Eskom	Standard	Technology

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TABLES

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1. INTRODUCTION

This specification defines Eskom requirements for the procurement and supply of new or replacement asynchronous motors whose voltage rating exceeds 1000V. There may be additional requirements with regard to electrical and mechanical components for motors to be used with variable speed drives or at nuclear sites or specialty operating systems and environments. The standard elements of this specification should, however, still be applicable and useful to specialty motors. It is understood that some elements of this specification may be adapted through the scope of work for specialty motors and applications.

2. SUPPORTING CLAUSES

2.1 SCOPE

This document covers requirements for form-wound ac squirrel-cage induction motors with voltage ratings from 3,300 Volts to 15,000 Volts as applied in Eskom power plants.

It is intended that this document be used in conjunction with the New Motor Technical Schedule of Appendix A in which the ratings, torque requirements, efficiency requirements, accessories, existing installation limitations, etc., are specified. Where the requirements of the Technical Schedule differ from those of this document, the Technical Schedule requirements shall have precedence and govern.

It is also intended that this document be used in conjunction with the references of Section 2.2. Where the requirements of this document differ from those of the references, the requirements of this document shall have precedence and govern.

2.1.1 Purpose

The purpose of this specification is to define Eskom requirements for the procurement, design, manufacture, testing, factory acceptance, transport, delivery, installation and commissioning of new medium voltage electric motors. The objectives of this specification are as follows:

- Provide a source of information for Power Station personnel when there is a need to purchase reliable medium voltage motors for either replacing existing motors or backup spares or new plants.
- Provide material that should be agreed upon and/or exchanged between the *Employer* and *Supplier.* Such material includes technical schedules, quality control and assurance, and tests.
- To ensure that Eskom accepts and receives a high quality asset that is serviceable, has sustainable, reliable and efficient operation throughout its intended service life, and is effectively maintainable.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions. The application of this document is mandatory to all parties involved in the procurement, supply, design, manufacture, inspection, testing, delivery, off-loading, installation, and commissioning, and acceptance of new medium voltage electric motors for all existing and new build Eskom Power Stations.

2.1.3 Exclusions

While this specification contains quality control and assurance (QC&A) requirements, it does not cover all material and workmanship issues that shall be addressed by the *Supplier* and/or OEM through a duly certified ISO 9001 quality management system. Other exclusions are requirements for motors to be procured for specialty applications and environments – such as Boiler Circulating Pumps and Class 1E Safety Related Non-Environmentally Qualified applications in the nuclear environment – as well as additional requirements with regard to stator windings and mechanical construction for motors to be supplied for variable frequency drives.

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2.2 NORMATIVE/INFORMATIVE REFERENCES

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

2.2.1 Normative

[1]	ISO 9001	*Quality Management Systems*.
[2]	240-54783039	*New MV Motor Technical Schedule A&B – Required Motor Specification & Tendered Motor Data Sheet.*
[3]	240-54783135	*New MV Motor Technical Schedule C – Manufactured Motor Data.*
[4]	240-54783158	*Standard Forms for Eskom Electric Motor Testing.*
[5]	240-56361435	*Transport of Power Station Electric Motors.*
[6]	240-56360387	*Storage of Power Station Electric Motors.*
[7]	IEE Std 620,	*IEEE Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Machines.*
[8]	IEEE Std 95	*IEEE Recommended Practice for Insulation Testing of AC Electric Machinery (2300 V and Above) with High Direct Voltage.*
[9]	IEEE Std 522	*IEEE Guide for Testing Turn Insulation of Form-Wound Stator Coils for Alternating-Current Electric Machines.*
[10]	IEEE 112	*IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.*
[11]	IEEE 43	*Recommended Practice for Testing Insulation Resistance of Rotating Machinery.*
[12]	NEMA MG1	*Motors and generators*.
[13]	IEC 60085	*Thermal evaluation and classification of electrical insulation.*
[14]	SANS IEC 60034-1	*Rotating electrical machines Part 1: Rating and Performance.*
[15]	SANS IEC 60034-2	*Rotating electrical machines Part 2: Methods for determining losses and efficiency of rotating electrical machinery from tests* (*excluding machines for traction vehicles*).
[16]	SANS IEC 60034-2-1	*Rotating electrical machines Part 2-1: Standard methods for determining losses and efficiency from tests* (*excluding machines for traction vehicles*).
[17]	SANS IEC 60034-4	*Rotating electrical machines Part 4: Methods for determining synchronous machine quantities from tests.*
[18]	SANS IEC 60034-5	*Rotating electrical machines Part 5: Degrees of protection provided by the integral design of rotating electrical machines* (*IP code*) *- Classification.*
[19]	SANS IEC 60034-6	*Rotating electrical machines Part 6: Methods of cooling* (*IC code*).
[20]	SANS IEC 60034-7	*Rotating electrical machines Part 7: Classification of types of construction, mounting arrangements and terminal box position* (*IM code*).
[21]	SANS IEC 60034-8	*Rotating electrical machines Part 8: Terminal markings and direction of rotation.*

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[22] SANS IEC 60034-9 *Rotating electrical machines Part 9: Noise limits.*

[23] SANS IEC 60034-11 *Rotating electrical machines Part 11: Thermal protection.*

[24] SANS IEC 60034-12 *Rotating electrical machines Part 12: Starting performance of single-speed three-phase cage induction motors.*

[25] SANS IEC 60034-14 *Rotating electrical machines Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration severity.*

[26] SANS IEC 60034-15 *Rotating electrical machines Part 15: Impulse voltage withstand levels of form-wound stator coils for rotating a.c. machines.*

[27] SANS IEC 60034-17 *Rotating electrical machines Part 17: Cage induction motors when fed from converters - Application guide.*

[28] SANS IEC 60034-18-1 *Rotating electrical machines Part 18: Functional evaluation of insulation systems Section 1: General guidelines.*

[29] SANS IEC 60034-18-31 *Rotating electrical machines Part 18: Functional evaluation of insulation systems Section 31: Test procedures for form-wound windings - Thermal evaluation and classification of insulation systems used in machines up to and including 50 MVA and 15 kV.*

[30] SANS IEC 60034-18-32 *Rotating electrical machines Part 18: Functional evaluation of insulation systems Section 32: Test procedures for form-wound windings - Electrical evaluation of insulation systems used in machines up to and including 50 MVA and 15 kV.*

[31] SANS IEC 60034-18-33 *Rotating electrical machines Part 18: Functional evaluation of insulation systems Section 33: Test procedures for form-wound windings - Multifactor functional evaluation - Endurance under combined thermal and electrical stresses of insulation systems used in machines up to and including 50 MVA and 15 kV.*

[32] SANS IEC 60034-18-34 *Rotating electrical machines Part 18-34: Functional evaluation of insulation systems - Test procedures for form-wound windings - Evaluation of thermomechanical endurance of insulation systems.*

[33] SANS IEC 60034-18-41 *Rotating electrical machines Part 18-41: Qualification and type tests for Type I electrical insulation systems used in rotating electrical machines fed from voltage converters.*

[34] SANS IEC 60034-18-42 *Rotating electrical machines Part 18-42: Qualification and acceptance tests for partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters.*

[35] SANS IEC 60034-25 *Rotating electrical machines Part 25: Guide for the design and performance of a.c motors specifically designed for converter supply.*

[36] SANS IEC 60034-26 *Rotating electrical machines Part 26: Effects of unbalanced voltages on the performance of three-phase cage induction motors.*

