

 Eskom	Specification	Asset Management
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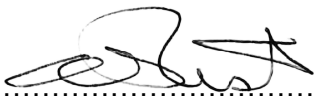
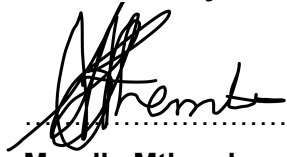


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EXECUTIVE SUMMARY

Centrifugal fans, while relatively simple in concept, are carefully designed machines which may operate under a variety of conditions, such as elevated temperatures, varying flows, and may be subject to severe conditions of erosion.

Centrifugal fans covered in this specification are Primary Air (PA), Forced Draught (FD) and Induced Draught (ID) fans.

The organisations' management and maintenance personnel must have a clear understanding that the execution of centrifugal fan maintenance cannot be presented as a "normal run of the mill" task. The effective maintenance of the machine presents a number of intricate details, and if not correctly managed with the appropriate knowledge and skill levels, it will result into severe plant production losses and stoppages, with potential for severe plant damage and personnel safety risks.

Continued operation of the plant, with known deficiencies, such as high vibrations, worn or cracked impellers, obstructed flows, etc. will result in the accumulation and exaggeration of damage to components with severe consequences of plant load losses or plant and personnel safety – and is best addressed on urgent basis, in order to sustain relative reliability between operational shut-downs.

The effective management of the Preventative Maintenance program, requires an 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 Centrifugal Fans is aimed at obtaining the best performance and life expectancy of components that are subject to high rotating stresses and ash erosive wear. Accurate detailed execution of repair scope strives to ensure that unplanned failures are eliminated in order to ensure effective operation and performance between fan inspection 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 PA, FD and ID Centrifugal fans, in order to ensure that the best operational service is obtained between repair intervals.

2.1.2 Applicability

This specification applies to all of the centrifugal type PA, FD and ID fans installed on Eskom fossil fired boilers.

The specification is to be used by both Eskom system engineers and maintenance contractors 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] 240-89218242: Boiler Centrifugal Fans Inspection Standard.
- [2] 240-121468227: Draught Group Balancing and Vibration Protection Levels Standard.
- [3] 240-106628253: Standard for Welding Requirements on Eskom Plant.
- [4] 240-131963944: Draught Plant Preservation Standard
- [5] 240-87694663: Fan Storage Standard
- [6] Station Draught Plant Return to Service procedure.
- [7] 240-61379840: Management & reporting of Strategic Spares.
- [8] 240-105658000: Supplier Quality Management specification
- [9] NACE No.1/SSPC-SP 5: Joint Surface Preparation Standard (White metal Blast cleaning)
- [10] ISO 8501-1 (SA 3): Pictorial Standards of Cleanliness

2.2.2 Informative

- [11] 240-111508338: Process Control Manual (PCM) for Outage Management
- [12] Applicable NDT and wall thickness monitoring standards.
- [13] 240-89218264: ID Fan's out of capacity guideline.
- [14] 240-89217730: Standard for Draught Plant Protection functions

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2.3 DEFINITIONS

Definition	Description
Dorsal Fin	Flow straightening plate installed adjacent to the shaft at impeller inlet.
Hot PA	Primary air fan which is supplied with heated air from the air heater
Inlet Louvre Damper	A damper-style mechanism positioned on the Fan intake, consisting of a set of vanes that provide a choking/opening function to control the air flow through the fan.
Impeller	Rotating component of a fan
Magnetic centre	Running position of the motor shaft in relation to its bearings.
Radial Vane Control	A mechanism positioned on the Fan intake, supported around the shaft and orientated radially towards the inlet cone, consisting of a set of vanes that provide a choking/opening function to control the air flow through the fan.
Shaft journal	Section where the bearing is fitted on a shaft
Suction cone	Shaped annular ring at impeller inlet
Wear liner	Replaceable sacrificial steel wear plate to protect high wear areas.

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
DE	Drive End
DPI	Dye-Penetrant Inspection
FD	Forced Draught
GO	General Overhaul
HAZ	Heat Affected Zone
ID	Induced Draught
ILD	Inlet Louver Damper
MMD	Mechanical Maintenance Department
MPI	Magnetic-Particle Inspection
NDE	Non-Drive End
NDE/T	Non-destructive Testing/Examination
NDT	Non-Destructive Testing
NRV	Non-Return Valve
OEM	Original Equipment Manufacturer

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Abbreviation	Description
PA	Primary Air
PM	Preventive maintenance (maintenance philosophy)
PRV	Pressure-Relief Valve
PS	Power Station
QCP	Quality Control Plan
RTS	Return To Service
RVC	Radial Vane Control
SAP	Software Maintenance Management System
SCM	Supply Chain Management
SOW	Scope of Work
T&IP	Test and Inspection Plan
UT	Ultrasonic Testing

2.5 ROLES AND RESPONSIBILITIES

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

2.6 PROCESS FOR MONITORING

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

2.7 RECORDS

The following documentation shall be produced as a result of this Specification;

- The Eskom Engineer shall develop Scope of Work documentation to the required level of detail to guide effective and complete scoping of outage and maintenance related tasks and activities. This will include all test and inspection activities required to assist with plant condition assessment (as captured in System/Equipment Test and Inspection Plans).
- The Eskom Engineer shall develop the referenced documents recommended in this Specification, pertaining to performance, fan integrity and erosion protection monitoring.
- Each relevant Power Station shall develop the spares stockholding capability to support the accurate execution of required scope for a specific outage or maintenance task.
- The Eskom Engineer must assess and guide the SCM team on the power station regarding spares holding and which items are deemed critical spares. An appropriate rotatable spares strategy shall also be considered and put in place as relevant. Any specific activities required to preserve spares while in the Power Station Stores/Warehouse shall be provided to the SCM and Maintenance site teams (e.g. regular turning of large impeller-rotor assemblies to prevent shaft “bow”).
- The Maintenance Contractor shall possess instruction documents to guide accurate execution of the detailed tasks in accordance to this guideline.

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- f) The Maintenance Contractor shall possess/develop Inspection Reporting documentation to facilitate effective and accurate condition Assessment, Reporting, Analysis and Quality Control of the task/activity execution.
- g) The Maintenance Contractor shall develop Quality Control documentation to secure effective verification and record-keeping of the quality of execution. The Eskom Engineer shall review such QC documentation to ensure that appropriate witness and hold points are implemented to confirm quality of workmanship and compliance to maintenance tolerances and specifications.
- h) The Maintenance Contractor shall submit a detailed list with spares requirements based on the requested Scope of Work related to a particular outage.

3. MAINTENANCE REQUIREMENTS

Unless specifically stated in this specification, all maintenance on fans must be conducted at the frequencies documented in 240-89218242: Boiler Centrifugal Fans Inspection Standard, or alternatively as documented in the Station specific Boiler Draught Plant Fan Inspection Philosophy document.

3.1 CENTRIFUGAL FANS SYSTEMS BREAKDOWN AND DEFINITION

3.1.1 Fan Casing

The fan housing structure including casing wear liners, inlet/suction cones, dorsal fins, shaft seals and the internal and external steel support stays and mounting flanges, but excluding the impeller and journal bearings/rolling element bearings.

