# Option 1: Turbine vibration diagnostic system

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# Description of the works For the Turbine vibration diagnostic system option

## Executive overview

The Works consists of:

* The design, supply, installation and commission of supplied turbine diagnostic system components and software that can interface to the vibration monitoring equipment provided in the main technical specification for three units.
* Provision of server for the diagnostic servers and archives and the installation of software to enable access to the diagnostic information.
* Implementation of the network connectivity needed to provide data exchange for diagnostic and monitoring data.
  + Implement station vibration diagnostic sub-net which needs to interface to the Station OCM network.
  + Configure data communication to enable data communication from provided vibration diagnostic server to unitised vibration monitoring systems.
  + Installation and configuration of end users to enable vibration monitoring at station level as well as enterprise level

## Interpretation and terminology

The following abbreviations are used in this Works Information:

|  |  |
| --- | --- |
| **Abbreviation** | **Meaning given to the abbreviation** |
| C&I | Control and Instrumentation |
| CD | Compact disc |
| DBMS | Database Management System |
| DCS | Distributed Control System |
| DS | Diagnostic System |
| DVD | Digital video disk |
| FAT, SAT | Factory-, Site Acceptance Test |
| GPS | Global Positioning System |
| HMI | Human Machine Interface |
| I/O | Input/Output |
| IP | Internet protocol |
| LAN | Local Area Network |
| Mbps | Megabits per second |
| NOS | Network Operating System |
| OCM | Online Condition Monitoring |
| OPC | OLE for Process Control |
| OEM | Original Equipment Manufacturer |
| PC | Personal Computer |
| PIMS | Process Information Management System |
| PLC | Programmable Logic Controller |
| p-p | Peak to peak |
| QA, QC | Quality Assurance, Quality Control |
| RPM | Revolutions per minute |
| SQL | Sequential Query Language |
| TCP/IP | Transmission Control Protocol/Internet Protocol |
| TSE | Turbine Supervisory Equipment |
| UPS | Un-interruptible power supply |
| z-p | Zero to peak |
|  |  |
| **Terminology** | **Definitions** |
| **Accelerometer** | A piezoelectric sensor containing integral amplification with an output proportional to acceleration |
| **Amplitude** | The magnitude of periodic dynamic motion *(vibration)*. Amplitude is typically expressed in terms of signal levels, e.g. millivolts or milliamps, or the engineering units of measured variable. |
| **Alarm (alert) set point** | A pre-set value of a parameter at which an alarm is activated to warn of a condition that requires corrective action |
| **Buffered output** | An unaltered, analogue replica of the transducer signal that preserves amplitude, phase, frequency content, and signal polarity. The purpose of this output is to allow connection of vibration analysers, oscilloscope, and other test instrumentation to the transducer signals. |
| **Communication Processor** | An interface module used in a monitoring system to communicate data from the monitor rack to the computer |
| **Direct data** | Referring to original data which has not been changed in any manner. Data, or signal, which exactly represents the original transducer signal. Sometime called unfiltered, raw, or all pass data or signal |
| **Displacement** | The change in distance or position of an object relative to a reference measurement system. Machinery vibration displacement is typically a *peak-to-peak* measurement of the observed motion, and is usually expressed in units of mils or micrometers |
| **Display** | An analogue meter movement, cathode ray tube, liquid crystal device, or other means for visually indicating the measured variables and status conditions from the machinery protection system. |
| **Duel voting logic** | A monitor feature whereby the signals on two channels must both be in violation of their respective set points to initiate a change in status *(two-out-of-two logic)* |
| **Dynamic data** | Data *(steady state and /or transient)* which contains that part of the transducer signal representing the dynamic *(e.g. vibration)* characteristic of the measured variable. Typical dynamic data presentation includes orbit, time-based waveform, spectrum, polar bode, cascade & waterfall plots. |
| **Eddy current** | Electrical current which is generated (and dissipated) in a conductive material when such material intercepts the electromagnetic field of a proximity probe |
| **Filter** | An electrical device that attenuates signals outside the frequency range of interest |
| **Frequency** | The repetitive rate of a periodic vibration within a unit of time. Vibration frequency is typically expressed in units of cycles per second *(Hertz)* or cycles per minute (to more easily relate to shaft rotative speed frequency). |
| **Gearmesh frequency** | A potential vibration frequency on any machine which contains gears. It is represented by the number of gear teeth times’ shaft rotative frequency. |
| **Key persons** | Any person, who the *Contractor* deems as key in the realisation of the *Works*, but not necessarily recognised in the Contract. This may include engineers from subcontractors or partners. |
| **Machine protection system** | Is implemented when vibration (or other) measurements are installed permanently on a machine and connected to a dedicated monitoring (monitor) system. Machine protection is necessary and valuable since it can prevent machine damage and consequential losses in the event that a sudden machine or process malfunction occurs. |
| **Machine management system** | Uses the data provided by the machine protection system, supplemented by additional machine and process measurements, which enable the true operation state and condition of the machine to be defined |
| **Monitor system** | Consists of signal processing, alarm/shutdown/integrity logic processing, power supply, display/indication, inputs/outputs, and protective relays. The monitor system can affect automatic shutdown or trip of the machine. |
| **Mode shape** | The resultant deflected shape of a rotor at a specific rotative speed to applied forcing function. |
| **Nodal point** | A point of minimum *(or zero)* shaft deflection in a specific mode shape. |
| **Oscillator-demodulator** | A signal-conditioning device that sends a radio frequency signal to a proximity probe, demodulates the probe output, and provides an output signal for input to the monitor system. |
| **Phase reference transducer** | A gap-to-voltage device that consists of a proximity probe, an extension cable, and an oscillator-demodulator and is used to detect a once-per-revolution mark. |
| **Polarity** | In relation to transducer, the direction of output signal change *(positive or negative)* caused by motion in specific direction *(towards or away from the transducer)* in the sensitive axis of the transducer. |
| **Probe orientation** | The angular location of a probe *(vibration transducer)* with respect to a polar coordinate system when viewed from the driver end of the machine. Typically, zero degrees are at top dead centre |
| **Proximity probe** | A non-contacting device that consists of tip, a probe body, an internal coaxial cable, and a connector and is used to translate distance *(gap)* to voltage. |
| **Radial vibration** | Shaft dynamic motion or casing vibration which is measured in direction perpendicular to the shaft longitudinal axis. |
| **Resolution** | The smallest change in applied stimulus that will produce a detectable change in the instrument output. |
| **Signal processing** | Transformation of the output signal from the transducer system into the desired parameter for indication and alarming. |
| **Static data** | Data which describes the quantitative characteristics of the measured parameter. Typically, static data is presented in various forms of trend graphs and displays lists of current values. Examples of static data include vibration amplitude, phase lag angle, frequency, average shaft position, rotating speed, and time. |
| **Supported life** | Spares, patches, upgrades and technical assistance available on the equipment and product support provided locally within South Africa. |
| **Transducer system** | A proximity probe, accelerometer, or sensor; an extension or accelerometer cable; and oscillator-demodulator (when required). The transducer system generates a signal that is proportional to the measured variable. |
| **Transient data** | data *(static and /or dynamic)* acquired under transient machine conditions *(start-up and coast down)* |
| **Turbo-generator** | Consists of the turbine, generator and exciter system |
| **Turbine Supervisory Equipment (TSE)** | Hardware used for machinery health monitoring on the turbine. The hardware is housed inside a three bay cabinet |
| **Vibration Diagnostic System** | Uses the data provided by the vibration monitor system, supplemented by additional machine and process measurements, which enable the true operation state and condition of the machine to be defined. This includes the condition monitoring network infrastructure and data/process server |
| **Vibration Monitor System** | Consists of signal processing, alarm/shutdown/integrity logic processing, power supply, display/indication, inputs/outputs, and protective relays. The monitor system can affect automatic shutdown or trip of the machine |

## 

## Employers Requriements

The works are performed in line with the standards, procedures, guidelines and requirements specified in the main technical specification for the following areas:

1. Quality & Performance Requirements
2. Design Standards, Guidelines And Codes
3. Requirements Related To Safety
4. Requirements Related To Availability
5. Requirements Related To Reliability
6. Requirements Related To Maintainability
7. Requirements Related To Technical Documentation

## Technical Specification Scope

## Overview

The *Contractor* is required to provide the Works which include:

