

 Eskom	Scope of work	Engineering
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Introduction

Condition monitoring of plant in Eskom Kendal power stations is monitored manually online and periodically with handheld /portable instruments. The reason for using portable instruments is that the equipment being monitored does not have online sensors on all the components that need to be monitored. Therefore, some condition monitoring, as prescribed in the *Maintenance Strategies*, must be done manually.

This document describes the context and process for handheld condition monitoring at Kendal power stations and defines the services and quality framework required to carry out effective handheld condition monitoring. Service sourcing matters are also covered together with technical requirements for the associated technology. It must be used to conduct and manage condition monitoring of plant, i.e., all equipment/rotating machines within the power station.

1. Supporting Clauses

1.1 Scope

This Document gives an overview of condition monitoring projects within Eskom Kendal Power Station. Including but not limited to, Boiler plant, Turbine Plant, Auxiliary plant. Refer to the Appendix A (The scope of work). The Condition Monitoring contracts manager is the P&T Manager. The contracts supervisor is the Senior Technician. The CM supplier is Contractor whose office is managed by the Site Manager.

Handheld Condition Monitoring encompasses but is not limited to the following technologies that are performed:

- Vibration Diagnostic and Analysis
- Infrared Thermography.
- Tribology – Lubrication sampling and analysis
- Ultrasound testing
- Visual Inspections
- Partial discharge

1.1.1 Purpose

This document provides Performance and Testing and System Engineers with information necessary to develop and implement effective CM management programs/systems. The document highlights areas of concern illustrated by associated skills levels, CM supplier management and CM integration issues and recommended corrective actions that will be planned over the next few years.

By applying this scope of work this will be of great benefit to the station on condition monitoring leading

- Increased plant availability leading to greater outputs and reduced loss of production
- Reduced system downtime due to unplanned failures following the detection and ratification of potential failures
- Reduced maintenance costs and possible reduction in human resource requirements
- Increased safety and reduction in human error

1.1.2 Applicability

This scope of work document shall apply to Eskom Kendal Power Station, on all actions and decisions regarding condition monitoring. This document shall be utilised by but not limited to the Maintenance and Engineering Departments.

1.1.3 Effective date

This document is effective from the date of authorization.

1.2 Normative/Informative References

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

1.2.1 Normative

- [1] ISO 9001 Quality Management Systems
- [2] 240-75850159 Eskom Definition of Requirements for Tools and Software for Handheld Condition Monitoring Standard
- [3] 240-75850159 Definition of Requirements for Tools and Software for Handheld Condition Monitoring Support
- [4] 240-474-10985 Lubrication Group Technology Strategic Report 2015
- [5] 240-75850289 Manual for Handheld Condition Monitoring,
- [6] GGL 36 -53 In-Service Monitoring of Lubricating Oils and Hydraulic Fluids

1.2.2 Informative

- [7] 36 – 1095 Eskom Vibration based Condition Monitoring of rotating auxiliary plant
- [8] 36 – 511 Eskom Infrared Thermography Standard
- [9] ISO 7919 Mechanical vibration - Evaluation of machine vibration by measurements on rotating shafts
- [10] ISO 18436 Condition monitoring and diagnostics of machines

1.3 Definitions

Condition Monitoring is the process of monitoring a parameter(s) of condition in machinery (vibration, temperature, oil etc), to identify a significant change which is indicative of a developing fault. It is a major component of predictive maintenance. The use of conditional monitoring allows maintenance to be scheduled, or other actions to be taken to prevent failure and avoid its consequences.

Vibration diagnostic and analysis can be defined as the cyclic or oscillating motion of a machine or machine component from its position of rest. Some of the most common machinery problems that cause vibration include:

- Looseness
- Misalignment of couplings, bearings, and gears

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- Unbalance of rotating components
- Gear wear
- Rubbing
- Deterioration of rolling-element bearings
- Aerodynamic/hydraulic problems in fans, blowers, and pumps
- Eccentricity of rotating components such as "V" belt pulleys or gears

Infrared Thermography (IRT) or (IR), thermal imaging, and thermal video are examples of infrared imaging science. Since infrared radiation is emitted by all objects above absolute zero according to the black body radiation law, thermography makes it possible to see one's environment with or without visible illumination. The amount of radiation emitted by an object increases with temperature, therefore, thermography allows one to see variations in temperature. When viewed through a thermal imaging camera, warm objects stand out well against cooler backgrounds.

Tribology is the science and engineering of interacting surfaces in relative motion. It includes the study and application of the principles of friction, lubrication, and wear. Tribology is a branch of mechanical engineering and materials science.

Partial Discharge is used to identify risks of failure in the stator windings of motors and generators as well as switch gear and isolated phase bus. Insulation failure is one of the principal causes of forced outages for generators, motors, switchgear and dry type transformers which result in considerable damage and lost revenues. Partial discharge monitoring systems can be used for permanent surveillance of insulation systems on GIS, transformers, rotating machines, motors, cables, or other high voltage equipment. These instruments are designed for long term data recording, alarm handling, event recognition, and system integration.

Steel cord belt inspection Steel Cord Scanning via the Magnetic Flux Leakage system is designed to detect anomalies or damage within the steel cords and splices of conveyor belting, invisible to the naked eye. When the system is operating, it locates areas of cord breakage, partially damaged, corroded cords, integrity of splices and health issues of the carcass. This information is available instantly with no conveyor downtime (depending upon the system combination Remote, Semi Remote or Full conveyor inspection), enabling full production to continue with limited or no interruption.

Ultrasonic refers to the measurement and analysis of sounds generated by rotating machines at frequencies beyond the range audible to people i.e. above 18 MHz.