3.1.2 Control Vanes

The control vanes refer to the fan flow control system. RVC's are generally fitted on the larger fans, and some of the smaller fans are fitted with ILD's.

3.1.3 Drive mechanism

The Drive mechanism refers to the drive, motor and coupling between fan and motor.

3.1.4 Shaft and Bearings

The shaft and bearings refer to the main shaft supporting the impeller or motor, and the support and thrust bearings. Bearings may be of white metal type with oil lubrication, or cylindrical roller bearings, with oil or grease lubrication.

3.1.5 Coupling

The coupling refers to the flexible transmission device that connects the motor to the fan. Couplings may be of Fixed type (fixed speed) or variable type such as Fluid drive couplings. Some fixed type couplings incorporate soft-start transmission devices to reduce motor start-up load.

3.1.6 Lubrication System

The lubrication system incorporates the associated mechanical (shaft driven) and/or electrical pumps, as well as associated piping, oil tanks, valves, filters and coolers. Lubrication systems may be of grease, oil bath or forced oil lubrication, with air or water cooling systems.

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3.1.7 Impeller

The impeller is the rotating component of the fan incorporating the blades that generate flow. Impellers may be single inlet (one side only) or double inlet (both sides). The blades may be of aerofoil design or flat plate design and may be fitted with wear protection plates.

3.1.8 Motor

All draught plant fans are driven by electric motors. The mechanical considerations of the motor include bearings, motor running magnetic centre, rotor-stator airgap settings, coupling setup and alignment. Bearings may be of roller bearing type or white metal, and may be grease or oil lubricated. Some have forced lubrication systems. Bearing cooling may be accomplished by water or air cooling.

3.1.9 Instrumentation

Relatively little instrumentation is used on the centrifugal fans, comprising of one or more bearing vibration sensors, bearing temperatures and lubrication system monitoring.

3.2 FAN CASING

3.2.1 Casing structure and supports

- a) All fans casings must be inspected visually at every outage as best possible and any damage and wear must be recorded to be able to estimate the repairs that need to be carried out in future outages.
- b) Thickness testing in high-wear areas must be conducted and reported at each fan inspection interval as required by 240-89218242: Boiler Centrifugal Fans Inspection Standard. As a general guideline the complete casing measurement should be recorded using a 1000mm x 1000mm matrix, in areas of mild erosion a 500mm x 500mm matrix should be used, and for areas of severe erosion a 50mm x 50mm matrix of measurements should be recorded.
- c) Erosion plotting must be standardised with the use of a set of procedures and lay-out template in order to present repeatable inspection & reporting results.
- d) The inspection findings are to be documented for record purposes so that future inspection findings can be comparatively mapped against previous outage findings.
- e) The external components of the fan casings are relatively maintenance-free, but any abnormality noted with inspection must prompt repairs, and where necessary, further investigated.
- f) Lagging and cladding should be complete and maintained in good condition.
- g) Casing flanges must be checked for damage and wear, and any damaged or loose casing bolts must be replaced.
- h) Casing doors must be inspected at every fan inspection interval. New packing/seals must be fitted on the doors that were opened for the specific outage.
- i) Prior to inspection or working on the fan, it is recommended that a good water wash cleaning should be conducted to remove layers of ash or dust that could hide defects. Care should be taken to prevent water ingress into the drive motor when performing water washing.
- j) Concrete fan casing supports must be inspected for integrity and looseness of bolts. Note that in some cases cone washers are used to allow for casing expansion on the supports. Casing holding down bolts must be in good condition and torqued to correct specification.

3.2.2 Internal support stays and turning vanes

- a) Internal support stays and turning vanes must be inspected visually at every outage as best possible and any damage and wear must be recorded to be able to estimate the repairs that need to be carried out in future outages.
- b) Prior to inspection of the interior of the fan casing, it may be necessary to clean ash or fuel oil build-up that could hide defects.

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- c) Where defects or potential cracking is suspected, it would be advisable to conduct NDE/T of the suspected risk areas.
- d) Internal supporting beams/stays and flow turning vanes (where fitted) must be properly inspected for wear and fatigue. In particular, hot PA fans and all ID fans are subjected to varying levels of ash particulate erosion. Where erosion levels are significant, protection plates are fitted on the upstream side of the beams, and must be replaced from time to time. Similarly, turning vanes will need replacement from time to time. It must also be noted that some Cold Primary Air Fans and FD fans are subject to erosion as well due to air heater recirculation operations.
- e) It is important to maintain and retain installed flow-distributing vanes (do not remove). Incorrect distribution of flow contributes to temperature variations and high erosion areas.
- f) Where splitter plates have been installed in the inlet boxes, they must be installed correctly as per drawings as they act as anti-swirl devices.
- g) The beam attachment points to the side walls may experience fatigue cracking, and must be carefully inspected for damage and repaired as needed. Where severe fatigue is identified, the root cause must be investigated and corrective actions taken to prevent recurrence.
- h) Careful attention must be given to the beam and turning vanes attachments. Where any significant wear or looseness is observed, refurbishment or repairs must be carried out to ensure that the attachments will not fail during operation.
- i) Access doors are relatively maintenance free but effective sealing must be ensured by replacing door sealing gaskets and packing. Damaged bolts and clamps must be replaced.

3.2.3 Casing Wear liners

- a) Wear liners are installed on the interior of fan casings in areas where highest erosion takes place. Where the wear plates are worn to 50% or more of the original installed/specified thickness they must be replaced.
- b) Where liners are fitted they must be inspected at every fan inspection interval and replaced as necessary.
- c) Where possible, liners should utilise materials that are resistant to erosive wear.
- d) Where liners are attached by bolts, counter-sunk-head bolts must be used.
- e) Where attachments are done using welding, proper welding procedures must be followed.

3.2.4 Inlet Cones

- a) All fans inlet cones must be inspected visually at every outage as best possible and any damage and wear must be recorded to be able to estimate the repairs that need to be carried out in future outages.
- b) Inlet cones can be subject to severe erosion for fans that experience particulates (ash, dust or pulverised fuel), and must be inspected at every fan inspection interval. Thickness testing should be conducted and findings recorded in order to plan for repair or replacements.
- c) Repairs should be conducted by means of window patches. In very high wear areas, thicker wear materials should be considered.
- d) Where inlet cone replacements are required, the replacement design must be of a split design to facilitate replacement without impeller removal.
- e) Measurements of suction cone clearance and penetration must be conducted and recorded after adjustment to specification.
- f) Securing bolts and brackets must be inspected for wear or damage and repaired as necessary.

3.2.5 Shaft seals

- a) Fan shaft seals must be inspected visually at every outage. Seal guards and bolts should be secure and undamaged.

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- b) Shaft seals should be removed at every fan inspection interval and checked for thickness and functionality and replaced as necessary. Floating seals should be free to move within their housings to adapt for thermal expansion of the casing during operation.
- c) Fan casings may be either centreline supported (shaft centreline) or bottom supported. As a consequence, thermal expansion will have differing influences on the shaft sealing arrangement. Care must be taken to set up the shaft seals in such a way as to prevent unintended rubbing during casing expansion.
- d) Shaft seals should normally not be tight against the shaft, except in the cases where designed to do so, such as the Kusile, Medupi and Majuba PA fans where carbon seals consisting of 3 segments are pressed against the shaft with a garter spring. In these cases it is acceptable practice to trim the lengths of the segments in order to obtain a smaller seal diameter required for contact on the shaft. The seal housing must be kept clean and lubricated with a dry lubrication. Ensure the correct fitment of the seals and the seal anti-rotation pin.