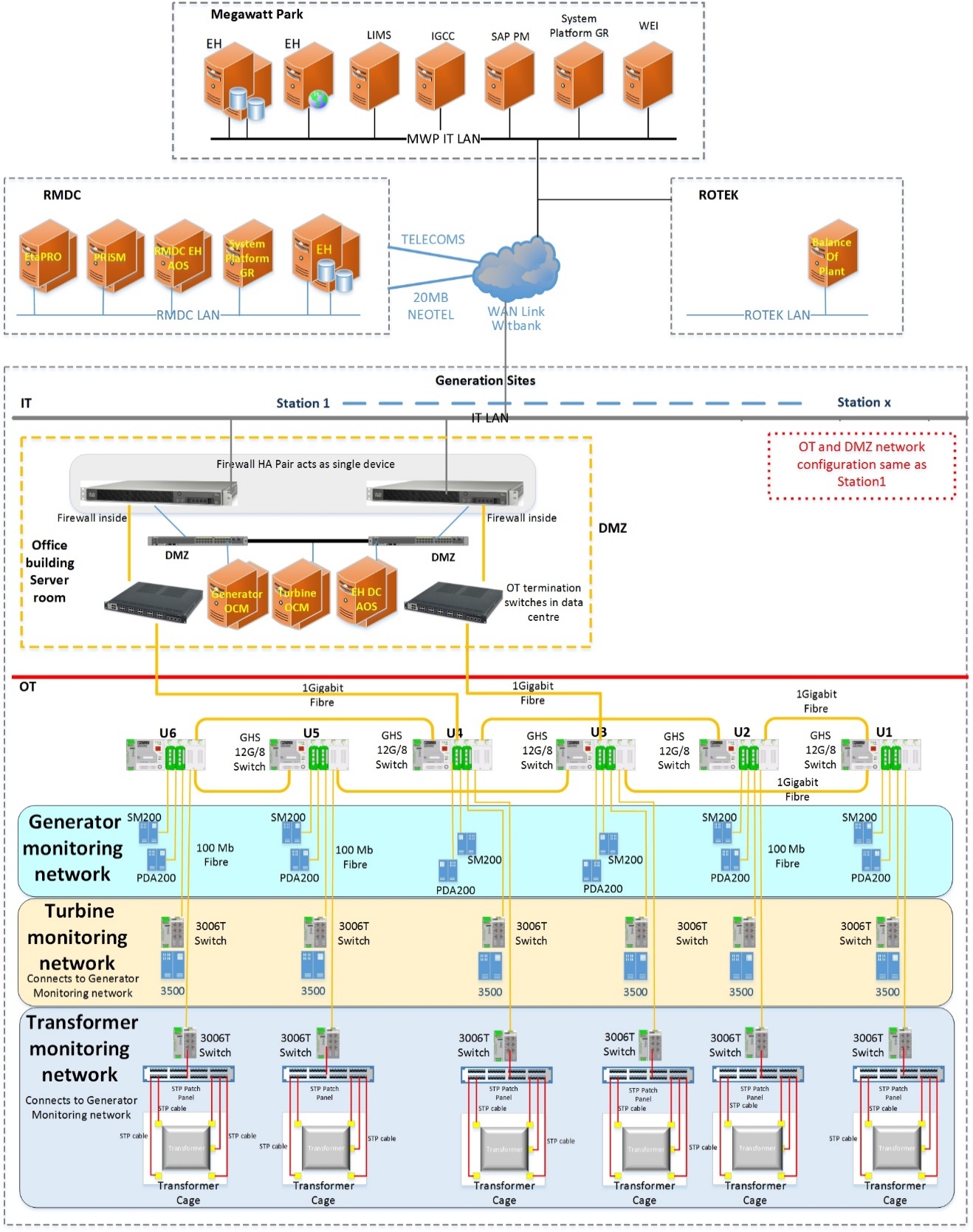
* + 1. The design, supply, install and commission of three unit’s vibration condition monitoring sub-network per station.
    2. The design, supply, install and commissioning of the new station diagnostic systems per unit for 3 units at Lethabo power station.
    3. Retrieving data from existing diagnostic information and providing access to historical diagnostic information.
    4. The training of the Engineering, Maintenance and Operating staff.
    5. The provision of all software licenses and copyright agreements of the works.
    6. The project as well as site specific documentation to support the effective maintenance and engineering of the diagnostic solution provided.

## General requirements of the *Contractor’*s to be delivered

The *Contractor* shall provide the Works to meet the requirement for a unitised turbine diagnostic system for Lethabo power station. The unitised vibration condition network provided by the *Contractor* will interface to the station condition monitoring network and will require specific hardware to interface to the existing network.

The *Contractor* shall provide the Works to meet the requirement for the vibration sub-nets which will be connected from the vibration monitoring system. Each unitised network will function as an island and will be separated from other networks via a firewall. The unitised islands will be identical in structure although network configuration will be different as well as unitised information.

The connections to the system are as per global network design given in figure 2



**Diagram 1 -** Global network design

The area within the overall condition network which is applicable to the Works is indicated in the red highlighted dashed blocks

## System Life expectancy

The hardware provided to support the diagnostic system shall provide a supported life of seven years for all data gateways and seven years for all network equipment.

The licence provided for software which provide data manipulation, transmission, archiving, analysis and viewing will be a once off purchase which will be valid for the life of the diagnostic software.

All future hardware and software upgrades for the system are backward compatible with the provided system. The OEM strategy for future upgrades to the diagnostic system follows a defined migration path, such that the installed system is easily upgraded if required.

All network, workstation and server equipment is available in South Africa as commercially- off- the-shelf (COTS) products.

All diagnostic solution OEM specific hardware required is supported locally within South Africa. This requires access to local spares as well as technical expertise and assistance. The *Contractor* provides for repair facilities of diagnostic related equipment.

## Functional Requirements

## Diagnostic Functions

The system provides full access via the Eskom station LAN to the diagnostic information and tools to enable engineers to access online as well as historical information. The *Contractor* provides the required viewer and diagnostic interface software required to access the diagnostic information which is compatible with Eskom laptops. The minimum numbers of site personnel which will require access are five.

The diagnostic system provides for graphic tools and calculations functions to support the engineer in analysing plant conditions.

Diagnostics are enabled by preconfigured trends, logs and curves as well as user defined trends and curves. Identified trends are preconfigured by the *Contractor* for each station. Analysis of trends and curves provide for cursors which the user can move to verify specify times and signal values. Trends and curves are time scalable as required by the user. The diagnostic system provides for additional analysis futures such as .zoom in and out of axis and display areas.

## Self-Test Internal Fault Diagnosis

The system shall have the capability to monitor the health of the overall diagnostic system and indicate to the system alarm log any fault condition. Fault conditions found must not prevent the continued operation of the rest of the system. The supplier shall provide a fault list indicating the causes and effects of faults that occur.

## Server

The turbine vibration diagnostic server provided by the Contractor which will provide the diagnostic functions and information archiving will be installed in the station DMZ. The Contractor provide for an industrial 19” rack mounted server which are standard for the Contractor’s diagnostic system solution.

## Remote Viewing

#### The system shall be able to display real-time data across the Eskom LAN / WAN as well as the process LAN. The tags displayed on these views shall be able to update at the rate of input update. Remote viewing shall include detailed views of all of the monitored parameters and systems, the ability to add plant views with associated real-time data and the ability to trend any combination of parameters together. The *Contractor* provides the required viewer and diagnostic interface software required to access the diagnostic information which is compatible with Eskom laptops. The minimum numbers of site personnel which will require access are five.

## System Data Storage and Recovery Requirements

## Storage and Database management

The *Contractor* shall provide a comprehensive database management system to facilitate both manual and auto archiving and retrieval of all data files including the system alarm logs. A menu driven procedure shall enable data storage for different machine states and from all signals to be selected for specific time windows for detailed analysis either locally or remotely. Access shall be granted to the *Employer* for manual backup of the stored data as well as the system recovery data.

The *Contractor* shall provide a database management system for archive and retrieval of all data files, the storage medium for data backup (including the space usage notification) and also recommend the necessary procedures for memory capacity. The monitoring system shall be configured to keep at least the last three months of all on-line data collected.

The *Contractor* provides all required software and procedures required to recover and restore the complete diagnostic system from failure.

## Recovery Requirement

The supplier shall provide the necessary proof that the system will guarantee the configuration of the software and system set-up on restart after a power failure and shut down conditions. The system shall be required to start up automatically after controlled and uncontrolled shut down conditions. After start-up the system shall automatically recognise the mode of monitoring and initialise the required communication processors. The system shall keep a log of all start-ups and shutdown event.

The *Contractor* provides procedures, configuration requirements, required tools and software to recover the *Contractor* diagnostic software after complete hardware failure. In addition the Contractor provides the procedures and software which will enable a new installation.

## Storage of data

## Storage of continuous Monitored Data

All dynamic, static and process data collected in continuous monitoring mode shall be stored in the following clearly defined and retrievable sets:

* A reference set.
* A user selectable data set taken at the normal monitoring rate.
* A user selectable data set at user selectable time intervals.

The *Contractor* provides for the storage of three years data within the hardware provided by the *Contractor*. The archiving system provides for DVD downloads to archive long storage data. The back-up process is provided by a manual service initiated from the diagnostic server.

## Storage of Transient Monitored Data

All data collected transient mode shall be stored in one of the following definable sets:

* Reference data sets for both run-up and run-down conditions.
* All variables (dynamic, static and process) in a user selectable set.
* All variables collected in a temporary file upon receipt of an alarm.
* A temporary set of pre-defined data (spectrum plots, DC values, bode plots, static and process variables) upon completion of a transient.

The temporary set, mentioned above shall be stored in a temporary file at the end of each run-up or run-down, an entry made in the system alarm log and the user suitably flagged.

## Storage of Barring Speed Data

All data collected during barring speed shall be stored in one of the following definable sets:

* A reference set of data
* A user selectable set of data taken at normal monitoring rates.
* A user selectable data set taken at user selectable time intervals.
* A complete set or user defined set of data upon receipt of any alarm or user request.

## Storage of Constant Speed, No load Monitored Data

The data collected during constant speed, no load condition shall be stored in the same format as the continuously monitored data.

## Reference & Baseline Data Collection

Reference data files shall be user selected for on-going comparison with current data. The diagnostic system shall have provision for the following reference and baseline signatures:

* **Start-up** **-** data acquired under transient condition – initial run-up.
* **Coast down -** data acquired under transient condition – run down.
* **Gap Reference -** data acquired whilst the machine is on barring or stand still to establish Bottom Dead Centre.
* **Slow roll vector –** data acquired preferably after a ‘hot’ shutdown, at low rotating speed where dynamic motion effects are negligible – run out compensation.
* **Waveform data -** absolute baseline data, collected after a new or overhauled machine returned to service, at normal operating & process conditions. Used for superimposing with current data.

The above reference files shall be clearly identified and easily accessible in the reference directory. This directory shall be updated as and when the new reference condition has been captured. Any change in the reference and baseline signature shall be logged in system event files.

## System Log Functions

## System Alarm Log

A facility to log alarm events, changes to reference sets, change of monitoring mode or any other change to the system defaults or operation shall be provided. The logs must be preconfigured for selective time periods or plant statuses. All changes in operating state shall be logged.

## User log

#### A user log shall be provided on which user observations and remarks can be applied with the options to attach the notes to a reference data set or print the user notes, selected by date, machine and measuring point

## System Display Configuration

All graphic displays shall, as far as possible, be accessible through the use of a standardised menu structure of soft key, or pointing device with the keyboard isolated. It shall be possible to easily identify and select the files and signals or parameters required for display via screen displays which present to the user the various data available on the system.