1.4 Abbreviations

Abbreviation	Explanation
°C	Degrees Celsius
ANSI	American National Standards Institute
CM	Condition Monitoring
CMPR	Compressor
dB	Decibels
GBOX	Gearbox
HP	High pressure
HV	High Voltage
ICML	International Council for Machinery Lubrication
IM	Information Management
IR	Infra-red
IRT	Infrared Thermography
LAN	Local Area Network
LAR	Limited access register
LP	Low pressure
LV	Low Voltage
MHz	Mega Hertz
MRT	Minimum Resolvable Temperature
MS	Micro soft
mV/g	Millivolt per gravitational acceleration
NEC	New Engineering Contract
P&T	Performance and Testing Section
PdM	Predictive maintenance
PPE	Protective Personal Equipment
RPM	Revolution Per Minute
SOC	State Own Company
SOC	State Own Company
SOW	Scope of Work
WAN	Wide Area Network

1.5 Roles and Responsibilities

- 1.5.1 **Performance and testing section** is responsible to manage the handheld Condition Monitoring services contract on behalf of the employer and ensure a sustainable strategy is maintained follow up the defects are attended
- 1.5.2 **Service Contractor** is responsible for the handling of instruments when testing, taking measurements on all condition monitoring machinery as per SOW, data collection, identifying, preparing, and analysing the data, load defects, timeous reporting and accuracy of predictions and also to make recommendations and always adhere to service of the contract but needs to be flexible

1 5 3 **System Engineer** is responsible for monitoring the plant performance on the particular system, interpret the report results for long term solutions and assess the root cause of all the failures *Implement and Design* new modification and technologies to help improve the plant availability and support P&T They should also help with procedures and maintenance strategy and also follow up the defect

1 5 4 **Maintenance Department** is responsible for the successful safe execution of the work in addressing all the loaded defects both Mechanical and Electrical, also adhere to the maintenance strategy

1.6 Process for Monitoring

Relevant reports shall be provided by the Service Contractor used to prove the effectiveness and efficiency of services and all reports must to be registered and archived via the documentation centre

The general steps in condition monitoring are stated here as introduction and discussed in detail in sections that follow The steps are

- a) Plan
- b) Measure
- c) Analyse
- d) Diagnosis and prognosis
- e) Report
- f) Recommend
- g) Acceptance testing
- h) Record all data and transactions in a database

Measurements are taken or data collected. The data is also analysed and compared with limits to identify the presence of any faults The operating purpose, limits and design are considered to determine and specify the required corrective work. After the work is done quality assurance testing is conducted to determine successful clearing of the fault conditions that required correction and to confirm or re-establish a baseline

1.7 Related/Supporting Documents

[1] 240-75850159 Eskom Definition of Requirements for Tools and Software for Handheld Condition Monitoring Standard

[2] 240-75850289 Manual for Handheld Condition Monitoring

2. Condition monitoring scope of work

2.1 Overview

Keeping equipment in a condition close to their designed or required operating state requires periodic *determination of their conditions and taking necessary remedial actions* The process of determining the conditions is commonly referred to as condition monitoring Condition monitoring is a form of predictive maintenance (PdM) Hence the purpose of condition monitoring is to keep machines in good health so that *the machines do not breakdown unexpectedly* Condition monitoring is a key input to maintenance planning

Condition Monitoring of equipment take place as specified in the equipment's maintenance plan. The maintenance plan specifies what failure modes are to be monitored, and frequency of monitoring. Hence equipment's maintenance basis drives the equipment's condition monitoring schedule. Condition assessments may uncover faults or non-conformities. Faults or non-conformities need to be corrected. The specified remedial work is managed by the maintenance management system.

Testing and quality assurance of corrective work is a part of the work execution phase.

The techniques measure equipment operating characteristics such as vibration, temperature, lubrication, etc. These characteristics can be interpreted to indicate the presence of problems within the machine. Condition monitoring techniques that are currently accepted and used at Kendal Power Station include:

- Vibration diagnostic and Analysis
- Thermal Imaging (Infrared Thermography)
- Tribology Oil Sampling and Analysis
- Ultrasonic
- Visual/ wear/physical
- Partial discharge
- Conveyor belts steel cord inspection

Condition Monitoring is expected to provide information that can be used to make decisions about plant operations, health, and maintenance. All activities covered in the scope of work must be executed following this work instruction.

2.2 Functions of condition monitoring

The condition monitoring function is responsible for the following:

- Determine the condition of all targeted equipment's
- Report the condition monitoring results to the plant owner and all other stake holders
- Advise on maintenance actions based on the condition results
- Inform stakeholders of any major developments affecting production, safety, or environment
- Co-ordinate the total station Condition Monitoring function
- Keep in touch with Condition Monitoring developments both within and outside of Eskom

2.3 Safety precautions and requirements

Safety is priority number one, and it cannot be compromised. For Eskom to achieve Zero harm within the practice of condition monitoring:

The contractor is responsible for ensuring the compliance to Eskom Holdings SOC Limited and Kendal Power station Specific policies, procedures, and standards.

Contractor shall be accountable for the compliance with the Occupational safety, Health and Environmental, risk and Quality requirements and Policies of Kendal Power station and Eskom Holdings SOC limited.

Contractor and the employer shall carry out risk assessments to establish what hazards to the health and safety of persons are attached to any work which is to be performed. Contractor shall adhere to live saving

rules as per Eskom Holdings SOC Limited The rules are created to enforce "Zero tolerance" of serious at-risk behaviours

These following steps should be strictly followed by the Service Contractor

- A full risk assessment to be completed correctly and identifying all hazards, Risk and controls by service contractor when applying or an LAR permit on the specific plant
- Notify the outside or unit control room about the job to be performed and apply for LAR
- Safety PPE (Personal Protective Equipment) to be worn
 - Overalls
 - Safety Boots
 - Hard Hat
 - Hearing Protection
 - Gloves
 - Eye Protection
 - Respiratory or Dust Musk

2.4 Outputs of condition monitoring

2.4.1 Vibration Analysis:

Vibration shall be done as per signed scope of work of vibration diagnostic analysis Changes to the SOW will be made as and when required and as per agreement between the Services Manager and the Contractor

The contractor to conduct the vibration tests on all the new replaced motors, pumps, gearboxes and also after the repair on the motors, pumps, gearboxes have been done

The contractor should be flexible and available when needed to take any vibrations within the power station

2.4.2 Thermography:

Plant to be scanned as per signed scope of work and as per ad hoc requests during investigations

2.4.3 Ultrasonic

This task will be conducted as per the signed scope of work

2.4.4 Steel cord belt inspection

This task will be conducted as per the signed scope of work

2.4.5 Partial discharge

This task will be conducted as per the signed scope of work

2.4.6 Tribology:

All oil samples must be sampled at the ideal conditions to avoid contaminations from the surroundings, and it must be sampled when the machine is in service