3.2.6 Dorsal Fins

- a) Fan dorsal fins (where fitted) and their mounting brackets must be inspected visually at every outage for damage, looseness or wear.
- b) Repairs or replacements must be conducted to ensure that these plates will not come loose or fall off during operation. The aim is to ensure that fans will reliably operate without defect until the next fan inspection interval.

3.3 CONTROL VANES

Two types of flow vane control are used on centrifugal fans, ie Inlet Louver Damper (ILD) or Radial Vane Control (RVC). ILD's are used mainly on smaller fans such as PA fans. Larger fans generally utilise RVC flow control.

3.3.1 Inlet Louver Dampers (ILD).

- a) ILD linkages, blades and bushes must be inspected visually at every outage for damage, looseness or wear. Any damages must be recorded to be able to estimate the repairs that need to be carried out in future outages.
- b) Thorough inspections must be carried out at every fan inspection interval and any defects must be repaired as necessary.
- c) Blade linkages must be removed and checked for looseness, excessive wear, deformation or damage and repaired or replaced as necessary.
- d) Blade bearings/bushes must be checked, and may need replacement at 6-yearly intervals.
- e) At 6-yearly intervals the actuators and operating levers should be removed for servicing and replaced.
- f) Following all maintenance and repairs, blade linkages must be adjusted to specification with damper blades synchronised. Mechanical stroke-checking must be conducted to ensure free and accurate operation.
- g) For some fans, control dampers must be set to prevent complete closing of dampers in order to prevent the fan from running in stall conditions. On fans where this is required, a minimum opening of 10% at the "fully closed" position should be maintained.

3.3.2 Radial Vane Controls (RVC)

- a) RVC linkages, lay shafts, blades and bushes must be inspected visually at every outage for damage, looseness or wear. Any damages must be recorded to be able to estimate the repairs that need to be carried out in future outages.
- b) Thorough inspections must be carried out at every fan inspection interval and any defects must be repaired as necessary.

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- c) Blade linkages must be removed and checked for looseness, excessive wear or damage and repaired or replaced as necessary.
- d) The operating ring and guide rollers must be inspected and checked for looseness, wear or damage and repaired or replaced as necessary.
 - i. Guide rollers setting (on eccentric shaft) should in general have a minimum clearance of 2 mm (measurements based on 5 open-positions (0, 25, 50, 75,100) for each roller) Rollers must be aligned and should not be excessively worn. Some rollers have bushes.
 - ii. Guide ring must be checked for wear by doing an ovality check, Worn rings may be rotated to a different operating position (which will be unaffected by the ovality) to extend the life of the ring.
- e) Blade bearings must be checked, and may need replacement at 6-yearly intervals.
- f) At 6-yearly intervals the actuators and operating levers should be removed for servicing and replaced.
- g) Following all maintenance and repairs, blade linkages must be adjusted to specification with damper blades synchronised. Mechanical stroke-checking must be conducted to ensure free and accurate operation.
- h) For some fans, control dampers must be set to prevent complete closing of dampers in order to prevent the fan from running in stall conditions. On fans where this is required, a minimum opening of 10% at the “fully closed” position should be maintained.
- i) As a general guideline, complete replacement of bushes, pins, links, operating ring rollers etc should be planned for every major GO.
- j) Lay shaft bushes must be inspected for wear and alignment, to ensure that vane openings on double inlet fans are synchronised.

3.4 DRIVE MECHANISM AND COUPLING

3.4.1 Drive Motor

- a) Main drive motors are designed to operate for 12+ years, but actual operating life would vary between different applications.
- b) The Main drive motor is maintained by electrical engineering on each site. However certain mechanical aspects are generally managed as part of draught plant system engineer responsibility.
- c) As a critical component, thorough motor electrical integrity testing and servicing should be scheduled on 12 year intervals in order to avoid unscheduled failures.
- d) Routine vibration condition monitoring analysis trends should also be closely monitored to identify any developing failures or significant deterioration in equipment condition.
- e) Following any maintenance intervention on motors, it is compulsory to verify the correct direction of rotation with Mechanical Control personnel as Witness.
- f) Online inspections must be carried out on a weekly basis. Visual inspections should cover running vibrations, bearing oil levels and temperatures, bearing oil leaks, looseness of motor hold down bolts, and cleanliness of air cooled bearing housings. Any anomalies must be recorded to be able to estimate the repairs that need to be carried out in future outages. Air cooled bearing housings should be kept in a clean condition to facilitate bearing cooling.
- g) Motor bearing vibrations are typically measured and reported by the stations on a monthly basis and trends provide indications of possible repair interventions.
- h) Motor hold-down bolts must be checked for tightness to correct torque specifications every 6 years (GO Cycle). If indicated in vibration data, the ad-hoc checks should be done during outages to ensure that no “soft foot” condition is present or indicated.
- i) Where vibration trends are increasing it may be necessary to check flatness of the motor base mounting pad (when motor is removed). Use of shims must be minimised, and used only for small final adjustments. Numbers of shims must be minimised and should be of non-corrosive materials, especially where exposed to outdoors, such as ID fans.

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- j) The motor white metal bearings should be opened, inspected and clearances measured and reported at 6-yearly intervals. Out of specification wear must prompt bearing replacement. Oil rings (where fitted) must be secure and in good condition and able to freely rotate. Oil seals must be inspected for damage or leaks, and repaired as necessary.
- k) Care must be taken to maintain the PTFE bearing insulation and earth wire on the DE bearing to facilitate the electrical megger test.
- l) Motor bearing labyrinth seals are subject to wear and should be serviced at every fan inspection interval.
- m) Oil baths (including sumps) must be cleaned at every fan inspection interval and filled to correct levels with fresh oil to specification. Oil bath housings must be maintained in a clean state to ensure sufficient cooling. Bearing housing side cover gaskets must be kept as stock items and replaced during these services.
- n) Some motors are connected to the fan bearing's forced lubrication system. Servicing of these systems must be combined with the Fan lubrication system maintenance activities.
- o) Where motor bearings are fitted with oil coolers, servicing and maintenance should be conducted as described in section 3.6.1 (Oil Lubrication System) of this document.

3.4.2 Main Drive Coupling

- a) The Main drive couplings used are mostly the Bibby spring type with serpentine springs that engage with slots on each coupling boss. These couplings are utilised mostly on larger fans such as ID and FD fans, while PA fans may use multidisc couplings, sometimes in conjunction with soft start Jolly couplings.
- b) In cases where the spring type couplings are supplied in segments, care must be taken to correctly fit the segments on coupling drive and non-drive end sides. Incorrect installation will result in increased vibration energy with resultant wear and high vibration levels transferred to the motor and fan.
- c) Coupling guards must be inspected visually at every outage for any damage or looseness. Any damages must be recorded to be able to estimate the repairs that need to be carried out in future outages.
- d) The health of the Main drive motor coupling is important, and to avoid the development of severe damage, it is to be inspected/repaired every fan inspection interval. Specific attention should be paid to ensure that sufficient lubrication is present in the spring slots after maintenance/repair activities.

