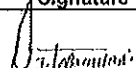


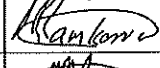



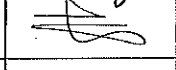
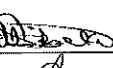

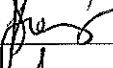
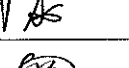


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Document Type	User Requirement Specification
Scope of Activity	Rotek Engineering Turbo Gen Services New Balancing Plant Facility (32 – 36 Ton)
Purpose	The purpose of this document is to define as far as possible the User Requirement Specifications for the procurement of a full Turnkey contract for a 32 – 36 Ton balancing plant to be supplied, erected, and commissioned at Rosherville inclusive of all equipment, construction (including building approvals by local authorities) and procurement activities.

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Appendix A: Rotor Specifics

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1. INTRODUCTION

The New Balancing Plant Facility will be constructed on the Rosherville premises, linked to the New Generator Services Workshop. Due to the sensitive and specialised nature of the scope of work and type of equipment it is essential that an experienced balancing plant supplier be appointed to supply, install, and commission the plant on a fully turnkey basis from initial earthworks, building approvals, construction, supply of all equipment up to and inclusive of skills transfer and commissioning

The information in this document will outline the requirements related to the Balancing Plant as far as possible. The information is a guideline to potential suppliers of the balancing plant and related facilities and activities, deliverables, and responsibilities. It would be expected of potential suppliers to augment this set of user requirement specifications after consultations with the end user, where it is deemed that additions to the scope of supply and activities are required.

2. DEFINITIONS AND ABBREVIATIONS

Item	Description
SDL	Supplier Development Localization
PPPFA	Preferential Procurement Policy Framework Act
EPS	Emergency Power Supply
NBR	National Building Regulations
UPS	Un-interrupted Power Supply
NFPA	National Fire Protection Association
ASIB	Automatic Sprinkler Inspection Bureau
°C	Degrees Celcius
ACW	Auxiliary Cooling Water
ECSA	Engineering Council of South Africa
C&I	Control and Instrumentation
HVAC	Heating, Ventilation and Air Conditioning
VDU	Visual Display Unit
OHSA	Occupational Health and Safety Act

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3. OPERATING, MAINTENANCE AND ENGINEERING REQUIREMENTS

3.1 Staffing

The current TGS balancing staff will be used to operate both the 300 Ton and new installed balancing plant. Each operating shift will have 4 permanent staff members.

3.2 Training

Training, both theoretical and practical, is to be done by training practitioners and internal subject matter experts as well as having a trainee/learner support programme i.e., mentoring/coaching. The level of knowledge with respect to envisaged training and special learning needs are to be analysed as a prerequisite to training. Certification requirements shall include ECSA, Higher Education & Training Institutions and SETA. The end users require all training to be done during the construction and commissioning to be done locally. Once training is completed there is to be a set of assessment criteria to determine competency. Training shall consist of both basic and advanced training and focus on skill enhancement, operating and maintenance of the new balancing plant.

3.2.1 Operator Training

Operator training will be required which will take the operators from a basic system knowledge of the systems required to operate the plant to an advanced knowledge of the balancing plant systems. Training will be structured to enable the operator to understand the operation of the process systems and components as well as electrical and control systems to enable quick fault identification of the balancing plant.


Operating and balancing training shall be provided by the OEM to various experienced Rotek personnel.

Training will be provided on the actual operation of the balancing section of the plant. The operator shall be trained to interpret results and to perform accurate adjustments to achieve the balancing requirements. Operator training will include training from basic balancing principals to advance knowledge to enable balancing of all types of rotating machinery. Specific attention to be given to new technology developments and the application thereof in the global balancing field.

To concentrate fully on operating tasks and decision-making, the operator shall be fluent in the use of the Human Machine Interface (HMI). This includes knowledge of the display hierarchy, its content, navigation links and paths, and dynamic behaviour of the HMI.

3.2.2 Maintenance Training

Maintenance training shall consist of a formal training programme prior to and during the implementation of the project. The training shall be done in line with the balancing plant maintenance philosophy to ensure that balancing plant staff are capable of maintaining and managing the plant, including control and instrumentation equipment.

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Maintenance, Engineering and Safety personnel shall work with the successful contractor (seconded) during the engineering, implementation, and commissioning phases of the project. This opportunity shall be used to gain valuable on-job training, knowledge experience on the systems.

3.2.3 Engineering Training

Engineering training shall consist of a formal training programme prior to and during the implementation of the project. Training shall be done in line with the balancing plants design philosophy to ensure that engineering staff are capable of working with and managing modifications on the balancing plant systems and infrastructure.

Engineering personnel shall work with and assist the successful contractor during the engineering, implementation, and commissioning phases of the project. This opportunity shall be used for on-job training and experience on the systems.

3.3 Human factor requirements

3.3.1 Link to Design Process

Human factors considerations shall be evaluated and applied in the design of all balancing plant systems, equipment, and components in all phases of the design life cycle.


Human factors engineering shall be firmly entrenched in the design of the plant and shall form an integral part of the formal design and verification processes.

The specific human factors areas shall include, but not be limited to, the following:

- The working environment shall be designed to be conducive to error-free operation and comfort, catering for long hours, night shifts, aesthetics, and all environmental conditions.
- Lighting levels, heating, ventilation, and air conditioning (HVAC) shall be provided and will be consistent with anticipated operation, balancing and maintenance activities.
- The design of the plant shall consider both reduction and attenuation of noise sources to reduce noise exposure during operation and maintenance activities, to levels consistent with OHSA standards.
- All human-machine interfaces whether for operating, maintenance, or repair, shall be reviewed by Rotek to ensure that plant is operable and maintainable well within human physical and cognitive capabilities and consider anthropological norms, population stereotypes and standards.

3.3.2 Human Factors – Operability

The use of modern and new technologies employed in the balancing plant shall be evaluated against operability and human factors requirements at successive stages of the design. The

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evaluations shall be based on qualitative and quantitative human performance measures and pre-defined acceptance criteria.

Factors of importance will include consideration of disabled and female employees factored into the plant designs.

The design of the main control (both for the process plant control and balancing plant control) suite, all operator interfaces, and the control and automation system, shall be done with direct Rotek Engineering personnel involvement in terms of requirements formulation, design reviews, verification, and validation.

3.3.3 Human Factors - Maintainability

The balancing plant designs shall be reviewed as per the Eskom Project Life Cycle model before finalisation by suitably qualified staff to ensure that the plant has sufficient features to ensure safe and efficient maintenance can be carried out. The following aspects shall be reviewed for all plant areas:


- Access to plant items
- Adequacy of lifting and handling devices
- Area available for in-situ work
- Adequacy of lighting to allow inspections and maintenance to be performed
- Interference with the operation and maintenance of other structures and systems
- Adequacy of the maintenance and storage facilities
- Draining and venting facilities on active systems
- Adequacy of spare parts
- Suitable electrical and compressed air supply points are provided and installed to ensure that portable tools can be used to perform maintenance activities.
- Cameras for balancing runs and security

3.4 Operating philosophy

The balancing plant as well as all support process equipment should be able to be operated intermittent for 50 years. The plant is operated and used when required. The plant must be able to operate simultaneously with the 300-ton balancing plant in terms of the power supply available. Although the plant operates intermittently it must be able to run for 120 hours uninterrupted.

Operating of the balancing plant will be carried out from a single control suite with the capability for the operation of the plant process equipment and balancing activities by one operator and one balancing technician.

The control suite should be developed based on the ISO 1:2000 (SANS 11064 – 1:2010) standard. The control centre concept for the plant must consider various factors, including the operating philosophy, staffing levels, physical plant layout, company culture, etc. A study

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incorporating all stakeholders (management, operating, maintenance, engineering, etc) must be conducted to determine the most suitable control centre concept and safety features before a detailed engineering study is done.

The control suite should be sized and designed to allow staff interaction during balancing activities which may include external personnel witnessing the balancing activities. Access to the panel should be limited to operating staff with other staff capable of viewing operating parameters safely during balancing activities.

The operators should be capable of communicating with plant personnel via an intercom system and sufficient safety equipment (emergency pushbuttons) are supplied both in the balancing pit, near process equipment and within the operating centre. Four high speed cameras are required within the balancing pit and the images viewed in colour from the control room.

The operators should be capable of reading the display screens from their normal standing and sitting position beside the panel without having to move their head to adjust for height, angle, or lighting. Back lit mimics are provided in the form of at least two 130 cm screens to enable Rotek clients to witness the balancing activities without interrupting the balancing pit operating staff.

Eco- Lighting in the control suite should be adjustable for brightness.

The operators as well as balancing technicians should be able to access all necessary documentation such as operating procedures, alarm cards and similar reference documents electronically in the control suite, with paper-based documents stored in an adjacent fireproof room.

Printer capability will include the ability to print all plant analogue data in graphical form, (configurable from the operator's console) as well as all balancing data such as vibration plots etc.). Standard A4 and A3 colour printing is required.


3.5 Maintenance philosophy

Over above the warranty period we require a 5-year maintenance plan with cost and a list of consumables. The supplier to ensure that they make provision for all consumables and material that is required to commission the machine. The machine must come with all tooling and accessories, including any auxiliary's equipment to run the machine.

The suppliers must provide a full maintenance handbook including a full list of consumables and spares.

3.5.1 Special Tools

If any specialised tools, maintenance, and inspection systems are required for the balancing plant it shall be designed, developed, procured, and tested to the same requirements as defined

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for the balancing plant, and shall be delivered with the balancing plant. A detailed list of special tools to be provided including spares for these tools.

All specialised tools (including slings and chains for lifting equipment etc.) must be supplied with all equipment.

All lifting equipment supplied as part of this contract shall be in accordance with the OHS act and approved by ERI GMR2.

3.5.2 Equipment Specification


To achieve the balancing plant life span while also attaining production targets, the plant shall be designed such that parts and components can be replaced, repaired, or reconditioned. The plant shall have features that permit part replacement, and shall be supported by extensive plans, data, and documentation to support the life of the components to be both electronic and blueprint hard copies. Replaceable and non-replaceable items shall be identified, and suitable plans and procedures identified to facilitate replacement or repair. Time of replacement and procedure to perform the task shall be provided.

3.5.3 Maintenance Programme

The development and periods of the maintenance and in-service inspection programs shall be initiated in the basic design phase of the plant, and similarly the requirements shall be reflected in the final design and construction details of the plant. The Rotek Owners engineer shall be consulted regularly in the development of the programs.

The design of the plant shall be optimised to minimise the need for maintenance, whether preventative maintenance or predictive maintenance. Specific reliability centred maintenance philosophies will be developed and handed over to Rotek during the project. The plant shall be designed to permit replacement of life-limited, and/or failed components over its lifetime. The plant shall have sufficient redundancy designed to allow for small components (i.e., pumps, coolers, filters to be maintained while the plant is in service.

A comprehensive in-service inspection and test program (largely based on Condition Based Maintenance) shall be developed, which includes all pre- and in-service inspections and tests, surveillances, and material ageing tests, which are not normally included in a maintenance program but are aimed at providing ongoing assurance that the design and design base assumptions are valid and have been realised. These tests and inspections shall enable the plant's integrity and operational readiness to be demonstrated at all times during the life of the plant. It is preferable to include on-line condition monitoring equipment that is linked to the information systems. Installation and removal of any plant to be accessible by crane and to be designed with lifting facilities. A list of all international specialised parts & patented equipment shall be provided.

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3.5.4 Long Term inspection

It is foreseen that the main components and the preventative maintenance program will drive the inspection regime. All inspection and preventive maintenance need to be done according to the maintenance philosophy for this new balancing plant.

The following is provided as guideline unless advised:

- Interim inspection: Every 3 years lasting 1 week
- Major inspection: Every 6 years lasting 2½ weeks.

The maintenance programme shall fulfil all the requirements of the Republic of South Africa's OHS Act latest edition taking into account the exemptions granted to Rotek (if any), and all other relevant local regulations. All legal requirements (i.e., hydrostatic testing of equipment where required, shall be met, and fall within the time frame of the inspection intervals. Wherever possible use of inspection panels and guards for quick visual inspection shall be provided.


3.5.5 Preventative Maintenance

A preventive maintenance plan shall be developed and documented based on the final plant design. A first draft shall be issued on completion of detail design phase. The plan shall identify the preventive maintenance requirements, tasks, methods, tools, personnel skills, and estimated worker-hours on a system basis for the categories of mechanical, electrical, civil and control and instrumentation maintenance.

The designer and vendors shall make explicit and detailed recommendations on the frequency and extent of preventative maintenance and shall provide a full engineering base for all such work to be performed or potentially to be performed during the life of the plant. The basis for these recommendations shall include consideration of previous experience obtained while maintaining balancing plants. The frequency and extent of preventative maintenance may be affected by the utilisation of predictive maintenance methods. These methods shall be based on the surveillance of carefully selected parameters and a special analysis of the results.

The design shall include provisions and systems for monitoring plant and equipment status, configuration, and performance and for detecting and diagnosing malfunctions as a basis for predictive maintenance plans and decision-making. Condition monitoring includes the monitoring and evaluation of transients. As a minimum the plant will have online condition assessment on the large electric motors, etc. and should also allow for sampling and condition analysis.

Lag and lead times to place orders internationally for all spares and replacement part to be specified as well as the supplier details.

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3.5.6 Access, Cranes and Facilities

Building design and equipment layout shall include features (e.g., cranes, hoists, monorails) to facilitate removal and replacement of major equipment items. This provision will be for all equipment that has to be maintained as well as equipment physically housed within the balancing pit.

Equipment and components shall be accessible from normally provided floors and platforms. Where components are not accessible from floors or platforms, special access, such as permanently installed ladders and local platforms, shall be provided.

Items of Plant and castings to be lifted by crane or other lifting devices shall be provided with integral lifting eyes, lugs, trunnions, or some other means approved by Rotek Eyebolts shall only be provided for minor items of Plant. The bearings of all major Plant shall be arranged for easy in situ replacement.

No piece of individual equipment shall need the assistance of specialised rigging equipment to be installed or to be remove. Jib or gantry cranes shall be supplied to lift equipment.