2.4.7 Failure Analysis:

Contractor must conduct an in-depth analysis to all failures of plant that is included in the scope of work and a detailed report to be compiled

2.4.8 Routine Condition Monitoring:

- Continuous assessment and improvement of CM program, measurement techniques, analysis of data, reports etc
- Capture and trending of information on problematic plant
- Reports on results to be submitted within 5 working days from data collection
- Report serious plant problems immediately to Engineering, Maintenance and Operating
- Format of the report to be agreed upon with Eskom prior to implementation
- Provide Maintenance and Engineering solutions and recommendations
- Establish root causes of failure trends
- Provide a monthly report on all the plant areas. The report should show trends and overall condition of the system
- Provide thermography reports within 24 hours after scans have been made
- Do follow up tests on maintained plant
- Discuss reports and recommendations with clients
- Prepare weekly report with recommendations on the tests done and present to management

2.4.9 Non-Routine Condition Monitoring:

Attend to special requests and investigation from Engineering and Maintenance departments -inclusive of vibration, Thermography, alignment and ultrasonic. Compile detailed reports immediately after the test has been done

2.4.10 Standby

Contractor will be expected to be on standby and work over the weekend when required. Work over the weekend will be attended to as call outs

Callouts and any other work performed outside of those hours will be charged to the Employer as a rate as detailed in the price list

2.4.11 Services and Standards:

The Contractor shall perform all services necessary to ensure that the plant is monitored in accordance with the agreed standards and procedures. The integrity of plant data shall continuously be checked and confirmed against history and any applicable standards

2.5 Equipment types and techniques

Rotating equipment shall be analysed with vibration measurements at least on the drive and non-drive end bearings, and other appropriate key points. Additional electromechanical equipment will be additionally analysed with Thermography. Electrical equipment such as transformers and electrical panels will be assessed with Thermography. Bearings to be scanned using the thermography and follow up to be done by the ultrasonic to determine how much lubricant is required for the friction.

Appendices A, SOW lists the parameters to be monitored per equipment type per technique. Categories of this equipment are suitable for the following predictive monitoring techniques that are applied routinely to equipment on site.

- Vibration Monitoring as per SOW
- Infrared Thermography as per SOW
- Ultrasonic as per SOW
- Partial discharge as per SOW
- Steel cord belt inspection as per SOW
- Tribology as per SOW

2.6 System Functionality

The Condition Monitoring system to provide the following functionality aligned with Eskom's IM standards

- Data collection and storage
- Manipulate, process and analyse data
- Algorithms for fault diagnosis and condition prognosis
- Store faults, condition, diagnosis, prognosis, remedy and work status
- Ability to remotely access information through the network
- Reporting capability including a suite of standard reports and also custom reports
- Interface with other Eskom systems e.g., SAP, etc

2.7 Fundamental Features

The system shall be based on open industry standards that meet Eskom's IM Standards that include.

- Software
- Database technologies
- Interface and integration technologies (specified later)
- The system shall comprise modular components
- The system shall appear as a single system combining software and Databases and for all condition monitoring techniques

2.8 Inter-Operability

a) The system shall use Eskom IM approved industry standard interfacing and Integration technologies so that instruments can be inter-changed where appropriate

b) The system shall use Eskom IM approved industry standard interfacing and integration technologies to ensure interaction and exchange data with other Eskom information systems. e g , SAP, MS office, email, etc

2.9 System Components

A basic Condition Monitoring system consists of the following components

- Sensors to detect the physical phenomenon that are to be measured
- Instruments to collect the data
- Software and associated database to process and analyse the data
- A reporting module
- Condition monitoring software and associated database connection to organise and view data and results and create customised reports
- A database to store the data and any results

Note All database and reports remains an Eskom property and shall be retained to Eskom at the end of the contract

2.10 Technical Scalability

a) Multi-vendor devices shall be supported Software shall use open industry standards (e g serial /USB, TCP/IP, ANSI, ISA, etc) to connect with measuring instruments so that multiple vendor devices may be used if required

b) Multi-user software licences Multiple users shall be able to operate the software concurrently

c) System fully operational over Local Area Network (LAN) and Wide Area Network (WAN)

d) Network Transport Protocol - TCP/IP

e) A common, Eskom IM approved database for multiple techniques

f) Condition monitoring software handles data of multiple techniques uniformly and with a single login

g) Condition monitoring software integrates seamlessly with analysis software tools

h) Number of hierarchies shall scale in line with the data bus and or hardware

i) Number of levels within a hierarchy shall scale in line with the data bus and or hardware

j) Number of measurement points shall scale in line with the data bus and or hardware

k) Measurements data per measurement point shall scale in line with the data bus and or hardware The Contractor shall supply a project implementation plan no later than 2 weeks after the contract notification It must include at least the following

- Site Establishment
- Manpower plan
- Organogram

2.11 Vibration Monitoring Techniques

- a) The vibration technique will be used to detect failure mechanisms and modes in rotating equipment such as fans, motors, pumps, gearboxes, etc
- b) Vibration measurement probes shall have the following functions and features
- Sensors shall be self-adhering, e.g , magnetic attachment, no hand held probes are allowed for safety and accuracy reasons
 - Tri-axial probes are optional
 - Probe and sensor Dynamic Range minimum of 96 dB
 - Probe sensitivities in relation to machine speed are shown in Table 1

Table 1: Probe sensitivities per machine speeds (Source - Eskom Standard)

Machine speed	Sensitivity
< 600 RPM	500mV/g
600RPM to 20 000RPM	100mV/g
> 20 000RPM	10mV/g

Specifications relevant to data collection and analysis have been combined as there is no preference for location of the analysis software. The following are the minimum functional and technical specifications for data collection, display and analysis

- a) Measure velocity, displacement, acceleration, or any combination
- b) Units Metric System
- c) Display previous readings with current readings
- d) Alarm capabilities
- Overall alarm levels
 - Spectral alarm bands
 - Narrowband envelopes
- e) Minimum frequency analysis capabilities.
- High Frequency
 - Low Frequency
 - Order Tracking
- f) Advanced functions.
- Normal Averaging
 - Exponential
 - Peak Hold
 - Synchronous Time, and
 - Negative Averaging
- g) Dynamic analysis of
- Overall spectra and waveforms,