[37] SANS IEC 60034-27 *Rotating electrical machines Part 27: Off-line partial discharge measurements on the stator winding insulation of rotating electrical machines.*

[38] SANS IEC 60034-29 *Rotating electrical machines Part 29: Equivalent loading and superposition techniques - Indirect testing to determine temperature rise.*

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[39]	SANS IEC 60034-30	*Rotating electrical machines Part 30: Efficiency classes of single- speed, three-phase, cage-induction motors* (*IE-code*).
[40]	SANS IEC 60044-1	*Instrument transformers Part 1: Current transformers*.
[41]	SANS IEC 60044-6	*Instrument transformers Part 6: Requirements for protective current transformers for transient performance*.
[42]	SANS IEC 60072-1,	*Dimensions and output series for rotating electrical machines. Part 1: Frame numbers 56 to 400 and flange numbers 55 to 1080.*
[43]	SANS IEC 60072-2	*Dimensions and output series for rotating electrical machines. Part 2: Frame numbers 355 to 1000 and flange numbers 1180 to 2360.*
[44]	SANS 064	*The preparation of steel surfaces for coating.*
[45]	SANS 679	*Zinc chromate primers for steel.*
[46]	SANS 1091	*National colour standards for paint.*
[47]	ISO 10816-1	*Mechanical Vibration - Evaluation of machine Vibration by measurements on non-rotating Parts - Part 1: General guidelines*

2.2.2 Informative

[48]	EPRI 1011892	*Guideline for the Specification of Replacement and Spare AC Squirrel-Cage Induction Motors having Voltage Ratings of 2,300 V to 13,200 V;* EPRI. Palo, Alto, CA.
[49]	IEC 60721-2-1	*Classification of environmental conditions – Part 2-1: Environmental conditions appearing in nature – Temperature and humidity*

2.3 DEFINITIONS

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

Clean Conditions – The processes and practices for preventing the introduction of foreign material ingress into a motor or one of its components

Current vs. Speed Curve – This is a curve of motor current versus speed between zero speed and maximum operating speed

DC Step Voltage test – The test is a controlled over-voltage test where designated voltage increments are applied at designated times and leakage current is recorded. The time increments can be constant or graded.

Employer – The Eskom business unit purchasing electrical motors to which this document is applicable

Medium Voltage – Voltage ratings of 1000V and above

Overall Vibration – The maximum vibration amplitude of unfiltered time-based vibration signal.

Overhaul – A basic refurbishment or a refurbishment with limited replacement of components (e.g., bearing replacements).

Partial Discharge – Partial discharges (PDs) are spark discharges that can occur in high-voltage insulation voids, on the surface of stator coils located next to the stator iron, or in the end winding regions of the core. Partial refers to the fact that some insulation remains intact, preventing complete and constant discharge to ground or from turn to turn.

Polarization Index (PI) – Variation in the value of insulation resistance with time.

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Repair – Those steps required to rework or replace motor components to restore the motor to original design specifications.

Rewind – The process that includes the removal and replacement of the stator winding system in the motor.

Rotor End Float – This applies to horizontal motors with sleeve or tilting pad bearings. It is the total rotor axial movement of an uncoupled motor when the rotor is pushed from one extremity to the other and is limited by the distance between shaft journal shoulders and the width of the bearing.

Rotor Lift – The total axial clearance in the thrust bearing of a vertical motor. It is measured at room temperature by placing the assembled motor in the vertical position on a stand and mounting a dial gauge off the bearing bracket to measure axial shaft movement. A jacking device is placed under the end of the motor shaft extension, the rotor is jacked up and the total axial movement is measured on the dial gauge.

Site – The location at which the motor shall be installed.

Supplier – the Company performing the scope of work as per this specification.

Technical Contact – The person appointed to resolve any technical issues that may arise at any phase applicable to the scope of this specification.

Thermal Limit Curves – Plots of maximum permissible safe time versus line current in the windings of an electrical machine under conditions other than normal operation. The presented curves are for locked rotor, starting and acceleration, and running overload conditions.

2.4 ABBREVIATIONS

Abbreviation	Description
DAR	Dielectric Absorption Ratio
ETD	Embedded Temperature Detector
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IR	Insulation Resistance
MV	Medium Voltage
NEC	New Engineering Contract
NEMA	National Electrical Manufactures Association
O&M	Operating and Maintenance
PI	Polarization Index
PR	Purchase Requisition
RTD	Resistance Temperature Detector
SANS	South African National Standards
SOW	Scope of Work

2.5 ROLES AND RESPONSIBILITIES

The RACI chart in Table X is used to describe the functions for the supply of new MV motors within the table:

A – Means accountable for delivering on the activity.

R – Means responsible and must be fully involved in the activity.

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C – Means must be consulted so as to provide input.

I – Means to be informed only but not required to be involved in the activity.

Table 1: Roles and Responsibilities Chart

Activity / Role	*Employer's* Project Manager	*Employer's* Technical Contact	*Employer's* Motor Specialist	*Employer's* Quality Management	End User	Driven Load OEM	MV Motor *Supplier*
A. Supplier Technical Eligibility	I	C	R	A	I	I	I
B. Driven Load Technical Data (Existing Plant)	I	R	I		A	C	I
C. Driven Load Technical Data (New Plant)	I	C/I	I		I	A	R
D. New MV Motor Technical Schedule A	I	R	A/C		C/I	C	I
E. Works Information	A	R	C		C		I
F. New MV Motor Technical Schedule B	I	I	I		I	C	A/R
G. Project Planning & Management	R	C	I		I	I	A/R
H. Technical Evaluation	I	R	A/C		C/I		
I. Detailed Design Engineering	I	R	A		C/I	C	A/R
J. Design Approval/Acceptance	I	R	A		I	I	A
K. Manufacturing QC&A	I	R	A/C	I			A
L. Non Conformance to Requirements	R	R	C	A	I		A
M. Delivery	C/I	I			I		A/R
N. Installation (Existing Plant)	A	C	I		R		CI
O. Installation (New Plant)	R	I	I		I	R/A	A/R
P. Commissioning (Existing Plant)	R	C	I		A		I
Q. Commissioning (New Plant)	R	I	I		I	A	C

2.6 PROCESS FOR MONITORING

A. *Suppliers* shall be regularly assessed/audited – by the Eskom Motor Care Group – against this specification, and appropriately scored to determine the *Suppliers'* technical profile ranking in the approved list of New Medium Voltage Electrical Motor Suppliers. Such audits shall be conducted whenever *Supplier* performance dictates and/or at a frequency does not exceed once every six (6) years. The profile score shall be used as indicated in the tender technical evaluation.

B. The Eskom Motor Care Group shall regularly conduct internal reviews to determine *Employer* adherence to this specification and its intended purpose effectiveness.

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2.7 RELATED/SUPPORTING DOCUMENTS

[50] 240-56357518 *Power Stations Electric Motors Procurement*.

3. REQUIREMENTS

3.1. SUPPLIER ELIGIBILITY

A. Only *Suppliers* that are on the *Employer's* valid list of Approved New Medium Voltage Electrical Motor Suppliers shall be eligible to supply new MV electrical motors.

B. All *Subcontractors* utilised by the *Supplier* are to be approved by the *Employer* prior to the *Supplier* utilising such subcontractors.