3.5.7 Spares


The various studies i.e., RAM will indicate what strategic spares will be needed as strategic stock holding. These spares shall be delivered to Rotek as part of the main equipment delivery. The supplier of the equipment shall clearly identify long lead equipment and it will be the choice of Rotek to purchase these either as part of the offering or separate orders in the list for the strategic spares the supplier as a minimum state the equipment, lead time and sub supplier's details in full.

3.6 Reliability and availability

In the overall design of the Plant preference shall be given to achieving and readily maintaining maximum reliability and availability.

Design for reliability and availability will be in accordance with BS 5760 Part 1 1985 – Reliability of Constructed or Manufactured Products, Systems, Equipment and Components.

Each item of Plant shall be suitable for the condition which it shall be expected to meet. And sufficient component reliability shall be designed into the Plant to enable overall Plant availability targets to be achieved throughout its design life. Reliability and redundancy calculations shall be performed using established methodologies to demonstrate the adequacy of the designs to achieve Plant performance targets where specific requirements are not stated in this document. Such analyses shall be an integral part of the design process in which cross-functional design decisions, cost-benefit trade-off studies and overall optimisation of the Plant are considered. The Engineer will be provided with the details of the methodology and results.

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4. SITE LOCATION AND LAYOUT CONSIDERTIONS

4.1 Site Requirements

The location of the balancing facility is captured on drawing BPR3-01-AR-1000

The balancing facility site must have provision for all associated infrastructure associated with its operations, these include making use of existing facilities on the Rotek premises where possible.

4.2 Layout considerations

The layout of the balancing plant associated infrastructure and materials handling plant must be optimised from both capital as well as lifecycle costing with due cognisance for ease of operating and maintenance.

- All power cabling running between buildings or equipment is either to be run in suitable cable racks or trays above ground, or in suitable cable tunnels. No buried cables will be accepted.
- All piping runs outside of main buildings is to be run in proper pipe tunnels, pipe trenches, or supported on suitable plinths above ground.
- Adequate facilities shall be provided with sufficient space to carry out maintenance effectively as well as a stores facility for the receipt, storage and issuing of plant spares. The final layout of maintenance facilities should be discussed and agreed between the Rotek and the supplier.
- Maintenance workshop buildings shall be sited as close to or attached to the main balancing plant building.


5. FACILITIES

5.1 Access

Access is provided via a security system that reads the normal ERI access cards to allow access and integrates into the existing Rotek security and access system. In the event of a power failure back-up power is provided for access point.

5.2 Structures & building works

The design of structures and other buildings shall comprise an investigation of the suitability and availability of space for these components of the facility and how they best serve the needs of the balancing plant. These shall be assessed with respect to locality, environmental issues, functionality and cost and future expansion and access.

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5.3 Finishes and Materials

Internal and external materials shall be selected to ensure energy efficiency, durability, comfort, safety, and health within the physical environment and shall be compatible with the function of the spaces.

All buildings and furniture are to comply with the Rotek/Eskom Corporate Identity and standard requirements. Ecology and environmental issues are to be considered.

5.4 Landscaping and Parking

The impact on the environment shall be minimised and landscaping of the site shall be integrated with the design of the structures. Environmental requirements and regulations to be consider.

Parking shall be provided to suit the requirements of the activities performed at the various structures and buildings. Parking areas for motorbikes and bicycles are to be considered.

5.5 Sewage reticulation


The design for sewage reticulation design shall comprise an investigation of the suitability, positioning, and availability of space for this service and how it will best serve the needs of the balancing plant. This shall be assessed with respect to environmental issues, functionality, and cost.

The sewage reticulation system is located on the Rotek site. It provides for effective sewage removal from the various buildings to the existing municipal sewage Particular attention shall be placed on the design of a cost-effective sewage reticulation system. Careful consideration must be given to pipe materials selected and to existing services, which must comply with the municipal bylaws.

5.6 Solid waste disposal

The location of communal disposal points shall be selected with sensitivity and careful planning to limit public nuisance of dust and odour. Provision shall be made for the final disposal of collected refuse, which shall be acceptable to the National Environmental management waste act, 2008 and local municipality by laws.

The potential pollution of water; oil; hydraulic and all contaminant sources shall be prevented. Oily water separator to be supplied.

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5.7 Facility drains system

Those sections of the balancing facilities footprint in which oil spills may be anticipated shall drain towards an oil separation facility. This facility must have the capacity to effectively remove the spilled oil from drains water. It shall consist of:

- A suitable silt settling facility to safeguard against silt deposition,
- An attenuation dam to prevent flow surges, storage
- Access roads to effectively operate and load the recovered oil for recycling.
- Environmental compliance and statutory approvals

With the proviso that clean water will remain clean and shall be channelled off site towards a drainage line or public stream, without causing soil erosion, storm water shall be separated from the station terrace on basis of quality and cascaded to an appropriate destination or impoundment. An automatically operated sluice system, controlled by a conductivity measuring device, shall separate storm water from the station terrace.

All dirty water shall be retained on site in an impoundment designed in accordance with the requirements as stipulated in Government Notice 704 (GN 704) and the Municipal bylaws. A suitable capillary breaker / liner shall be incorporated to safeguard the ground water against pollution. Dirty water impoundments shall have a central concrete pathway to allow for access of cleaning equipment without damaging the liner / membrane.


The materials of construction of the drainage system shall be commensurate with the expected water quality.

6. FIRE PREVENTION AND PROTECTION AND SAFETY

A fire risk assessment must be initiated early in the design process to ensure that the fire detection and fire protection systems meet the requirements of the relevant applicable local and international standards for this type of facility as well as complying with any additional Rotek insurance requirements.

From 2003, Eskom Holdings agreed, in areas where SANS is silent, to follow the requirements and recommendations of the NFPA (National Fire Protection Association) Codes. While it is preferred that the NFPA Codes be applied in this project we will accept compliance to other major European codes.

The existing fire facilities are also to be taken into account during design. Sloping floors or an adequate system to allow for drainage in the event of any spillage will be incorporated in the design.

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6.1 General Fire Protection Systems and Equipment

6.1.1 Water supply and distribution

It is recommended by the "Fire Protection Specialist" to use the most efficient fire protection system, like the Foam System.

Currently we do not have a water protection system at our current 300 Ton balancing plant. They installed the foam system in certain areas at the 300 Ton Balancing plant. The aim is to protect the whole balancing plant, including the transformers with a foam system, therefore there is no need for water supply and distribution system, pump house, pumps, jockey etc.

6.1.2 Fire Detection systems

A fully functional, automatic fire detection system must be provided throughout the new Balancing Plant, like a foam system. The detection system types are to be suitable for the environment that they are to be used in. Fire detection zones must be equipped with local audible and visual alarms with annunciation in a constantly attended location, such as the main control suite. Audible fire alarms should be distinctive from other plant system alarms. The fire detection system is to be interlocked with the HVAC system, the smoke extraction system, and with any lifts provided as part of the balancing plant installation. Emergency Push button control systems to be installed in balancing plant.

Where gaseous fire suppression systems are specified in the fire risk assessment, they are to be suitable for the environment that they are to be used in (i.e., no Carbon Dioxide in areas occupied by personnel). All gaseous fire suppression systems are to be equipped with their own local control panels, audible and visual alarms, and electrical and manual abort switches. All local control panels are to form part of the overall fire detection system detailed in section 6.1.2.


6.1.3 Loss Prevention Considerations

Loss prevention considerations should cover but not be limited to the following areas:

- Fire protection and detection systems must be provided for all areas associated with the balancing plant
- Lubricating oil systems for the balancing plant and associated equipment
- Fire protection and detection systems shall be provided for electrical distribution equipment such as transformers, circuit breakers, switchgears and control room.
- A fire protection system for transformers shall be designed to operate while transformers are energised.
- Oil-insulated transformers must be separated from adjacent structures and from each other by firewalls and blast walls, spatial separation, or other approved means for the purpose of limiting the damage and potential spread of fire from a transformer failure.
- Indoor transformers must of the resin filled type.

Grouped electrical cables:

- Consideration should be given to the use of fire-retardant cable insulation.

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- Grouped electrical cables should be routed away from exposure to hazards or be protected must be ducted; water and fireproof covers and suspended off the floor.
- The layout of electrical cables shall minimise exposure to control and signal cables from power cables. Where cables penetrate fire walls, the penetrations must be sealed off
- Cable trays and supports shall be constructed of non-combustible material. Care should be taken to avoid routing cable trays near sources of ignition or flammable and combustible liquids.
- Electrical cabling for backup and standby plant should not be grouped together with that for normal / regular operations.
- Cables to earth as per regulations.

7. INFORMATION, CONFIGURATION AND DOCUMENTATION MANAGEMENT

7.1 Configuration Management

The supplier shall develop a comprehensive configuration management program to ensure that plant structures, components and computer software conform to approved design requirements. In addition, the plant's as-built physical and functional characteristics shall be properly reflected in selected plant documents and databases, including those for design, procurement, construction, operation, testing and training. The configuration program shall be applicable for use throughout all phases of the balancing plant life, including the design phases, and shall form part of deliverables for hand-over to the Balancing Plant Owner for use during commissioning and operation phases.

7.2 Plant Codification


The plant structures, systems and components shall be coded according to Eskom & ERI codification method of coding. The method will be to sufficient detail to ensure that the plant can be operated, maintained, and isolated safely.

All designs, testing, commissioning, operating maintenance and training documentation and databases shall be suitably and comprehensively marked, cross-referenced, and indexed with the allocated codes.

Eskom KKS codification system to be considered for suitability of use on the balancing plant.

7.3 Documentation

A documentation system shall be established to provide for the preparation, review, approval, issuance, distribution, revision, and validation of documents essential to the management, performance, and verification of work.

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The documentation management system shall comply with the requirements of IEC 61355 for the Classification of document if the supplier does not have his own classification system.

The supplier shall supply all information required for the operation and maintenance to Rotek through an OMM (Operation & Maintenance Manual). The supplier to provide all manufacturing drawings.

The supplier shall comply with the requirements of IEC 62079 for the preparation of technical instructions for the operation, maintenance, and servicing of the Works.

Two hard copies of all O&M hardcopy files, electronic copies and CDs and documentation created during the full lifecycle of the project is provided at hand over of the plant.

7.4 Documentation Format Requirements

The supplier shall deliver all data, drawings, and documents generated in the supplier designed system of choice to the Engineer in the following public domain formats:

1. Data: The Contractor shall supply the following spreadsheets such as equipment list, line list, valve list, instrument list, and speciality item lists in Excel (Office 2010 compatible format).
2. Drawings: drawings shall be delivered in digital format in either DGN (version eight or later) or DWG (version 2004 or later). Including Electronic copies and CDs
3. Documents: documents shall be delivered in electronic format (MSOffice 365; SAP and SharePoint compatible or Adobe Acrobat pdf files Including Electronic copies and CD's).

Drawings shall be as built to scale, clear colour coded and in full detail. All important dimensions shall be given and the material, of which each part is to be constructed, shall be indicated in lists or bills of materials. Blueprints of all plant is to be provided including contract details for the supplier / manufacturer.

Drawing or information creation tools shall consistently be applied to create standardised content, i.e., one symbol library shall be used for all Process P&ID's.

All records of design, manufacturing and construction that could be of use in evaluating ongoing plant condition shall be captured in a format that allows their use over the plant life. Manufacturing and construction work control packages and anomalies, repairs and rework, material certificates and non-destructive testing results shall be included in the quality assurance data package for the plant as part of final hand-over.

As a minimum the following documentation will be supplied as deliverables and this list is not exhaustive:

- Piping and instrumentation diagrams of all systems
- Calculation and sizing sheets for all equipment.

- Pipe work isometrics
- Plant arrangement drawings
- Structural drawings
- Foundation drawings
- Balancing plant plot plan
- Equipment data sheets
- Concrete rebar drawings
- Line lists
- Tie in lists
- Instrumentation lists
- Functional documentation i.e., logic diagrams
- Mechanical Equipment lists.
- Control philosophies
- RAM studies
- HAZOP Studies
- FMECA studies
- Full Operating and Maintenance Manuals
- All equipment sub-contractor's manuals, datasheets etc.
- Conceptual and detailed design reports with calculation notes.

8. TECHNICAL REQUIREMENTS


8.1 Design Criteria

8.1.1 General Design

The Works shall be based on existing proven equipment which has operated for a sufficient length of time to have demonstrated performance and availability.

Preference should be given to established local standards (SANS) where possible although these requirements do not specifically require these to be used. The supplier is allowed to use any established code for his design provided that the code is internationally recognised i.e., ASME, EN. Where specific design codes are used within this document these will be adhered to. If the supplied deviates from these, he shall obtain approval from Rotek first.

The supplier shall ensure the Codes and Standards and codes of practice are all the same standards and codes of different nationalities shall be avoided. Any deviation from this requirement shall be subject to the approval of the Engineer. The mixing of international Codes

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and Standards (e.g., ISO, etc.) with those of a particular nationality is permissible provided that this has been approved by the Engineer and that there is complete compatibility between the Codes and Standards so offered.

8.1.2 Legal and Regulatory requirements

Equipment and all plant shall meet all South African legal and regulatory requirements. The South African legal and regulatory requirements regarding plant and machinery are all contained in the OHS Act 85 of 1993 including Regulations and all incorporated Standards. The equipment shall also comply fully with the requirements of South African law including the OHS Act No.85 of 1993 as amended.

8.1.2.1. Driven Machinery Regulations

All lifting machines shall comply with the requirements of DMR18, Relevant standards are:


- BS 466:1984 Specification for power driven overhead travelling cranes, semi-goliath, and goliath cranes for general use.
- BS 2573-1:1983 Rules for the design of cranes. Specification for classification, stress calculations and design criteria for structures.
- BS 2573-2:1983 Rules for the design of cranes. Specification for classification, stress calculations and design of mechanisms.
- SANS 10160-6 Basis of structural design.... Actions induced by cranes and machinery

8.1.2.2. Ladders

- To comply with General Safety Regulation 13a.
- Includes access ladders or cat-ladders installed for access to cranes or roof-mounted equipment.
- If more than 5m in length, must have a cage not more than 700mm away, starting 2,5m above floor & ending 900mm above landing

8.1.2.3. General Safety Regulations

- Use & storage of Flammable Liquids – General Safety Regulation GSR 4
- Flammable liquid means a liquid that forms a vapour which is explosive & has a closed-cup flashpoint of less than 55 °C - GSR 1
- Rooms where Flammable Liquids applied - GSR 4(1), (2) & (3)
- Spray booths where Flammable Liquids sprayed - GSR 4(4), (5), (6), (7), (8) & (9)
- Flammable Liquid Store – GSR 4 (10) & (11)
- All Johannesburg Emergency Management Services Bylaws relating to the above.