➤ Phase

2.12 Thermography

2.12.1 Thermography specifications

IR cameras shall have the following minimum functions

- a) Include a visual camera
- b) Provide for reflected background temperature (emissivity) compensation and or adjustments
- c) Adjustments when transmission medium is other than air
- d) Auto Hot/Cold Spot Recognition (temperature alarms)
- e) Perform image averaging
- f) Digitally adjust the level, span, zoom and pan on images
- g) Provide a range of different colour palettes
- h) Allow for both visual and infrared images on reports
- i) Transfer image descriptions automatically into the report
- j) Export IR and visible images in file formats recognisable by MS Office products
- k) Data transfer to host computer system via serial, USB, or Ethernet

2.12.2 Technical specifications for IR cameras

IR cameras shall have the following minimum technical specifications

- a) Temperature shall be in °C with range -20°C to +300 °C (Additional temperature ranges may be facilitated by lens changes)
- b) Measurement precision shall be $\pm 2^{\circ}\text{C}$ or 2% of full scale
- c) Minimum resolvable temperature (MRT)-temperature sensitivity shall be $\leq 0.1^{\circ}\text{C}$ at 30 °C
- d) Spectral range for high temperature applications 3-5 μm
- e) Spectral range for lower temperature applications 8-12 μm

2.13 Ultrasound

Ultrasound is a predictive maintenance and energy conservation technology used to locate leaks, detect electrical emissions and inspect mechanical conditions in operating equipment. T technology has a vast array of applications including leak detection (compressed air, vacuum, fluids), assessing bearing CM and optimum bearing lubrication levels, identifying electrical discharges such as arcing tracking and corona, bypassing valves, defective steam traps, and hydraulic defects

2.14 Partial discharge

Partial discharges (PD) are small electrical current sparks that occur in the high voltage *electrical insulation* in stator windings whenever there are small air gaps or voids in or on the surface of the insulation. As a stator winding deteriorates from coil winding vibration in the slot, operation at high temperatures, or contamination, the partial discharge activity increases. Thus, partial discharge monitoring can be used to detect the primary causes of stator winding failure and generally give two or more years of warning of a machine failure.

2.15 Tribology

As per standard Eskom 36-53

- 1 Appearance and smell (odour),
- 2 Particle Quantification (PQ),
- 3 Cleanliness -(ISO 4406 1999)
- 4 Total acid number (TAN) -ASTM D974
- 5 Total base number -(ASTM D974, ASTM 2896, ASTM D 664)
- 6 Viscosity -(ASTM D445)
- 7 Crackle test for free water
- 8 Water content -(ASTM D1533-Karl Fischer Reaction Method)
- 9 Water Content -(ASTMD1744-Karl Fischer Reagent)
- 10 Demulsibility and water separability (IP 19, ASTM D1401, ASTM D 2711)
- 11 Wear debris analysis (WDA) or Ferrography
- 12 Additive content and wear metals -(ASTM D5185-ICP) or FTIR or RDE (ASTM D6595),
- 13 Rust inhibitor -(ASTM D665)
- 14 Flash point -(ASTM D92-Cleveland open cup, ASTM D93-Pensky-Martens closed cup)
- 15 Volume resistivity -(ASTM D1169 -Fire resistant fluids (FRFs only))
16. Density -(ASTM D1298 (FRFs))
- 17 Air release value -(ASTM D3427)
- 18 Foaming characteristics -(ASTM D892)
- 19 Insolubles, pentane and toluene -(ASTM D893 procedures A and B, ASTM D4055)
- 20 Oxidation stability -(ASTM D2272 (RBOT))

2.16 Technical specifications for data handling tools

Any portable data tools shall comply with these additional requirements

- a) Minimum IP-65 rating. The air can be dusty, and instruments shall be protected against dust ingress. Moisture levels could be high, and instruments shall be sealed from moisture.
- b) Ambient operating temperatures shall range from -10°C to 50°C
- c) Battery powered instruments shall be able to operate for at least 8 hours or be achieved with a spare battery changed with no loss of data.

- d) Instruments shall be used both indoors and outdoors Display screens shall be readable both indoors and outdoors
- e) The manufacturer shall specify the how often instruments shall be calibrated and who is an acceptable calibration authority
- f) Capability to transfer the output into an Eskom IM accepted, common database
- g) Interface with each other if needed,
- h) Use non-proprietary Industry best practice standards to interface with other devices and software,
- i) Have common open industry best practice generic user interfaces,
- j) Perform as many data gathering functions as possible to minimise the total number of tools required for data gathering

2.17 Calibration of instruments

All instruments must have valid calibration certificates at time of use and available on request All measuring equipment and instrumentation used to provide the works are provided with a SANAS (South African National Accreditation System) Calibration Laboratory test certificate

2.18 Licenses

All software used by the service provider must have valid current licences

3. Acceptance

This document has been seen and accepted by

Name	Designation

4. Revisions

Date	Rev	Compiler	Remarks

5. Development Team

The following people were involved in the development of this document

6. Acknowledgements

Thanks to all System Engineers for their comments/suggestions/inputs during the development of this document

Appendix A

	KENDAL POWER STATION								
	CONDITION MONITORING SCOPE OF WORK								
NO	PLANT DESCRIPTION	Number of machines					MACHINES	Vibration Frequency	Tribology frequency
		mtr	gbx	fan	pmp	cmpr	STATION		
	BOILER PLANT								
1	DRAUGHT GROUP								
1 1	FD FAN								
	Motor	12					12	Monthly	3 Monthly
	Fan			12			12	Monthly	3 Monthly
1 2	ID FAN								
	Motor	12					12	Monthly	3 Monthly
	Fan			12			12	Monthly	3 Monthly
1 3	PA FAN								
	Motor	12					12	Monthly	3 Monthly
	Fan			12			12	Monthly	3 Monthly
2	MILLING PLANT								
2 1	Mill motor	30					30	Monthly	3 Monthly
2 2	Mill Gearbox		30				30	Monthly	3 Monthly
2 3	Mill Trunnion Bearings						30		3 Monthly