3.4.3 Spring Couplings

- a) Spring couplings are commonly referred to as Bibby couplings.
- b) Thorough inspections requiring coupling guard removal must be carried out at every fan inspection interval. Internal components of the coupling must be cleaned and the springs removed for checking of wear or damage. A wear report documenting the inspection and measurements must be compiled and evaluated by the system engineer in consultation with contractors engineering for possible replacement of the springs, or the entire coupling.
- c) Prior to reassembly of the coupling, the gap between the coupling bosses must be checked for compliance with specifications (typically 3-5mm), using the motor magnetic centre running location as basis for the measurement.
- d) During assembly, care must be exercised to ensure that the spring centralising pins or rubber inserts on the outside of the coupling flanges are correctly installed to prevent drift of the spring away from the central position during operation.
- e) Note: an excessive gap between coupling halves is an indication of change or abnormal conditions, and must be investigated / monitored.
- f) Alignment of the motor and fan shaft must be completed to specification (typically 0.1mm) and results recorded prior to reassembly of the coupling.
- g) The springs must be re-greased prior to assembly of the coupling and replacing the coupling guard

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- h) Spring replacement and/or hub replacement on the bibby couplings must be done with matched spring pairs and or matched hub sets. If this is not done correctly, it leads to vibration problems on the fan.

3.4.4 Multi-disc Couplings

- a) Thorough inspections requiring coupling guard removal must be carried out at every fan inspection interval. Components of the coupling must be thoroughly cleaned to check for loose or missing bolts, wear, corrosion or damage. A wear/damage report documenting the inspection and measurements must be compiled and evaluated by the system engineer in consultation with contractor's engineering team to assess the need for possible partial or full replacement of the coupling.
- b) The multi-disc assembly must also be inspected for bent disc plates or sections as this is an indication that the coupling disc assembly must be replaced. A typical mode of failure is when the plates buckle due to deformation of mounting-pins and holes. Minor buckling with no cracks on the plates can be tolerated and the free-end must not make contact with the mating flange.
- c) Prior to reassembly of the coupling, the gap between the coupling bosses must be checked for compliance with specifications, using the motor magnetic centre running location as basis for the measurement.
- d) Note: an excessive gap between coupling halves is an indication of change or abnormal conditions, and must be investigated / monitored.
- e) Alignment of the motor and fan shaft must be completed to specification and results recorded prior to closing up the coupling guards.

3.4.5 Soft start (Jolly) couplings

- a) Thorough inspections requiring coupling guard removal must be carried out at every fan inspection interval. Oil sample analysis will indicate the condition of internal components of the coupling and can be used to prompt for full servicing or replacement.
- b) Oil changes must be done according to OEM specification, and careful attention must be given to filling the coupling to the correct oil levels.
- c) Filler plugs and thermal fuse plugs must be checked for condition and leaks..
- d) Prior to reassembly of the coupling, the gap between the coupling bosses must be checked for compliance with specifications, using the motor magnetic centre running location as basis for the measurement.
- e) Note: an excessive gap between coupling halves is an indication of change or abnormal conditions, and must be investigated/monitored.
- f) Alignment of the motor and fan shaft must be completed to specification and results recorded prior to closing up of the coupling guards.
- g) Where multidisc couplings are connected to the soft start coupling, inspection and maintenance must be applied as per section 3.4.4 above.

3.4.6 Fluid couplings

- a) On some older fans, the gas volume flow is controlled by a variable speed fluid coupling rather than control vanes.
- b) Online visual inspections of fluid couplings must be carried out on a daily basis. Visual inspections should include running vibrations, coupling oil leaks and oil and oil cooler operating temperatures. Scoop control linkages should be checked for looseness or damage. Any anomalies must be recorded to be able to estimate the repairs that need to be carried out either immediately or in future outages.
- c) Before every fan inspection interval oil samples should be extracted for analysis, and results used for planning of refurbishments or replacement of the oil. Oil replacement/top-up should be done according to prescribed levels to ensure correct operation of the coupling.
- d) At 6- yearly intervals the fluid couplings should be removed and factory overhauled.

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3.4.7 Rubber couplings

- a) Where fans utilise pin and rubber bush type couplings, maintenance is limited to visual inspection of the pins & bushes at every fan inspection interval, and a detailed stripped inspection on 6-yearly intervals.
- b) Where fans utilise rubber-in-compression type couplings (such as Holset couplings), maintenance is limited to visual inspection of the coupling housings and the rubber inserts at every fan inspection interval, and a detailed stripped inspection and replacement of the rubber inserts on 6-yearly intervals.
- c) Alignment of the motor and fan shaft must be completed to specification and results recorded prior to closing up of the coupling guards.

3.5 FAN SHAFT AND BEARINGS

3.5.1 Fan Shaft

- a) The fan shaft generally requires no maintenance, unless some damage is caused due to a shaft seal or bearing failure, or if periods of high vibrations were experienced.
- b) High vibrations may be caused by a bent shaft, out of balance rotor, loose bearings or bearing mountings, or damaged or excessively worn bearings. A bent shaft may occur if the fan is not properly stored (including neglect to attend to the periodic rotation of the fan), or if a fan is stationary for a significant period of time in a hot environment (such as an ID fan in single draught group operation or due to a fire in the gas cleaning plant).
- c) At 6-yearly (GO Cycle) intervals shaft surface finish must be inspected and dimensions of the bearing landings, thrust collars and shaft seal landings must be measured and reported for engineering evaluation.
- d) Where shaft journals are worn or damaged, they may be refurbished by micro welding to increase the journal diameter, and machined back to specification. Where such repairs are done, a reputable and experienced repairer must be sourced and utilised.
- e) Shafts must never be hoisted with lifting equipment with slings located in the vicinity of the journal bearing positions of the shaft.

3.5.2 Fan bearings

- a) Fan bearings must be externally visually inspected at every outage for damage, looseness or wear. Any damages must be recorded to be able to estimate the repairs that need to be carried out in future outages.
- b) Online visual inspections of fan bearings must be carried out on a daily basis. Visual inspections should include running vibrations, bearing oil levels and temperatures, bearing oil leaks, and looseness of bearing hold down bolts. Any anomalies must be recorded to be able to estimate the repairs that need to be carried out either immediately or in future outages.
- c) Fan bearing temperatures and vibrations on the majority of the large fans are monitored on-line on a continuous basis. On some stations (and particularly on the smaller fans such as PA fans) there is no vibration on-line monitoring. Vibrations are typically measured and reported by the stations on a monthly basis and trends and vibration signature data provide indications of possible repair interventions.
- d) At 1-yearly intervals bearing housing to pedestal and pedestal attachment hold-down bolts must be checked for tightness to correct torque specifications. The bolts must be suitably protected against corrosion and locknuts should be used.
- p) Where vibration trends are increasing it may be necessary to check flatness of the bearing housing installation surfaces and ovality, wear or damage of the bearing housing. Use of shims must be minimised, and used only for small final adjustments. Numbers of shims must be minimised and should be of non-corrosive materials, especially where exposed to outdoors, such as ID fans.
- e) In the case where vibrations persist, the bearing should be removed and the bearing pedestal must be checked for flatness.