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8.1.2.4. Pressure Equipment

Coded vessels and similar items shall be designed to one particular code as required in terms of the South African OHS Act No.85 of 1993 as amended, and plant shall meet PER (Pressure Equipment Regulations) regulations.

New Compressed air receivers must comply with Pressure Equipment Regulations and SANS 347*. New Pipelines for compressed air having a diameter greater than 143mm must, in general, comply with Pressure Equipment Regulations and SANS 347*.

Repairs & Modifications of pressure equipment must comply with Pressure Equipment Regulations and SANS 347*. Inspection of pressure equipment must be done by an Approved Inspection Authority holding a certificate from the Department of Labour. SANS 10227* Criteria for operation of AIAs in terms of PER's.

Fire Extinguishers must comply with Pressure Equipment Regulation 19 as well as:

- SANS 1475* The Production of reconditioned fire-fighting equipment – Part 1: Portable and wheeled (mobile) rechargeable fire extinguishers
- SANS 1910* Portable refillable fire extinguishers
- SANS 1567* Portable rechargeable fire extinguishers – CO2 type
- SANS 10105* The use & control of fire-fighting equipment.

8.1.3 Metrication

The International Organisation for Standardisation (ISO) system of weights and measures is to be used in all documents, correspondence, and drawings.

Bolts, nuts, and studs, unless for a special purpose, shall be to Metric standards.


The Contractor shall supply metric sized Plant and Material, unless otherwise approved by the Engineer. Where available, the metric equivalents of specifications, standards and codes of practice shall apply.

8.2 Main parameters and requirements

The balancing pit shall be able to cater for all the equipment captured in Appendix A.

Main design parameters are

1. The New Balancing Plant (32 – 36 Ton) Facility Floor Space will be estimated 1300 m².
2. The maximum length of Rotors for Balancing purposes will be 9000 mm
3. The Maximum Diameter of Rotors will be 2800 mm
4. Maximum Balancing Speed 20000 rpm

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5. Structural design to handle rotor weights from 1000 kilograms to 36 Tons
6. Bearing and Length of Rotors up 32 Ton:
 - i) Rotor mass – 1000Kg to 32 000 Kg
 - ii) Total length – 2000mm to 5100mm
 - iii) Bearing centres – 1500mm to 4000mm
 - iv) Journal diameters – 80mm to 500mm


The plant will meet the following specific requirements within one rotor set-up:

1. Low speed balancing
2. High speed measurement of balance condition at operational speed
3. Dynamic straightening of flexible rotors
4. Control of material strength by centrifuging of rotors at overspeed
5. Investigation in operational bearings.
6. Vacuum operation

8.3 Process Systems

All systems that are required to enable the balancing of all types of rotating machinery including heat runs on generator rotors are supplied. All equipment to enable safe removal and installation of the rotating machinery that requires balancing are supplied. These include but are not limited to the following:

- Oil lubrication unit and system for drive system
- Jacking oil system
- Vacuum oil lubrication system for the balancing pit bearings
- Vacuum evacuation units
- Oil purification unit
- Cooling water system
- Machine base, bearing pedestals and transport bogies
- All required drive and intermediate shafts required.
- All gearing requirements.
- Fire detection and protection systems
- Heating and ventilation systems for the main plant as well as offices.
- All electrical equipment required for the operation of the plant.

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8.3.1 Oil Systems

The lubricating and jacking oil systems comprising coolers, oil tanks, pumps, piping, non-return valves, control valves etc. and all other fittings and items to complete the systems shall comply with the requirements specified below and shall be contained, in so far as is practicable, in the oil room or chamber. The room shall incorporate features to eliminate fire risk.

The system shall be designed with such thermal capacity so that the balancing plant safely runs down from full speed to a stop, should CW supply to the coolers be lost at full speed.

Precautions shall be taken to minimize internal corrosion in oil tanks and drain pipes. System to comply with environmental regulations.

All oil pump suctions shall be provided with a strainer. Jacking oil pumps are fed by lube oil system therefore no separate strainers.

8.3.1.1. Oil Coolers

Two 100% duty oil coolers shall be provided such that with one cooler out of service, the required oil temperature conditions shall be maintained. The oil coolers shall be provided with an automatic system for the control of temperature of the oil. The system shall maintain the specified oil temperatures without manual intervention. All necessary oil and water pipework and valves shall be supplied, and provision shall be made so that any cooler can be completely isolated while the remainder are in service.

The oil inlet and outlet valves shall on no account be capable of shutting off the flow of oil to the bearings while the balancing plant is in service. The coolers shall be capable of changing over to the standby unit on load without interruption of oil flow. Provision is made to feed oil to the standby cooler, to allow adequate venting prior to service.


The cooling medium shall be water taken from the cold auxiliary circulating water (ACW) supply and delivered to the ACW hot return. Water velocity in the tubes shall be between 1.5 and 2.2 metres per second.

The oil coolers shall be so arranged that water leakage into the oil circuit is prevented by operating at an oil pressure higher than the water pressure. A drain valve capable of being locked in the closed position shall be fitted to each cooler. Air release valves shall be fitted to both the oil and water side. Bund walls to have sufficient capacity in the event of any spillages.

The plant includes for the required supervisory and control equipment.

8.3.1.2. Oil Tanks

The capacity of the oil tank shall be sufficient for efficient functioning, typically 8 to 12 circulations per hour through the lubrication system.

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The capacity shall be based on the normal working level in the tank with all the system components and pipework full. The design and arrangement of the tank and its equipment shall be such as to assist in the separation of any entrained air and water from the oil before it passes back into circulation.

Suitable oil sampling points with valves are provided. Inlet and drain connections are provided to the station oil handling pipework. The lowest level in the tank includes a lockable drain valve. A strainer is included at the oil return to the tank.

A level indicator and alarms shall be provided on the tank, the alarms being initiated by either high or low oil level or any faults due to any pressure loss.

Removal and filling facilities to be easily accessible for service providers.

8.3.1.3. Full Duty Main Pumps

Two full duty oil pumps complete with the necessary piping and valves shall be provided to supply oil to equipment bearings. Each pump shall have sufficient capacity to supply all the oil required under all conditions of operation. Means shall be provided for regulating the delivery pressure of the pumps where feasible. The main pumps shall be driven by AC motors. Electrical pumps to remain in service in the event of a power failure.

8.3.1.4. Emergency Bearing Oil Pump

A DC motor driven pump shall be provided to start automatically in the event of low-low lubricating oil pressure or failure of the main pumps or failure of the AC supply. Manual starting / switch off shall also be possible In the event of an emergency.

The pump shall be of sufficient capacity to permit a safe rundown of the set. The pump shall be powered by an uninterruptible power supply (UPS). The pump shall deliver downstream of any coolers or filters to minimise the risk of interruption of emergency oil supply to equipment bearings.

8.3.1.5. Jacking Oil system

A jacking oil system shall be provided for jacking the equipment being balanced as well as any stiffening requirements. The system shall comprise two 100% duty AC motor driven high pressure jacking oil pumps.

The jacking oil system shall include relief, non-return and isolating valves and all necessary piping and other fittings and items to complete the system. The jacking oil pumps take suction from the same tank as the lubrication oil.

8.3.1.6. Oil Recovery System

The oil sides of all oil coolers, and all oil filters, pipework, pump casings, secondary tanks, and other items of the lubricating oil and jacking oil systems shall be provided with suitable drainage points (valves) at all the lowest points to permit complete drainage of the systems. Each drainage point shall be provided with a tundish and piping which shall be led to the turbine oil recovery tank. Bund walls to have sufficient capacity in the event of any spillages.

8.3.1.7. Oil Room or Chamber

The lubricating oil system comprising main oil and other tanks, pumps, coolers, filters and strainers, oil purifier and accessories, and integral piping and valves and other fittings shall be contained in a fireproof oil room in the balancing plant building. The Plant shall incorporate features to eliminate fire risk and shall include the installation of a fire detection system. Floors are to be sloping to drain away in the event of any spillages.

The oil room shall have sufficient sump capacity to contain the complete oil charge to enable it to be drained to the dirty oil system without overflow to the site drainage system.

8.3.1.8. Dirty Oil Recovery system

All sources of dirty oil in Balancing Plant shall be directed to a dirty oil recovery sump or tank in the located outside of the balancing plant building below ground level. Removal facilities to be easily accessible to TGS Balancing Plant Personnel. Install a sump pump in the waste oil recovery tank.

8.3.1.9. Oil Filters


Oil filters sufficient in number to pass the full flow of oil, with one stand-by filter, shall be installed (for each turbo-generator) downstream of the oil coolers. It shall be possible to change filters and access standby filters such that they can be changed and cleaned on load without interruption to the oil supply.

The filters shall be provided with automatic by-pass arrangements. In the event of pressure drops exceeding the predetermined value, filters shall be by-passed. Filters shall include differential pressure alarm and indication.

8.3.1.10. Automatic Oil Purifiers

An automatic self-cleaning oil conditioning coalescer shall be provided for the plant oil system and arranged so that the oil supplied to it shall be taken from near the bottom of the associated turbine-oil tank and returned to some part of the tank remote from the point of removal.

The extracted dirty water and sludge shall be deposited in a specially designed covered tank to be provided not to the discharge into storm water services but removed off site. The tank shall also be equipped with a high-level alarm, annunciating on the oil conditioner local panel, or

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other location acceptable to the Rotek. Adequate control and protection shall be provided to prevent clean oil flowing to the tank and spillages.

The conditioning unit shall be capable of conditioning the contents of the oil tank in approximately 8 to 10 hours whether turbine generator is in service or not. After continuous operation of the conditioning unit, the oil shall contain no more than 100ppm water and 16/13 particulates as per ISO 4406. Sampling points shall be provided before and after the conditioning unit.

All necessary accessories and special tools for the coalescer shall be provided.

8.3.1.11. Lubricating Oils

Oil used in the turbine oil systems shall be of "ashless" technology utilising at least "Group 2" base oils. All lubricants, including oils and greases shall be of local RSA supply from a single supplier.


A lubricants schedule covering the entire plant before any lubricant is delivered to site. The schedule includes the specifications of the lubricants. The schedules, specifications and a proposed supplier are submitted to Rotek for approval.

8.3.2 HVAC requirements

8.3.2.1. General

The design and installation are to comply with the latest amendments of:

- Occupational Health and Safety Act (OHASA) 85 –1995
- Safety and Quality Specifications, GGS 0462 rev 0
- Standard Building Regulations, Preambles and SANS 101200 requirements.
- Electrical apparatus for explosive gas atmosphere SANS 60079 part 15
- Classification of hazardous locations SANS 0108-1974
- BS 5720 British Standard: Code of practice for mechanical ventilation and air conditioning in buildings
- BS 8233 British Standard: Code of practice for sound insulation and noise reduction in buildings
- ASHRAE 62 American Society of Heating Refrigeration and Air Conditioning Engineers. Ventilation for acceptable indoor air quality
- ASHRAE 55 Thermal environmental condition for human occupancy
- ASHRAE 52/76 Standard test method
- SANS1424 Filters used in air conditioning and general ventilation
- SANS 1238 Air conditioning ductwork
- SANS 0173 Installation, testing and balancing of air-conditioning ducting
- SANS 193/BS476 Fire dampers
- ASHRAE G1 Guideline for commissioning air conditioning systems

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8.3.2.2. Requirements

The supplier is required to take full responsibility for the provision of the complete HVAC system, which include, but is not limited to the following:

- Heating, ventilation and/or cooling of balancing pit process equipment areas, offices, control rooms, toilets, switchgear rooms, equipment rooms etc.
- Smoke extraction via ventilation system
- Ventilation (or cooling and filtration) of other heat generating areas and equipment in within the balancing plant area.
- Controls and instrumentation (thermostatically controlled fans).
- Interface with the smoke detection system
- Control panels, switchboards and associated electrical equipment.
- Cabling between switchgear panels and equipment
- All other associated items of plant and equipment necessary for the complete works.

8.3.2.3. Design conditions

Outdoor Conditions:

The outdoor condition is an interpretation of the SA weather bureau data as follows:

Maximum 32°C dry bulb / 21°C wet bulb

Minimum -6°C dry bulb / 80% Relative Humidity

Indoor Conditions:

Permanently occupied spaces and plant/equipment rooms must be maintained to a design condition of 22°C+/-2°C (20-24°C). Humidity control must be provided in areas with sensitive electronic equipment.


8.3.3 Auxiliary cooling water system

The system comprises dual circuits to ensure appropriate water quality in the closed auxiliary cooling water system heat exchangers circuit. This includes:

- A common open cooling circuit incorporating evaporative type cooling
- A closed cooling water circuit incorporating the ACW plant heat exchangers
- Surface heat exchangers connecting the two.
- All equipment i.e., pumps, non-return valves, control valves etc. will be supplied.
- Plant and equipment to be compatible with local conditions.

8.3.3.1. Common Open Cooling Cycle

The following requirements shall be incorporated:

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- The open cooling cycle is a common (i.e., non-unitised) circuit of an evaporative type.
- Induced draught axial flow fans, gearboxes if applicable, drives, enclosures etc. for the correct functioning of the system.
- Two-speed electrical motor/gearbox combination, or variable speed drive, directly coupled to the fan
- Full heat load capacity is maintained with one cooling unit out of service.
- Circulating pumps including one standby for the entire common circuit. Appropriate pump isolating and discharge pressure and Non-Return Valves are provided.
- Permanently installed Quality monitoring system of water on auxiliary cooling systems. Access to be freely available for manual sampling.
- Appropriate means to minimise water spillage and drift losses from the evaporative cooling system, e.g., due to winds, is incorporated in the design.
- The common open circuit pump suction header is always under positive water head under all operating conditions. Automatic air releases are provided on the common pump suction header or pump volute as required.
- The standby pump volute is under positive water head.
- Make-up water is supplied directly into ponds.
- Appropriate means to avoid a vortex at pond outlet to the common suction header is incorporated. The pond outlet to the common suction header will remain under the water surface under all operating conditions.
- Appropriate means are provided to isolate any one of the cooling units for maintenance purposes. In this case the pond levels in the remaining in-service ponds remain balanced

8.3.3.2. Closed Cooling Cycle


The following requirements shall be incorporated:

- A closed circuit incorporating all the plant heat exchangers with necessary pumps, valves, etc.
- Circulating pumps including one standby.
- Commissioning strainers are incorporated.
- Demineralised water make-up connections and chemical dosing connections are provided.
- A suitable head tank is provided to satisfy pump NPSH requirements and to control the pressure in the closed loop. The elevation of the head tank is determined to ensure that all parts of the cooling circuit remain under positive head under all operating conditions.