3.2. CONTRACTUAL

3.2.1. Furnished by *Employer*

The *Employer* shall provide the *Supplier* with the following:

A. The name, telephone number, fax number, and e-mail address of the *Employer's* Representatives including but not limited to Procurement, Project Management and Technical Contacts.

B. A complete Technical Schedule-A (Required Motor Specification Data Sheet), which provides technical requirements and pertinent information on the driven load for the required motor. The form to be completed is in Eskom Document 240-54783039.

C. Timely review and acceptance/approval of submitted documentation that requires *Employer* acceptance or approval.

3.2.2. Furnished by *Supplier*

At appropriate stages of the procurement or contract period, the *Supplier* shall provide the following contractual requirements:

A. A written statement affirming that all provisions of the *Employer's* specification will be met or clearly state exceptions and adequately describe proposed alternatives.

B. Statement of the warranty duration for all material and workmanship.

C. Written proposal for the motor/s that meet the intent of technical requirements specified by the *Employer*.

D. Provide all materials, tools and labour required to fulfil the contracted scope of work.

E. Liability for motor damage while motors are in the *Supplier*'s custody.

F. Return of completed versions of Technical Schedules B, C, and D, and Test Data Sheets contained in Appendices E and F to the *Employer's* Technical Contact. The Technical Schedules and Test Data Sheets shall be computer printed and legible.

G. Produce a Quality Control Plan and submit it to the *Employer* for approval prior to commencing motor manufacture.

H. Ensure Clean Conditions are practised while the motor components are being manufactured and assembled.

I. Walk down the existing motor installation to review installation limitations and interface requirements for replacement or backup spare motors, unless otherwise stated as not required in the *Employer* scope of work. Contractor to inspect the existing/proposed motor installations and site to obtain all the necessary data and plant/site information to ensure the new

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motor/replacement parts interface with the site/plant correctly. The new motor/proposed parts must be installed on the proposed site/plant without interfering with operation and plant and with no alteration required on existing operation, site or plant. Should the existing site/plant need to be altered in any way to accommodate the new motor/replacement part, the Employer shall be notified, as part of the detailed design freeze, to give approval prior to work commencing.

3.2.3. Communications

The following contractual communication requirements shall be met:

A. The *Supplier* shall not deviate from this specification without obtaining prior written authorization from the *Employer's* Technical Contact.

B. Where possible, the *Supplier* shall perform all work in their works. The *Supplier* shall obtain written authorisation from the *Employer* prior to having any work on the motors or their components performed at a subcontractor's facilities.

C. The *Supplier* must give a minimum 5-days advance notice for the *Employer* to witness any hold point activity that has been agreed to require the *Employer's Representative*. Such notice shall be directed to the identified *Employer's Representative*.

3.2.4. Motor Performance and Construction Guarantees

The *Supplier* shall guarantee and be responsible for the following:

A. Rigid adherence to the design, arrangement and dimensions of parts and assemblies as shown on the *Employer* accepted manufacturing drawings for the design freeze phase. Deviations shall only be acceptable if authorised in writing by the *Employer.*

B. The quality of all materials and workmanship, and the suitability of all materials and tools for their application.

C. Motor efficiency, power factor, and temperature rise of no less than the value specified in the *Supplier's* tender and/or design freeze. The design freeze motor efficiency, power factor, and temperature rise performance shall not be lower than the tendered performance values.

D. Under normal power supply conditions, motors shall, without exceeding the design temperature rise, be capable of:

D.1. The specified number of starts per hour;

D.2. Operating continuously at rated output.

E. Under sustained and intermediate abnormal conditions, motors shall be capable of starting and driving the driven machines without exceeding the winding temperature rise specified in SANS IEC 60034-1 for the required thermal class and rating class.

F. Under transient abnormal conditions, motors shall continue operating without damage. The motor shall produce rated torque with the voltage reduced to 85% and frequencies down to 95%.

G. Motor efficiencies, power factors and torques guaranteed by suppliers shall not be subject to decreases in respect of tolerances of any kind. Similarly, guaranteed starting currents and temperature rise shall not be subject to increases for any reason.

H. The guarantee against poor motor reliability and workmanship during construction shall apply to all motors for two years after the takeover date.

I. The air-gap variances shall not be more than 5% of the average value.

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J. The onus shall rest with the *Supplier* to rectify, at his own expense and to the *Employer*'s satisfaction, any shortcomings or defects in the motor and any consequential motor component damage. This guarantee shall apply to all motors for two years after the takeover date.

3.3. DOCUMENTATION

3.3.1. Language

All documentation submitted between the *Employer* and *Supplier* shall be in English.

3.3.2. *Employer* Data

The *Employer* is responsible for providing the following:

A. Tender documents that shall include a completed version of Technical Schedule-A in Eskom Document 240-54783039.

B. If the required motor is to replace or serve as a backup spare for an existing motor design, the following information shall be provided with Technical Schedule-A.

   B.1. Motor outline drawing that shall include the existing motor mounting dimensions, shaft height, shaft diameter and details including coupling requirements, maximum overall dimension limits, interface location for terminal boxes (main power supply, auxiliary, and accessories), and cooling water (if applicable). This drawing shall have an *Employer* drawing reference number to be referenced on the new motor outline drawing.

   B.2. Torque versus speed curves for the motor and driven load.

   B.3. Operating environment conditions and installation limitations such as ambient temperature, pollutants, base vibrations, detailed seismic response spectra for the installation location if appropriate, and lifting equipment capacities.

C. *Employer's* motor outline drawing number to be referenced on the new motor outline drawing by the *Supplier*.

D. *Employer's* standard drawing title block to be used on all drawings provided by the *Supplier*.

3.3.3. *Supplier* Data

The *Supplier* is responsible for providing data in the following sub-sections, all of which shall meet these general requirements:

A. All submissions shall be typed and legible.

B. Where soft copies are submitted, these shall not be scanned but converted to PDF for submission.

3.3.3.1. At Tender Phase

Detailed information and drawings to enable the *Employer* to make a complete and fair analysis of the tender/s shall be supplied for the proposed motor design to meet the requirements of Technical Schedule-A. The required details shall include but not limited to the following:

A. Preliminary outline drawing indicating motor mounting dimensions, shaft height, shaft diameter and coupling detail, maximum overall dimensions, weight for total motor and removable heat exchanger (if applicable).

B. A completed version of Technical Schedule-B in Eskom Document 240-54783039.

C. Torque and Current versus Speed Curves for the motor at 100%, 85%, and 75% of motor rated voltage. The torque versus speed curves shall include the driven load torque versus speed curve to show accelerating torque margins.

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D. Motor thermal limit curves as per IEEE Std 620.

E. Details of offered accessories such as type of temperature detectors and location thereof, space heaters, vibration sensors, surge arrestors, differential protection current transformers, etc.

F. Description of stator coil insulation system (strand, inter-turn and ground-wall), wedging and bracing method, and corona suppression system (if any). Justification for the proposed insulation and bracing system in relation to the motor application shall also be provided.

G. Description of rotor bar retaining method in the slots, brazing method and short circuit ring.

H. Details of Customers that have used the same or similar design, together with descriptions of those previously manufactured motors.

I. Statement to indicate agreement with any specified guarantee requirements.

3.3.3.2. After Contract Award

Unless otherwise specified in the contract documents, the documents submittal delivery date requirements shall be as stated in the forthcoming subsections.