A ready reference to all user-defined configuration settings shall be displayed by appropriate selection from a menu option. When moving between screen overlays as much information as possible shall be transferable to appropriate selection fields to avoid the need to repeatedly input the same information. All screen overlays shall have a Help facility available and no inappropriate menu items or soil key labels shall be displayed.

Variables and signals are displayed in the same unit of measure and range as the source data.

## Display Format Requirements

Each system shall have a start-up screen displaying the last set of alarms received (system alarm log entries). The start-up screen shall also display a menu giving access to the various functions and to the turbo-generator data groups. The display screen shall be sized to accommodate the display format requirements legibly. User definable mimics are to be included. The system shall be capable of displaying compensated and uncompensated amplitude and phase data.

The diagnostic solution will provide for the following types of plots.

|  |  |
| --- | --- |
| **Plot Type** | **Description** |
| Dynamic Time-base plots | These plots are used to present the instantaneous amplitude of a signal as a function of time. It can be analogue signal inputs as well as pre-processed digital signals such as vibration amplitude and phase. At least six of these plots are to be shown on the visual display unit simultaneously, each tract with a different colour. The Y-axis of these plots shall be displayed in standard engineering units (mm/s, µm, MPa, etc.). There must be a facility to manually or automatically set the ranges of the Y-axis scales. Single and Multi variable charts shall be available with the single variable charts displaying the alarm limits. A rolling display window will be used and shall automatically update at a period corresponding to the selected sample rate. |
| Historical Trend plots | These plots are the same as the dynamic time-base plots but are used for variable progression over long periods at user selectable intervals (daily, weekly, monthly. etc.). Historical trend plots shall be obtainable from the long term storage memory and shall be in the same format as the dynamic time-base plots. Trends shall be based upon averaged data and extend over full lifetime of the condition monitoring system as installed. The trends shall be independently accessible by the user and shall be defined by the machine identification i.e. turbo-generator and a time window. |
| Bar Charts | These charts shall indicate current values for each variable point configured on a machine train, with full-scale range and pre-set alarm limits displayed. The system shall be capable of displaying at least twenty charted values at a time. All bar charts are to be clearly identified and display different colours on reaching levels or alarm set points. |
| Waterfall plots | These plots shall be used to trend spectrums over short and long periods of time. An XYZ standard axis system shall be used. The Y-axis shall indicate amplitude, the Z-axis shall indicate time and the X-axis shall indicate frequency range. The time period between spectrums shall be user selectable for both short and long term trending and will be spaced on the Z-axis proportional to time. The Y-axis shall be displayed in standard engineering units. The X-axis shall be displayed in either Hz or rpm with the choice left to the user. The scaling of the axes shall be both automatic and user definable. A zoom facility on the X-axis must be available. |
| Orbit plots | An orbit plot is used to show the dynamic motion of the shaft in the bearing with signals from two probes. The orbit's X-Y plot shows the amplitudes from two orthogonal vibration measurements plotted against each other. The scaling of the axes shall be both manual and automatic. The alarm values shall be displayed, such that limit circles are shown. A locus shall be displayed showing the movement of the shaft. |
| Spectrum Plots | These plots shall show frequency spectrum over a selected frequency range for all the dynamic variables. An XY axis shall be used with the Y axis indicating the amplitude in standard engineering units and the X axis the frequency range in either Hz or rpm. At least six of these plots shall be shown on the visual display unit at one time. The spectrums shall be updated if required at a user selectable frequency. The Y axis range shall be set either by the user or automatically. A zoom facility shall be available on the X axis. |
| Bode Plots | These plots shall be used during the transient monitoring modes to display the amplitude and phase information of all the dynamic variables. The Y axis shall be used for both the amplitude and phase information. The requirements for the amplitude information are the same as for the Spectrum Plots. The X-axis shall be used for the frequency range in either Hz or RPM. The zoom facility shall work on both the amplitude and phase plots simultaneously. At least tour bode plots must be displayed on the visual display unit at the same time. The Y-axis on the phase information shall be displayed in degrees. Wrapping of the phase plot shall be achieved without losing resolution and clarity. |
| Polar Plots | These plots shall be used to display the amplitude and phase information of the various frequency components derived from the dynamic variables. These plots shall be able to show instantaneous information as well as clearly identified historic information. A facility shall further be provided to display the envelope alarm limits and to change/set these limits. If instantaneous values are shown the user shall be able to select the frequency of updating. At least six of these plots are to be displayed on the visual display unit at a time. |
| Cascade Plots | These plots shall be used to display frequency spectrums during transient monitoring modes or from data obtained from this mode. An XYZ standard axis system shall be used. The Y-axis shall indicate amplitude, the Z-axis shall indicate machine speed and the X-axis shall indicate frequency. The speed intervals between spectrums shall be user selectable and shall be spaced on the Z-axis proportional to the speed. The Y-axis shall be displayed in standard engineering units. The X-axis shall be displayed in either Hz or rpm with the choice left to the user. The scaling of the axes shall be both automatic and user definable. A zoom facility on the X-axis must be available. |
| Machine Train Diagram | This shall provide a display of a user configured machine diagram with appropriately positioned vibration and process point labels, current overall values and alarm status. |
| Quick view Plots | This is invoked by clicking on a single button icon to produce a four plot tiled screen consisting of a train alarm list and spectrum, orbit/time base and overall trend plots for the selected point. |
| Acceptance region | It is a polar format representation of vibration vector data as a function of time. The selected vector may be lX or 2X. A set of alarms may be defined for amplitude and phase. |
| Shaft Centreline | A shaft centerline plot displays changes in radial rotor position with respect to a stationary bearing over a range of time or speed. The DC gap voltage from two orthogonally-mounted proximity probes determines the averaged position change. |
| Plus Orbits and Plus Spectrums | A display of orbit and spectrum plots alongside other plot types. Each plus orbit or plus spectrum is displayed for a particular sample selected from the activated plot. |

Table 1 – Functional analysis summary

## Engineering and Configuration Tools

The *Contractor* provides one portable engineering workstations. The engineering and configuration tools will provide access to the diagnostic equipment as well as vibration sub-network. The engineering tools will enable the following functionalities, assessment of the equipment health, component configuration, and view and analyse access to the diagnostic system, wiring documentation, manuals and procedures related to the maintenance and engineering of the equipment.

As part of the diagnostic virtual server services engineering services will be provided at the virtual server. This engineering service will provide for user configurations of displays, alarms and trends, access to system limits, administrator functions of the different network components as well as database management and cyber security related activities.

## System Software Requirements

## Operating System

The *Contractor* provides all required operating software for clients and servers within his scope. Software provided are the latest supported revision of the required operating system which has proven in use experience. All original software disks and documentation are to be submitted to Eskom at handover. This includes software drivers for add-on PC cards or tools.

## Software Configuration

The *Contractor* installs all required software to meet the functional requirements of the diagnostic system as described in the option.

Installation software required to recover the system in the event of a failure are provided to the *Employer* before sectional completion. The software is categorised per installation and software licences are clearly defined.

The language for all software navigation, menus, help files and libraries is English.

## System Display Requirements

All the displays for the system need to be provided and accessed in the display section of the diagnostic system. The displays for each of the diagnostic systems need to be housed in this common software environment. This needs to allow for display on a local server, engineering workstation or display across the Eskom LAN / WAN. The displays need to be infinitely configurable by the user. The individual components should be added in a “plug and play” manner. The system needs to recognise a new component and add its functionality to the existing software environment. Displays need to be identified by a unique tag.

## Interfacing Requirements

## Unitised vibration network switches to condition monitoring network

The switch configuration is as per the Eskom OT LAN design. Refer to appendix A. The *Contractor* specified his performance criteria for networks to ensure that the station condition monitoring network meets the requirements of the vibration diagnostic solution.

## Interphase to Historians

The system shall interface with the eDNA enterprise historian using OPC. The interface will be via OPC between the enterprise historian and the virtual vibration diagnostic server.

## OPC Interface

The diagnostic software utilises process variables to enable specific analysis. The *Contractor* specifies process variables. The process data will be obtained from the exiting Eskom eDNA enterprise historian via a non-redundant OPC interface.

OPC interface(s) are implemented using either of the following communication methods:

1. OPC via Tunnelling
2. OPC/XML.

Software required ensuring the stability and security of the OPC interface(s) is installed and configured on all relevant virtual servers.

All software to link with the Eskom standard historian, Aviva eDNA, must be provided by the *Contractor*. Getting this link operative is the responsibility of the *Contractor*.

The Contractor provides as a minimum for the following information exchange.

|  |  |
| --- | --- |
| **Measurement** | **Source - Historian** |
| **Turbine** | |
| **HP - IP Turbine** | |
| Bearing temperatures x 12 | OPC |
| Bearing drain oil temperature | OPC |
| Lube oil supply temperature | OPC |
| Steam inlet flow | OPC |
| Steam inlet pressure | OPC |
| Steam inlet temperature | OPC |
| Steam exhausts flow | OPC |
| Steam exhausts pressure | OPC |
| Steam exhausts temperature | OPC |
| Valve position | OPC |
| **LP Turbine** | |
| Bearing drain oil temperature | OPC |
| Steam inlet flow | OPC |
| Steam inlet pressure | OPC |
| Steam inlet temperature | OPC |
| Steam exhausts flow | OPC |
| Steam exhausts pressure | OPC |
| Steam exhausts temperature | OPC |
| Extraction flow | OPC |
| Extraction pressure | OPC |
| Extraction temperature | OPC |
| Condenser pressure | OPC |
| **Generator** | |
| Bearing drain oil temperature | OPC |
| Power output (MW) | OPC |
| Power Factor | OPC |
| Megavar Output | OPC |
| Winding temperature | OPC |
| Stator coolant pressure | OPC |
| Stator coolant temperature | OPC |
| Field coolant pressure | OPC |
| Field coolant temperature | OPC |
| **Exciter (Dynamic)** | |
| Bearing drain oil temperature | OPC |
| Field current | OPC |
| Field voltage | OPC |
| **Gearbox** | |
| Bearing drain oil temperature | OPC |
| **Feed pumps** |  |
| Bearings temperatures x 8 per feed pump | OPC |

Table 2 – OPC interface

## Bus communication

This communication is relevant to the extraction of the required vibration information from the vibration monitoring system via a communication module directly from the vibration monitoring system. This interface provides for the supply of relevant modules, software and configuring of interfaces between the vibration monitoring system, the bus module and the vibration unitised switch.