8.3.3.3. Interface between Cycles

The following requirements shall be incorporated:

- Surface heat exchangers with corrosion resistant material for heat transfer between the two circuits above.

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- Appropriate redundancy in the heat exchangers is incorporated.
- Heat exchanger layout allows for crane access for maintenance purposes.
- Heat exchangers can withstand maximum discharge head generated by either the open circuit or closed-circuit pumps.
- Strainers are installed on the inlet side to the plate heat exchangers on the open cooling side.
- In-service backwash facilities are provided for each heat exchanger. Appropriate means are provided to backwash the heat exchanger and the inlet strainer.
- Stubs, which can be used for chemical cleaning of heat exchangers, are provided.

8.3.4 Air requirements

8.3.4.1. Instrument Air (Control Air)

It is preferred that all control on the plant makes of electrical component control and not pneumatic. If it is required to have pneumatic control on any piece of equipment the air shall be supplied as part of the new balancing plant.

This instrument air compressor plant shall be powered from a secure electric supply and will include an air receiver and an air-drying system. All piping supply to instrument consumption points (also for pneumatic actuators) shall be galvanized.

8.3.4.2. Service air


Service air for the use of pneumatic tools as part of the maintenance strategy will be made available to various points in the plant where maintenance activities will take place. This includes the workshops as described in previous sections of the requirements.

The service air will be a permanent installation for Rotek's use once the works have been completed required and size of connection.

8.3.5 Evacuation systems

The vacuum pumping station or stations main requirement shall be sized to achieve 100 Pa within 30 minutes of the evacuation process starting.

The vacuum pumping station includes for two systems with the required redundancy as indicated in the RAM studies. This however may vary on the supplier design, but the main requirement as mentioned above must be met.

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8.3.5.1. Main vacuum pumping station

This Main vacuum pumping system is used to evacuate the main vacuum pit.

The main vacuum pumping station includes as a minimum the following:

- One set of vacuum pumps with AC driven motors. The set includes a standby pump.
- Mounting frames as required.
- Piping, compensators, valves, seals etc. as required to meet the requirements.
- All instrumentation and instrument cables.
- All electrical equipment including cabling, terminal boxes etc.

8.3.5.2. Auxiliary vacuum pumping station

This system ensures that there is a vacuum tight seal for the penetration through the balancing pit door to the Generator Services workshop.

Requirements are the same as for the main vacuum pumping station.

- One set of vacuum pumps with AC driven motors. The set includes a standby pump.
- Mounting frames as required.
- Piping, compensators, valves, seals etc. as required to meet the requirements.
- All instrumentation and instrument cables.
- All electrical equipment including cabling, terminal boxes etc

8.3.6 Other process systems


All other process systems and equipment are supplied to ensure that the balancing plant functions as captured in these requirements. Depending on design these will include:

- Oil degasification system
- Hydraulic system to move the penetration door
- Any other process systems.

8.4 Civil Requirements

The full design, preparation of drawings, specifications, and compilation of the bills of quantities for the reinforced concrete, steel and finishing works and the subsequent construction of the balancing plant will be provided.

8.4.1 Soil conditions

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The supplier of the equipment shall make his own assessment of the site situation and make whatever additional site investigations including drillings and testing he considers necessary to assist in his assessment.

If any additional studies are required copies of the report on geotechnical investigations at the Project Site will be provided to Rotek

The supplier shall have access to site for any additional Geotechnical investigation purposes before the Stated Date of 12 months after the Commencement Date but will have to fit in with any civil construction work in progress and not cause any delay to such works.


8.4.2 Buildings

The building and civil work to be provided by the supplier includes but shall not be limited to:

- The balancing plant structures and foundations incorporating columns to support any craneage.
- All offices, boardrooms, ablution facilities, control rooms are provided.
- Craneage with a safe working load sized to support the largest assembled piece of equipment within the balancing pit as well as process equipment area for maintenance, operation, and installation.
- Roofing and wall cladding of the balancing and associated structure.
- Elevator and staircases if required.
- Cable ducts.
- Pump pits.
- Pipe trenches.
- Dirty water drainage.
- Clean water drainage
- Sewerage drainage.
- All services (electrical C; IT; Data) etc.
- Car parks.

Offices shall include at least the following:

- One lockable office for the manager sized to include for desk, filing cabinets and small round four seat conference table.
- Open plan office space for 8 staff members sized to include for filing cabinets, a rail mounted filing cabinet for documentation, printers etc.
- A boardroom with video conferencing facilities. One screen for video and one screen for presentation conference is provided. All sound equipment is provided.
- A small boardroom for meetings of approximately 12 people
- A kitchen with the required automatic water boilers, microwaves etc
- A "green area" where the staff can pause, have lunch etc. This area should be able to cater for 16 people.
- Small workshop (pedestal grinder, drilling/milling machine)
- Small workshop (electrical testing)

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- Ablution facility for all staff, male and females as well as disabled persons.
- A Fireproof Vault for documentation storage.

The design and construction will include drainage systems below and above natural ground level (floor drainage to suitable points, pipe trenches, cable trenches oil separation, ducts, culverts and drainage to suitable points, roof drainage connected to the drainage system, etc.).

8.4.3 Design and execution requirements for civil works

8.4.3.1. General

The Contractor shall ensure that the layout of all buildings, structures, cable trenches and service routes are sized and positioned for optimum space usage and efficient operation. Investigations of potential Operational Effects to existing plants on the Rotek site and facilities within the area of New Balancing Plant and Vice Versa will be carried out where required. The new balancing plant will integrate seamlessly into the new generation services building.


The supplier shall ensure that a competent Qualified Person (Professional Engineer and Architect), experienced in the design of explosion proof balancing facilities is fully responsible for the design of the civil and architectural works within the supplier's scope. The Works shall be designed to suit the plant operational requirements. This facility will meet all statutory compliances i.e., Bomb Proof, Fire Protection SANS0400, NBR of South Africa and Local Municipal Bylaws as well as Nationals Building Regulations. As a minimum the same type of fire and explosion proof measures employed on the existing 300-ton plant will be met.

8.4.3.2. Balancing pit design

The supplier shall carry out the full detailed design of the reinforced concrete required for the balancing pit (including taking account of any supporting system such as mass concrete infill over rock or piling). The Contractor shall provide fully detailed balancing pit construction drawings including reinforcement schedules. The designs shall include a full dynamic and seismic analysis of the foundation block.

The dynamic analyses shall follow the methods of analysis outlined in DIN 4024 or other such internationally recognised standard. The calculations for the dynamic analyses shall include details of the acceptable and predicted settlements, range and acceptable limits of amplitudes and frequencies in various modes of vibration and under various dynamic load conditions, the relationship between machine frequency at various running speeds and the natural frequency of the table, supporting structure, foundation/soil mass and the assumptions made regarding soil characteristics.

The response to machine unbalanced loads shall be in accordance with the limits specified in ISO 10816-1.

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8.4.3.3. Buildings, structures etc.

Buildings, structures, equipment foundations & support structures and ancillary structures shall be designed for the worst combination of dead loads, construction live loads, plant loads, seismic, impact and dynamic effects due to operation of plant, crane loads, maintenance loads, earth pressure, wind loads and temperature effects. Equipment foundations shall be designed to withstand vibration load effects in accordance with an appropriate international standard acceptable to Rotek.

The following criteria as defined by SANS 10160 should also be noted in context of the seismic loading:

- Partial Load Factor of 1.6 for earthquake loads (SANS 10160, Table 2)
- Importance Factor of 1.2 for structures with 'very serious' consequences of a failure
- Behaviour Factor of 2 for structures required to remain elastic (SANS 10160, Table 31)
- All structures to be designed for wind loads or earthquake loads, whichever produces the most unfavourable effect (SANS 10160, Clause 5.1.1c)

The Contractor shall comply with codes for buildings and structures wholly within his scope of works including but not limited to the following:

SANS 10021	2002	The waterproofing of buildings (Including damp-proofing and vapour barrier installation)
SANS 10062	2003	Fixing of concrete interlocking roofing tiles
SANS 10082	1988	Timber buildings
SANS 10100-1	2000	The structural use of concrete Part1: Design
SANS 10100-2	1992	The structural use of concrete Part2: Materials and the execution of work
SANS 10109-	1995	Concrete floors Part1: Bases to concrete floors
SANS 10109-2	2004	Concrete floors Part1: Finishes to concrete
SANS 10143	1980	Building drawing practice
SANS 10144	1995	Detailing of steel reinforcement for concrete
SANS 10145	2000	Concrete masonry construction
SANS 10155	1980	1980
SANS 10160	1989	The General Procedure and Loadings to be adopted in the Design of Buildings
SANS 10161	1980	The design of foundations for buildings

SANS 10162-1	2005	The Structural use of steel Part1: Limit States design of hot-rolled steelwork
SANS 10162-2	1993	The Structural use of steel Part2: Limit States design of cold-formed steelwork
SANS 10162-4	1997	The Structural use of steel Part4: The design of cold-formed stainless steel structural members
SANS 10163-1	2003	The Structural use of Timber Part1: Limit-states design
SANS 10163-2	2001	The Structural use of Timber Part2: Allowable stress design
SANS 10164-1	1980	The structural use of masonry Part1: Unreinforced masonry walling
SANS 10164-2	2003	The structural use of masonry Part2: Structural design and requirements for reinforced and prestressed masonry
DIN 4024 PART 1		Machine foundations, flexible structures that support machines with rotating elements
DIN 4024 PART 2		Machine foundations, rigid foundation for machinery with periodic excitation


8.4.3.4. Drainage system

Only clean and dirty water may discharge into the drains and shall be designed as separate systems. No solids or grit shall be allowed to drain into the systems. Oil: Chemical waste and effluent, if relevant, may not be discharged into the drains but must be returned to the Rotek oil/water separator. Cleaning effluent will be collected and neutralised in accordance with the municipal bylaws.

8.4.3.5. Calculations for design

All calculations relating to civil, structural, and building work shall be submitted to the Rotek for acceptance and review at both concept and detail design phase. Calculations shall be arranged in a logical sequence and shall include such sketches and annotations as may be required.

Before commencing the detail design of the civil and structural works, the supplier shall produce a design document for acceptance consideration by the Rotek titled 'Design Criteria of Civil and Structural works with the design and construction remaining the main contractor's responsibility.

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8.4.3.6. Grouting

Grouting requirements of all plant, equipment and structural steelwork shall be given and implemented by the supplier. The supplier shall provide details of materials and method of grouting including epoxy type non-shrink materials for consideration by Rotek.

8.5 Electrical systems

8.5.1 General

All works shall be performed in accordance with Electrical Industry practises, and the requirements of the contract. All electrical designs shall meet or exceed the minimum requirements contained in the following national standards and codes:

8.5.2 Standards

- ISO, International Organization of Standards
- IEC, International Electrotechnical Commission
- South African National Standards (SANS)
- Employer Standards and Specifications
- IEEE, Institute of Electrical and Electronics Engineers
- All applicable local utility standards and codes of practice

8.5.3 Standards


A list of Standards that may be applicable to the electrical design and construction are given in the table below. (Can use list from Sere project URS. Discuss with the team)

8.5.4 Design Life

All equipment shall be new and conform to its intended purpose, having a design life of at least 50 years and be free from any latent defects. Any components that do not meet this requirement shall be identified prior to procuring, stating the anticipated design life for that component, the replacement quantities required and the anticipated timeframes and cost for supplying such replacement components.

8.5.5 Supply Quality

To ensure the long-term health, reliability, and availability of the electrical plant all the electrical equipment shall tolerate the specified electrical power supply normal and abnormal conditions.

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These conditions include e.g., voltage fluctuation, frequency fluctuation, voltage imbalance, harmonic content, typical system faults defined for each type of power supply.

The equipment should be designed to resume normal operation without any disruption to the plant process, when any one or a combination of the supply conditions occur, excluding a loss of supply. The resumption after the disruption should be achieved without sustaining damage to the plant and without operator intervention. The equipment should be able to withstand the stresses resulting from these supply conditions, as well as any other phenomenon which is likely to occur on the supply system and/or on the respective equipment, without affecting the normal life expectancy of the equipment.

The load drawn by the equipment should be such that the total harmonic distortion (THD) of the current drawn does not exceed 1% under normal operating conditions. A combination of loads that exceeds the harmonic current component specification can cause a THD value that is detrimental to the equipment life expectancy.

The equipment should also be able to withstand the three-phase symmetrical through fault currents, where applicable, without the life expectancy of the equipment being affected. In exceptional cases, some equipment may not be capable of operating after a full through fault.

Supplier to connect electrical cables to the plant MV and LV rooms.


8.5.6 Redundancy (only if two incomers are required)

In general, the power supplies should be arranged on the dual redundancy principle with bus coupled electrical boards. Failure of a transformer, cable, or breaker of one supply to the respective board can be overcome by closing the bus coupler and supplying both boards from one transformer therefore enabling plant operation whilst repair work is carried out.

8.5.7 Load Flow and Fault Studies

A load flow study shall be performed to establish the voltage levels of the boards under full load and no-load conditions respectively. The optimal transformer tap settings should be determined. The fault study should be performed to establish the maximum fault currents that can be experienced for all the different plant operating scenarios.

Load flow and fault studies are performed to evaluate the functioning of the complete network under the specified normal and abnormal power supply conditions. During normal load flow conditions, the voltage on any part of the system should not drop below 95% and should not exceed 105% of nominal. During disturbances, e.g., the starting of any electric motor, voltage levels should not drop below 85% of nominal value.

