope of work that can practically be executed to the required standard and quality.

4) Continued detail inspections that form part of the initial SOW inspections, incorporating measured wear of components and the status of adjustable settings, is performed, documented and reported by the Contractor. Significant anomalies or damage identified during such inspections must be brought to the attention of the Eskom System Engineer as soon as practically possible so that remedial action can be planned and undertaken based on the risk of equipment failure versus impact on outages schedule and duration.

5) The inspection is guided by a pre-formulated document, ensuring that all possible visual damage is assessed and reported in walk-through sequence.

b) Measured Inspection of components condition and reporting

1) CAUTION – All rotating "Control" measurements must be done with rotation in the NORMAL direction of rotation.

2) The continued detail inspection of measured details, as stipulated for the individual items contained in this document, is recorded on an individual sheet per component. The Inspection Sheet will provide full details of what is measured, measured results, reference specification, and recommended actions.

3) Complex inspection results (such as shaft or hood alignments), requiring an increase of Outage Scope is analysed by the Contractor's Engineers and recommended actions are recorded on the data-sheet.

4) The reports are submitted to the Employer's Engineer as a controlled, edited, and complete document for evaluation and planning a review of the initially defined Scope of Work – Referred to as the "Rev. 1 SOW".

5) The outcome of the Rev.1 Scope of Review evaluation meeting would be a finalised Scope, requiring minimal to zero further changes, and results in the finalisation of a detailed Contractual Task Order with associated program of work and Quality Control documentation.

c) The inspection sheets shall cover the following minimum (but not limited to) inspection areas (as detailed in each scope/plant section in this Specification, and as applicable to each individual Power Station/plant). The inspection document shall be clear in indicating current/measured condition v/s required design base condition, thus motivating the requirement for repair.

1) Inspect air heater rotor for damage and erosion.

2) Inspect radial seals for damage and erosion.

3) Inspect axial seals for damage and wear.

4) Inspect circumferential seals for damage and wear.

5) Inspect sector plates for damage and erosion.

6) Inspect axial seal plates for damage and erosion.

7) Inspect hot end and cold end Rotor sealing interfaces for damage and erosion.

8) Inspect casing internally for damage and erosion.

9) Inspect drive system for oil leaks.

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10) Inspect bearing lubrication system for oil leaks.
11) Inspect drive mechanism – Pin-rack and pinion – for wear and condition.
12) Inspect element packs for damage, erosion and loose plates.
13) Inspect element pack supports for damage and erosion.
14) Inspect stay rods in ducting for damage and wear.
15) Inspect fire protection system for damage and erosion.
16) Inspect the expansion joints and covers for damage and wear.
17) Inspect shaft seals for damage and wear.
18) Inspect the soot-blower system for erosion, damage and movement.
19) Inspect sealing actuators (e.g. sector plate) for damage and correct operation.
20) Inspect Fire-fighting system and water drainage and confirm operability.

d) Further detailed Scoped Inspections

1) Inspection on components that are to be stripped for complete assessment and maintenance, are separately Scoped for execution, and are typically items such as the following:
   - Bearing wear condition.
   - Element pack wear sampling.
2) The condition and recommended replacement/action is reported and agreed on an “as and when executed” basis.

5.2.3 Scope of Work Management

a) The effective translation of plant inspection observations and measured recordings into repair and maintenance scope is a key element in providing the assurance of reliable RTS performance.

b) The key role-players required to execute every element of the defined management process are the following personnel:

1) Employer and Contractor System Engineers.
2) Maintenance execution manager or supervisor.
3) Employer and Contractor Contract’s manager/controller.
4) Contractor’s maintenance staff performing the activities defined in the scope of work.

c) The key mandatory management activities required to provide assurance and continuous improvement to processes and performance in line with ISO 9001 Quality Standards are as follows:

1) Scope clarification and provisional formulation of the Contracted Scope.
2) Complete submission of inspection report.
3) Report analysis and recommendation.
4) Scope of Work review (Rev.1) and Task order finalisation.
5) Issue of Scope variations and approval.
6) Well-defined and completed Quality Control Plans (QCP’s).
7) Maintenance task work instructions to sufficient level of detail to ensure quality work and prevention of re-work on complex tasks.

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8) Reference of maintenance task work instruction and/or Weld Procedure Specification (WPS) numbers in the QCP's for cross-referencing purposes.