As a minimum the Contractor provides for the following signals as part of the unitised information exchange between the turbine vibration condition monitoring equipment and the turbine vibration diagnostic system.

|  |  |  |
| --- | --- | --- |
| **Turbo-Generator Sets** |  |  |
| **Parameter** | **Signal** | **Rack Output** |
| MAIN TURBINE SHAFT ECCENTRICITY | mV | Buffered |
| TURBINE ABSOLUTE EXPANSION POSITION | mV | Buffered |
| HP TURBINE FRONT BEARING VIBRATION | mV | Buffered |
| HP TURBINE FRONT DIFF. EXPANSION | mV | Buffered |
| HP TURBINE FRONT SHAFT VIBRATION X PROBE | mV | Buffered |
| HP TURBINE FRONT SHAFT VIBRATION Y PROBE | mV | Buffered |
| HP TURBINE REAR SHAFT VIBRATION X PROBE | mV | Buffered |
| HP TURBINE REAR SHAFT VIBRATION Y PROBE | mV | Buffered |
| TURBINE END THRUST | mV | Buffered |
| TURBINE END THRUST | mV | Buffered |
| TURBINE SHAFT POSITION | mV | Buffered |
| TURBINE SHAFT POSITION | mV | Buffered |
| BEARING VIBRATION HP TURBINE REAR/IP TURBINE FRONT | mV | Buffered |
| IP TURBINE FRONT SHAFT VIBRATION X PROBE | mV | Buffered |
| IP TURBINE FRONT SHAFT VIBRATION Y PROBE | mV | Buffered |
| IP TURBINE REAR BEARING VIBRATION | mV | Buffered |
| IP TURBINE REAR DIFF. EXPANSION | mV | Buffered |
| IP TURBINE REAR SHAFT VIBRATION X PROBE | mV | Buffered |
| IP TURBINE REAR SHAFT VIBRATION Y PROBE | mV | Buffered |
| LP TURBINE 2 FRONT BEARING VIBRATION | mV | Buffered |
| LP TURBINE 2 FRONT SHAFT VIBRATION X PROBE | mV | Buffered |
| LP TURBINE 2 FRONT SHAFT VIBRATION Y PROBE | mV | Buffered |
| LP TURBINE 2 REAR BEARING VIBRATION | mV | Buffered |
| LP TURBINE 2 REAR SHAFT VIBRATION X PROBE | mV | Buffered |
| LP TURBINE 2 REAR SHAFT VIBRATION Y PROBE | mV | Buffered |
| LP TURBINE FRONT BEARING VIBRATION | mV | Buffered |
| LP TURBINE FRONT SHAFT VIBRATION X PROBE | mV | Buffered |
| LP TURBINE FRONT SHAFT VIBRATION Y PROBE | mV | Buffered |
| LP TURBINE REAR BEARING VIBRATION | mV | Buffered |
| LP TURBINE REAR DIFF. EXPANSION | mV | Buffered |
| LP TURBINE REAR SHAFT VIBRATION X PROBE | mV | Buffered |
| LP TURBINE REAR SHAFT VIBRATION Y PROBE | mV | Buffered |
| TURBINE CENTRELINE KEY PHASOR | mV | Buffered |
| EXCITER FRONT BEARING VIBRATION | mV | Buffered |
| EXCITER FRONT SHAFT VIBRATION X PROBE | mV | Buffered |
| EXCITER FRONT SHAFT VIBRATION Y PROBE | mV | Buffered |
| EXCITER REAR BEARING VIBRATION | mV | Buffered |
| EXCITER REAR SHAFT VIBRATION X PROBE | mV | Buffered |
| EXCITER REAR SHAFT VIBRATION Y PROBE | mV | Buffered |
| GEN FRONT BEARING VIBRATION | mV | Buffered |
| GEN FRONT SHAFT VIBRATION X PROBE | mV | Buffered |
| GEN FRONT SHAFT VIBRATION Y PROBE | mV | Buffered |
| GEN REAR BEARING VIBRATION | mV | Buffered |
| GEN REAR SHAFT VIBRATION X PROBE | mV | Buffered |
| GEN REAR SHAFT VIBRATION Y PROBE | mV | Buffered |
|  |  |  |
| **Steam Feed Pump Turbine** | **Rack** | **Rack Output** |
| **Parameter** |  |  |
| BFPT DE RELATIVE SHAFT VIBRATION X PROBE | mV | Buffered |
| BFPT DE RELATIVE SHAFT VIBRATION Y PROBE | mV | Buffered |
| BFPT FRONT BEARING VIBRATION | mV | Buffered |
| BFPT NDE RELATIVE SHAFT VIBRATION X PROBE | mV | Buffered |
| BFPT NDE RELATIVE SHAFT VIBRATION Y PROBE | mV | Buffered |
| BFPT REAR BEARING VIBRATION | mV | Buffered |
| BFPT SHAFT POSITION | mV | Buffered |
| SFP DE RELATIVE SHAFT VIBRATION X PROBE | mV | Buffered |
| SFP DE RELATIVE SHAFT VIBRATION Y PROBE | mV | Buffered |
| SFP FRONT BEARING VIBRATION | mV | Buffered |
| SFP KEY PHASOR | mV | Buffered |
| SFP NDE RELATIVE SHAFT VIBRATION X PROBE | mV | Buffered |
| SFP NDE RELATIVE SHAFT VIBRATION Y PROBE | mV | Buffered |
| SFP REAR BEARING VIBRATION | mV | Buffered |
|  |  |  |
| **Electrical Feed Pump** | **Rack** | **Rack Output** |
| **Parameter** |  |  |
| **Pump A** |  |  |
| EFP A DE BEARING VIBRATION | mV | Buffered |
| EFP A DE RELATIVE SHAFT VIBRATION X PROBE | mV | Buffered |
| EFP A DE RELATIVE SHAFT VIBRATION Y PROBE | mV | Buffered |
| EFP A MOTOR DE BEARING VIBRATION | mV | Buffered |
| EFP A MOTOR DE RELATIVE SHAFT VIBRATION X PROBE | mV | Buffered |
| EFP A MOTOR DE RELATIVE SHAFT VIBRATION Y PROBE | mV | Buffered |
| EFP A MOTOR NDE BEARING VIBRATION | mV | Buffered |
| EFP A MOTOR NDE RELATIVE SHAFT VIBRATION X PROBE | mV | Buffered |
| EFP A MOTOR NDE RELATIVE SHAFT VIBRATION Y PROBE | mV | Buffered |
| EFP A NDE BEARING VIBRATION | mV | Buffered |
| EFP A NDE RELATIVE SHAFT VIBRATION X PROBE | mV | Buffered |
| EFP A NDE RELATIVE SHAFT VIBRATION Y PROBE | mV | Buffered |
| EFP A PHASE REFERENCE PROBE | mV | Buffered |
|  |  |  |
| **Pump B** |  |  |
| EFP B DE BEARING VIBRATION | mV | Buffered |
| EFP B DE RELATIVE SHAFT VIBRATION X PROBE | mV | Buffered |
| EFP B DE RELATIVE SHAFT VIBRATION Y PROBE | mV | Buffered |
| EFP B MOTOR DE BEARING VIBRATION | mV | Buffered |
| EFP B MOTOR DE RELATIVE SHAFT VIBRATION X PROBE | mV | Buffered |
| EFP B MOTOR DE RELATIVE SHAFT VIBRATION Y PROBE | mV | Buffered |
| EFP B MOTOR NDE BEARING VIBRATION | mV | Buffered |
| EFP B MOTOR NDE RELATIVE SHAFT VIBRATION X PROBE | mV | Buffered |
| EFP B MOTOR NDE RELATIVE SHAFT VIBRATION Y PROBE | mV | Buffered |
| EFP B NDE BEARING VIBRATION | mV | Buffered |
| EFP B NDE RELATIVE SHAFT VIBRATION X PROBE | mV | Buffered |
| EFP B NDE RELATIVE SHAFT VIBRATION Y PROBE | mV | Buffered |
| EFP B PHASE REFERENCE PROBE | mV | Buffered |

Table 3 – Unitised vibration monitoring interface to diagnostic system

## OEM Relationship

The parent OEM of the diagnostic system takes full accountability of the works and provides a design report which confirms that the technology provided for the project as well as the design provided meets the OEM specification and requirements.

## Reliability

The equipment selected meets an equipment failure rate of less than 0.2% of the installed base over a calendar year.

## Availability

The availability of the complete diagnostic system over its life in percentage of time is 99, 9% or greater measured annually. Any downtime for software updates and upgrades is included in the availability calculation. The availability excludes hardware upgrades.

## Expandability

The sub-network switch which is provided per unit provides as a minimum one additional output and one additional input spare port.

All spare terminals in the junction boxes/terminal strips and marshalling are terminated. A 10% spare I/O (installed) is targeted.

The supplier shall clearly indicate all limitations on expansion of the system which include hardware related limitations such as I/O as well as software such as viewer and user limitations.

To prevent the massive capital outlay of the replacement of the entire system in the future, it is required that the new system is expandable and upgradeable at “component” level. This means that it should be possible to upgrade the individual items of hardware or software without having to perform major upgrades on the rest of the system

## Accuracy

The variables displayed within the diagnostic system will have zero deviation or difference from the same variable displayed in the source. For example if the vibration monitor system local indication display a vibration value of 200 then the same signal will display 200 in the vibration diagnostic system.