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- f) Two prominent fan bearing types are in use on Eskom Power Stations – Rolling element bearings and White metal Sleeve-type bearings:
- g) Rolling element bearings.
 - 1) Roller element bearings are used mainly on the smaller fans such as PA fans. They may be either grease or oil lubricated.
 - 2) Grease lubrication may be via manual intervention or automatic greasers. In both instances lubrication frequency and capacity must be as per bearing OEM specification.
 - 3) Oil lubricated bearings may be lubricated by an oil bath/sump oil-containing system local to the bearing or via an external pump/circulation system.
 - 4) Where a vibration condition monitoring program is implemented, roller element bearing maintenance and replacements will be guided by the condition monitoring trends.
 - 5) In the event that no vibration condition monitoring is implemented, roller element bearings must be opened and inspected for condition and cleanliness at every fan inspection interval.
 - 6) Accurate assessment and the cleanliness of servicing/installation is the key element to prolong bearing life and require the deployment of trained personnel for maintenance execution.
- h) White metal Sleeve bearings:
 - 1) White metal bearings are oil lubricated. Lubrication may be by an oil bath/sump oil-containing system local to the bearing or via an external pump/circulation system.
 - 2) A locating/thrust bearing is installed on the drive end bearing of the fan, and uses white metal bearing pads to prevent fan shaft axial movement.
 - 3) As a guideline, the white metal bearings should be opened, and inspected at 6-yearly (GO Cycle) intervals. Clearances (including those of the locating/thrust bearings) as well as lip and crown clearances must be measured and reported. Out of specification wear (typically more than 25% of manufacturing specification for Crown-clearance) must prompt bearing replacement.
 - 4) Oil rings (where fitted) must be secure and in good condition and able to freely rotate. They should not be worn, and ovality should typically not be greater than 1mm. Oil seals must be inspected for damage or leaks, and repaired as necessary.
 - 5) Accurate assessment and the cleanliness of servicing/installation is the key element to prolong bearing life and require the deployment of trained personnel for maintenance execution. A layer of grease must always be applied on the lower sleeve before installing the shaft.
 - 6) Labyrinth seals must be cleaned and checked for damage prior to refitting. Fitted sizes must be recorded for record keeping and a mandatory inspection must be conducted and recorded to verify correct installation, including leak holes, anti-rotation pin installed, etc.
 - 7) Oil baths should be cleaned and filled to correct levels with fresh oil to specification. Oil bath housings must be maintained in a clean state externally to ensure sufficient cooling.
 - 8) The majority of fan bearings are lubricated by a dedicated forced lubrication system. Servicing of these lubrication systems must be carried out as detailed in the section on the Fan lubrication system maintenance.
 - 9) Fan bearing lubrication piping must be flushed prior to re-installation onto the bearing. Cleanliness during maintenance activities on bearings and lubrication systems is of utmost importance as dirt and particle ingress will result in bearing damage.
 - 10) As a general guideline - re-metaling or replacement of bearings should be planned for as an activity to be done on every GO.

3.6 OIL FORCED LUBRICATION SYSTEMS

3.6.1 Oil lubrication system

- a) Many fans are fitted with mechanical shaft-driven pumps as well as an electric pump for the forced lubrication system, but some fans have no mechanical pump, only two electric pumps.
- b) Online inspections of the lubrication systems must be carried out on a daily basis. Visual inspections should include running vibrations, oil levels and temperatures, oil leaks, and oil flow and pressures. Where bearing pressures or flows are low, online change-over on the duplex filter to a clean filter may be necessary and the dirty filter should be replaced. Inspection records should indicate if filter

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change-over was done and the final position of the duplex filter change-over lever. Any additional anomalies must be recorded to be able to estimate the repairs that need to be carried out either immediately or in future outages.

- c) Most of these forced lubrication systems are part of the Station Tribology (Oil Analysis) program and the analysis findings should be regularly reviewed by the system engineer to confirm acceptable performance of oil against specifications and to identify any anomalies that may warrant further actions (e.g. water in oil or metal particles observed in the oil samples taken).
- d) Oil forced lubricated systems are serviced through reservoir inspection and oil cleaning or replacement at every fan inspection interval. The reservoir internally should be free from rust or sediment, and there should be no debris restricting flow into the suction strainer. Internal pipes should be in good condition and not leaking. Cleaning of the reservoir internals should be done only with lint-free cloths. New gaskets should be used to ensure good hatch sealing. Refilling of oil must always be done using an external oil filtration unit
- e) In addition, NRV's and PRV's must be checked for integrity and correct function. When opened for internal inspection, seals should be replaced.
- f) As a guideline, at 6-yearly (GO Cycle) intervals, all pumps, motors and couplings should be removed and inspected for damage, and refurbished or replaced as necessary. Pump services must include flow and pressure checks. Care must be taken to ensure that the oil reservoir and foot strainers are clean and sediment free before reassembly.
- g) Flexible hoses must be replaced at 12-yearly intervals. Pipes that are exposed to direct sunlight or are otherwise damaged may need to be replaced at more frequent intervals.
- h) Where lubrication systems are fitted with coolers, servicing must include cleaning/flushing of the coolers on the oil and water side and ensuring that they are not corroded, damaged or leaking. Whenever coolers are opened, the gaskets or O-Rings must be replaced. Coolers must be pressure tested at 6-year (GO Cycle) intervals.
- i) Where pipes or oil channels are corroded or are scaled, a chemical flush may be necessary, followed by oil flushing and refilling using an external oil filtration unit.
- j) Prior to commissioning of the lubrication system after servicing, pipes must be flushed by bypassing bearings.
- k) Refilling of the lubrication tank must be carried out using an external oil filtration unit.
- l) Control system filters, pumps, pressure & flow set-up and cooler requires health verification with re-commissioning after each cleaning intervention, guided by a dedicated procedure and check-list.
- m) During commissioning pressures and flows must be set and proportioned according to specification between DE and NDE bearings.

3.6.2 Jacking oil system

- a) Many of the larger fans are fitted with jacking oil systems to facilitate fan rotation during start-up or maintenance periods.
- b) Jacking oil systems are to be serviced in conjunction with the main lubrication system. Piping, nozzles and pumps associated with the jacking system must be inspected, cleaned and serviced in the same manner as documented for the main lubrication system.
- c) Control system filters, pumps, pressure & flow set-up and cooler requires health verification with re-commissioning after each cleaning intervention, guided by a dedicated procedure and check-list.

3.7 FAN IMPELLERS

3.7.1 Inspection and Repairs

- a) Fan impellers must be visually inspected at every outage for damage and wear. This is especially important in cases where fans have been subjected to high vibrations, high dust burdens or where fans have been run in stall conditions. Any damages must be recorded to be able to estimate the repairs that need to be carried out in future outages.
- b) Full NDT inspections must take place before reaching the maximum operating hours or number of fan starts that are stipulated in the specific station fan inspection standard – or the Eskom Boiler

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Centrifugal Fans Inspection Standard 240-89218242. Note that the station Fan inspection standard may stipulate more frequent inspection intervals based on fan configuration, e.g. Hot Vs Cold PA fans, or hot air recirculation capability.