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8.5.8 Transformers

For calculating the rating and impedance of transformers, the following should be considered:

- The power ratings are determined by considering the average loading (as per load flow above) and the worst-case starting condition in accordance with IEC60726 for dry-type transformers and IEC60076 for oil-cooled power transformers.
- If interconnection of two power supplies is required, one transformer is required to supply both supplies with the total load calculated above whilst at the same time allows for the simultaneous starting of the load representing the worst case, typically the largest load with the longest starting time.

The following factors shall be taken into consideration in determining appropriate transformer sizes:

- Network impedance for a heavily loaded network.
- Different operating modes of the plant, e.g., with the diesel generator running.
- The required power supply conditions.
- Average load, highest load, and transient load (starting of big motors).
- Nominal taps are rated for system voltage, but the LV side is increased to include the transformer voltage drop (e.g., $11 + 0,5 = 11,5$ kV)
- Standard equipment sizes.

The applicable specifications for dry- and oil-type transformers are:

- IEC60726 for dry-type transformers, IEC60076 for oil-cooled transformers.

8.5.9 Medium Voltage Switchgear


MV switchgear and control gear will be of the indoor use, metal-enclosed, floor mounted withdraw able type and classified as IAC in terms of IEC 62271-200. The switchboards will be of a modular design to allow for the addition of identical designed functional units.

The supplier will be required to design, supply, install and commission new Eskom approved MV & LV switchgear with all auxiliary equipment such as protection equipment, instrument transformers, busbar protection and all required special tools for maintenance, operating and engineering purposes, including standalone busbar protection scheme with dedicated CT's.

The metal-enclosed switchgear and control gear will be of a proven design and fully type tested. The design of the switchgear and control gear will comply with the requirements and details as specified in IEC 62271-200.

Oil filled circuit-breakers, voltage transformers and other components are not acceptable due to the explosion and fire risk in indoor applications.

Components contained within the metal-enclosed switchgear and control gear must be designed, manufactured and tested in accordance with their respective relevant specifications.

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The switchgear and control gear design must include for the compensation for the specific altitude and site conditions.

The required minimum degree of protection for the functional unit shall be IP 4X on the external housing and IP 2X inside the unit, in accordance with IEC 60529.

The protection relays must be able to monitor bearings & stator winding insulation temperatures under vacuum with alarm and trip configuration and be able to send temperature signals to the Control Room.

The switchgear components shall be made easy to remove, install and accessible.

The switchgear must be supplied with assurance for availability of local support and spares availability for the remaining life of the switchgear. A component replacement schedule should be supplied where components of the switchgear cannot reach the end of life as specified.

The following must be considered in determining the MV switchgear rating:

- Network impedance for a heavily loaded network
- Different operating modes of the plant
- Different transformers tap positions
- Average load, highest load, and transient load
- The contributions to fault currents by electric motors
- Standard equipment sizes
- The contributions to fault currents by electric motors.


Note: No insulation tape or putty will be accepted. Oil filled circuit-breakers, Oil voltage transformers and any other oil filled components are not acceptable due to the explosion and fire risk in indoor application.

8.5.10 Low Voltage Switchgear

The switchgear and control gear will be of a proven design and fully type tested. The design of the low voltage switchgear and control gear will comply with the requirements and details as specified in IEC 60947.

The same factors taken into consideration in determining the rating of the MV switchgear are applied to the LV switchgear rating. The required minimum degree of protection for the functional unit shall be IP 4X on the external housing and IP 2X inside the unit, in accordance with IEC 60529.

LV circuit breakers on transformer incomers must have the facility to be operated remotely and locally and the protection function must be automatic, without operator interaction. The low voltage for protection relays and incomer circuit breakers closing and tripping is 220 V DC. The 230 V AC is taken from one of the bus phases and neutral through a moulded case circuit breaker (MCCB) for the spring rewind motor supply. All non-transformer LV circuit breakers must be fitted with integral current limiting and thermal over current devices. Interlocking must be maintained under any switching condition.

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All LV motors (whether controlled directly or with a variable speed drive) shall be started and stopped remotely. Investment protection motors shall have a permanent installed module unit for ease of operation. The local operation must be subjected to protection interlocking, but not to process interlocking and password protection.

All LV feeders to supply boards and feeders to LV auxiliary electrical loads other than motors and variable speed drives shall normally remain closed and are closed locally after they have tripped due to a downstream electrical fault.

The control voltage for the LV motor starters shall be 230 V AC.

All the starters in the LV switchgear rated at up to 55 kW as well as all air circuit breakers shall be of the withdrawable type while all the other starters and feeders shall be of the fixed pattern. The withdraw ability of starters will contribute significantly to the improvement of availability and maintainability of the switchgear and will also simplify future modifications.

Circuit breaker open/close status information shall be fed to the operational control system for display on dedicated display screens in the control centre. Remote operator interaction shall also be via these display screens.


Local indication devices associated with each circuit shall be mounted on the compartment door (fix pattern) or on the front plate of the drawer (withdrawable switchgear) and labelled.

The protection relays must be able to monitor bearings & stator winding insulation temperatures with alarm and trip configuration and be able to send fault and temperature signals to the Control Room.

8.5.11 Switchgear Rooms and Electrical Equipment Rooms

All switchgear rooms will be equipped with air-conditioning systems that will be able to control the ambient conditions to between 20°C to 22°C for 99% of the time, and never to exceed 32°C. The relative humidity will be controlled between 55% and 60% for 99% of the time. The air-conditioning systems will be fully redundant to allow maintenance on all associated equipment to be carried out while the plant is in operation, without compromising the specified values stated above. The switchgear rooms will be maintained under a positive pressure, to minimise dust ingress. Power supplies to the air-conditioning system will be fully redundant and will be so configured that the electrical supply equipment can be taken out of operation for maintenance without interruption to the air-conditioning systems or its auxiliaries or controls.

All doors to switchgear rooms will be fire doors and will be equipped with automatic closers and locks for which a master key would be made available to open all doors to switchgear rooms. The doors and rooms will be so designed as to not allow any damage to the doors during an arcing or explosion incident occurring within the switchgear room. Every switchgear room will have at least two entrances. At each entrance to a switchgear room, will be a means of diverting and/or preventing water from the outside to enter the room.

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All switchgear rooms will be equipped with fire protection and detection systems. One telephone will be installed in each switchgear room. Each switchgear room will be equipped with an intercom system speaker. Every substation room will have at least one process information system network connection point. Each switchgear room will be equipped with normal fluorescent lighting, as well as with essential lighting with battery backup for cases when supply to normal lighting fails. Each door to the switchgear rooms will be equipped with illuminated exit signs with battery backup.

All switchgear rooms will be installed with AC plug outlets that will comply with the details and requirements of SANS60884. A plug outlet will be provided every 10m on every wall and 1m above the floor. Every room will be equipped with at least one heavy duty three phase welding plug outlet.

No water, drainage or sewerage piping is allowed to be routed through any area of switchgear rooms, except for fire protection pipe work. The switchgear rooms are to be equipped with ample drainage facilities to cater for the full activation of the fire protection system. The roof of the switchgear rooms will be totally sealed, not allowing liquids to penetrate from the outside.

Cable trenches will run for the entire length under every board and panel installed in switchgear rooms. The trenches will tie into cable ducts, tunnels or chambers, for the purpose of easy routing. The cable trenches will have ample dimension to accommodate all cables from the boards and panels. All cable trenches is required to be sealed upon completion of the installation of the boards, panels and cables, so as to limit the spreading of fires.


8.5.12 Motors

All electrical motors used in the Balancing plant shall comply with the following requirements:

- OHS Act 85 of 1993, Electrical Machinery Regulations (EMR) and all incorporated standards.
- IEC/SANS 60034
- IEC/SANS 60072
- SANS 1091
- SANS 1804

General Requirements:

- All motors shall be designed, manufactured, tested, and perform in accordance with the latest revision of the applicable standards listed above.
- The motor Supplier shall take into consideration all relevant characteristics and operating conditions pertaining to the driven machine and the motor environment and shall be responsible for designing or selecting from a standard range, a motor that will perform as required by the purchaser.
- A minimum efficiency class code of IE3 for S1 duty and intermittent duty with 80% or higher cyclic duration factor motors shall be supplied for new plants and

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replacements. Reliable motors with high efficiency, high power factor and low input power consumption values are required to support the Eskom Energy Efficiency drive.

- Electric motors for converter applications shall be selected and sized to accommodate additional losses and stresses associated with converters (electric drives) in order to maintain the motor service life.
- The Supplier to confirm all the interfacing with related equipment and subcontractors to ensure the motors will function reliably within the required environment. The Employer to be made aware of all shortcomings and risks which may affect the functioning of the motor.

8.5.13 Cabling and Racking

All power cables used in the Balancing plant shall comply with the requirements of SANS 10198 & 1339.

Cables shall be fully supported on, and strapped to, supporting steelwork in the form of a ladder rack or cable trays. Outdoor cables shall be shielded, where necessary, from ultraviolet radiation. Cable route markers are to be installed. Power cables for emergency supplies such as standby backup pumps are to be routed on different cable racks. Power cables of different voltage ratings shall be routed on different racks.

8.5.13.1. Cable Documentation

The cable numbering and coding shall be in accordance with the KKS system of numbering. Cable schedules detailing each cable, its number, type (in code), length, source and destination (each in KKS code and clear text) shall be compiled and used for the initial cable installation and thereafter kept for maintenance purposes.


8.5.13.2. Fire Protection for Cables

Cable penetrations through walls and into different building areas shall be adequately fire sealed using approved materials, with a 2 h fire retardant rating at a 1000°C. The design will be reviewed at the fire stops and seals, including the materials, their characteristics with regard to flammability and fire retardancy, and their fire underwriters rating. All cable and cable tray penetrations through walls and floors as well as any other types of cableways or conduits should have fire stops installed.

8.5.14 DC & UPS System

A DC System shall be installed in the facility for the following functions:

- Supply DC equipment which is required to continue operating when the AC supply has been lost, e.g., for protection.

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- Supply standby equipment required to operate only when AC supplies have been lost, e.g., Control & instrumentation loads, emergency lubrication oil pumps, and emergency lighting.

The DC System shall comply with the requirements of IEC 61936 & SANS 10142.

A 24 V DC power shall be used for control and instrumentation equipment and alarm systems for the balancing plant with a half hour back up time, The UPS kick in times for control of the plant to be confirmed. Equipment powered from these sources should accept voltages from 20 to 30 V. Ripple voltages on these supplies are to be limited to 5%.

A UPS system shall be provided for process control equipment, associated with the safe and reliable operation of the entire plant operational system under normal and abnormal operating conditions.

8.5.15 Diesel Generator & UPS System

An appropriately rated diesel generator is required or a UPS System to power standby loads during a loss of AC supply.

The Diesel Generator shall comply with the requirements of SANS 8528 and the OHS Act.

The sizing of the diesel generator shall be based on the following:

- The steady state standby load.
- The starting currents drawn by standby motors; and
- The required power supply conditions.


8.5.16 Hazardous Locations

All areas in the balancing plant that requires classification of hazardous locations in terms of OHS Act 85 of 1993, Electrical Machinery Regulations (EMR) 9 and incorporated standards (e.g., SANS 10108 — 2005) is to be identified, and all electrical installations in such areas will fully comply with the requirements of the relevant national standards.

8.5.17 Earthing and Lightning Protection

An earthing system shall be provided in the balancing plant, to perform the following functions:

- Safety protection of staff.
- Provide earth fault current path that enables electrical protection to prevent or mitigate plant damage.
- Protect plant against lightning effects.
- Protect electrical components against incoming surges.
- Provide a path for dissipation of electrostatic discharge; and
- Provide a reference point for electrical signals.

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The earthing system shall consist of earth networks and earth electrodes, and the aim is to achieve a low impedance path to earth.

The earthing system and lightning protection shall comply with the requirements of the following standards:

- OHS Act 85 of 1993, Electrical Machinery Regulations (EMR) 18.
- IEC 62305
- IEC 61000
- SANS 1063,
- SANS 10142-1
- SANS 10313

8.5.18 Lighting and Small Power Installations

All electrical installations on site shall comply with the relevant safety requirements and standards. (List of Standards)

In all areas the installations shall be designed with personnel safety as the first criteria. The completed installation shall provide adequate lighting and electrical supply to allow employees and other contractors to do their work safely and efficiently and comply with the always OHS Act.

8.6 PROCESS CONTROL AND INSTRUMENTATION

The control systems of the plant shall be designed to take into account the mechanical plant performance, control and operating philosophy, protection needs, and maintenance requirements as specified.


8.6.1 Automation and Standardisation.

8.6.1.1. Automation

The control system shall provide for fully automatic operation (all control loops in automatic) as the preferred operating regime, as well as various levels of automation should manual intervention or control of a specific sub-group or control loop be required.

8.6.1.2. Standardisation

The control systems for the balancing plant shall be standardised as far as possible, to ensure simpler operation and maintenance, as well as reduce lifecycle management costs. The philosophy of standardisation shall include for such items as all field equipment, all DCS and PLC related equipment, peripheral devices, networks and network equipment, software, interfaces etc.

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8.6.2 Control and automation system

The control and automation system, including plant protection, operator interface and information system shall employ fully integrated modern distributed control system technology. The system shall employ a uniform approach across all plant areas with respect to design philosophy, basic functional characteristics, system interfaces, documentation, standard function blocks and engineering tools.

The control and automation system shall be designed primarily in terms of structure and interaction based on a functional viewpoint of the plant, and not physical systems. Function allocation to hardware shall ensure integrity of functional areas and shall avoid unnecessary data transfers across data networks. The various functional areas shall be controlled from a number of independent controllers called Automation Units. Each Automation Unit shall be fully self-contained to perform the data acquisition from field transducers, signal processing, control algorithms for both analogue and binary control, field device actuation and links to the data network. Each functional area shall be allocated to its own Automation unit.

The control and automation system shall be suitably designed to achieve the plant performance and safety requirements, and shall be highly reliable, fail-safe, self-checking with comprehensive internal diagnostics. Safety-related instrumentation and control shall be designed with a fail-safe mode.