The accuracy of information retrieved from historical data is not affected by compression processes used during archiving or storage of data.

## Network Cabinets

The vibration sub-network switches are accommodated within new network cabinets which are installed within each unitised equipment room. For easier cable management, all connectors on rack mounted components must be rear facing in the network cabinet as long as it does not compromise the efficiency of the airflow through the network cabinet or devices themselves.

Network cables and power cables entry will be confirmed during basic design. Where 24VDC is employed, blocking diodes are provided as part of the internal power distribution system within the network cabinets

Each network cabinets must have the following characteristics:

* Front and rear access via cabinet doors
* There must be no open spaces between the rails and sides of the rack enclosure. This ensures the network cabinet air flow is managed correctly
* Blanking panels are installed on all unused slots to manage air flow efficiency and reduce hot spot temperature in the network cabinet
* Flexible brushes or shields must be used to prevent air leakage from cables via cable entries
* Internal cable management systems are used for both horizontal and vertical cable management
* Intelligent rack mounted power distribution units (PDU) are used
* Network cabinets must have sufficient depth to allow free air flow around cables in rear.
* Any cable cut-outs beneath the network cabinet must be sealed to prevent air leakage using raised floor grommets
* Environmental condition within equipment rooms are exposed to temperatures of between 22°C and 27°C and have a high presence of dust.
* Cabinet must meet as a minimum IP54 specification

## Engineering Workstation

The *Contractor* provides one portable engineering workstations. The engineering workstations provide access to the relevant diagnostic system hardware equipment as well as vibration sub-network equipment.

The engineering workstation has all the required software which is needed to provide maintenance and engineering activities on the related equipment. The engineering workstations provide access to all supportive documentation which is required for maintenance and engineering activities. The engineering workstation complies with the Cyber Security requirements specific to workstations.

## Switches

Network switches provided at the vibration condition network cabinets must preferably be the same as the hardware equipment used for existing network communication within the station OT environment or the condition monitoring network as described in appendix A.

Interface equipment to the condition monitoring network as described in appendix A must however utilise the same equipment which provide for expansion options to include the vibration monitoring network.

## Functional Requirements

## Monitoring Modes required from the diagnostic System

The diagnostic system shall be capable of monitoring with different operating modes depending on the status of the plant and/or individual machines. These different monitoring modes are typical

## Continuous Monitoring

This shall be the normal diagnostic monitoring mode of the system. It shall include monitoring of the turbo-generator sets on load. All variables must be monitored in this mode. The turbo-generator sets shall be running at rated speed. The data shall further be available for plotting on the relevant time based displays as described in display format requirements section 2.3.8 of this document. All the variables shall be monitored at a maximum scan time (delta time) of ten (10)seconds for all the signals associated with the monitored equipment (machine*).* During this period the following tasks shall be completed by system.

## Transient Monitoring Mode

This mode is applicable when machine operating speed (rpm) is changing, usually involving start-up, shutdown, overspend or unplanned trip. For the run-up modes the speed variance shall be indicated as positive and for the run-down modes negative. The system shall be capable of monitoring an acceleration/deceleration rpm as per the OEM specification. The systems shall be capable of automatically acquiring slow roll data and have the capability of recording in the slow roll values.

The variables to be monitored shall be the same for run-up and run-down conditions. All dynamic variables shall be monitored. Separate sets of reference data shall be kept for the run-up and run-down conditions. The end of the transient mode for the run-up condition shall be the identification of either the continuous monitoring mode or the constant speed monitoring mode. The end of the run-down mode shall be identified by the turbo-generator speed dropping to barring speed which will initiate the barring speed monitoring mode.

The system shall be capable of automatically initiating transient event data collection, when machine rpm changes and falls within the pre-set minimum and maximum threshold. After completion of one transient event, collected data shall be stored automatically in transient event files and the system reset for next transient event. Provision for manual activation and aborting of transient and steady state events shall also be allowed within the configuration.

For turbo-generator sets, the transient data shall be collected at speed (delta rpm) change not more than 10rpm increments for both start-up and shutdown events. For Boiler Feed Pump Turbines (BFPT’s), which normally operates at higher speed, transient data shall be collected at speed increments not more than 20rpm. Higher than 20 delta rpm selection may lead to poor transient data and distorted response of balance resonance.

The actual speed and time at which the data collection starts for each point shall be recorded. Should the rate of change of speed over any period during run-up or run-down be too fast for the data acquisition or process plant, the system shall automatically calculate the minimum speed intervals at which data can be collected and continue monitoring. In this event the date, time and speed increment must be captured and entered into the system alarm log. The system shall continuously check whether the specified rate can be resumed.

In order to minimize amount of captured data and improve system response time, monitoring system shall for every 10 static vector samples (amplitude & phase), collect one waveform sample for each vibration point. The transient mode ‘enabled’ state shall not effect steady state (delta time) sampling mode.

## Barring Speed Monitoring Mode

This mode is only applicable to the turbo-generator and shall monitor the condition of the turbo-generator at barring speed. It shall be automatically identified by the turbo-generator speed being above 0 rpm and below 100 rpm or the OEM specified barring speed rpm. In this monitoring mode, the data acquisition, collection and storage of the group of input signals shall be carried out at a ten (10) second scan time for all the signals associated with the turbo-generator.

The DC values of all the dynamic variables shall be monitored. This mode of monitoring shall be used to identity the slow roll vector of the various shaft collars and used for compensation of the dynamic variables during the high speed and transient monitoring modes (if required).

## Constant Speed, No load Monitoring

The turbo-generator shall be monitored at a constant speed and zero load on the generator. This mode shall be identified by the machine running at constant speed and the generator load not greater than 0 MW. The supplier shall indicate how the speed overlap between this and the transient monitoring mode is addressed. During this monitoring mode the same signals (except the generator load) shall be measured and at the same speed as for the continuous monitoring mode.

## Alarm Handling

All alarms to be triggered by the diagnostic system shall be the result of an automatic comparison between the most recent measured variables and a user defined value for the specific variable/measurement concerned. If the measured variable (dynamic, static or process variable) exceeds the pre-set alarm value, an alarm signal shall be triggered and a unique user defined data set shall be stored. For each individual variable a data set may be defined and as a minimum four alarm levels (Very High, High. Low and Very Low) must be provided for each variable.

The system shall provide the possibility to choose calculated alarm limits which can vary as a function of other system variables. Calculation facilities to obtain the most reasonable boundary limits based on statistical analysis or archive data shall also be available. A predetermined hysteresis set by the *Employer* shall be assignable to each alarm signal input to avoid repeated flashing alarms.

As a minimum the following information shall be sent simultaneously to the system alarm log:

* Machine and signal identification.
* The date and time of occurrence.
* The value of measured variables.
* A brief description of the fault.

The alarms in the system alarm log shall be accessible to all users at all times but only the system administrator must be capable of erasing any system alarm log entries that they deem is no longer necessary. The system alarm log shall have the capacity to store a large number of alarms.

Any changes in alarm settings shall be logged and only the system administrator should be permitted to override and delete alarm log entries.

Provisions shall also be made for software alarms to be disabled during the transient events and individual equipment / machine maintenance period.

The machinery diagnostic and monitoring system shall provide configuration for several types and different levels of alarms as required for different monitoring modes. This configuration shall include the following alarm types required for complete system monitoring:

#### Software Alarms

#### Maximum and Minimum Values

#### Envelope alarms

#### Step Changes alarm

#### Acceptance Region Alarms

The *Contractor* will be responsible to implement an alarm ratification and management system which will optimise the system alarms. The aim of this process will be to eliminate nuisance alarms and confirm implemented alarm levels.

## Cyber Security

The *Employer* has an internal Cyber Security standard, document 240-55410927, which needs to be complied with. The boundaries of the both the unitised vibration sub-nets and Station vibration monitoring network are protected from unwanted intrusions via firewalls. A firewall with provide for deep packet inspection need to be provided. The virtual diagnostic servers will be configured within the Eskom DMZ.

Open 3rd party systems do not connect directly to the virtual diagnostic server. Such 3rd party systems connect to the virtual diagnostic server via the DMZ. Eskom will provide the DMZ, the Contractor ensures that the limitations as implemented within the existing Eskom DMZ do not reduce the performance, access or reliability of the diagnostic system provided by the Contractor.

The sub-net hardware provided by the Contractor are compatible and support existing Network intrusion detection system (NIDS), intrusion prevention systems, antivirus software and network management software utilised by the condition monitoring network.

Every network switches’ unused ports are blocked via the network management system. Access to the unit sub-network switches is possible via unit Engineering workstations while to the common condition monitoring network switches is possible via the common network monitoring workstation. USB ports on all relevant hardware must be software locked to prevent data access via USB storage devices.

Antivirus software is installed on all workstations. All workstations are supported by regular updates with the latest OEM approved security patches.

Unauthorised access is denied on all servers and clients’ Basic Input Output System (BIOS) through password protection. Only applications and services that are necessary are activated on servers such that communication and potential points of attack are restricted to an absolute minimum. All users with extended access rights such as administrators, engineers, etc. are automatically logged off after a pre-defined idle time.

All actual security conditions and the initiated and implemented measures are documented in a uniform structure in a Cyber Security manual to be submitted during the project conceptual design.

## Licencing

The *Contractor* provides a reference list of software and associated licences. The *Contractor* confirms the financial requirements, user limitations and restrictions related to the software licences.

## Power Supplies

Existing power supplies available at the station will be made available to the *Contractor*. The *Contractor* provides for the *Contractor’s* calculation and specifications for the power supply requirements for the equipment provided by the *Contractor* to the *Employer* to allow identification of suitable power supply source at the station.

All power supply connections are subject to Safety Clearance by the *Contractor* and witnessed by the *Employer* representative before energising of any new circuit. Safety precautions of isolation of power supply connections, with appropriate locking-off and disconnection where appropriate, must be observed during the execution of the Work; to be agreed between the *Contractor* and the *Project Manager*.