- c) Prior to conducting NDT or thickness testing, fans must be cleaned, normally by means of micro-blasting where deposits are sticky, or hand cleaning as a more cost effective solution when easy to do so, e.g., PA or FD fans. The specification for the micro-blasting material is given in section 3.7.2 (NDT Inspections) below.
- d) Thickness measurements on identified areas of the fan must be conducted as per agreed scope and thickness test reports must be submitted for evaluation by the system engineer in consultation with contractors engineering to determine the need for further action.
- e) Thickness testing in high-wear areas must be conducted and reported at each fan inspection interval. As a general guideline the complete measurement should be recorded using varying measurement distances depending on degree of erosion on a particular area. Measurements around the profile of blade noses may be as close as 50mm or less, while in other areas 300mm or 500mm may be sufficient.
- f) Erosion plotting must be standardised with the use of a set of procedures and lay-out template in order to present repeatable inspection & reporting results.
- g) The inspection findings are to be documented for record purposes so that future inspection findings can be comparatively mapped against previous outage findings.
- h) Some fans may be subjected to high dust burdens. To protect the structural integrity of the fan, erosion protection is fitted in high wear areas. Erosion protection may be in the form of erosion protection cover plates (liners) and/or deflector rings. In areas of very high erosion, more than one liner may be fitted on top of one another in layers. Deflector rings are fitted to deflect erosive particles from structural components (such as blade nose to centre plate welds) onto an area that is more easily protected and repaired, such as a primary or secondary liner on blade noses.
- i) Management of erosion requires regular thickness testing of wearable components. Erosion protection plates should be replaced before 50% of the original thickness is reached. On structural components (such as drive sheets, side plates, blade surfaces) the allowable operating limit is 66% of original material thickness. Engineering evaluation of thickness test outcomes must guide further action to be taken (repairs or replacement).
- j) All defects (cracks) identified on impellers must be evaluated by engineers and appropriate repairs or replacements must be conducted according to the engineering assessments and repair procedures.
- k) All repairs to fan impellers must be conducted according to engineering developed repair procedures. All welding and pre- and post-weld heat-treatment must be conducted as per the Eskom welding standard 240-106628253: Standard for Welding Requirements on Eskom Plant.
- l) Where severe damage is identified that could affect the structural integrity of the fan (such as deep or long cracks, or severe erosion, the integrity of the impeller and its repair-ability must be evaluated by the contractors engineer in consultation with the Eskom System Engineer and Eskom Engineering specialist. Pending the evaluation it may be necessary to scrap the impeller.
- m) All fans must be balanced prior to being put into service. Running vibration levels must comply with the requirements of the Eskom Draught Group Balancing and Vibration Protection Levels Standard.

3.7.2 NDT inspections

- a) NDT must be carried out before and after repairs.
- b) Prior to conducting NDT, contractors must ensure that surfaces have been cleaned, normally by means of micro-blasting where paint or hardened ash/oil deposits must be removed, or hand cleaning as a more cost effective solution when easy to do so, e.g., deposit-free PA or FD fans.
- c) Where micro-blasting is required, the following general rules must be applied:
 - i. Cleaning must be done to ISO 8501-1 (SA 3) or NACE No.1/SSPC-SP 5/ quality.

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- ii. Blasting should be conducted to the extent that it is sufficient for surface cleaning for NDT purposes without eroding the base material of the fan/impeller.
- iii. The blasting must not utilise dangerous substances that could be a hazard to humans, Eskom's plant or the environment.
- iv. The blasting material should not cause excessive dust.
- v. At completion of the blasting activity a close-out report must be produced which records the following minimum information:
 - Name of company executing the micro-blasting activity.
 - Blasting media product information including Data Sheets (Technical Product information) and Material Safety Data Sheets for the material as well as material grade, or profile and size range.
 - Verification that all grit residue has been cleaned out of the fan casings at the end of the blasting activity.
- d) Suitable blasting media that is currently commonly used on Eskom draught plant is Blastrite Microblast Grade 30/60.
- e) Blasting material may be sourced from alternative suppliers, but as a guide should comply with the following requirements:
 - i. Profile Range: 40-75 micron
 - ii. Hardness: 6-8 Moh scale
 - iii. Free Silica: < 1%
 - iv. Aluminium Oxide: < 25% (or within regulatory requirements)
 - v. Non-Hazardous to Humans or environment.
 - vi. Particle embedment into the fan material should be minimal.
 - vii. Data Sheets (Technical Product information) and Material Safety Data Sheets for the material must be submitted to Eskom site engineers for approval prior to use.
 - viii. Blasting material should preferably have been approved by an accredited laboratory utilising either of the following two standards:
 - SANS 10234 Globally Harmonized System of classification and labelling of chemicals (GHS)
 - ISO 11014 Safety data sheet for chemical products — Content and order of sections
- f) It is the contractor's responsibility to arrange for the turning of the rotors (taking care to protect bearings) and to manage scaffolding as required.
- g) All NDT reports that identify defects must be evaluated by the Contractors engineer in in order to develop an appropriate repair procedure.
- h) NDT reports must be comprehensive and unambiguous, and must include the following information:
 - i. Impeller specific identity data, such as site, location, serial number
 - ii. A pictorial or diagrammatic representation of the impeller should be included, indicating common names of components of the impeller and identifying areas that will be subject to NDT
 - iii. A pictorial or diagrammatic representation of a fan blade indicating all NDT measuring points.

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- iv. Measuring points must include all areas of high wear, as well as areas of high stress, such as blade to drive plate and side plate welds.
- v. Results must be referenced to blade number and position on the blade
- vi. Photographs showing significantly damaged areas should be included in the report.
- vii. Results must be evaluated and verified by a suitably qualified NDT technician

i) Types of NDT

- i. MPI (Magnetic Particle Inspection) is the most commonly utilised test method on Centrifugal fans
 - ii. DPI (Dye Penetrant Inspection) is used on materials that have poor magnetic properties, such as austenitic materials or welds, for example on fan balance weights.
 - iii. UT (Ultrasonic Testing) is used when MPI and DPI are not effective, for example when sub-surface defects are suspected or where direct access to the test area is obstructed.
- j) Final NDT to be carried out after the “waiting period” as per procedure 240-106628253: Standard for Welding Requirements on Eskom Plant. The fan may be run during the waiting period.
- k) Where small indications are deemed repairable by grinding out the crack, NDT must be done after grinding to verify the crack has been removed entirely, before repairs can begin.