2 4	Girth Gear & Pinion Gear					30	Monthly	
2 5	Mill Gearbox Lub Oil Motor and Pump	30				30	Monthly	
2.6	Mill Trunion HP + LP Oil Pump Motor	30				30	Monthly	
2 7	Mill Motor Lub Oil Motor and Pump	30				30	Monthly	
2 8	Mill Feeder Gearbox		30			60	Monthly	3 Monthly
2 9	Mill Feeder Motor	30				60	Monthly	
1 10	Mill Seal Air Fans (motor + fan bearings)	60		60		120	Monthly	
3	SECONDARY AIR HEATER							
3 1	SAH Motor	12				12	Monthly	
3 2	SAH Gearbox		12			12	Monthly	3 Monthly
3 3	SAH Guide Bearing					12		Monthly
3 4	SAH Support Bearing					12		Monthly
4	BOILER WATER CIRC PUMP							
4 1	Boiler Water Circ Pump	18		18		36	Monthly	
5	SCANNER AIR FAN							
5 1	Scanner air fans (Purge air)	12				12	Monthly	
6	SO3 PLANT							
6 1	SO3 Air Blower		6			6	Monthly	3 Monthly
6 2	SO3 Air Blower Motor	6				6	Monthly	
6 3	SO2 Cooler Fan Motor	6				6	Monthly	
6 4	SSC Hydraulic Pack X6	6				6		Monthly
6 5	Sulphur Common Plant p/p motor x4	4				4	Monthly	

6 6	HP bypass valve X12	12				12	Monthly	Monthly
TURBINE PLANT								
	Turbine Main oil tank X 6					6		Monthly and Yearly R-bot
1	ELECTRIC FEED PUMPS							
1 1	Motor	18				18	Monthly	
1 2	Main Pump	18				18	Monthly	
1 3	Gearbox		18			18	Monthly	
1 4	Booster Pump				18	18	Monthly	
1 5	Pump and motor tribology, (1 tank per EFP)					18		Monthly
2	UNITIZED COMPRESSOR							
2 1	Motor	6				6	Monthly	
2 2	Compressor					6	Monthly	3 Monthly
3	CONDENSATE, CONDENSER PLANT							
3 1	CEP Motor	12				12	Monthly	Monthly
3 2	CEP Pump				12	12	Monthly	Monthly
3 3	CPP Booster Pump Motor	12				12	Monthly	
3 4	CPP Booster Pump				12	12	Monthly	
3 5	LP Heater 2 Drain Pump Motor	12				12	Monthly	
3 6	LP Heater 2 Drain Pump				12	12	Monthly	
3 7	Elmo Vacuum Pump Motor	18				18	Monthly	
3 8	Elmo Vacuum Pump				18	18	Monthly	
3 9	Make up pumps				12	12	Monthly	

3 10	Make up pump motors	12					12	Monthly	
4	GAS TURBINE								
4 1	AC lube oil pump motor	2					2	Monthly	
4 2	AC lube oil pumps				2		2	Monthly	
4 3	Fuel (Diesel) sampling						2		6 Monthly(diesel tanks sampling), Trucks on Request
5	FORCE COOLING COMPRESSOR								
5 1	Motor	1					1	Monthly	
5 2	Compressor					1	1	Monthly	
	OUTSIDE PLANT								
1	MAIN COOLING WATER PUMPS								
1 1a	MCW Pump Motor, units 1, 2, 3	9					9	Monthly	3 Monthly
1 2a	MCW Pump, units 1, 2, 3				9		9	Monthly	3 Monthly
1 1b	MCW Pump Motor, units 4, 5, 6	6					6	Monthly	3 Monthly
1 2b	MCW Pump, units 4, 5, 6				6		6	Monthly	3 Monthly
2	AUXILIARY COOLING								
2 1	Open Circuit Pump Motor	8					8	Monthly	
2 2	Open Circuit Pump				8		8	Monthly	

2 3	Close Circuit Pump Motor	8				8	Monthly	
2 4	Close Circuit Pump			8		8	Monthly	
2 5	Aux Cooling Fan Motor	6				6	Monthly	
3	FUEL OIL PLANT							
3 1	LP Fuel Oil Pump Motor	6				6	Monthly	
3 2	LP Fuel Oil Pump			6		6	Monthly	
3 3	HP Fuel Oil Pump Motor	6				6	Monthly	
3 4	HP Fuel Oil Pump			6		6	Monthly	
4	ASH CONDITIONING PUMPS							
4 1	Ash Conditioning Pump Motor	12				12	Monthly	
4 2	Ash Conditioning Pump			12		12	Monthly	
	AREATION BLOWERS							
4 3	Motor	12				12	Monthly	
4 5	Gear Box				12	12	Monthly	3 Monthly
4 6	Clean And Dirty Motors	6				6	Monthly	
4 7	Clean And Dirty Pumps			6		6	Monthly	
4 8	Dust Suppression Motors	4				4	Monthly	
4 9	Dust Suppression Pumps			4		4	Monthly	
4 10	Cross over plant	4	4			4	2 Monthly	
4 11	Sewage plant	2	2			2	2 Monthly	
5	COAL OVERLAND CONVEYORS							
5 1	CS 1A Motor	1				1	Monthly	

5 2	CS 1A Gearbox		1				1	Monthly	3 Monthly
5 3	CS 1B Motor	1					1	Monthly	
5 4	CS 1B Gearbox		1				1	Monthly	3 Monthly
5 5	S 1A drive 1 Motor	1					1	Monthly	
5 6	S 1A drive 1 Gearbox		1				1	Monthly	3 Monthly
5 7	S 1A drive 2 Motor	1					1	Monthly	
5 8	S 1A drive 2 Gearbox		1				1	Monthly	3 Monthly
5 9	S 1B drive 1 Motor	1					1	Monthly	
5 10	S 1B drive 1 Gearbox		1				1	Monthly	3 Monthly
5 11	S 1B drive 2 Motor	1					1	Monthly	
5 12	S 1B drive 2 Gearbox		1				1	Monthly	3 Monthly
5 13	S 2A Motor	1					1	Monthly	
5 14	S 2A Gearbox		1				1	Monthly	3 Monthly
5 15	S 2B Motor	1					1	Monthly	
5 16	S 2B Gearbox		1				1	Monthly	3 Monthly
5 17	S 4A Motor	1					1	Monthly	
5 18	S 4A Gearbox		1				1	Monthly	3 Monthly
5 19	S 4B Motor	1					1	Monthly	
5 20	S 4B Gearbox		1				1	Monthly	3 Monthly
5 21	S 5A drive 1 Motor	1					1	Monthly	
5 22	S 5A drive 1 Gearbox		1				1	Monthly	3 Monthly
5 23	S 5A drive 2 Motor	1					1	Monthly	
5 24	S 5A drive 2 Gearbox		1				1	Monthly	3 Monthly
5 25	S 5B drive 1 Motor	1					1	Monthly	
5 26	S 5B drive 1 Gearbox		1				1	Monthly	3 Monthly
5 27	S 5B drive 2 Motor	1					1	Monthly	
5 28	S 5B drive 2 Gearbox		1				1	Monthly	3 Monthly