9) Development, management and continuous improvement of sufficiently detailed work instructions for maintenance tasks of high complexity or risk.

10) Post mortem consolidation meeting.

11) Incorporation of remedial/continuous improvement recommendations stemming from post-mortem outage meetings into future work and outage scopes.

d) Failure to provide detailed input and management of the activities, results in wasteful expenditure and performance degradation.

5.2.4 Quality Control Documentation

The complex and multitude of verifications required to secure effective performance of the air Heaters require detailed and tightly controlled Quality Control Plans (QCP's). The following important aspects are to be incorporated into the planning and execution of QCP's:

a) Inspections are executed by the correctly skilled persons, trained on the execution procedure, required assembly lay-out, and critical points of evaluation.
b) Inspections are guided by the use of detailed check-sheets, in order to ensure all inspection items are covered and findings captured.
c) All recording-sheets are referenced on the QCP.
d) Inspection of adjustments or settings are presented for verification, with the specifications and recorded results-sheet.
e) Measured inspection results are verified, especially when recommendations based on the results require the addition of repair scope.
f) Scope activities involving the "closing-up" of an item (meaning no further witness of the internal condition is possible) shall always be a Witness Hold point intervention.
g) The method of consolidating small inspection points into one single witness hold point (with associated checklist), is considered mandatory practice.
h) All final inspections (before closing doors) shall be guided by a documented check sheet and signed-off by relevant delegated persons stipulated on the QCP. Check sheets shall cover typical items such as cleanliness, scaffold removal, door seals & latches, bolts fitted, final set-up measurement reports compiled, pinion & gearbox settings, commissioning executed, and doors closure.
i) Inspections shall comply to all Eskom safety and Permit-to-Work requirements and regulations.

5.3 DOCUMENTATION OF PROOF TESTS AND INSPECTIONS

5.3.1 Important "Proof of Functioning or Compliance" Tests

The following mandatory tests and verifications shall be fully documented and submitted for acceptance/approval:

a) Element pack wear measurement, analysis and trending

b) Fire-fighting system testing

c) Cold Seal setting verification/proof

d) Hot seal settings verification/optimisation

e) Soot-blower function and stroking

f) Final inspection verification and sign-off

g) Return to Service monitoring and recording of critical parameters

h) Air Heater Leakage testing and trending

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i) Element pack differential pressure and trending of comparable flow/operating conditions

5.3.2 Document Acceptance Requirements

The relevant Power Station shall maintain records that certify that the mandatory proof tests and inspections were completed as required. These records shall include the following information as a minimum:

a) Description of the test and inspection performed.

b) Dates of the tests and inspections.

c) Name of the person(s) who performed the test and inspections.

d) Name of the person(s) who witnessed the test and/or inspection (where required).

e) Results of the tests and inspections.

f) Where required, wear rate predictions and projections for future outage/maintenance intervention planning.

g) Actions recommended for rectification.

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6. AUTHORISATION

This document was reviewed and accepted by:

Name & Surname	Designation
William Garnett-Bennett	Senior Consultant - Draught Plant
Mike Lander	Senior Advisor - Draught Plant
Herbert Grobler	Senior Engineer - Draught Plant
Riekie Swanepoel	Chief Technologist - Operating, Maintenance & Outage Management CoE

This document must be implemented by:

Position
Medupi Draught Plant System Engineer
Medupi Boiler plant Engineering Manager
Kusile Draught Plant System Engineer
Kusile Boiler Plant Engineering Manager

7. REVISIONS

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April 2020	0	N Rust	Draft under development
September 2020	0.1	W Garnett-Bennett	Final Draft for Review Process
October 2020	0.2	W Garnett-Bennett	Final Update Draft after Review Process
October 2020	1	W Garnett-Bennett	Final Document for Authorisation and Publication

8. DEVELOPMENT TEAM

The following people contributed towards the development and review of this document:

- William Garnett-Bennett (Senior Consultant, Generation: Boiler Draught plant).
- Herbert Grobler (Senior Engineer, Generation: Boiler Draught Plant).
- Mike Lander (Senior Advisor, Sustainability: Boiler Draught Plant).
- Nico Rust (Corporate Consultant, Asset Management Engineering: Boiler Draught Plant).

9. ACKNOWLEDGEMENTS

None

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