3.7.3 Wear liners

- a) Wear liners are installed on surfaces of the fan impeller in areas where high erosion takes place.
- b) Erosion protection may be in the form of erosion protection cover plates (liners) and deflector rings. In areas of very high erosion, more than one liner may be fitted on top of one another in layers. Deflector rings are fitted to deflect erosive particles away from structural components (such as blade nose to centre plate welds) onto an area that is more easily protected and repaired, such as an additional liner/layer – referred to as a nose cap liner on blade noses.
- c) Where the wear plates are worn to 50% or more of the original installed/specified thickness they must be replaced. If the wear rate is known to be low, this replacement may be postponed as agreed with the Eskom system engineer.
- d) Liners may be attached by welding (e.g. large surfaces such as blades) or by bolts (eg Nose liners of hot PA fans), while attachment-welding should be positioned to prevent exposure to erosion.
- e) All welding and pre- and post-weld heat-treatment must be conducted as per the Eskom welding standard 240-106628253: Standard for Welding Requirements on Eskom Plant. In particular, attention must be given to the differences in repair methods required for welding onto the Impeller parent material (original structure), compared to welding secondary liners onto primary liners. Welding onto the original structure requires more specialised treatment and should be avoided where possible.
- f) No impeller which had previously fitted liners may be returned to service with significantly worn or without wear liners without Eskom Engineering approval, especially if the resultant erosion would lead to damage to the original (parent) material/structure.
- g) Where liners are fitted they must be inspected at every fan inspection interval and replaced as necessary. Note that in cases where severe erosion takes place, Stations are required to produce a station specific fan inspection policy requiring shorter periods between inspections in order to secure the prevention of damage to the Impeller structure.
- h) Where possible, liners should utilise materials that are resistant to erosive wear.
- i) Where liners are attached by bolts, counter-sunk-head bolts must be used.
- j) Where attachments are done using welding, proper welding procedures must be followed.
- k) Some fans in Eskom have “walking-stick” liners which are weld-attached to the drive plate adjacent to the blades. Normally these liners are relatively long lasting and not replaced as regularly as the

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secondary liners on the blades. It must be noted that when replacing the secondary liners on the blades, the secondary liners may not be welded directly to the walking-stick liner.

- l) Prior to the supply and installation of wear liners on fan impellers, Contractors must have/provide the following for Eskom Engineering review:
 - a. Engineering drawings showing size and installation information for each liner.
 - b. Engineering approved repair procedures

3.8 DRAUGHT PLANT PRESERVATION AND STORAGE

3.8.1 Preservation during extended outages

When fans are shut down for any reason, preservation of the plant must be conducted as documented in 240-131963944: Draught Plant Preservation Standard.

- a) Preservation activities are progressively implemented depending on the length of the outage, and time into the outage.
- b) Preservation activities are aimed at maintaining the fan and its systems in best possible condition to prevent deterioration and include items such as:
 - i. Bearings
 - ii. Lubrication system
 - iii. Impeller rotation
- c) Some of the activities associated with preservation must be reversed prior to return to service – as documented in 240-131963944: Draught Plant Preservation Standard.

3.8.2 Long term storage of impeller spares

Stations are required to maintain stocks of draught plant critical spares as per 240-61379840: Management & reporting of Strategic Spares. Spares must be stored in a manner that protects and does not compromise the serviceability of spares.

In particular spare fan impellers must be rotated at predetermined intervals to prevent shaft sag. This activity is documented in 240-87694663: Fan Storage Standard

3.9 INSTRUMENTATION

Reference is made to the Draught Plant “Minimum Protection Requirements” applicable to Centrifugal fans.

The purpose of listing the critical instrumentation is to:

- a) Compile a Draught Plant RTS (Return to Service) procedure with critical instrument verifications for reliability.
- b) Guide the Operating and Maintenance Engineers with the purpose and application of the provided instrumentation.

Prior to commissioning the Centrifugal Fan maintenance personnel are prompted for deliberate actions to test and verify the accurate functioning of instrumentation in order to facilitate the condition and performance assessment of the fan.

3.9.1 Process and Protection Instrumentation

- a) Gas and air inlet thermocouples – erosion protection details where stipulated with re-commissioning will required due care to verify correct installation and operation accuracy.
- b) Bearing temperature measurement - re-commissioning care to verify correct installation and operation accuracy is required.

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- c) Lubrication system pressure/flow/temperature – inherent critical verification is required to prevent spurious trips or possible component damage.
- d) Bearing fan vibration monitoring – inherent critical verification is required to prevent spurious trips or possible component damage.

3.9.2 Condition monitoring instrumentation

- a) Motor drive amps – are important indicators to flag possible fan loading imbalances or upstream process variations that affect fan performance. It is many times also an indicator (together with high vibration levels) that the fan may be running against a closed flow control damper.
- b) Motor winding temperatures – are important indicators to flag possible motor insulation or phase imbalance problems.

3.10 SPARES AND MANAGEMENT OF SPARES BOM

- a) Management of Spares requires dedicated effort and a commitment to continual improvement of the details and strategy to optimise the BOM for the plant system, in order to secure effective execution of Maintenance activities and outages.
- b) Spares lists are to be structured in accordance to plant layout and headings (as per the relevant AKZ or KKS Plant Breakdown Structures).
- 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, resulting from operational changes, prolonged operational periods, and the inter-related effect of failures, spares-holding must be complete – in this case implying for the maximum scope applicable to any major scheduled outage. Partial stock-availability will result in partial repairs, with a spiralling decline in performance, and significant increases to plant system unreliability (resulting in partial load losses on the unit and power station in question).
- 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 list, and to confirm the required spares BOM, after evaluating the Outage Scope submission.

4. INSPECTION AND TESTING

4.1 ONLINE INSPECTION

4.1.1 Plant-walk verification

The aspects to be monitored with daily/weekly plant walks are important reporting points to flag failure, detect early signs of failure and the monitoring of changing process conditions and are summarised as noted below:

Recording and reporting of visual observations is made to Maintenance personnel, and load-affecting deficiencies are elevated to the System Engineer. Abnormal deviations or concerning observations made and actions taken should be formally logged in the Operator Log (FLIP) system.

- a) Bearing Lubrication systems – Fan and Motor.
 - 1) Pressures to each bearing should be in the specified range.
 - 2) Lubrication tank for correct oil levels, cleanliness – including filler cap breather filter. General check for oil leaks on the tank or piping and change-over filters in good condition. Blocked filters will be revealed by reduced bearing pressures.

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- 3) Bearing temperature. Correct seating/placement of thermocouples and cabling.
 - 4) Oil Cooler oil or water leaks and temperature.
 - 5) Bearing and casing vibration. Abnormal levels of noise and vibration or loose bolts. Correct placing/seating of vibration sensors and cabling. Subjective observation of higher than normal vibration should be reported for further investigation.
 - 6) Bearing and motor hold down bolts, looseness or soft foot.
 - 7) Coupling - oil leakage, looseness.
- b) Unusual noise or fan casing leakage is observed and noted
- 1) Unusual noise could indicate a fan running in stall condition, loose internal components or damage and should prompt for further investigation.
 - 2) Increase in casing vibrations should prompt further investigation.

4.1.2 Contractors documentation

- a) On-load plant walk-down/inspection documentation should be developed/in place, containing effective reporting guidelines for trending, and flagging of anomalies of critical failures.
- b) Report format, layout and content are approved for use with the Eskom Engineer, and are subject to practicality changes and learning points.
- c) A comprehensive 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 handover to Eskom at termination.

4.2 OUTAGE CONDITION AND SOW INSPECTION DOCUMENTATION

4.2.1 Preventative replacement SOW

- a) The Employer System Engineer compiles and submits the basic Scope of Work, based on known life-cycles of individual components, as stipulated in the applicable sections of this document. Where appropriate, consideration shall also be given to plant condition monitoring reports that may be indicative of faults or problem conditions that must be investigated and/or rectified during the outage.
- b) The Contractor Engineer reviews the Scope of Work, and proposes additions to the Scope of Work 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 scope, thus requiring some verification and update of the actual scope after the Outage have commenced (first outage condition inspection).