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5 29	S 6A drive 1 Motor	1					1	Monthly	
5 30	S 6A drive 1 Gearbox		1				1	Monthly	3 Monthly
5.31	S 6A drive 2 Motor	1					1	Monthly	
5 32	S 6A drive 2 Gearbox		1				1	Monthly	3 Monthly
5 33	S 6B drive 1 Motor	1					1	Monthly	
5 34	S 6B drive 1 Gearbox		1				1	Monthly	3 Monthly
5 35	S 6B drive 2 Motor	1					1	Monthly	
5 36	S 6B drive 2 Gearbox		1				1	Monthly	3 Monthly
5 37	CS 2A Motor	1					1	Monthly	
5 38	CS 2A Gearbox		1				1	Monthly	3 Monthly
5 39	CS 2B Motor	1					1	Monthly	
5 40	CS 2B Gearbox		1				1	Monthly	3 Monthly
5 41	S 8A Motor	1					1	Monthly	
5 42	S 8A Gearbox		1				1	Monthly	3 Monthly
5 43	S 8B Motor	1					1	Monthly	
5 44	S 8B Gearbox		1				1	Monthly	3 Monthly
5 45	T1A Motor	1					1	Monthly	
5 46	T1A Gearbox		1				1	Monthly	3 Monthly
5 47	T1B Motor	1					1	Monthly	
5 48	T1B Gearbox		1				1	Monthly	3 Monthly
5 49	T2A Motor	1					1	Monthly	
5 50	T2A Gearbox		1				1	Monthly	3 Monthly
5 51	T2B Motor	1					1	Monthly	
5 52	T2B Gearbox		1				1	Monthly	3 Monthly
5 53	T3A Motor	1					1	Monthly	
5 54	T3A Gearbox		1				1	Monthly	3 Monthly
5 55	T3B Motor	1					1	Monthly	

5 56	T3B Gearbox		1				1	Monthly	3 Monthly
5 57	T4 Motor	6					6	Monthly	
5 58	T4 Hydraulic pack		6				6	Monthly	3 Monthly
5 59	T5A Motor	1					1	Monthly	
5 60	T5A Gearbox		1				1	Monthly	3 Monthly
5 61	T5B Motor	1					1	Monthly	
5 62	T5B Gearbox		1				1	Monthly	3 Monthly
5 63	T5C Motor	1					1	Monthly	
5 64	T5C Gearbox		1				1	Monthly	3 Monthly
5 65	T5D Motor	1					1	Monthly	
5 66	T5D Gearbox		1				1	Monthly	3 Monthly
5 67	T5E Motor	1					1	Monthly	
5 68	T5E Gearbox		1				1	Monthly	3 Monthly
5 69	T5F Motor	1					1	Monthly	
5 70	T5F Gearbox		1				1	Monthly	3 Monthly
5 71	ECB 30 Motor and Gear Box	6					6	Monthly	3 Monthly GB
5 72	ECB 31 Motor and Gear Box		6				6	Monthly	3 Monthly GB
5 73	ECB 32 Motor and Gear Box	6					6	Monthly	3 Monthly GB
5 74	ECB 40 Motor and Gear Box		6				6	Monthly	3 Monthly GB
5 75	ECB 41 Motor and Gear Box	6					6	Monthly	3 Monthly GB
5 76	ECB 42 Motor and Gear Box		6				6	Monthly	3 Monthly GB
5 77	ECB 43 Motor and Gear Box	6					6	Monthly	3 Monthly GB
6	ASH PLANT CONVEYORS								
	Ash Transverse Conveyors ETK							Monthly	
6 1	ETK 11 Motor	2					2	Monthly	

6 2	ETK 11 Gearbox		2				2	Monthly	3 Monthly
6 3	ETK 12 Motor	2					2	Monthly	
6 4	ETK 12 Gearbox		2				2	Monthly	3 Monthly
6 5	ETK 21 Motor	2					2	Monthly	
6 6	ETK 21 Gearbox		2				2	Monthly	3 Monthly
6 7	ETK 22 Motor	2					2	Monthly	
6 8	ETK 22 Gearbox		2				2	Monthly	3 Monthly
6 17	ETK 13 Motor	1					1	Monthly	
6 18	ETK 13 Gearbox		1				1	Monthly	3 Monthly
6 19	ETK 23 Motor	1					1	Monthly	
6 20	ETK 23 Gearbox		1				1	Monthly	3 Monthly
								Monthly	
	Ash Shiftable Conveyors - ETK 14 / 24								
6 21	ETK 14 Motor	2					1	Monthly	
6 22	ETK 14 Gearbox		2				1	Monthly	3 Monthly
6 23	ETK 24 Motor	2					1	Monthly	
6 24	ETK 24 Gearbox		2				1	Monthly	3 Monthly
6 25	ETK 14 Motor Link	1					1	Monthly	
6 26	ETK 14 Gearbox Link		1				1	Monthly	3 Monthly
6 27	ETK 14 Motor Boom	1					1	Monthly	
6 28	ETK 14 Gearbox Boom		1				1	Monthly	3 Monthly
6 29	ETK 24 Motor Link	1					1	Monthly	
6 30	ETK 24 Gearbox Link		1				1	Monthly	3 Monthly
6 31	ETK 24 Motor Boom	1					1	Monthly	
6 32	ETK 24 Gearbox Boom		1				1	Monthly	3 Monthly
6 33	Ash Plant Moving heads hydraulic system						4		3 Monthly
6 34	Ash stacker and spreader crawler gearboxes		4				4	3 Monthly	3 Monthly