Measured data shall be continuously checked for validity, whether used for operator information, for control, calculations, or plant history. Data validation shall be an integral part of the control & automation system's functions. Data validation shall include signals monitored for wire break, out-of-range values, power supply failure, card removal, out-of-scan and simulated inputs, short circuit, and pole disagreement. All signals have data quality attributes of good, bad, out-of-scan and substituted value which is carried forward to the control system, operator interface or information system. Change-over contact monitoring is only applied where specific plant operational functionality requirements require it.


Interfaces of the control and automation system to specialised equipment or standalone equipment shall be standardised, based on internationally accepted norms or de facto standards. Furthermore, the control and automation system shall be time synchronised via a dual GPS system for time tagging of signals, events and displays. Provision for 20% reserve power availability shall be included for in the base design of the control and automation system and the system shall be expandable for up to 20% hardware and 30% software without requiring redesign of the configuration.

The control and automation system and its support systems, power suppliers and data networks shall be immune to electromagnetic interference and shall conform to internationally accepted EMC standards for heavy industry.

8.6.3 Operator Control Centre

Operator control centre facilities, in conjunction with the automation and control systems, shall enable the operator to operate the plant in all control modes and under all abnormal and

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emergency conditions without challenging the operator's abilities to adequately cope with the situation. It shall be always possible for the operator to be fully cognisant of the plant's states and trends (situational awareness) and to observe the automation and control system's status, operation, and integrity.

The design of the operating control centre shall be based on the ISO 11064 international standard. The operating control centre shall be sized to accommodate additional staff and observers for balancing and emergency situations.

The control centre shall house any necessary emergency panels to cater for any failures of computerised control and automation systems.

A communication system shall be provided for the operator to communicate verbally and in electronic form to all parties involved in normal and abnormal events within the plant and balancing pit area. Visual communication to external balancing pit area is required.

The operating control centre shall house all necessary support systems, such as documentation, references, procedures, and computerised support systems necessary for the execution of his duties. Printers shall be provided for logs, reports, hard copies of displays and other documents as required by the operators.

The entire control centre environment shall be designed with due consideration to human factors, safety, access, emergency evacuation, aesthetics, shift work, and interpersonal communications.


8.6.4 Operator Interface

The operator control interface shall present an integrated and standardised set of displays and facilities which shall be designed to and conform to ergonomic principles. The design approach of the operating and balancing software interfaces, and the underlying functionality of the control and automation system behind the interfaces, shall be consistent across all systems and functional areas.

A comprehensive and integrated alarm handling system shall be employed, which clearly distinguishes between different alarm types. Alarm information shall not be lost or inaccessible whilst navigating through displays, and alarm presentation shall dynamically provide the operator with information matched to the current situation and its criticality.

Displays shall be configured in a clear and unambiguous manner to provide the operator with information relevant to the task. Icons and symbols shall be used consistently throughout the displays for all units. Symbols of plant in low level displays may be based on outline or physical structure of the plant device if ergonomically appropriate.

Response time for acknowledgement of any display control command shall not be longer than 200 milliseconds. Any display selected or requested by the operator, including trend displays and dynamic data, shall be completed within two seconds. Feedback that any command issued by the operator to change the status of a plant device, such as motor, valve or damper has been received by the switchgear, shall be displayed within 500 milliseconds and feedback

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that the plant device has reached its desired position shall be displayed within 500 milliseconds of the event.

Navigation shall be clear, simple, and unambiguous. A comprehensive method of display access across all types of display shall be provided, while at all times providing the operator with an overview of high-level plant status. Selection of any display should not require more than two keystrokes. In alarm or abnormal conditions only one keystroke shall be required to access the relevant display.

No set or sequence of key strokes shall cause the operator interface to fail or stop responding. Any incorrect operation shall be indicated to the operator by audible signal or text message. In all cases a standardised back track facility shall be available for the operator to escape from displays. True system errors are fully indicated as to type, cause, and remedial action.

Text, numbers, and symbols are readable from the normal operating position being it seated or standing at the control desk. Additionally, zooming functionality shall be available on all displays. This zooming function shall be accessible through a single keystroke.

8.6.5 Engineering workstation

Engineering workstation facilities shall be provided as an integral part of the respective control and automation systems.

The engineering workstation shall be connected to the control system via a dedicated process or data LAN. The engineering workstation shall provide documentation management, full diagnostic facilities, configuration, and parameter design and change facilities.


The engineering workstation shall be an integrated system providing facilities for the full application engineering of the control and automation system including the operator interface. This includes all the functional software and hardware engineering, as well as all field component configuration and connection, cabling and termination engineering, and VDU display and report configuration.

All documentation shall be produced using the forward documentation process to ensure an accurate reflection of the system configuration and status at all times. Application programs shall have a graphical representation. All drawings shall reflect their latest change or modification by suitable means. The functional control diagrams shall be configured such that they reflect every destination of signals, including those having multiple destinations.

All changes and modifications to application software shall be made using the engineering workstation. Testing of the changes are made automatically before it is permitted to transfer anything to the control system modules via the bus system, and these changes shall be procedure controlled to ensure that the control and status of plant on load is not compromised. All tuning constants shall be parameterised and can be altered online without disturbances to the control system or to the plant.

Full diagnostic and system maintenance facilities shall be provided on the engineering workstation, such that the user is able to determine the health of the system, identify and pinpoint or trace any module failure or malfunction in both on-line and off-line mode.

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The system provides a comprehensive database management system and interface for the engineer to view, optimise and organise configuration data.

A comprehensive back-up and disaster recovery system shall be provided for all programmes, configuration, and parameter data on all plant. Full security of data, safety and integrity of all control functions and data shall be guaranteed. The system shall be fully protected from possibilities of data corruption, external changes, computer viruses and software corruption.

A standardised connection shall be provided to enable external users to view or download data from the Engineering Database for use in other application programmes. This connection provides full security and integrity of data in the engineering workstation database, such as security against external influences, viruses, and other sources of code corruption.

8.6.6 Control & automation system design life

The control and automation system shall be designed for a minimum operating life of 30 years. In order to achieve this life span while also attaining production targets, the system shall be designed such that parts and components are easily accessible and can be upgraded, replaced, or repaired (i.e., following a migration path for replacement of equipment with lesser life).

8.6.7 Control & automation system reliability and availability


The control and automation system, including the field is to be designed to achieve overall plant reliability as well as availability target of at least 95 % and above without the need for preventative maintenance requiring outages, excessive maintenance effort, or special operating conditions.

8.6.8 Environmental conditions

All control and instrumentation equipment and enclosures shall be selected and installed within the environmental parameter limits specified by its design.

In cases where equipment is installed in an uncontrolled environment, the actual on-site environmental conditions shall be evaluated to determine the degree of protection required for the selection of the correct enclosure that the equipment shall be installed in, to ensure reliable equipment operation within its specified operating environmental conditions.

In cases where environmental conditions are controlled, they should be monitored to ensure that the quality is maintained within the defined criteria.

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8.6.9 Field equipment

8.6.9.1. Primary Devices

Primary devices including orifice plates, control valves etc shall be selected, supplied, installed and tested based on the mechanical and process design of the respective plant areas. Care should be taken to ensure that the appropriate accuracy of measurements shall be provided throughout the working range of plant or equipment.

Design base records shall be kept and included in the final operating and maintenance manuals. The process design base records should also include the process tap and the root valve and easily accessible.

8.6.9.2. Field Measuring Devices

The field measuring concept and devices shall be selected to provide an integrated design together with the control system particularly taking into account access, installation standards, device standardisation, and on load maintenance.

The selected devices in terms of accuracy, stability, and repeatability shall be in line with the plant maintenance philosophy requirements. All measuring devices in direct contact with the process medium shall be capable of withstanding statutory hydraulic tests with-out prior isolation or recalibration after such events.

Where process information is required, maximum use shall be made of transmitters, and the use of binary and limit switches shall be kept to a minimum. Equipment for special applications such as fail safe, protection applications and hazardous locations, shall be based on the specific requirements for the application.

Where bus type communications are used for the field measuring device interface, care should be taken to ensure appropriate functional distribution to prevent the loss of critical equipment or devices due to bus failures.


All field measurements shall provide self-monitoring information, via the control and instrumentation system, to a typical Asset Management System, to allow for condition-based maintenance.

8.6.9.3. Actuators

Actuators for general applications shall be 3 phase electric actuators and are to incorporate motor, integral reversing starter, local control facilities and terminals for remote control and indication connections housed within a self-contained sealed enclosure. The actuator shall include a device to ensure that the motor runs with the correct rotation for the required direction travel irrespective of the phase connection sequence of the power supply. For ease of maintenance the power and control interface to the actuator shall be via plugs.

In order to ensure the integrity of the enclosure, setting of torque levels, limit settings and configuration of the indication contacts etc. shall be carried out without removal of any covers.

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The actuator shall incorporate local controls for open, close, and stop and a local/stop/remote mode selector. This mode selector shall be lockable in any of the following positions: local control only, stop (no electrical operation), remote plus local stop only.

For special applications such as hazardous areas, actuators shall be selected based on specific application requirements

Where bus type communications are used for the actuator interface, care should be taken to ensure appropriate functional distribution to prevent the loss of critical equipment or devices due to bus failures.

All actuators shall provide self -monitoring information, via a suitable interface, to a typical Asset Management System, to allow for condition-based maintenance.

8.6.10 Power supplies

The power supply concept shall provide a consistent and integrated design together with the control system particularly taking into account supply security, redundancy, quality, common modes of failure, battery standby times, and on load maintenance.

All permanent or temporary installations shall be subject to the statutory requirements in the OHS Act of 1993 and SANS 11042 for the wiring of premises which include the issuing of a certificate of compliance.

8.6.11 Cabling

An integrated cable concept together with the control system shall be developed, by taking into account the technology and configuration options available with modern control systems. The concept shall be of proven design for application in the respective plant areas to ensure that the safety, availability, and reliability requirements are always met.

The routes for control and instrumentation and power supply cabling and the racking shall provide a consistent and integrated design together with the control system particularly taking into account different routes to eliminate common modes of failure and separate routes for the redundancy within the control system physical distribution.

The selection and installation method of cabling and associated equipment, such as racking and junction boxes shall be based on the environmental conditions it will operate in. (such as temperature, chemical, vibration, water ingress, dust ingress mechanical damage etc,)


All cabling insulation shall be fire retardant and halogen free and shall conform to environmental standards and easily accessible if ducted.

8.6.12 Control centre civil requirements.

8.6.12.1. Control and Computer Centres

The control and computer Centre designs shall make provision for accommodating all equipment and human requirements, materials, maintainability, operability, and management

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features which will ensure a safe and hazard free working environment under all normal and abnormal operating conditions.

The working environment shall be designed to be conducive to error-free operation and comfort, catering shifts work. Lighting levels, heating, ventilation, and air conditioning (HVAC) shall be provided in compliance with applicable standards and regulations, code, equipment environmental classification and general industrial practice. Flooring in the control Centre shall have sufficient low resistance to allow dissipation of static charges when grounded or connected to any lower potential.

The design of the control Centre shall consider both reduction and attenuation of noise sources to reduce noise exposure during plant operation, to levels consistent with OHSA standards. Fire retardant material / panels to the use on the floors and ceilings.

8.6.12.2. Equipment and Engineering Rooms

The design shall make provision for accommodating all the control equipment required to control the plant. The design shall include materials, maintainability, operability, and management features which will ensure a safe and hazard free working environment.

The working environment shall be designed to be conducive to error-free operation and comfort, catering for long hours. Lighting levels, heating, ventilation, and air conditioning shall be provided in compliance with applicable regulations, code, and general industrial practice. Flooring in the control Centre shall have sufficient low resistance to allow dissipation of static charges when grounded or connected to any lower potential Easy access to floor / wall ducts for cables and all electrical parts.

9. BALANCING DATA ACQUISITION AND SOFTWARE REQUIREMENTS


The new 32 – 36 tonne balancing plant shall include all data acquisition and software requirements to enable balancing of all types of rotating equipment as specified in the design criteria.

This section shall be seen as a functional specification. Where specific capabilities are included, they shall be regarded as the minimum requirements.

9.1 Applicable standards

The following documents contain provisions that, through reference in the text, constitute requirements

- API Standard 670, fourth edition, December 2000, Reaffirmed 2003, Machinery Protection Systems.
- API Standard 613, fifth addition, February 2003, Special Purpose Gear Units for Petroleum, Chemical & Gas Industry.

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- ISO 10816- International Standard, Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts.
- ISO 10817-1 International Standard, Rotating shaft vibration measuring systems.
- ISO 7919 International Standard, Mechanical vibration of non-reciprocating machines

9.2 Details of Parameters to be monitored

The following is a brief description of the parameters to be monitored by monitoring and diagnostic system on each individual pedestal.

9.2.1 Primary Parameters to be monitored

Per pedestal including equipment drive trains				
Parameter	Instrument	Rack Input	Rack Output	3 rd Party Link
Shaft Speed/Phase Reference	Proximity probe	mV	4-20mA & Modbus	OPC
X&Y shaft vibration	Proximity probe	mV	4-20mA & Modbus	OPC
X&Y pedestal vibration	Seismic probe	mV	4-20mA & Modbus	OPC
Bearing metal temperature	Thermocouple – Type J	mV	4-20mA & Modbus	OPC


9.2.2 Secondary/Process Parameters to be monitored

Per pedestal including equipment drive trains			
Parameter	Instrument	Range	Source
Bearing drain oil temperature	Thermocouple – Type J	4-20mA	Process DCS
Bearing oil supply temperature	Thermocouple – Type J	4-20mA	Process DCS
Bearing jacking oil pressure	Pressure transmitter	4-20mA	Process DCS

The monitoring and diagnostic system shall have provisions made to select and interface required process data via industry standard interface system from plant control and automation systems. In order to correlate primary parameters with other plant parameters, it is essential to monitor these process parameters.

9.2.3 Condition of Signals to be monitored

The system shall make use of the signals connected to the existing plant monitoring systems. Should any fault occur on the system installed, it shall not affect the normal function of the signal sources. In addition, no degradation due to the input circuitry or due to feedback from the data acquisition system must occur. Where it is necessary to improve the existing signal, the primary signals shall be sufficiently amplified to prevent any corruption of the signals. This

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shall be in addition to screened cabling. It must also be ensured that no aliasing errors will be present in the dynamic signals after amplification.