The *Contractor* is required to provide and install, cabling and termination in accordance with his power supply design from the supply point which Eskom makes available.

## Cables requirements

The *Contractor* is responsible for all required cable supply and installation associated with the execution of the option by suitable qualified personnel.

## Cabinet cabling

* The *Contractor* utilises either Cat 6  FTP (Foiled Twisted Pair) or Cat 6 STP (Shielded Twisted Pair).
* Cables used for patch/fly leads between network components are provided complete with required plugs and provide enough slag to allow neat cable routing within the cabinet.
* The *Contractor* standardise on the colour coding of the cabinet communication cables.
* Each cable are clearly marked with a cable label at both source and destination points.

## Network cabling

* Fibre optic cables are used between the vibration diagnostic switch and the condition monitoring switch.
  + The mode of fibre is determined by the longest link and not by the shortest and all interfaces are standardised the identified mode.
* If multi-mode cable is used it must be at least of OM3 Specification
* Only Single mode cables should be used with OS2 as the lowest spec.
* Fibre cables are connected to patch panels using LC connectors. The connection ensures that required minimum radius for cable is adhered to and that the cable is secured at the cabinet to remove strain from the connector.
  + The *Contractor’s* network interface design between the vibration network switch and the condition monitoring switch are able to support the 100Mbit transmission range by providing network cable that can support a 10 Gigabit transmission.

## Other cabling

As specified in main technical specification requirements for cabling.

## Cable management system

As specified in main technical specification for cable management.

## Labelling requirements

As specified in main technical specification requirements for cable management.

## Execution Requirements

## Pre-FAT

The *Contractor* conducts a pre-factory acceptance test at the *Contractor’s* premises in preparation for the FAT. The Pre-FAT is shown in the Accepted Programme.

The *Contractor’s* engineers completely test and verify the performance of the Virtualisation and communication of the diagnostic system to 3rd party interfaces against this Works Information.

The *Contractor’s* Pre-FAT tests are documented as part of the *Contractor’s* QC procedure.

The *Contractor* submits the QC procedures and Pre-FAT test and inspection results to the *Project Manager* prior to the commencement of FAT.

## FAT

During FAT, the *Contractor* demonstrates that the vibration diagnostic system meets the requirements of this Works Information and the detailed engineering design freeze documentation.

The FAT is done at the *Contractor’*s premises. The *Contractor*, OEM and the *Project Manager* witness the FAT.

The scope of the equipment tested at FAT is as follows:

1. Signal processing for solutions engineered in the final design.
2. Functional performance of the diagnostic system functions and tools. Actual inputs are simulated to confirm functionality.
3. Server panels are inspected to confirm drawings and compliance to accepted functional specifications.
4. Network configuration is tested.
5. Cyber security compliance functionality.
6. Back up functionality of the system as per the site procedure.
7. Data access from the system data archive drives and accuracy of the historical data.
8. Disaster recovery of the system.

The *Contractor* provides all facilities and simulation systems at the FAT venue such that full testing of the vibration diagnostic system’s functions can be done. The *Contractor* ensures that all the types of equipment within the detailed design is represented in the FAT. The vibration diagnostic system hardware and software is available and operational in time for the individual tests.

The *Project Manager* determines if any further testing is required in addition to that specified, such as that of any new technologies being used.

##### FAT Procedure

The *Contractor* prepares a detailed test procedure in preparation for FAT. As a minimum, the proposed FAT procedure identifies the following:

1. Major test activities
2. Comprehensive list and description of the individual tests to be performed
3. How the tests are to be prepared and conducted
4. Test dates and durations
5. Checklists - how the test results will be documented
6. Acceptance Criteria
7. How the identified discrepancies will be processed
8. Retesting requirements

##### FAT Report & FAT Completion

A Final FAT Report is prepared by the *Contractor* that includes the following as a minimum:

* + 1. Test procedures used during FAT
    2. Detailed Test results
    3. Discrepancies identified during the tests
    4. Resolution of the discrepancies
    5. Retests conducted and results thereof
    6. FAT certificate

The *Contractor* submits the Final FAT Report to the *Project Manager* for acceptance. FAT Completion is achieved upon acceptance of the Final FAT Report by the *Project Manager*.

## Pre-Outage Installation Work

The following work may be completed by the *Contractor* prior to a unit outage on the condition that the work does not present a risk to running plant.

* + 1. Installation of main racking
    2. Installation of trunk cabling
    3. Installation of network cabling
    4. Installation of network cabling infrastructure
    5. Installation of secondary racking
    6. Installation of network cabinets
    7. Installation and commissioning of networks
    8. Virtualisation of servers
    9. OPC interface to 3rd Parties.
    10. Interface to Eskom LAN
    11. Installation and commissioning of user interfaces
    12. Vibration Diagnostic server configuration and process information.

## Site Integration Test (SIT)

The SIT only begins once the following has occurred:

* + 1. The first type of installation of the vibration diagnostic interface to a vibration monitoring system have been installed in their final locations and connected to permanent power supplies
    2. All network equipment has been installed and communication configured, installed in final locations and connected to permanent power supplies
    3. All interfaces to installed 3rd party systems have been implemented. 3rd party systems not yet ready for interfacing will undergo a separate SIT.

The SIT is carried out before plant commissioning commences to ensure:

* + 1. Correct performance of the vibration diagnostic system.
    2. Correlation between the values displayed in the diagnostic system versus signal values displayed by the Employer’s control and HMI system
    3. Functionality of the vibration diagnostic system.
    4. Compliance with the Works Information and the detailed engineering design freeze documentation
    5. Confirmation of operation of all plots related to the functional requirements of the diagnostic system.
    6. Confirmations that all alarm configurations for all measurements and operation of alarms and events are completed. The performance of the alarm handling system must comply with 240-56355466, Alarm System Management Guideline, and must be verified during the detailed design phase of the *works*.
    7. Different plant mimics configured and related information and coding is correct.
    8. Remote accessibility of the diagnostic system on the unit via the local Eskom LAN users as well as remote support facilities
    9. Cyber security compliance functionality.
    10. Back up functionality of the system as per the site procedure.
    11. Data access from the system data archive drives and accuracy of the historical data.
    12. Disaster recovery of the system.

In the event of an error in any test (hardware or software) the fault is logged, analysed and resolved. The *Contractor* is allowed to rectify the fault and retest for the full duration on condition that the *Project Manager* finds the fault to be minor. Major faults such as process server failure, system stall and network failure or major faults as determined by the *Project Manager* may lead to the termination of the SIT. The *Contractor* rectifies the fault and re-starts the SIT after proving the compliance and performance of the rectified piece of equipment by carrying out the appropriate diagnostic tests.

##### SIT Procedure

The *Contractor* prepares a detailed test procedure for the SIT. As a minimum, the proposed SIT procedure identifies the following:

* + 1. Major test activities
    2. Comprehensive list and description of the individual tests to be performed
    3. How the tests are to be prepared and conducted
    4. Test dates and durations
    5. Checklists - how the test results will be documented
    6. Acceptance Criteria
    7. How the identified discrepancies will be processed
    8. Retesting requirements

##### SIT Report & SIT Completion

A Final SIT Report is prepared by the *Contractor* for each type of installation that includes the following as a minimum:

* + 1. Test procedures used during SIT
    2. Detailed Test results
    3. Discrepancies identified during the tests
    4. Resolution of the discrepancies
    5. Retests conducted and results thereof
    6. SIT certificate

The *Contractor* submits the Final SIT Report to the *Project Manager* for acceptance. When all tests are successful and the Final SIT Report is accepted by the *Project Manager*, the system is classified as ‘ready for installation’. The system is then deemed ready for installation on similar vibration monitoring equipment.

## Commissioning

#### Commissioning is defined as bringing into service all items of the works, and meeting the functional requirements and performance criteria of the Works Information.

Commissioning includes all testing and verification of the stated performance criteria with:

* + 1. Minimum Testing and Assessment criteria
    2. Works Information.
    3. The detailed engineering design freeze documentation

Commissioning for any sub-section of system does not start until the all the pre-requisite activities for that sub-section have been completed and accepted as completed by the *Project Manager*. The *Contractor* provides sufficient personnel for the satisfactory and timely commissioning of equipment; including the re-commissioning of all existing equipment that will form part of the vibration diagnostic system. The *Contractor* co-operates fully with the *Project Manager* or Representative(s) in the commissioning of system for which the *Employer* supplies equipment specified.

The *Employer* uses the *works*, without taking over the *works*, before Completion of the commissioning and acceptance of the *works*.

The *Contractor* provides all the test equipment for the commissioning of the vibration diagnostic system, the sub-assemblies and the user interfaces. The *Contractor* certifies that equipment is in a suitable and safe condition for use before it is placed in service.

The *Contractor* provides a test procedure to the *Project Manager* two weeks prior to the site acceptance testing for review and acceptance. The *Employer’*s representatives witness the acceptance test and the acceptance of the test is a hold point. The test must confirm as a minimum the operation of the following areas:

### Cold Commissioning

As a minimum, the cold commissioning activities conducted by the *Contractor* consists of:

* + 1. Power on off all equipment.
    2. Simulated signal transfer from the vibration monitoring equipment to the vibration diagnostic system with the support of the *Employer*.
    3. Verification of earthing installation.
    4. Minimum Assessment and Testing Requirements as defined in basic design
    5. Testing of fibre optic cables
    6. Network communication.
    7. OPS interfaces
    8. Confirmation of virtualised server operation.
    9. Testing of system functionality

##### FUNCTIONAL TESTS

The functional tests form part of the cold commissioning of the vibration diagnostic system and include the checking of all:

* + 1. Measurement loops
    2. Alarms.
    3. User interface mimics, plots, logs and algorithms.
    4. Networking functional testing.
    5. Virtual machine functional testing.
    6. Failure modes functional testing of both hardware and of software functions.