3.3.3.2.1. Within 14-Days of Employer Order

A. The *Supplier* shall submit a project management plan/schedule that indicates but not limited to dates for the submission of drawings and other technical data requiring *Employer* approval/acceptance.

B. Quality Control Procedure (QCP) and Inspection Test Plan (ITP) for the *Employer's* influence and approval.

3.3.3.2.2. Within 45-Days of Employer *Order*

The following information shall be provided by the *Supplier* to the *Employer* for detailed design review, comment, and acceptance:

A. Preliminary outline drawing indicating certified motor mounting dimensions, shaft height, shaft diameter and coupling detail, maximum overall dimensions, weight for total motor and removable heat exchanger (if applicable), interface location for terminal boxes (main power supply, auxiliary, and accessories), and cooling water (if applicable). The rated kW output, speed, supply voltage, line current, frequency and phases shall be clearly shown.

B. A completed version of Technical Schedule-B that shall, where necessary, show revised data due to the motor detailed design.

C. Torque and Current versus Speed Curves for the motor at 100%, 85%, and 75% of motor rated voltage. The torque versus speed curves shall include the driven load torque versus speed curve to show accelerating torque margins.

D. Starting Current versus Time Curves for the motor at 100%, 85%, and 75% of motor rated voltage.

E. The hot and cold motor thermal limit curves at 100%, 85%, and 75% of motor rated voltage. A series of graphs shall be plotted for each voltage level.

F. The negative phase sequence current withstands capabilities of the motor.

G. Efficiency, Power Factor, Current and Slip versus Load Curves from 25% to 125% load, in 25% increments, at rated voltage.

H. Bearing details including Vendor, type, arrangement, locations of temperature pockets and details of inserts, showing all oil pipes and their flanges, fits/clearances on the shaft and housing, loads on

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bearings, shaft run-out or endplay, maintenance requirements, expected operating temperatures, and selection criteria used for the bearing to suit application.

I. Stator and rotor winding and core manufacturing drawings and details.

J. Details of foundation requirements, showing embedded parts and static and dynamic loading on the foundations for starting, run up, normal and fault conditions.

K. Nameplate drawing with all details to be contained therein.

L. An equivalency/interchangeability review for the new versus existing motor designs, if applicable. Deviations between the new and old designs shall be stated in the review.

M. A Quality Control, Inspection and Test Plan for *Employer* review, influence and approval.

3.3.3.2.3. <u>Within 75-Days of Employer Order,</u>

The following information shall be submitted to the *Employer* for design freeze approval. Drawings and data not specified, but considered by the *Supplier* to be necessary for a thorough understanding of the motor construction, operation and maintenance may also be submitted.

A. Detailed final outline drawings including but not limited to the *Employer* outline drawing reference number and detailed drawing of the motor base plate showing full construction details with dimensions.

B. Fully dimensioned drawings of the shaft showing all tolerances.

C. Final stator and rotor winding and core manufacturing drawings and details.

D. Cross-sectional drawing of the motor showing the rotor and stator construction, end-winding bracing arrangements and clearances from the end-shields, airflow, shaft and bearing locations, rotor and stator core with slot dimensions, rotor and stator winding dimensions including slot fits and clearances, etc.

E. Detailed drawing of main and auxiliary terminal boxes, with identification and physical arrangement details of terminals for external cabling connections. This drawing shall include cross-sectional dimensions of the power supply terminal boxes.

F. Final details of accessories such temperature detectors and location thereof, space heaters, vibration sensors, oil level indicators, surge arrestors, differential protection current transformers, etc.

G. Drawings of air-to-water heat exchangers, if applicable.

H. A cross sectional drawing of the assembled motor, showing overall component dimensions and clearances, e.g. end-winding clearances from the end shields.

I. All data specified in Technical Schedule-B.

3.3.3.2.4. <u>No later than 90-Days prior to scheduled delivery</u>

The following information shall be submitted to the *Employer* for review and approval, and to prepare for motor installation and commissioning.

A. One draft copy of Installation, Operating and Maintenance Manual. Information contained in this manual shall include but not limited to:

   A.1. All drawings and performance data specified as required within 90-Days of *Employer* order, in reduced but legible form where necessary.

   A.2. Installation instructions.

   A.3. Operating instructions, including starting limitations.

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A.4. Maintenance and protection data and requirements.

A.5. Instructions on how to completely disassemble and assemble the motor for major inspections, repairs and overhauls.

A.6. Replacement parts catalogue.

A.7. Section for future insertion of test data.

A.8. Storage requirements.

A.9. Trouble shooting guide.

A.10. Serial numbers of same or similar design motors that are electrically and mechanically inter-changeable with the motor manufactured for the *Employer*. Details of those inter-changeable motor end-users.

B. Three (3) paper copies of Installation, Operating and Maintenance Manuals shall be submitted within 30-Days of *Employer* approving the draft copy. One electronic format of the approved manual, in a book-marked CD, shall be submitted to the *Employer* together with the hard/paper copies.

3.3.4. Drawings

A. The *Employer* holds title to all drawings

B. Outline drawings shall have the *Employer* reference drawing number

3.3.5. Test Data

A. The data sheets contained in Appendix C, E, and F shall be completed by the *Supplier*, after the motor has been assembled and tested, to show the results of the tests specified in Quality Control and Testing.

B. The test data sheet shall be approved by the *Employer* before the motor is shipped.

3.4. DESIGN AND CONSTRUCTION

3.4.3. General

A. Motors manufactured to this specification must be mechanically interchangeable and electrically similar to the motors they are to replace or are to be spares for. Any new motor, which is a replacement or spare for an existing installation, shall be designed and constructed such that its installation does not result in any site modification.

B. The motor manufacturer shall ensure that he is aware of, and takes 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 *Employer*.

C. All motors shall be designed, manufactured, tested and perform in accordance with the latest revision of SANS IEC 60034.

D. Only rigid rotors are acceptable.

E. Motors shall be designed and built for high reliability and energy efficiency throughout either the Power Station's expected useful life or 25 (Twenty Five) years, whichever is greater.

F. Only service proven designs, including all individual motor components, shall be tendered. If a design has a component/s that has not been proven for at least two years in service, the affected parts and the extent of their experience shall be declared in the deviation schedule of the tender/proposal.

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3.4.4. Electrical Details

3.4.4.1. Motor Rating

Motors shall be suitably rated for use on the system specified for the particular application.

3.4.4.1.1. Output Rating and Duty Class

The motor rating plate shall indicate the motor rating and duty rating in terms of this specification.

A. The output rating (P_N) of each motor shall not be less than the maximum design loading of the driven machine.

B. The driven machine shaft input power (P_{Mech}) required at its duty point, which shall be determined from the driven load performance curve at MCR, shall be the basis of motor output rating. The motor output power rating shall be such that the driven load shaft input power at MCR is;

   B.1. Not higher than 90% of the motor rating, i.e. $P_{Mech} \leq 0.9 \times P_N$, and

   B.2. At the best efficiency and power factor region/point of the motor efficiency and power factor versus load curves.

C. The rating class of each motor shall be declared in Technical Schedule-A by selecting one of the Duty Types (S1 to S10) defined in SANS IEC 60034-1.

3.4.4.1.2. Voltage and Frequency Ratings

Appendix G shows the typical electrical motor ratings for different power supply voltages used at Eskom Power Stations.

A. The standard power supply equipment parameters and normal and abnormal conditions of the power supply system shall be listed in Technical Schedule-A of an enquiry document.