9.3 Monitoring modes and requirements per mode

The monitoring and diagnostic system shall be capable of monitoring with different operating modes depending on the status of the equipment being balanced and these modes can be described as follows:

9.3.1 Continuous Monitoring Mode

This shall be the normal monitoring mode of the system. All parameters must be monitored in this mode. The turbine centreline shall be running at rated speed. The data shall further be displayed on the relevant time-based displays as described in display format requirements Table 1 of this document.

9.3.1.1. Alarm and Responses

For the dynamic parameters refer to Table 1. For a description of these alarms and their responses refer to section 9.8 (System Alarm Requirements).

The process parameters shall have minimum/maximum alarms with the required responses as described in section 9.8.


9.3.1.2. Monitoring Rate

All the parameters shall be monitored at a maximum scan time (delta time) of ten (10) seconds for all the signals associated with the monitored equipment machine and or panel boards. During this period the following tasks shall be completed by system:

- Acquisition of all dynamic data set out in Table 1.
- Acquisition of all process variable signals and their conversion to engineering units (where applicable).
- Comparison of the above signals with alarm levels and the initiation of system alarm log flagging if the alarm levels are reached.
- Storage of data to memory.
- Display of data when specified by the user.

9.3.1.3. System/Alarm Events

Sufficient number (minimum 400) of system/alarm events entries shall be provided with expansion option. The monitoring and diagnostic system shall provide hardware alarm notification when there is a fault on protection system. The alarm event shall be logged, and end user shall be warned of the status change on the display station screen.

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9.3.1.4. Accuracy

The required accuracies for the amplitude and phase values for each of the first four shaft speed orders of the equipment, the overall vibration amplitude level and any sub-synchronous components relative to full scale are:

- Amplitude: $\pm 2\%$
- Phase: $\pm 2^\circ$
- Speed ± 1 rpm.

All process variable data shall be converted into standard engineering units and shall be within an Accuracy of $\pm 1\%$.

9.3.2 Transient Monitoring Mode

This mode is applicable when machine operating speed (rpm) is changing, usually involving start-up, shutdown, over-speed, or unplanned trip. For the run-up modes the speed variance shall be indicated as positive and for the run-down modes negative. The systems shall be capable of automatically acquiring slow roll data and have the capability of recording the slow roll values. The system shall be fully compatible with various speed reference inputs and speed reference trigger shall be automatically configured by the system such that the machine is not run before the speed reference is configured. No loss in data due to speed reference probe malfunction during transients is allowed. Automatic initiation with manual initiation option available for the rundown/up mode is required.

The parameters to be monitored shall be the same for run-up and run-down conditions. All dynamic parameters 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 machine dropping below 100 rpm. The system shall be capable of handling speed variations of 150 rpm/sec.


9.3.2.1. Alarms and Responses

Refer Table 2 for the required alarms on the dynamic parameters. Section 9.8 gives a description of the alarms and the required response.

9.3.2.2. Monitoring Rate

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. Transient data and steady state data shall be stored in such a way that they can be differentiated. Provision for manual activation and aborting of transient and steady state events shall also be allowed within the configuration.

The transient data shall be collected at speed (delta rpm) change not more than 10rpm increments for both start-up and shutdown events. The actual speed and time at which the data collection starts for each point shall be recorded. The time shall be synchronous with the

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monitoring and protection system clock. 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 the system alarm log. The system shall continuously check whether the specified rate can be resumed.

In order to minimise 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 affect steady state (delta time) sampling mode.

9.3.2.3. Process Parameters

All the process parameters shall be monitored during transient. The system shall have the capability to display any of the process parameters during a run-up or run-down at analysis or acquisition stations.

9.3.2.4. Logs

An entry shall be made into the system alarm log for every run-up or run down irrespective of whether any alarms are received or not.

9.3.2.5. Accuracy

The required accuracies for the amplitude and phase values of the first four multiples of running speed, overall vibration and sub-synchronous components and DC volt gap (relative to full scale) shall be:

- Amplitude: $\pm 2\%$
- Phase: $\pm 2^\circ$
- Speed: ± 1 rpm

9.3.3 Slow roll Speed Monitoring Mode

This mode shall be automatically identified by equipment speed being above 0 rpm and below 100 rpm or the OEM specified slow roll speed rpm.

9.3.3.1. Alarms and Responses

Refer to Table 3: Barring speed monitoring mode, for the required alarms during this mode of monitoring. The description of these alarms and the response upon receipt of them are given in section 9.8.

Parameters	Components	Displays	Alarms	Storage
All	Overall values; Running speed components (0,5X, 1X, 2X); Process information values; Power and Speed date and time	Machine Train diagram or Mimic	Amplitude: max/min limits	Always/all
	Overall values; 0,5X, 1X, 2X running speed and phase; DC values	Bar graph or Bar chart	Amplitude and phase: max/min limits	
	Point ID; Overall: Probe gap; (0,5X, 1X, 2X amplitudes and phases); Alarm status; Transducer status; Speed and process parameters	Current values	None	
	Trend at least 8 parameters on one display; Overall values (0,5X, 1X, 2X running speed components and process information	Trend	Amplitude: max/min limits	
	Represent vibration vector as function of time (applies to 1X & 2X)	Acceptance region	Amplitude and phase: max on same plot format	
	Time domain waveform with speed reference marks. Baseline data superimposed on waveform to view change in rotor response	Time base	None	
	Dynamic path of shaft centreline within bearing clearance	Orbit for orthogonal (XY) Shaft observing proximity probes	None	
	Average position of shaft with respect to bearing clearance. Uses proximity probe gap information	Shaft Centreline	Alarm for Excessive shaft movement in bearing housing	
	Spectrum (5 - 1000 Hz) X-axis either frequency or order; Y-axis user selectable for amplitude units	Spectrum and full spectrum; waterfall spectrum	None	
	Plot any vibration or process variable against any other vibration or process variable	X versus V plot	None User selectable	User selectable
	(1X, 2X amplitude and phase) Superimpose historical data for analysis	Bode	Amplitude and phase: max/min limits	Always/all
	(1X, 2X amplitude and phase in true vector format. Baseline data can be superimposed onto plot for analysis	Polar	None	
	Display of orbit and spectrum plots alongside other plot types. Each orbit or spectrum is displayed for a particular sample selected from activated plot	Plus orbits and plus spectrums	None	
	Invoked by clicking a single button or icon to Quick view plot None produce 4 plot tiled screen consisting of user selected multiple plots	Quick view plot	None	

Table 1. Requirements for Continuous Monitoring Mode.

Parameters	Components	Displays	Alarms	Storage
	Point ID; Overall: Probe gap; (0,5X, 1X, 2X amplitudes and phases); Alarm status; Transducer status; Speed and process parameters	Current values	None	Always/all
	Trend at least 8 parameters on one display; Overall values (0,5X, 1X, 2X running speed components and process information	Trend	Amplitude: max/min limits	
	Time domain waveform with speed reference marks. Baseline data superimposed on waveform to view change in rotor response	Time base	None	
	Spectrum (5 - 1000 Hz) X-axis either frequency or order; Y-axis user selectable for amplitude units	Spectrum and full spectrum; waterfall spectrum	None	
	(1X, 2X amplitude and phase) Superimpose historical data for analysis	Bode	Amplitude and phase: max/min limits	
	(1X, 2X amplitude and phase in true vector format. Baseline data can be superimposed onto plot for analysis	Polar	None	
	Display of orbit and spectrum plots alongside other plot types. Each orbit or spectrum is displayed for a particular sample selected from activated plot	Plus orbits and plus spectrums	None	
	Dynamic path of shaft centreline within bearing clearance	Orbit for orthogonal (XY) Shaft observing proximity probes	None	

Table 2 : Requirements for Transient Monitoring mode

9.3.3.2. Monitoring Rate

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, during which time the following tasks shall be completed:

- Measurement of all DC components.
- Comparison of the data with the alarm levels.
- Data storage.
- Data (if requested).

9.3.3.3. Dynamic Parameters

The DC values of all the dynamic parameters shall be monitored and no process parameters are required. Refer to Table 3 for the required display, alarm, and storage requirements. This mode of monitoring shall be used to identify the slow roll vector of the various shaft collars and used for compensation of the dynamic parameters during the high speed and transient monitoring modes when required.

9.3.3.4. Accuracy

All DC component values to be measured to within the accuracies specified of their measuring instrumentation. During this mode, the shaft speed shall be measured and stored within an accuracy of ± 1 rpm.

9.4 System Software Requirements

9.4.1 Operating System


The operating system shall be specified by the supplier and agreed to by Rotek.

Parameters	Components	Displays	Alarms	Storage
	Point ID; Overall: Probe gap; (0.5X, 1X, 2X amplitudes and phases); Alarm status; Transducer status; Speed and process parameters	Current values	None	Always/all
	Trend at least 8 parameters on one display; Overall values (0.5X, 1X, 2X running speed components and process information	Trend	Amplitude: max/min limits	
	Average position of shaft with respect to bearing clearance. Uses proximity probe gap information	Shaft Centreline	Alarm for Excessive shaft movement in bearing housing	

Table 3 : Requirements for Slow Roll Monitoring mode

9.4.2 System Security and User Levels

The system shall provide different levels of software security to allow access for operators, engineers, diagnosticians, and maintenance personnel. A minimum of two levels of access is required. Access control to desktops and servers shall be granted via passwords which shall be a user defined. The lower-level user shall have only read access (e.g., graphic displays, alarm logs, etc.). The top-level user shall further be able to configure and administer the system.

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9.4.3 System Start Up and Configuration

The system shall guarantee the configuration of the software and system set-up on restart after a power failure and shut down conditions. The system shall be capable of starting 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 events.

9.4.4 Software requirements for external workstations

The system shall be accessible from remote workstations situated on the Rotek LAN, WAN or via a virtual private network. It is acceptable to use either thin or thick client for this purpose.

9.5 System Data Storage Requirements

The database shall be completely open and conform to all the required Rotek architectural standards. The database shall store all the data and events associated with the acquired condition monitoring information. The system shall provide a comprehensive database management system with interface for the system administrator to view, optimise, add to, delete, and organise configuration data. The condition monitoring and diagnostic system database shall reside on the Rotek user LAN

9.5.1 Storage and Memory

The system shall be capable of facilitating 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 Eskom IT service provider for manual backup of the stored data.

9.5.2 Storage of Continuously 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.
- All data or user selectable data sets upon receipt of an alarm or user requirements.

9.5.3 Storage of Transient Monitored Data

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

- Reference data sets for both run-up and run-down conditions.
- All parameters (dynamic, static and process) in a user selectable set.

- All parameters 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 parameters) 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.

9.5.4 Storage of Slow roll 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.

9.5.5 Database Management


The database management system shall be capable of archive and retrieval of all data files. The monitoring system shall be configured to keep at least the last 12 months of all balancing collected.

9.5.6 Reference & Baseline Data Collection

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

- Start-Up - data acquired under transient condition – initial run-up to running speed
- Coast Down - data acquired under transient condition – run down.
- Gap Reference - data acquired whilst the machine is on slow roll or stand still to establish Bottom Dead Centre.
- Slow Roll Vector – data acquired preferably after a coast down, 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.

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9.5.7 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, with the additional options of routing these to any terminal or system printer. The logged information shall include but shall not be limited to the information listed in System Alarm Requirements of this document. All changes in operating state shall be logged. Provisions shall also be made for Software alarms to be disabled during the transient events and individual equipment/machine maintenance period.

9.5.8 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.

9.6 System Display Requirements

All the displays for the system need to be housed in the display section of the system. The displays for each of the condition monitoring and diagnostic systems need to be housed in this common software environment. This needs to allow for display on a local computer or display across the ERI 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 any new display component and add its functionality to the existing software environment.

9.6.1 System Display Configuration

All graphic displays shall, as far as possible, be accessible through the use of a standardised menu structure or 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 item shall be displayed.

9.6.2 Display Format Requirements


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 condition monitoring and diagnostic system shall be capable of producing the plots in display formats as described in Table 4.

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, μ m, 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 and diagnostic 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 parameters. 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 parameters. 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 four 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 parameters. 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 1X 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 4 : Display Requirements

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9.7 Remote Viewing

The system shall be able to display real-time data across ERI LAN/WAN. 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. It is acceptable to use either a thin or thick client for remote viewing functionality.

9.8 System Alarm Requirements

All alarms to be triggered by the system shall be the result of an automatic comparison between the most recent measured parameters and a user defined values for the channel 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 the entire time period that the alarm condition exists. For each individual variable a data set may be defined. 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 parameters. Calculation facilities to obtain the most reasonable boundary limits based on statistical analysis or archive data shall also be available.


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 parameters.
- A brief description of the fault.

Upon receipt of an alarm variable where no data set has been defined, the system shall, as default store all dynamic, static and process parameters of that particular machine. This data shall only be made permanent data upon the request of the user. Only the system administrator shall be able to destroy this data.

The alarms in the system alarm log shall be always accessible to all users 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 an unlimited number of alarms.

Upon receipt of an alarm or set off alarms from a user selectable group, the monitoring system shall be able to notify a group of users. Any changes in alarm settings shall be logged and only the system administrator should be permitted to override and delete alarm log entries. The new and old alarm values and the date at which they were changed shall also be logged. The facility should also exist whereby any alarm can be activated or deactivated at any time during

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the operation, but only by the system administrator. Acknowledgement of alarms shall only be performed by the system administrator with recommended actions to the responsible person to execute those actions.

The monitoring and diagnostic system shall provide configuration for several types and different levels of alarms. The protection of the plant shall be controlled by the control system and not the monitoring and diagnostic system. The configuration of the monitoring system shall include the following alarm types:

9.8.1 Hardware Alarms

Hardware danger alarms are triggered by the control system and are audible, to be configured with the highest severity. Hardware alert alarms are triggered by the control system.

9.8.2 Software Alarms

There are a minimum of two software alarms required, namely:

- Alert alarms which shall be set above normal operating deviation with the lowest severity.
- Danger alarms which shall be established below the protection system Alert value to provide earlier detection of occurring changes.
- To be audible.