6 35	Ash stacker and spreader crawler motor	4					4	3 Monthly	
6 36	Ash stacker and spreader slew gearboxes (helical and planetary)		8				8	3 Monthly	3 Monthly
6 37	Ash stacker and spreader slew drive motor	4					4	3 Monthly	
6 38	Ash stacker and spreader slew bearing grease analysis						2		3 Monthly
	Conditioned ash Conveyors ETK								
6 39	01ETK 11 Motor	1					1	Monthly	
6 40	01ETK 11 Gearbox		1				1	Monthly	3 Monthly
6 41	01ETK 21 Motor	1					1	Monthly	
6 42	01ETK 21 Gearbox		1				1	Monthly	3 Monthly
6 43	02ETK 11 Motor	1					1	Monthly	
6 44	02ETK 11 Gearbox		1				1	Monthly	3 Monthly
6 45	02ETK 21 Motor	1					1	Monthly	
6 46	02ETK 21 Gearbox		1				1	Monthly	3 Monthly
6 47	03ETK 11 Motor	1					1	Monthly	
6 48	03ETK 11 Gearbox		1				1	Monthly	3 Monthly
6 49	03ETK 21 Motor	1					1	Monthly	
6 50	03ETK 21 Gearbox		1				1	Monthly	3 Monthly
6 51	Ash Plant Moving heads hydraulic system conditioned ash conveyors				6		6		3 Monthly
	Ash conditioners								
6 52	11-01ETK10 AM101 1B Ash conditioner - Fly ash Bunker 1 Motor	1					1	Monthly	
6 53	11-01ETK10 AM102 1A Ash conditioner - Fly ash Bunker 1 Motor	1					1	Monthly	
6 54	11-01ETK20 AM101 2A Ash conditioner - Fly ash Bunker 1 Moto	1					1	Monthly	

6 55	11-01ETK30 AM101 3B Ash conditioner - Fly ash Bunker 1 Motor	1					1	Monthly	
6 56	11-02ETK10 AM101 1B Ash conditioner - Fly ash Bunker 2 Motor	1					1	Monthly	
6 57	11-02ETK10 AM102 1A Ash conditioner - Fly ash Bunker 2 Motor	1					1	Monthly	
6 58	11-02ETK20 AM101 2A Ash conditioner - Fly ash Bunker 2 Motor	1					1	Monthly	
6 59	11-02ETK30 AM101 3B Ash conditioner - Fly ash Bunker 2 Motor	1					1	Monthly	
6 60	11-03ETK10 AM101 1B Ash conditioner - Fly ash Bunker 3 Motor	1					1	Monthly	
6 61	11-03ETK10 AM102 1A Ash conditioner - Fly ash Bunker 3 Motor	1					1	Monthly	
6 62	11-03ETK20 AM101 2A Ash conditioner - Fly ash Bunker 3 Moto	1					1	Monthly	
6 63	11-03ETK30 AM101 3B Ash conditioner - Fly ash Bunker 3 Motor	1					1	Monthly	
6 64	11-03ETK30 AM101 3B Ash conditioner - Fly ash Bunker 3 Motor	1					1	Monthly	
6 65	11-01ETK10 AM101 1B Ash conditioner - Fly ash Bunker 1 Gearbox		1				1	Monthly	3 Monthly
6 66	11-01ETK10 AM102 1A Ash conditioner - Fly ash Bunker 1 Gearbox		1				1	Monthly	3 Monthly
6,67	11-01ETK20 AM101 2A Ash conditioner - Fly ash Bunker 1 Gearbox		1				1	Monthly	3 Monthly
6,68	11-01ETK30 AM101 3B Ash conditioner - Fly ash Bunker 1 Gearbox		1				1	Monthly	3 Monthly
6 69	11-02ETK10 AM101 1B Ash conditioner - Fly ash Bunker 2 Gearbox		1				1	Monthly	3 Monthly

6 70	11-02ETK10 AM102 1A Ash conditioner - Fly ash Bunker 2 Gearbox		1				1	Monthly	3 Monthly
6 71	11-02ETK20 AM101 2A Ash conditioner - Fly ash Bunker 2 Gearbox		1				1	Monthly	3 Monthly
6 72	11-02ETK30 AM101 3B Ash conditioner - Fly ash Bunker 2 Gearbox		1				1	Monthly	3 Monthly
6 73	11-03ETK10 AM101 1B Ash conditioner - Fly ash Bunker 3 Gearbox		1				1	Monthly	3 Monthly
6 74	11-03ETK10 AM102 1A Ash conditioner - Fly ash Bunker 3 Gearbox		1				1	Monthly	3 Monthly
6 75	11-03ETK20 AM101 2A Ash conditioner - Fly ash Bunker 3 Gearbox		1				1	Monthly	3 Monthly
6 76	11-03ETK30 AM101 3B Ash conditioner - Fly ash Bunker 3 Gearbox		1				1	Monthly	3 Monthly
6 77	11-03ETK30 AM101 3B Ash conditioner - Fly ash Bunker 3 Gearbox		1				1	Monthly	3 Monthly
7	COAL STACKER / RECLAIMER 1 & 2								
7 1	Boom Conveyor drive motor	2					2	Monthly	
7 2	Boom Conveyor drive gearbox		2				2	Monthly	3 Monthly
7 3	Intermediate Conveyor motor	2					2	Monthly	
7 4	Intermediate Conveyor gearbox		2				2	Monthly	3 Monthly
7 5	Hydraulic pack				2		2	Monthly	3 Monthly
								Monthly	
8	BUCKET ASH ELEVATORS							Monthly	
8 1	Motor	12					12	Monthly	
8 2	Gearbox		12				12	Monthly	3 Monthly
9	ESP ASH CONVEYORS								