B. Motors shall be designed to deliver continuous rated output with a balanced three-phase line-to-line rated terminal voltage and 50 Hz power supply as stated in Technical Schedule-A of an enquiry document. Performance data and tests are to be based on this rated voltage.

C. Unless otherwise specified in Technical Schedule A the motor shall start, accelerate and run the driven equipment successfully with any permitted variation in voltage and/or frequency.

3.4.4.1.3. Operation with Variations in Voltage and Frequency ratings

A. Motors shall be capable of delivering rated power output with continuous variation in voltage and/or frequency up to the limits specified in Table A3 or Technical Schedule A if specified, without damage and exceeding the allowed temperature rises.

B. Motors shall, without damage, be capable of accelerating and reaching rated speed due to the abnormal voltage deviations defined in Table A3 or Technical Schedule-A, if specified.

3.4.4.1.4. Service Factor

A. Unless otherwise specified in Technical Schedule-A, motors shall be designed for the service factor of 1.0.

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3.4.4.1.5. <u>Thermal Class (Temperature Limits)</u>

A. Stator windings shall be insulated with a Class F (155°C) or higher insulation system that has been proven by usage or tests as per applicable parts of SANS IEC 60034-18.

B. Unless otherwise specified in Technical Schedule-A, the winding temperature rise (ΔT) at rated output shall not exceed 80ºC (Class B Insulation System), as measured using the resistance method, subject to the following:

B.1. The reference coolant temperature on which to base the design is either 40ºC or more – if otherwise specified in Technical Schedule A. The reference coolant temperature specified in Technical Schedule A shall not, therefore, be less than 40ºC.

B.2. The design reference coolant for machines with primary and secondary coolants shall be the secondary coolant, with temperatures as stated above.

C. Both the resistance and ETD methods shall be used to determine winding temperatures as per SANS IEC 60034-1. If the resistance method cannot be conducted by the *Supplier*, the ETD method may be approved for use as the only method provided that the ETD location can be proven, through the *Employer* witnessed infrared thermographs during the test, to be at the hottest part/s of stator components.

D. The *Employer* reserves the right to reject a motor where any of the two methods show a rise above the contracted winding temperature rise.

E. The temperature differential between same components that are in the same position shall not exceed 2°C. The temperature differential between all stator components shall not exceed 5°C. The *Employer* reserves the right to reject a motor with thermal scans that show temperature differentials above the stated limits.

F. Test facilities shall be equipped with calibrated infrared thermal imaging camera/s. The *Supplier* shall conduct thermal image scans of all visible running motor components, including open (removed heat exchanger) stator windings and core, during routine and performance testing. These thermal images shall form part of the motor test reports.

3.4.4.2. Starting Requirements

3.4.4.2.1. <u>Normal starting</u>

Unless otherwise specified in Technical Schedule-A, motors shall be designed for the following normal starting requirements:

A. Motors shall be suitable for direct-on-line (DOL) starting.

B. Motors shall be designed for at least three consecutive starts per hour when initially cold. That is, a motor starting cold (at ambient temperature) and subjected to an immediate trip shall be capable of one immediate restart after coasting to rest and of subsequent restarts at 30-minute intervals.

C. Motors shall be designed for two consecutive starts per hour when hot. That is, a motor that is subjected to a trip while at operating temperature shall be capable of one immediate start after coasting to rest and of subsequent restarts at 30-minute intervals.

D. Motors with high load inertia that may make it impractical to meet the 30-minute restart capability of normal designs, shall have an alternate rest interval stated by the *Supplier.*

E. The motor starting information shall be either included in the nameplate or on a separate Starting Information plate.

F. Starting currents for induction motors shall not exceed the following values, including saturated conditions;

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F.1. 6 Per unit for motors rated up to 1MW, and

F.2. 4.5 Per unit for motors rated 1MW and above.

G. Motors shall be capable of accelerating the driven load from standstill to full speed and operate the driven equipment taking into account the load inertia, load torque, required starting time, and power supply variations provided in either this standard (see next section) or Technical Schedule-A. Where the starting current limit stated above results in undesirable acceleration performance, the *Supplier* shall request to deviate from the starting current limits, a deviation that shall not be unreasonably declined.

3.4.4.2.2. Starting with Variations in Voltage and Frequency ratings

Induction motors shall successfully start and accelerate to running speed a specified load with the following voltage and frequency variations, without exceeding the allowed temperature rise when hot:

A. A voltage drop of up to 25% of rated voltage, with rated frequency.

B. ±5% of rated frequency, with rated voltage.

C. ±15% of combined (sum of absolute values) rated voltage and frequency, provided the frequency variation does not exceed 5% of its rated value.

D. Double cage motors shall only be supplied for approved applications.

E. The minimum safe stall time for a ‘hot’ motor shall be at least 10% longer than the starting time when the voltage drop during start-up is 15%. The margin between the hot locked rotor thermal limit curve and starting time current curve at 85% voltage shall, therefore, be no less than 10%. Where this requirement cannot be met for high inertia load applications, the following shall apply;

E.1. The margin between ‘hot’ motor accelerating thermal limit curve and starting time current curve at 85% voltage shall be no less than 10 seconds, and

E.2. The motor shall be designed and supplied with fully functional speed switch supervision components and circuitry to provide input required for locked rotor motor protection.

3.4.4.3. Torque

3.4.4.3.1. Standard Torque

Unless otherwise specified in Technical Schedule-A, the standard application minimum torque requirements are:

A. Locked Rotor Torque (T_1), as percentage of rated full load torque (T_N), with rated voltage and frequency supply shall be equal or higher than;

A.1. 60% for motors rated below 1MW, and

A.2. 45% for motors rated 1MW and above.

A.3. The motor torque profile shall be designed such that the minimum starting times stated in Technical Schedule-A, at different voltage levels, are not exceeded.

B. Breakdown Torque (T_b), as percentage of rated full load torque, with rated voltage and frequency supply shall be;

B.1. 175% for motors rated below 1MW, and

B.2. 150% for motors rated 1MW and above,

C. The accelerating torque margin between the motor and required load torque, at the minimum starting voltage, shall not be less than 10% of the motor full load torque.

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3.4.4.3.2. High Torque

Unless otherwise specified in Technical Schedule-A, high torque applications shall have the following minimum torque requirements at rated voltage and frequency:

A. Locked Rotor Torque shall be 200% of rated full load torque.

B. Breakdown Torque shall be 190% of rated full load torque.

C. The accelerating torque margin between the motor and required load torque, at the minimum starting voltage, shall not be less than 10% of the motor full load torque.

3.4.4.4. Stator Windings and Insulating System

3.4.4.4.1. General Requirements

A. The stator core and winding shall be constructed as a separate entity that can be fitted into and removed from the stator frame thus allowing for easy repair and replacement of the windings and core, if necessary.

B. Windings shall be insulated with a Class F or higher insulation system that has been proven by usage or tests as per applicable parts of SANS IEC 60034-18. All materials employed in the stator winding system shall be compatible and suitable for continuous operation at a Class F (155°C) hot spot temperature or higher.

C. Unless otherwise specified in Technical Schedule-A, the winding temperature rise limit shall be that of Thermal Class B at rated output.

D. Stator windings, unless otherwise specified in Technical Schedule-A, shall be designed to have a surge/impulse withstand capabilities specified in SANS IEC 60034-15 at a rise time of 0.1 to 0.2 μs and at 1.2μs, or longer.