9.8.3 Diagnostics Alarms (Amplitude Alarms)

Exceeding a defined level of amplitude for dynamic parameters in the following manner:

- Component amplitudes of the three rotational speeds (1X, 2X and 3X shaft running speeds)
- Overall vibration amplitude for the entire frequency range (5 Hz-1000 Hz) and for the sub-synchronous components (5 Hz- 23 Hz)
- DC values from all dynamic signals


9.8.4 Maximum and Minimum Values

Minimum and maximum values exceeding pre-set values for all process parameters.

Should be configured for the process parameters such as pressure, flow etc. Also useful alarm for early warning of DC volts gap changes.

9.8.5 Envelope Alarms

Minimum and maximum values exceeding user pre-defined boundaries of amplitude and phase.

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Each channel shall have two alarms boundaries in order to form the envelope on the Polar plots for each of the first three shaft rotational speeds orders i.e., 1X, 2X and 3X shaft running speed.

9.8.6 Step Changes Alarm

Minimum and maximum values exceeding a user pre-defined difference between two successive measured values.

The following dynamic signal measurements shall be monitored:

- Component amplitudes of the three rotational speeds (1X, 2X and 3X shaft running speeds)
- Overall peak-to-peak vibration level over the entire frequency range (5 Hz-1000 Hz)
- 4DC values from all dynamic signals

9.8.7 Acceptance Region Alarms

This envelope, user pre-defined alarms should provide boundaries for 1X & 2X amplitude and phase (vector measurements).

9.8.8 Additional Alarm Notification


The diagnostic and monitoring system shall be capable of indicating other mechanisms and means for alarm notification systems such as mobile, e-mail, pop-up window etc.

9.9 System Processing Functions Required

9.9.1 Signal Component

The dynamic data shall be measured and processed with the following requirements:

1. Use of anti-aliasing mechanisms, incorporating phase error corrections if necessary.
2. User selectable high pass filtering (2Hz, 5Hz and 10Hz).
3. A user selectable number of averages shall be selectable with a minimum of 1 data averaging.
4. User selectable low pass filtering and band pass filtering.
5. Use of a suitable time frame window for the sampled data (preferably user selectable).
6. A user selectable resolution of at least 3 Hz over the entire frequency range (5Hz - 1000 Hz), with the resolution upon zooming increased to 0,2 Hz.
7. A user selectable frequency range for processing and display.

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9.9.2 The following signal components are required to be analysed:

1. Amplitude and phase of the first 4 shaft rotational order i.e.: 1X, 2X, 3X and 4X running speed.
2. Overall vibration level of the entire frequency range (5 Hz - 1000 Hz) and of the sub-synchronous range (5 Hz - 23 Hz)
3. Spectrum plot of entire frequency (5 Hz - 1000 Hz) and with the ability to analyse the sub-synchronous components (5 Hz - 23 Hz) with the same number of lines.

The above data shall be capable of being represented in peak-to-peak or RMS values and to be plotted in velocity (mm/s) or displacement units (μm).

9.9.3 Slow Roll Vector Compensation

The system shall provide, on user request, for the compensation of any (mechanical or electrical) run out on the shaft collars/areas where displacement probes are used. If the system is such that slow roll compensation is automatically updated, the user must be informed if there is any change to the compensation.

9.9.4 System Time Synchronisation

The diagnostic and monitoring system shall be equipped with a GPS clock. All data in the system shall be stored with the time reference synchronised with this internal clock. To enable time correlation of data captured on this system with other data captured, the internal clock shall have an accuracy of ± 10 seconds per year and the time difference between the external station master clock and the diagnostic and monitoring system internal clock must never exceed 10 seconds.

9.10 System Hardware Specifications

9.10.1 Cubicles for Data Acquisition Plant


The system shall be installed in the equipment room and meet the requirements for equipment rooms.

9.10.2 Interchangeability of Plant

The system shall be designed to allow the maximum amount of interchangeability of components to minimise the amount of spares holding.

9.10.3 Self-Test Internal Fault Diagnosis

The system shall have the capability to monitor the health of the overall system and indicate in the system alarm log any fault condition. Any fault conditions found must not prevent the continued operation of the rest of the system. The system shall provide a fault list indicating

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the causes and effects of faults that occur. Each signal that is monitored shall be provided with a fault indication (e.g., LED or flag) to detect transducer, cable or connection faults.

9.10.4 Expandability of the System

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 shall be possible to upgrade the individual items of hardware or software without having to perform major upgrades on the rest of the system. The system shall be almost infinitely expandable. In addition, the display system shall be designed to be almost infinitely configurable in terms of the number of digital and analogue inputs.

9.10.5 System Reliability, Availability and Maintainability

To achieve a high standard of availability the MTBF value of the total system shall be at least 6000 hours. The system shall be designed in such a way that maintenance on the hardware can be done by changing cards or modules within the system and the mean time to repair (MTTR) on site shall be kept to minimum.

9.10.6 Transducer and Sensor Arrangements

The transducer and sensors are shared between diagnostic and monitoring system, and monitoring and protection system. In order for diagnostic and monitoring system to operate as required, the location, arrangement and mounting of transducers are explained in detail in Table 5.


The accuracy of the transducers system in the testing and operating environment shall be as described in API 670

9.10.6.1. Radial Shaft Vibration Probes

For monitoring radial bearings, two radially orientated probes are required. To ensure a proper operation of the system, these two probes shall be located as described in Table 5.


The vibration levels shall be measured in μm peak-to-peak for displacement, mm/s rms for velocity and g"s for acceleration. Double integration of an accelerometer signal to provide a displacement measurement shall not be accepted.

To ensure the correct data into the diagnostic and monitoring system, the surface area to be observed by the probes (probe areas) shall be concentric with the bearing journals and free from stencil and scribe marks or any other mechanical discontinuity, such as an oil hole or keyway. The final surface finish shall not exceed surface roughness of 4 μm (refer to ISO 4287 or API 670 for more details).

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Item	Description
Location & Orientation of Radial shaft Vibration Probes	<ul style="list-style-type: none"> • Coplanar, 90 degrees (± 5 degrees) apart and perpendicular to the shaft axis (± 5 degrees). • If practical, located 45 degrees (± 5 degrees) from each side of the vertical centre. • Referenced such that when viewed from the driver end of the machine train the Y probe is on the left side of the vertical centre and the X probe in on the right side of the vertical centre regardless of the direction of shaft rotation. • Located within 75 millimetres of the bearing. • Located such that they do not coincide with a nodal point.
Location & Orientation of Phase Reference Transducer	The minimum width of the marking groove shall be one and one-half times the diameter of the probe tip. The minimum length shall be one and one-half times the diameter of the probe tip and the minimum depth must be 1.5 millimetres. All edges shall be trimmed to a minimum radius of 0.8 millimetres. The one-event-per-revolution mark shall be long enough to allow for thermal expansion and rotor float. Phase reference probes shall be radially mounted to sense one-event-per-revolution mark.
Location & Orientation of Casing Transducers	Casing (seismic) transducers intended to monitor radial casing vibration shall be located on the radial bearing housing. Location and number of transducers shall be jointly developed by the machinery monitoring system supplier and the rotating equipment end user. Consideration such as case-to-rotor mass ratio and bearing support stiffness shall be taken into account.
Mounting of Probes	Probe holders shall be free from natural frequency that could be excited by machine-generated frequencies. The free cantilevered length of a probe holder sleeve shall not exceed 200 millimetres. Longer lengths require the use of a probe holder sleeve support guide. When a probe is internally mounted, the probe holder shall be at least 10 millimetres thick. The probe lead shall be securely tied down to prevent cable whipping or chafing resulting from windage or oil. No cable connections shall be made inside the machine.
Mounting of Oscillator-Demodulators	The mounting location shall be selected so that minimum vibration is imparted to the oscillator-demodulator. The mounting location shall be selected so that the oscillator-demodulators are not subjected to ambient temperatures exceeding their operating range.
Mounting of Casing Transducers	The boss or surface must be part of the machine casing. All cables shall be enclosed in conduit. The conduit shall be attached to an enclosure, not to the seismic transducer.
Identification of Transducers	Each probe lead, extension cable and oscillator-demodulator shall be plainly marked to indicate the location and service of its associated probe or sensor. This tagging shall be visible without disassembly of the machine or removal from machine.

Table 5: Location of Instruments

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To ensure the accuracy of data for monitoring and diagnostics, these probe areas shall be properly demagnetized or otherwise treated so that the combined total electrical and mechanical run-out does not exceed 25% of the maximum allowed peak-to-peak vibration amplitude or 6 micrometres, whichever is greater. The gauss levels of the proximity probe area shall not exceed ± 2 gauss. The variation of gauss levels around the circumference of the proximity probe area shall not exceed 1 gauss.

The probe shall not be affected by any metal other than that of the probe area. This is necessary for the accuracy of data into the monitoring and diagnostic system.

9.10.6.2. Phase Reference Transducer

A one-event-per-revolution mark and a corresponding phase reference transducer are required on the driver side for each machinery train. When a Gearbox is used, in addition a one-event-per-revolution mark and a phase reference transducer are also required for each output shaft. The phase reference shall be measured in degrees.

9.10.6.3. Casing Transducers

Casing (seismic) transducers intended to monitor radial casing vibration shall be located on the radial bearing housing. Location and number of transducers shall be jointly developed by the machinery monitoring system supplier and the rotating equipment end user. Consideration such as case-to-rotor mass ratio and bearing support stiffness shall be taken into account.

9.10.6.4. Mounting of Probes

All probes shall be mounted in holders that permit adjustment and are retractable or removable. Internal mounting of probes is acceptable or when externally mounted probes do not allow true measurement of the rotor-to-bearing relative motion, but internally mounted probes do.

Mounting of probes shall provide true relative displacement between the bearing and the rotor. This can be achieved by internally or externally mounted probes depending on the installation.


9.10.6.5. Mounting of Oscillator-Demodulators

Ad-hoc connections to oscillator-demodulator shall be done on the mounting boxes. All mounting boxes shall be located for ease of access and on the same side of the equipment. These boxes shall not be mounted on the machine.

9.10.6.6. Mounting of Casing Transducers

Specific machined and finished casing (seismic) transducer mounting points are required for mounting transducers.

9.10.6.7. Identification of Transducers

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The tagging of instruments shall be visible without disassembly of the machine or removal from machine.

9.11 Mounting of Input Modules

The individual components of the balancing plant condition monitoring and diagnostic system shall be housed in a centralised rack system or distributed subsystem(s) that consist of all the systems condition monitoring tools.

9.12 Power Supply to the System

The power supply shall be universal i.e., both AC and DC sources should be useable. The system shall be backed up by the UPS. Time frames for UPS to kick in, in the event of a power failure to be advised.

9.13 Removal/Adding/Changing of Additional Systems

Removal/adding changing of field equipment shall be done on a "plug and play" basis.

9.14 Communication Protocols to the Rotek Data Historian

The monitoring and diagnostic system shall be able to communicate with the real time historian on the user LAN. The system shall be OPC compliant.

9.15 Standardisation

The design and where possible, equipment's shall be standardised across the installation of the system.

9.16 Maintenance of Monitoring and Diagnostic System

Details for the maintenance of the system as described in other sections of this requirement's document must be supplied.

10 SHAFT CURRENT AND VOTAGE MONITORING SYSTEM

The aim is to monitor the voltages and currents that exist on the shafts of rotors under tests. Furthermore, the system will provide graphical readouts, as well as alarms when the monitoring system detects out of normal conditions.

The system consists of the following:

- Current earthing brush (gold bristle type brush, of the Sohre LW type)
- Voltage Sensing brush (gold bristle type brush of the Sohre L type)
- Earthing Shunt
- Data Acquisition Unit

Appendix A.
Rotor Specifics

Customer	Component	Overall Length in mm	Largest Diameter in mm	Journal Diameters in mm	Total Massa in Kg
Arnot	HP	6300	990	280 & 315	10204
	IP	6585	1441	315 & 452	20499
	BFPT	2550	432	110	1750
Camden	HP	5520	1600	254 & 356	19813
	BFPT	2800		152	1625
Duvha	HP	5112	1290	305 & 406	15240
	IP	5852	1891	406 & 507	31500
	BFPT	2540	1524	178	3810
Grootvlei	HP	6039	1788	320 & 360	15873
	LP	5835	2820	400	30840
	BFPT	2500	1360	220	3500
Hendrina	HP	5940	1550	350	18500
	LP	6878	2900	350 & 380	31973
	BFPT	2500	1000	120	2800
Kendal	HP	4530	3600	280 & 380	16000
Koeberg	BFPT	2270	1257	140	2350
Kriel	HP	7005	1034	280 & 35	14200
	IP	7440	1600	355 & 425	29000
	BFPT	3590	1294	180	4880

Customer	Component	Overall Length in mm	Largest Diameter in mm	Journal Diameters in mm	Total Massa in Kg
Komati	HP AEG 125 MW	5180	1400	300 & 320	10640
	LP AEG 125 MW	6280	2720	320 & 350	24500
	Gen AEG 125 MW				32000
	HP AEI 125 MW	5925	1400	216 & 356	10046
	LP AEI 125 MW	5899	2460	356 & 381	26000
	Gen AEI 125 MW	9046	940	380	32000
	HP AEG 100 MW	5520	1400	225 & 320	8115
	LP AEG 100 MW	6325	2600	320 & 370	28000
	Gen AEG 100 MW	8862	996	350	30000
	HP MAN 100 MW	4927	1342	220 & 400	6739
	LP MAN 100 MW	5510	2308	400	29000
	Gen MAN 100 MW	8862	996	350	30000
Lethabo	HP	5958	1206	280 & 380	12300
	IP	6178	2151	380 & 450	26500
	BFPT	3654	1350	200	5510
Matimba	HP	6098	1248	280 & 380	12300
	IP	6178	2170	380 & 480	26500
Matla	HP	6143	1299	280 & 380	13100
	IP	5913	2009	380 & 480	23800
	BFPT	4997	1385	250	7400
Majuba	HP	5112	1290	305 & 406	15240
	IP	5852	1891	406 & 507	31500
Tutuka	HP	5112	1290	305 & 406	15240
	IP	5852	1891	406 & 507	31500
	BFPT	2540		178	3810