### Hot Commissioning

##### The Contractor submits the Cold Commissioning test results to the Project Manager. Hot commissioning is where the plant processes are placed into operation. Hot commissioning activities such as monitoring of main turbine and auxiliary plant are performed to ensure operation of the vibration diagnostic system and correlation to plant conditions as reported by vibration monitoring systems before start up, during start up and after start-up of the associated plant. The commissioning activities are carried out in conjunction with the Project Manager.

Commissioning is at the discretion of the *Project Manager* for equipment which cannot be commissioned separately.

In cases where various components (existing or new) are connected to form an integrated system, the *Contractor*, at the time of commissioning, carries the responsibility for the correct functioning of the whole of the system.

If a defect is identified in the equipment interfacing to, or external to the *Contractor’s* scope the *Contractor* informs the *Project Manager* or Representative(s) immediately.

## Site Acceptance Tests (SAT)

Commissioning is concluded with the Site Acceptance Test (OAT). The site acceptance test is performed per unit. The *Contractor* requests commencement of the site acceptance test from the *Project Manager*.

The minimum SAT testing and inspection requirements are:

* + 1. SIT complete and accepted.
    2. Cold and Hot commissioning complete and accepted.

The site acceptance test requires the verification of the vibration diagnostic system performance, accuracy and reliability before, during and after the return of the associated mechanical plant. The site acceptance test further requires a 30 day operational verification period. The verification period will restart from day 1 if a defect associated with the Contractor’s design or equipment failure is experienced during the 7 day operational verification period.

SAT acceptance further include acceptance of associated labelling, documentation and training.

## Optimisation stage

#### The optimisation stage consists of optimisation of the vibration diagnostic system. The phase commence after SAT is accepted by the *Project Manager*. The optimisation period requires the verification of the vibration diagnostic system and corrections which may be identified to setting, configuration, coding, algorithms and displays. The *Contractor* keeps record of the optimisation changes and ensures that future installations are updated with the identified optimisation. Optimisation will be required on the first unit of each station for a period of one month. After this period corrections/defects will be addressed as per the defect period requirements.

# Training workshops and technology transfer

The *Contractor* provides for the following training:

|  |  |  |  |
| --- | --- | --- | --- |
| **Training Group** | **Number of training sessions** | **Number of participants per session** | **Intent of training** |
| Maintenance | 3 | 6 | Enable first line maintenance of the diagnostic systems as well as the vibration monitoring network equipment. |
| System Engineering training | 3 | 6 | Enable engineers to make modifications and create new user interfaces, update configuration. Perform administrative duties. Support fault finding on the vibration network. |
| Users | 3 | 6 | Familiarise the user with the diagnostic system information and functionality. |

Table 4 – Training requirements

The training will be held at venue provided by the *Employer* within South Africa. The training on hardware, network and software is official OEM certified training. The *Contractor* provides the *Employer* with the training curriculum for the acceptance by the *Project Manager.* The language for training facilitation as well as documentation is English. The *Contractor* compiles training manuals for official training courses. The *Contractor* also supplies these manuals in electronic format.

The training on hardware, network and software is official OEM certified training.

# Engineering and the *Contractor*’s design

## Transporting

The *Contractor* is required to transport and deliver all equipment which is used to complete the *Works.* The *Contractor* provides for a storage facility at the relevant sites at the identified area provided by the *Employer*.

No *Contractor* would be allowed to transport passengers on the back of open light delivery vehicles (LDV’s). It is a legal requirement to provide safe transportation of *Eskom* and *Contractor* employees- therefore the following will be enforced:

All passengers must be transported in a closed vehicle with proper and adequate seating, fitted with safety belt for the number of passengers to be transported. No passengers may be transported on the back of a light delivery vehicle (LDV) whether open or closed.

Tools and equipment must be properly secured.

Only authorised drivers may transport passengers.

Proof must be submitted on request in terms of valid roadworthiness of the vehicle/s.

The above must apply to on site and off site transportation of passengers.

## Installation and site work

Site installation will be carried out for all the diagnostic and monitoring systems by the *Contractor* under the supervision of the *Contractor* specified specialist Engineer. The commissioning for all the diagnostic and monitoring systems will be carried out by the *Contractor* specified specialist Engineer

The installation and access for installation are dependent on the production risk associated with the work the *Contractor* performs. Upfront work will be allowed after a risk assessment provided by the *Contractor* in conjunction with the *Employer* justifies the execution of the work.

Work to be performed on units which are in service and which risk does not justify on load access will need to be executed during unit outages. The *Employer* provides the *Contractor* with the outages planned for the duration of the Works. Outages may however change in duration as well as planned execution dates. The *Contractor* therefore provide for a flexible approach which can accommodate changes in outage related work without a compensation event.

## Use of *Contractor’s* design

No additional exceptions.

## Equipment required to be included in the works

As a minimum all tools and equipment required for the maintenance of the installed equipment as per the Works Information. The *Contractor* is responsible for commissioning spares for the equipment which he delivers as part of the Scope of Work.

## As-built drawings, operating manuals and maintenance schedules

Operating manuals are required for all equipment supplied under the Works requirements.

## Completion and correction of Defects

As per main technical specification.

## Access given by the Employer for correction of Defects

Where NCR’s and Defect notifications are issued, the *Contractor* acknowledges receipt within 48 hours and proposes corrective and preventive actions to the *Project Manager* as per the contract response period. The corrective and preventive actions will include the implementation and completion dates. Progress on all NCR’s and Defect notifications issued to the *Contractor* must be reported to the *Project Manager* on monthly basis.

The *Contractor’s* Quality Manager Keeps a register of all NCR’s and Defect notifications issued

Deviations from the Contract are treated as a non-conformance. Records of NCRs and Defect notifications are kept and form part of the data book records.

During the contract execution phase, the *Contractor* will be monitored by the *Project Manager* for performance on quality related aspects. The monitoring will be in the form of audits and assessments

## Warranties

All warranties for the equipment, standard software and application software provided are included as part of the *Works.*

The warranties and guarantee’s period commence from the installation date.

## Service and Maintenance during contract execution

The *Contractor* provides service and maintenance support for the equipment and systems included in the Works. This includes the following tasks:

|  |  |
| --- | --- |
| Software support | * Updates on antivirus software and patches. * Updates on software revisions. * 3 Monthly back-ups of data. * 6 Monthly clean-up of registers. |
| Hardware | * As per Notification Defects |
| Configuration Management | * Setup of alarms and thresholds. * Changes to displays. * User access and administrative duties. |
| Call out response | * Response within 24 hours to defects notified by the relevant site for defects which impact production. * Response within 72 hours to defects notified by the relevant site for defects which do not impact on production. |
| Reports | * Six monthly reports will be compiled per completed site to confirm system performance and availability. |

**Table 5** – Maintenance requirements

## Appendix A – OCM Network Design

### Introduction

The following documented detail describes the components and functions of the data backhaul network for Generator, Turbine and Transformer monitoring. The purpose of this network is the transport statistical and performance data from the Generator, Turbine and Transformer monitoring systems to the Enterprise Historian which is located in the site DMZ and the forwarded further in the Eskom network. The Enterprise historian is located in the DMZ on a switch stack on a high availability pair of firewalls The network will have a switch node at each generator and thus the number of generators on site will determine the number of switches in the network.

This network is not designed for the transmission of control data as it is not optimized in redundancy and optimum fast failover times. This can be accomplished with software upgrades and additional hardware.

### Network Overview

An industrial Ethernet ring of 1Gigabit Ethernet on optic fibre forms the core of the network between the generator monitoring stations. The links run between even numbered switches on one cable route and on the odd numbered switches on another route. These fibre cable routes takes different cableways in the power station where they should not run two fibre optic cables in the same cable tray. The odd and even connections are done on both sides of the ring to complete the ring. The IP termination and default gateway is on the firewall set in the IT server room in the Administration building. Any other devices that must be connected to the switch which are not on the same floor will be connected by 100Megabit Ethernet on optic Fibre connection such as the SM200 and PDA 200 for the generator monitoring.

Turbine monitoring have a single switch per turbine located in the System1 cabinet connected back to the ring with 100Mbit optic fibre connection from a 3006T switch.

The Transformer monitoring also have a single 3006T switch per transformer located in a room as close as possible to the Transformer Cage. This switch will be connected back to the main GHS12/8 switch as indicated on the diagram below. The connections between the Switch and the analysers in the transformer cage will be CAT6 STP as specified in the cabling specifications