E. Each stator winding shall have a minimum number of embedded temperature detectors (ETDs) installed as per the section on stator ETDs.

F. The stator coils are to be form wound, in open slots. Designs incorporating semi-closed slots, closed slots or random wound coils are not acceptable.

G. Star-connected windings are preferred.

H. Continuous taping of pre-formed bars is preferred.

I. Approved measures against corona shall be applied to the slot portion of all coils.

J. Winding insulation shall be oil-resistant and non-hygroscopic.

K. End-windings shall withstand direct-on-line starting under maximum voltage conditions.

L. The design of end-winding coil spacing and interconnections shall allow for adequate space between all coils and interconnections. End-windings with coils, whose insulation is in direct contact with each other, i.e. do not have any blocking and/or tying, shall be rejected.

M. The connections between the windings and terminals shall carry the maximum starting current for the worst case run-up time without overheating, and shall withstand the forces arising from the starting current without damage.

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3.4.4.4.2. Strand and Turn Insulation

A. Acceptable materials for use as strand insulation are; double Dacron glass, Nomex 418, and mica tape wrapped or fused over bare copper or Class 180°C and higher, or equivalent.

B. An appropriate number of ½ lapped layers of mica tape shall be used as dedicated turn insulation over strands insulated with acceptable materials. Motors rated above 6kV shall have a minimum of two ½ lapped layers of mica tape. Kapton polyamide film is not acceptable as turn insulation material.

C. Turn insulation shall be reinforced at the coil knuckles and the conductor stacks shall be fully consolidated in the straight sections of the coil legs before application of ground-wall insulation.

3.4.4.4.3. Groundwall Insulation

A. The coils are to be insulated with necessary layers of ½-lap mica tape supported by glass cloth, polyester mat, or floc compatible with the VPI epoxy, or polyester resin to ensure proper resin penetration and bonding. Tapes containing polyester (Mylar™), Polyamide (Kapton™), or other films are not acceptable.

B. It is preferable for the ground-wall insulation on the end windings and connections to have the same number of layers of insulation as the slot portions.

C. All windings shall have corona suppression applied. For motors above 6 kV, this shall consist of carbon or graphite semi-conductive tapes applied to the slot sections that shall extend at least 25mm beyond the end of the core. Silicon carbide grading tape is to be used on the end windings. This shall overlap the semi-conducting slot section tape and extend to approximately 50mm past the first bend of each coil. 3 300 V Motors may have semi-conductive tape applied to their slot section. Paints are not acceptable.

D. Corona suppression tapes may slow the flow of resin into the insulation system during VPI processing and, therefore, require a longer treatment time than normal. All motors shall, therefore, be put through the VPI process that is not shorter than that normal for 11kV windings.

E. The maximum clearance between the coils and the core slots shall be 0.25mm/side for global VPI windings.

3.4.4.4.4. Surge Rings

A. Surge rings are required for all machines. These shall be made from mica tape insulated steel, synthetic resin bonded fiberglass, or “dry glass sleeving filled with unidirectional glass fibres” for global VPI stator windings. Fiberglas rope surge rings may be used in addition to installed metal or resin bonded fibreglass rings to provide additional support.

B. Dacron™ felt packing, or equivalent, shall be installed between the end winding and solid surge rings.

3.4.4.4.5. Blocking and Tying

A. Materials acceptable for use in end-winding lacing and tying are; heat shrinkable tape, rope, cord, or tie materials made of glass roving. Tapes of 100% Dacron are not allowed. Use heat shrinkable tape, or rope, cord, or tie materials made of glass roving for tying end-windings.

B. Acceptable end-winding blocking materials are; epoxy or polyester-saturated Dacron® or Nomex ® felt materials or glass mat.

C. In large motors, where the spacing between coils is greater than 19 mm, the felt material should be wrapped around NEMA grade polyester/glass laminate, or G-10 or G11 epoxy/glass laminate

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blocks. If possible, felt wrapped blocking shall be tied in such a way that both a north/south and an east/west wrap exists around each block (also known as a butterfly tie).

3.4.4.4.6. <u>Fillers and Packing</u>

A. The under-wedge packers (filler strips) shall be rigid glass epoxy laminates to enable the replacement of wedges without possible damage to the global VPI stator winding insulation. Rigid polyester fibreglass and a felted Nomex ®, or equivalent, may also be used as the under-wedge filler to achieve the coil protection and secure fit objective. Use of only soft under-wedge packing material is unacceptable.

B. Mid slot and bottom packers as well as side packers, if necessary, shall extend at least 13 mm beyond each end of the stator core.

C. With semi-conductive tape applied to all coil straight portions, filler strips and side packing shall also be made of semi-conductive material which has conductivity limits of 1,000 to 10,000 ohms/square shall be used.

3.4.4.4.7. <u>Wedges</u>

A. Epoxy glass wedges are to be cemented into the stator slot with suitable bonding material.

B. Magnetic slot wedges are not preferable. Where the motor OEM design requires usage of magnetic wedges, the *Employer* shall accept such usage based on justification provided by the *Supplier*. Such justification shall include, but not limited to; advantages for the magnetic wedge material, method of installation to secure wedges in the slot, and at least two years of successful in-service experience.

C. Wedges made of glass mat polyester materials such as GPO-1 are not acceptable.

D. The entire length of the slots shall be wedged and wedges shall be notched at core vent ducts.

3.4.4.4.8. <u>Winding Installation</u>

A. Care shall be taken that coil insulation is not damaged during the winding installation process. Coils with damaged insulation are not acceptable.

B. All coils and interconnecting leads on the end-windings shall be separated from each other with appropriate spacing for cooling airflow and blocking/tying.

C. Surge Testing of individual coils shall be performed during the winding installation process. These tests must be performed on each coil before and after installation into the stator slots, and after slot wedging and end-winding bracing is complete, but before winding connection.

D. Coil resistance to the core shall be recorded after coil wedging to ensure continuity between semi-conductive tape and the iron core.

3.4.4.4.9. <u>Coil Connections</u>

A. All connections between coils, phase rings, and leads must be brazed with a material containing at least 15% silver and must be completely sealed with full ground wall insulation of mica tape, and a final layer of glass or Dacron® armor tape.

B. Coil jumpers shall be constructed from copper conductors that have at least the same cross section as those in the coils and shall be insulated will full ground insulation.

C. All coil connections shall be insulated with the same number of layers of mica tape as the coil.

D. The use of motor lead cables for connections, jumpers, etc., around any part of the end windings, is not acceptable.

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3.4.4.4.10. Motor Lead Cables

A. Motor lead cables shall be rated to carry at least 125% of motor full load current and have an insulation covering that has a thermal rating of at least 150°C.

B. Lead spacing and clamping devices shall be used between winding and terminal box and where lead cables pass through the stator frame to the terminal boxes.

C. A 500mm slack shall be provided on each lead cable.

D. The motor lead cables shall be protected from impregnation or ingress of resin during the VPI process to maintain mechanical flexibility, or else the motor leads shall be installed after stator impregnation.

E. Motor lead cable data (e.g. cable size, current and temperature rating, cable and insulation materials, length and outside diameter) shall be shown on either stator data or motor outline drawing.

3.4.4.5. Stator Core

A. The arrangement of the core pack shall allow dismantling and restacking of the core. The stator core laminations should be rotated by 180^o while being restacked during a repair.