4.2.2 Compulsory Inspection/assessment

- a) The purpose of the first outage inspection is to assess the real condition of the Fan and to confirm the actual Scope of Work.
 - 1) The Contractor's key experienced personnel conducts and reports on inspections.
 - 2) The initial visual walk-through inspection is performed with the involvement of the Employers Engineer (as a minimum).
 - 3) The Inspection content is tailored and defined for each specific outage type, e.g. all the stipulated measurements cannot be scheduled for a limited-duration shut-down opportunity.

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- 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 and documented by the Contractor.
 - 5) The inspection is guided by a pre-formulated document, ensuring that all possible visual damage is assessed and reported in walkthrough sequence.
- b) Measured Inspection of components condition and reporting
- 1) The continued detail inspection of measured details, as stipulated for the individual items contained in this document, is recorded on sheets, detailing what are measured, measured results, reference specification, and recommended actions.
 - 2) Complex inspection results (such as fan NDT results), requiring an increase of Scope, is analysed by the Contractors Engineers and recommended actions are recorded on the data-sheet.
 - 3) The reports are submitted to the Employer's Engineer as a controlled, edited, and complete document for evaluation and planning a review of the Scope of Work – Referred to as the Rev. 1 SOW.
 - 4) 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 and Quality Control documentation.
- c) The inspection sheets shall cover the following inspection areas (as detailed in each scope/plant section in this Specification) as a minimum (but not limited to) and as applicable to each individual Station/plant. The inspection document shall be clear in indicating current/measured condition versus required condition, thus motivating the requirement for repair.
- 1) Fan casing, motor and bearing mountings.
 - 2) Coupling guard and coupling external condition
 - 3) Fan casing and cross bracing condition, including thickness reports, condition of liners and erosion protection, door seals, suction cone, dorsal fins.
 - 4) Fan shaft seals.
 - 5) Lubrication system and bearing oil or cooling water leaks, including supply and return lines.
 - 6) Fan control system (RVC/ILD), links, pins, bushes, blades, control rings, guide rollers, control shafts and actuators.
- 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 as follows:
 - Bearing wear condition (for both Fans and Motors).
 - Bearing Labyrinth seal inspection and replacement.
 - Impeller structural NDT (liners removed)
 - Coupling Inspection
 - Shaft and Impeller NDT and thickness reports and results.
 - Shaft coupling condition.
 - Shaft Alignment report and results.
 - Final Vibration reports.

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- 2) The condition and recommended replacement is reported and agreed on an “as and when executed” basis.

4.2.3 Scope of Work management

- a) The effective translation of plant inspection observations and measured recordings is a key element with providing the assurance of reliable RTS performance.
- b) Adoption of quality control standards are designed to ensure continuous improvement to processes and performance (ISO 9001).
- c) The key role-players required to execute every element of the defined quality 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.
- d) Failure to provide detailed and accurate input and continuous management of the activities, results in wasteful expenditure and performance degradation.
- e) The key mandatory management activities to provide the above assurance are as follows:
 - 1) Scope clarification and provisional formulation of the Contracted Maintenance/Outage Scope of Work.
 - 2) Complete submission of inspection reports.
 - 3) Report analysis and recommendation.
 - 4) Scope of Work review (Rev.1) and Task order finalisation.
 - 5) Issue of Scope of Work variations and approval.
 - 6) Post mortem consolidation meeting.

4.2.4 Quality Control Documentation

The complex and multitude of verifications required to secure effective performance of the fans require detailed and tightly controlled Quality Control Plans (QCP's). The following important aspects are to be incorporated into 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.
- c) All recording-sheets are referenced on the QCP.
- d) Inspection of adjustments or settings is 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 intervention.

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- g) The method of consolidating small inspection points into one witness point (with associated check-list), 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, re-fitting plant identification tags back onto equipment that was worked on, scaffold removal, door seals & latches, bolts fitted, final set-up measurement reports compiled, alignment and balancing reports, commissioning executed, and doors closure.

4.3 COMMISSIONING

Prior to any commissioning activities, components and sub-systems of the fans that have been subject to preservation must be returned to operational state as per 240-131963944: Draught Plant Preservation Standard.

Commissioning of the fans must take place prior to return to service, and includes commissioning of:

- a) The lubrication system, verify correct operation, flows and pressures.
- b) The cooling system flow and temperatures.
- c) The associated instrumentation, including:
 - i. Fan bearing vibration sensors
 - ii. Bearing temperatures
 - iii. Lubrication flow and pressures
- d) The rotating assembly (dynamic balancing of the Rotor)
 - i. Balancing of the rotor must be included as an activity in the outage plan.
 - ii. Balancing must be completed to the levels specified by 240-121468227: Draught Group Balancing and Vibration Protection Levels Standard.
 - iii. Temporary “clip-on” balance weights may not be used as a long term balancing solution. All temporary weights must be removed prior to returning the fans to service.
 - iv. Allowance must be made for the waiting period prior to conducting the final NDT inspections on the rotor (including balance weights) as per 240-106628253: Standard for Welding Requirements on Eskom Plant. Note that the fan may be test-run during the waiting period.
- e) The fan flow control system (RVC or ILD) operation must be set to ensure that blade movement is synchronised, and the movement of linkages are smooth and cover full range of operation. This is commonly known as stroke-checking. For double inlet fans, the movement of the control vanes must also be balanced between left and right hand side of the fans.

Requirements for fan test-runs

- a) Prior to closing the fan access doors to commence balancing or test-runs, it is important that a comprehensive internal inspection of the fan and casing is conducted to ensure that all loose items such as tools, plates, welding equipment (such as hot boxes) have been removed.
- b) It is imperative that two-way radio communication is available from the fan to the control room, in case the fan must be shut down quickly.
- c) Journal bearing temperatures as well as thrust bearing temperature must be closely monitored to ensure they remain within an acceptable operating range.
- d) The operation of the fan flow control system (RVC or ILD) operation must be monitored to ensure that movement of linkages are smooth and complete, and balanced between left and right hand side of the fans (for double inlet fans).

4.4 DOCUMENTATION OF PROOF TESTS AND INSPECTIONS

4.4.1 Important “proof of functioning or compliance” tests

The mandatory tests and verifications that are to be documented and submitted for acceptance/approval are as follows:

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- a) Bearing clearances.
- b) Impeller NDT and material thickness reports.
- c) Shaft Alignment setting verification/proof.
- d) Fan control function and stroking.
- e) Final inspection, door closing verification and sign-off.
- f) Fan balancing reports.
- g) Material compliance reports (where corrosion plates or protection material is specified).
- h) Return to Service monitoring and recording of critical parameters.

4.4.2 Document acceptance requirements

The relevant Power Station shall maintain records that certify that 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) Results of the tests and inspections.
- e) Actions recommended for rectification.

5. AUTHORISATION

This document was reviewed and accepted by:

Name & Surname	Designation
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6. REVISIONS

Date	Rev.	Compiler	Remarks
July 2020	0	M Lander	Draft under development for review
August 2020	0.1	M Lander	Final Draft of Reviewed document
August 2020	1	M Lander	Final Document for Authorisation and Publication

7. DEVELOPMENT TEAM

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

- William Garnett-Bennett (Senior Consultant, Group Technology, Boiler Draught plant).
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8. ACKNOWLEDGEMENTS

- None.

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