9 1	First collecting conveyors motors	12					12	Monthly	
9 2	First collecting conveyors gearbox		12				12	Monthly	3 Monthly
9 3	Second collecting conveyor motors	12					12	Monthly	
9 4	Second collecting conveyor gearbox		12				12	Monthly	3 Monthly
9 5	Ash hopper collecting conveyor motors	48					48	Monthly	
9 6	Ash hopper collecting conveyor gearbox		48				48	Monthly	3 Monthly
9 7	Top bunker conveyors motors	6					6	Monthly	
9 8	Top bunker conveyors gearbox		6				6	Monthly	3 Monthly
10	COARSE ASH CONVEYORS								
10 1	Sicon belt motor	6					6	Monthly	
10 2	Sicon belt gearbox		6				6	Monthly	3 Monthly
10 3	Apron Conveyor motor	6					6	Monthly	
10 4	Apron Conveyor gear box		6				6	Monthly	3 Monthly
10 5	Coarse Ash Conveyor Motor	6					6	Monthly	
10 6	Coarse Ash Conveyor gearbox		6				6	Monthly	3 Monthly
									3 Monthly
11	LP SERVICES - STATION COMPRESSORS								
	Centac compressor motor	3					3	Monthly	
	Centac compressor					3	3	Monthly	3 Monthly
	Electric fire pumps	2			2		2	Monthly	
	Diesel fire pumps	2			2		2	Monthly	
	TH1 Fire pump electric	1			1			Monthly	
	TH1 Fire pump diesel	1			1			Monthly	
	TH1 Fire pump jockey	1			1			Monthly	

12	Water Treatment Plant							
12 1	Vacuum pump				3		3	Monthly
12 2	Vacuum pump motor	3					3	Monthly
12 3	Demin plant supply pump				4		4	Monthly
12 4	Demin plant supply pump motor	4					4	Monthly
12 5	Anion supply pump				4		4	Monthly
12 6	Anion supply pump motor	4					4	Monthly
12 7	Potable water pump				4		4	Monthly
12 8	Potable water pump motor	4					4	Monthly
12 9	Motive water pump				2		2	Monthly
12 10	Motive water pump motor	2					2	Monthly
12 11	Demin water pump				2		2	Monthly
12 12	Demin water pump motor	2					2	Monthly
12 13	Rinse recycle pump				1		1	Monthly
12 14	Rinse recycle pump motor	1					1	Monthly
12 15	Brine pump				1		1	Monthly
12 16	Brine pump motor	1					1	Monthly
12 17	Caustic soda off - loading pump				1		1	Monthly
12 20	Caustic soda off - loading pump motor	1			1		2	Monthly
12 21	Mixed bed blower motor	2			2		4	Monthly
12 22	Filter air blower motor	2			2		4	Monthly
		mtr	gbx	fan	pmp	cmpr		
		775	311	102	209	22		
	TOTAL	1537						

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Appendix B

- Thermography, stroboscopic and Belt scan (steel cord inspection) condition monitoring

1 The table below is the thermography and stroboscopic scope of work to be done

THERMOGRAPHY				
	DESCRIPTION	INFRARED IMAGE	TEMPERATURES	COMMENTS
1	Generator Transformers			
1 1	Bushings	Yes	Bushing connection temperatures	1 Transformer can be tested at any load between 386 MW and 686 MW 2 A summary table with all the temperatures to be Supplied
1 2	Main "Tank"	Yes	Casing temperature	
1 3	Cooler banks	Yes	6 inlet and 6 outlet temperatures	
1 4	Tap changer	Yes	Casing temperature Monthly	
2	Unit Transformers A & B			
2 1	Coolers	Yes	Average temperature on top part Monthly	1 A summary table of all the temperatures to be Supplied.
3	Service Transformers A & B			
3 1	"Tank"	Yes	Average temp of tank	1 A summary table of all the temperatures to be Supplied
3 2	Coolers	Yes	Average temp on top of coolers	
4	EFP Transformers A, B & C			

4 1	"Tank"	Yes	Average temp of tank	1 Scan all 3 transformers, include standby one.
4 2	HV & LV connections	Yes	Temps of all HV & LV connections	2 A summary table of all the temperatures to be
4 3	Coolers	Yes	Average temperature on top part Monthly	Supplied
5	Outage work On request, electrical boards, Transformer energisation etc	Yes Yes	As per request	As requested
6	Mill pinion gear	Yes	Temperatures of hot and cold spots Monthly	1 A summary table of all the temperatures to be Supplied
7	Coal Stock Yard	Yes	Temperature profile of coal stock Pile surface area	
8	ESP TX (x 168)	Yes	Average temp of SIR/TR (3 Monthly)	1 A summary table of all the temperatures to be Supplied
9	Sulphur Common Plant (x2)	Yes	Average temp of tank (Monthly)	1 A summary table of all the temperatures to be Supplied
10	ALL HV Motors	Yes	Temperature of the Terminal box Monthly	1 A summary table of all the temperatures to be Supplied

11	H2 Plant	Yes	Temperatures of Electrolyser connections Monthly	1 A summary table of all the temperatures to be Supplied
12	PULLEY BEARINGS(ASH/COAL) Plant	Yes	Temperatures of hot and cold spots Coal (monthly) and outside ash (2 weekly)	1 A summary table of all the temperatures to be Supplied
13	Gearbox, motor and fluid coupling bearings	Yes	Temperatures of hot and cold spots Monthly	1 A summary table of all the temperatures to be Supplied
14	22KV Breaker scans (RED,WHITE,BLUE Phases Gen side and Gen TRFR side including IPB)X 6	Yes	Temperatures of hot and cold spots Monthly	1 A summary table of all the temperatures to be Supplied
15	Electrical Boards (HV/LV) and cable chamber spread	Yes	Temperatures of hot and cold spots 6 Monthly	1 A summary table of all the temperatures to be Supplied
16	Boiler casings x6	Yes	Temperatures of hot and cold spots Monthly	1 A summary table of all the temperatures to be Supplied
17	22KV and 11KV lines (Coal/ ash Plant	Yes	Temperatures of hot and cold spots Monthly	1 A summary table of all the temperatures to be Supplied

STROBE LIGHT INSPECTION		
1	Mill pinion gear	Do a strobe light inspection on whole girth and pinion gear to identify cracked teeth, contact profile etc <i>Digital photographs to be taken of normal and abnormal conditions This activity will take place every month</i>

Appendix C

Key performance indicators

The Contractor shall provide all services stipulate in the contract and comply with the following key performance indicators

- All reports for the services shall be submitted within 5 working days after data has been collected
- Contractor shall respond to all call outs requests
- Contractor shall report to site within an hour after call-out has been made
- Contractor shall ensure zero unpredicted failures
- Contractors shall ensure 100% PM compliance
- Contractor shall ensure that no early warnings issued against by the Service manager for poor performance
- Contractor shall ensure Zero safety incidents