B. The stator core shall be assembled from low-loss silicon steel laminations with proven insulation coating.

C. Core laminations shall have no ragged edges (burrs) before stacking. They shall be accurately registered and stacked to present even surfaces in the winding slots and stator bore.

D. Steel laminations shall be held under compression by solid compression plates (steel clamping rings) and tooth supports at each end. Tooth support and duct spacers shall be held securely by a locking mechanism or tack-welding.

E. Segmented stator cores shall be securely mounted, at two locations, on dovetail or similarly shaped keys.

F. Filing of slots to smooth-out uneven core surfaces is not allowed.

G. Once the stator core is assembled and before the stator winding is installed, the core shall be subjected to a rated flux test to determine watts loss (W/kg).

3.4.4.6. Rotor

3.4.4.6.1. Rotor Core

A. The ends of the rotor core pack shall be secured with solid compression plates. These shall be securely tack-welded to steel-end laminations or locked into them.

B. Rotor laminations shall be fixed to the shaft and clamped longitudinally so that the maximum torque is transmitted without distortion of, and without separation between, the rotor laminations.

C. The arrangement of the core pack shall allow dismantling and restacking of the core. The rotor cores laminations shall be able to be rotated by 180^o while being restacked during a repair.

D. Precautions shall be taken for the case where a rotor bar breaks that it will not come out of the rotor slot and damage the stator winding.

3.4.4.6.2. Rotor Windings and Sliprings

A. Rotor bars shall be tightly fitted in the slots over their entire length to avoid fatigue failure of the bars from bar vibration within the slot.

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B. A description of the rotor bar retaining method shall be included in the tender.

C. Securing of the bars shall allow for axial movement of the cage due to operational contraction and expansion of the bars. Pinning of the bars shall be consistent and not induce cracking of the bars. Use of a jack hammer is not allowed.

D. Insulated rotor bars are not allowed.

E. Slot filler materials including varnish treatments, which may deteriorate with time and heat, and metal liners shall not be used.

F. The rotor bars shall be carefully fitted into the slots and not cause damage to the bar. Metal hammering as a method of inserting rotor bars after the bars have been cut to size is not allowed.

G. All rotor bars shall be of equal length and concentric before being brazed onto the shorting ring. The *Employer* reserves the right to reject a motor with any evidence to the contrary.

H. Rotor bars shall be solidly brazed to the rotor shorting rings. Under-bar brazing as the only brazing method is not allowed.

I. Only one-piece forged end-rings shall be used. Formed shorting rings with brazed or welded joints are not acceptable. Recessed rotor bar brazing area end-rings are preferred.

J. Where rotor windings are brought out to sliprings, these shall be ventilated in a manner that precludes the accumulation of carbon dust between the sliprings. Slipring depth shall allow for the required regrinding without replacement, over the specified life of the motor. Sliprings shall be totally enclosed in dustproof housing with facilities for easy visual inspection during normal operation.

3.4.4.6.3. Die Cast Rotors

A. Only fabricated rotors are preferable.

B. Die cast rotors may only be offered for motors rated up to 250 kW where the design is service-proven. In the absence of a specification for the rotor type in Technical Schedule-A, it shall be taken that only the fabricated rotor may be offered.

C. The *Employer* reserves the right to reject a motor that was tendered without clear reference to the die cast rotor cage being offered. This is applicable to all motors, including designs rated up to 250 kW.

D. Steps shall be taken to eliminate porosity for accepted die cast aluminium rotors.

3.4.4.6.4. Rotor Run-out

Rotor run out values shall be measured and shall meet the following acceptance criteria:

A. Shaft extension total indicator runout (TIR) values shall not exceed those given in NEMA MG-1, Section 4.9.7. Run out limits for shaft extensions with diameters larger than 160 mm shall be agreed between *Supplier* and *Employer*.

B. Shaft journal and bearing mounting seat TIR’s shall not exceed 0.0254 mm.

C. For shaft proximity probes, the TIR on the shaft opposite the probe shall not exceed 0.0254 mm.

D. Rotor core OD TIR’s as measured at both ends and at the centre shall not exceed 0.0508 mm.

E. If the motor has a vertical frame with a tilting pad thrust bearing, the thrust runner shall be mounted on the rotor for TIR checks. The TIR on the thrust bearing face(s) shall not exceed 0.0254 mm.

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3.4.5. Mechanical Details

3.4.5.1. Inter-changeability of parts

A. All corresponding parts of all motors of the same type and size shall be interchangeable.

3.4.5.2. Enclosure and Cooling

A. Appendix H lists the types of enclosure and cooling methods to be provided for various motors.

B. Motor designs with the degree of protection rating below IP44, as per SANS IEC 60034-5 are not allowed.

C. Motor designs with a closed air circuit arrangement for the primary coolant are preferred. Should the open circuit arrangement be necessary, air intake filters be provided and shall be easily removable for replacement or cleaning. The filters shall be furnished with a differential pressure indicator.

D. The machine-mounted independent component method of moving the coolant, i.e. characteristic numeral #6 for method of movement in Table 3 of SANS IEC 60034-6, is not allowed.

E. If air-to-water cooling is required to remove heat from the motor winding, core, and other parts, the cooler shall be designed to maintain its air outlet temperature (primary coolant) below 40ºC at rated load, when using a water supply as described in Technical Schedule-A. The water supply temperature range and water quality condition as well as supply and drain pipe interface dimensions will be given in Technical Schedule-A.

3.4.5.3. Frames, Housing and Fixing Arrangements

A. The motor housings for power station motors shall be made of either cast iron or fabricated steel. Motors above 800 kW shall have a fabricated box-frame construction.

B. Bearings shall be end-shield mounted so that motors can be moved without the rotors being disturbed relative to the stator. For applications where this requirement compromises drive train stability, pedestal mounted bearings are acceptable.

C. The height of the shaft centre line above the underside of the motor mounting pads or feet shall not vary by more than 1.25 mm from the design value.

D. The feet or mounting pads of the motor shall be accurately machined to a level plane.

E. Motors shall be complete with parts required for mounting and aligning, including those parts to be embedded in concrete foundations.

F. A machined base plate or frame shall be supplied with each motor. Holding-down bolt holes in bed-plates, frames and motors shall be provided with adequate clearances for positioning during alignment.

G. Packing shims allowing for height adjustment of approximately 7.5 mm shall be provided. Blind holes for holding-down bolts shall be provided in all base plates for frames.

H. Jacking bolts shall be provided at each end of the base plate for positioning and aligning the motor in both horizontal directions as well as vertically.

I. Vertical motors shall be provided with cowls to prevent the accumulation of foreign matter and water on the motor.

3.4.5.4. Heat Exchangers

A. For motors of frame size 355 and above, where air to air heat exchangers are used, the exchangers shall be flexibly mounted on the motor to minimize vibration transmitted to the heat

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exchangers. The minimum diameter of bolt for fixing the heat exchangers in position shall be 12 mm. If aluminium alloy cooler tubes are used and expanded into tube plates the latter shall be at least 8 mm thick. All sharp edges shall be removed from the holes in the tube plates before the tubes are expanded into the tube plates. For high vibration applications, steel tubes shall be used and these shall be welded into the tube plates.

B. Air-to-Water heat exchangers shall be provided with flexible water connections and shall use stainless steel tubes and tube-plates. The cooling water flow velocities through the tubes and headers shall be designed and selected within the limits specified in Technical Schedule A to promote good heat transfer, limit fouling, and prevent erosion and corrosion. The heat exchanger design shall be included in the detailed design submissions for acceptance by the *Employer*.