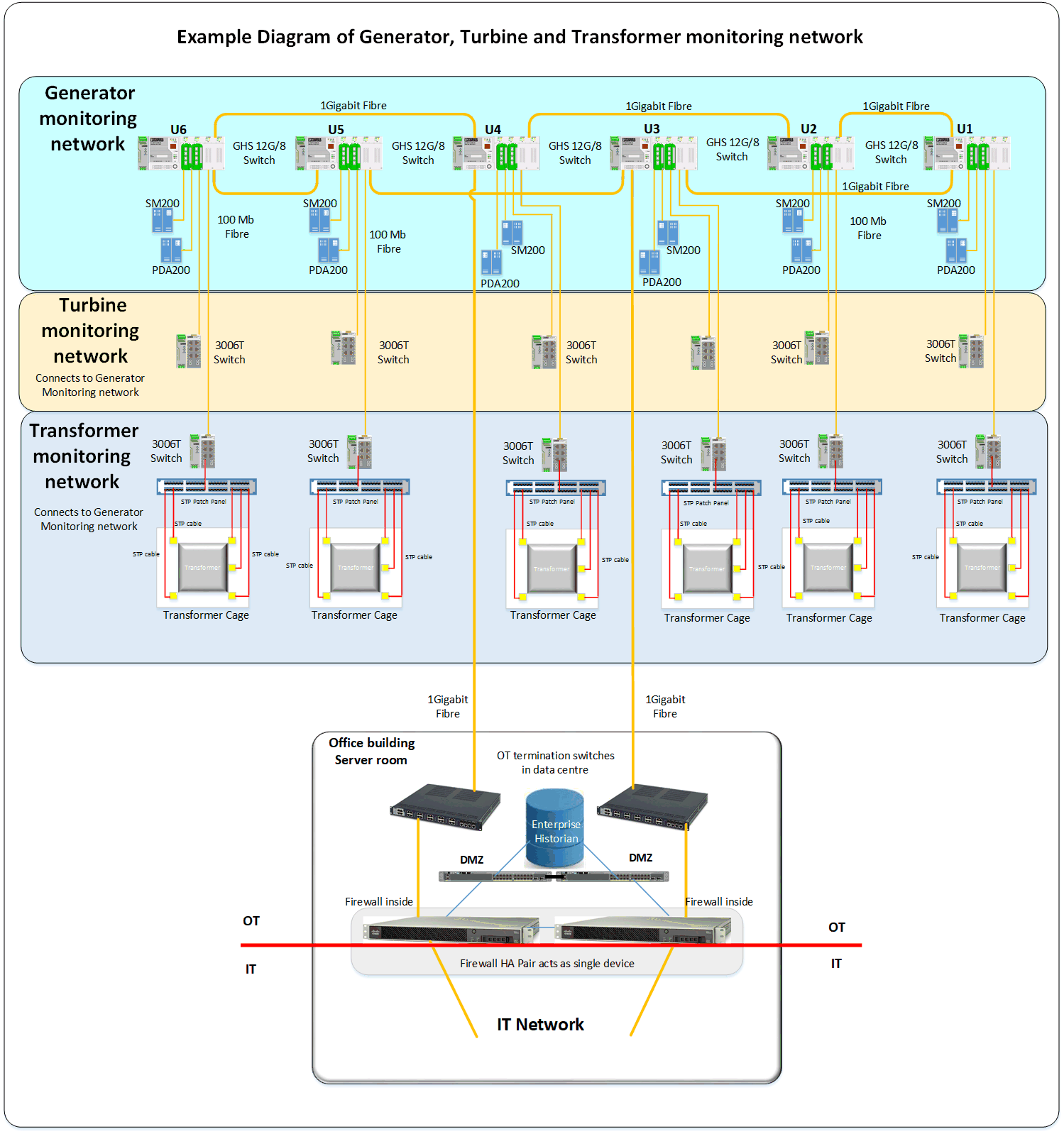


Diagram 2 – Monitoring Network Diagram

### Network Switch Equipment

IP20 or IP30 environmental rating (IEC 60529).

* Application in an Industrial DIN-rail enclosure for layer 2 switches and 19 Inch rack mount for layer 3 switches.
* Passive cooling with no moving parts.
* Operating temperature 0C…+60C.
* Ambient relative humidity 5% to 95% (non-condensing).
* Power source 24 DC or 220V AC.
* Copper Ports (RJ-45):
  + 10/100/1000 Base TX
* Fibre ports (SFP)
* 1000Base-LX Multimode and Singlemode
* Industrial Ethernet Ring Network with Seamless Redundancy compliant to IEC 62493-3
* Network switches:
* Managed Layer 2 for the Automation Level
* Manager Layer 3 for the networked interface to LAN
* Two front panel connectors for DC power and alarm signals
* Fault Signal Contact
* Network management
* Internal temperature sensors
* Two independent alarm relays
* Network Switches port configuration Options:
* The compact industrial Ethernet switches shall have the following as a minimum:
* Two copper ports (RJ-45)
* Two SPF ports
* The industrial Ethernet switch chassis expandable to 24 ports shall have the following as a minimum:
* Six copper ports (RJ-45)
* Four SFP ports
* Two dual-purpose ports (RJ-45 or SFP)
* Capability to expand ports up to 24 ports with extension modules (RJ-45 or SFP)
* The 24 port 19 inch rack mount layer 3 Ethernet switch shall have the following as a minimum:
* Six copper ports (RJ-45)
* Four SFP ports.

### Switching Bill of Material

Table 6 – Switching Bill of Material

|  |  |  |
| --- | --- | --- |
| Description | QTY | Comment |
| 6 port switch with 100mb Multi- mode uplink | 6 | 6 port switch with 100mb Multi- mode uplink |
| Power supply with built in surge protection | 6 | Power supply with built in surge protection |
| 2port x 100mb SC Multi- mode expansion card | 6 | 2port x 100mb SC Multi- mode expansion card |

### Configuration Management

Switch Configuration Management software (BootP IP addressing tool called IPAssign) will be installed on the system administrator’s laptop.

Hands-on training to use this software need to be arranged as part of installation handover. Alternatively, e-learning and guideline documents are available.

### IP Address Structure

A Class C IP subnet will be used and will provide enough address spacing for all the devices and applications.

The networks have an IP address range with a class C network mask applied. This will allow for 254 usable IP addresses.

As more than one system is going to work on the network in the single IP subnetwork, it is important that the IP addresses are used controlled and systematically.

All the systems use the IP addresses of the same range. By using a structured allocation of addresses traffic and systems can be easily identified and duplication of addresses can be avoided. The use of this specific system is really for the benefit of people who look at the decimal values rather than the binary values.

Example: Subnet 172.22.4.0 - Mask 255.255.255.0

### Cabling Specification

It is an objective to ensure that only one mode of optic fibre is used in a site. The mode of fibre is determined by the longest link and not by the shortest. The purpose of that is to make support easier by standardising on equipment and spares, and to reduce troubleshooting and repair time.

The cabling specifications were drawn up to specifically eliminate Electromagnetic Interference EMI and Radio Frequency Interference RFI that is caused by induction onto long lengths of unprotected copper cable.

**UTP Copper cabling**

* All copper cables must be of the shielded variety. Either Cat 6  FTP(Foiled Twisted Pair) or Cat 6 STP (Shielded Twisted Pair)
* Links may be up to 90m permanent link excluding patch and fly leads.
* No copper cables should be used between floors or between buildings even if shielded.
* A shielded cable route may go up or down via other floors as long as the termination is on the same floor as the Patch panel.
* Inside the cabinet where the switch is normal patch leads can be used.
* Shielding must only be done at the patch panel side.
* The cabinet and patch panel earth must be connected with a minimum size of 6 AWG to the building earth.

**Optic Fibre**

* If multi-mode cable is used it must be at least of the OM3 Specification
* Fibre patch panels must be clearly marked with route details
* Fibre routes must be marked every 10 meters with a cable marker to identify route
* No inter switch connections may be copper (even when shielded) always fibre.
* Fibre cables must be unshielded and preferably un-armoured heavy duty duct fibre. HDD
* Only Single mode cables should be used with OS2 as the lowest spec.
* Fibre in Patch panels must terminate on LC connectors
* In a small power station where the fibre optic runs are all below 300m, OM3 Multimode standard cable may be used. This should only be done if no cable run exceed 300m. This is done for two reasons.
* The 10 Gigabit Specification for OM3 multimode is 300M and that futureproof the cabling installation that can have a longer lifespan.
* If the cabling installer underestimate the cabling distance and overshoot the 300m the run will still work on multi-mode as long as it is under 550m. If it exceeds 550meter the Single mode cable must be used.

Table 7 – Turbine Monitoring Cable BOM

| Turbine Monitoring Cabling BOM | | | |
| --- | --- | --- | --- |
| Item | Description | Qty | Unit |
| **U1** | | | |
|  | IP 65 data Cabinet | 0 |  |
|  | Backbone fibre |  |  |
|  | 12 Core HDD duct OM3 Fibre cable (Link to U1 main) | 60 | meters |
|  |  |  |  |
|  | 24 Port fibre patch panel | 2 |  |
|  | LC Duplex Midcouplers | 6 |  |
|  | LC Duplex pigtails | 12 |  |
|  | Splicing | 12 |  |
|  | OTDR testing | 24 |  |
|  | SC-LC Duplex OM3 2m patch cord | 1 |  |
| **U2** | | | |
|  | IP 65 data Cabinet | 0 |  |
|  | Backbone fibre |  |  |
|  | 12 Core HDD duct OM3 Fibre cable (Link to U2 main) | 60 | meters |
|  | 24 Port fibre patch panel | 2 |  |
|  | LC Duplex Midcouplers | 6 |  |
|  | LC Duplex pigtails | 12 |  |
|  | Splicing | 12 |  |
|  | OTDR testing | 24 |  |
|  | SC-LC Duplex OM3 2m patch cord | 2 |  |
| **U3** | | | |
|  | IP 65 data Cabinet | 0 |  |
|  | Backbone fibre |  |  |
|  | 12 Core HDD duct OM3 Fibre cable (Link to U3 main) | 60 | meters |
|  | 24 Port fibre patch panel | 2 |  |
|  | LC Duplex Midcouplers | 6 |  |
|  | LC Duplex pigtails | 12 |  |
|  | Splicing | 12 |  |
|  | OTDR testing | 24 |  |
|  | SC-LC Duplex OM3 2m patch cord | 2 |  |

### Cable Distances

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | | **Cable Distances - Lethabo Power Station** | | | | | | | | | Unit | Cable length |  | Unit | Cable length |  | Unit | Cable length | | U 1 |  |  | U 2 |  |  | U 3 |  | | Link to U 2 | 60 |  | Link to U 4 | 210 |  | Link to U 5 | 165 | | Link to U 3 | 165 |  |  |  |  |  |  | | Link to SM200 | 60 |  | Link to SM200 | 60 |  | Link to SM200 | 60 | | Link to PDA200 | 60 |  | Link to PDA200 | 60 |  | Link to PDA200 | 60 | |  |  |  |  |  |  |  |  | | Server Room Link | |  | Cable length |  |  |  |  | | U3 Link to Server Room | |  | 240 |  |  |  |  | |  |  |  |  |  |  |  |  | | Turbine monitoring Links |  |  | Cable length |  |  |  |  | | U1 Link to Turbine Monitoring | |  | 60 |  |  |  |  | | U2 Link to Turbine Monitoring | |  | 60 |  |  |  |  | | U3 Link to Turbine Monitoring | |  | 60 |  |  |  |  | |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |  | |  |  |  |  |  |  |  |
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