C. Water leaks from air-to-water heat exchanger tubes shall not ingress the motor windings. Drains from driptraps in the heat exchangers shall be led away in tubing supplied with the exchanger, to an approved drain point.

D. The tube side of the air-to-water heat exchanger shall be hydrostatically tested as at 1.3 times the design pressure, for one hour. No leakage is permitted, including at gasketed joints.

E. The *Supplier* shall be responsible for obtaining all relevant certificates and registrations including those required for pressure parts. Certificates and registrations should be obtained prior to delivery of equipment to site.

F. All heat exchangers shall be readily demountable. Replaceable, resilient gaskets shall be inserted between the cooler housing and the motor to exclude dust.

G. Unless otherwise specified in Technical Schedule-A, the primary coolant cold air (heat exchanger outlet air) temperature detectors shall be provided on as per Section Primary Coolant ETDs. The number of these temperature detectors shall be equal to the primary cooling circuits.

3.4.5.5. Bearings

3.4.5.5.1. General

A. Bearing design and selection shall be suitable for continuous service under the conditions of application and shall be mounted in housings that are dust, oil, and grease tight. All motors, including for indoor use, shall have suitable protection against water and dust ingress into the bearings.

B. In general, motor bearings shall be of the same type as those of the driven machine. The bearing types to be supplied shall be plain sleeve bearings, tilting pad thrust bearings, or ball and/or roller bearings.

C. The bearing assembly design shall ensure that a collapse of bearings does not result in the rotor and stator core rub. The bearing assembly design drawings shall clearly indicate the feature/facility to meet this requirement.

D. Each bearing shall be provided with a temperature detector in the most heavily loaded area, either on the stationary race of the rolling element bearing or within 3 mm of the white metal of a sleeve or tilting pad bearing. Unless otherwise specified in the Technical Schedule-A, the temperature detector shall be in accordance with Bearing ETD specifications.

E. Each bearing shall be designed to operate at a normal running temperature that is well within, at least 20°C lower than, its design withstand temperature under the specified Site operating conditions. Where this requirement cannot be met due to special design considerations, the *Supplier* shall specify the special lubricant required. When a motor is run on no-load at the works, the bearing temperature rise shall be within acceptable limits specified for motor acceptance.

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F. For maintenance purposes, the *Supplier* shall provide the *Employer* with detailed requirements of the lubricant type, grade, replacement intervals and volume. The lubricant type shall be pre-approved by *Employer* to reduce the number of different lubricants held by the Power Station.

G. For bearing protection settings, the maximum allowable operating temperatures for each bearing shall be given to the *Employer*.

H. Unless otherwise specified in Technical Schedule A, bearing insulation is a requirement for all motors whose rating ≥ 800 kW and where measured shaft voltage exceeds either 100 mV for rolling element bearings or 200 mV for sleeve bearings.

3.4.5.5.2. <u>Ball and Roller Bearings</u>

A. Ball/roller bearings shall not be used for all motors above 1MW and 2-pole motors above 500kW.

B. The life of ball and roller bearings shall not be lower than L10h life of 100,000 hours, under actual service conditions. The detailed design submission to the *Employer* shall show an approved method of calculating the life of ball and roller bearings.

C. Bearings shall preferably be provided with covers or end caps in their housings which are readily removable, or can be backed-off without dismantling the motor to permit a positive check of the grease present.

D. The greasing arrangements for ball and roller bearings shall be such that greasing can be carried out while the motor is running. Greasing facilities shall be easily accessible when the motor is in service. Grease fittings with durable plugs shall be provided and located to ensure complete re-lubrication of the bearings.

E. Grease renewal periods shall not be less than 4000 hours.

F. The grease outlet opening shall have a grease relief device, e.g. valve or removable plug, which can be opened before greasing to prevent excessive grease build-up during re-lubrication and closed after excess grease ejection. Excess grease shall be discharged to the motor exterior into a tray that is in an easily accessible position.

G. Shock pulse measurement nipples must be installed on all NDE bearings that cannot be accessed for vibration measurement due to the covering fan cowl.

3.4.5.5.3. <u>Sleeve and Tilting Pad Bearings</u>

A. The design life of sleeve bearings shall be unlimited.

B. Sleeve bearings in horizontal motors shall be of the horizontally split type with split bearing brackets or housings. The shells of the bearing shall be locked so as to prevent rotation in the housing. The design shall also permit bearing replacement without removing the bottom half of the bearing bracket or pedestal.

C. Tilting pad bearings shall preferably be of a design that shall permit the shaft to rotate in either direction. Radial loads are to be taken by a journal bearing, either of the sleeve or tilting pad type. In vertical motors the journal guide bearing shall be an integral part of the thrust bearing.

D. Unless otherwise specified in Technical Schedule-A, white metal bearings shall have self-contained lubrication, not oil-circulating units with external oil supply, that can be put into operation immediately, without having to verify oil flow or oil pressure. The bearing oil housing shall have a reservoir of sufficient depth to serve as a settling chamber for foreign matter.

E. Sleeve bearings shall be insulated from the motor housing. To enable checking of the bearing insulation the drive-end bearing shall be provided with means to short-out the insulation. Insulation applied internally to the bearing is preferred. If necessary, shaft earthing gear shall be provided at the drive end of the motor.

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F. Where bearings have a vacuum seal, it shall have insulation material between itself and the shaft. This is to prevent a short circuiting and circulating shaft currents, in case the rotor becomes eccentric to the vacuum seal.

G. Sleeve bearings shall be of the plain journal type and not segmental type. They shall be self-aligning and lubricated by a single disc integrally mounted on the shaft, or by a single oil ring of substantial proportions, running in an oil reservoir. Means of inspecting the oil rings shall be provided, where used.

H. For ease of maintenance, all reservoirs shall be drainable with conveniently located and removable drain and top-up plug installed. Where the bearing oil reservoir is inaccessible, e.g. within the fan cowl and obstructive heat exchanger and fan chamber, the oil drain and top-up plugs/valves shall be brought out for convenient access without removing the covering/obstructing component.

I. The oil bath shall be fitted with a conveniently located and easily visible oil level indicator built into the bearing housing. Where the bearing oil bath is within a covering component, the oil level indicator shall be brought out for access without removing the covering component.

J. The motor standstill and running oil levels shall be clearly visible on the oil level indicators. The standstill and running oil level markers shall non-perishable and supplemented by an engraved plate adjacent to each oil site glass. Oil level indicators shall have contrasting background colour to that of oil for better visibility of the oil condition and level.

K. The oil reservoir shall be thoroughly cleaned of oil, grease, and foreign material and shall be painted with a white, two-part epoxy paint.

L. Suitable pressure equalizers and vents shall be provided to prevent loss of oil and to maintain the proper oil level. Under no circumstances shall oil ingress the motor. The detailed design submission shall include a description of how the bearing assembly prevents loss of oil and oil ingress into the motor housing.

M. Where specified in Technical Schedule A of an enquiry document that the motor bearings shall be flood lubricated, it shall be in addition to bearings being disc or ring lubricated. If flood lubrication is specified the oil shall be taken from the lubrication system of the driven machine. If this is not possible, a separate, self-contained flood lubrication system shall be provided for the motor. The system shall be as simple as possible but shall include an oil filter and cooler with alarm contacts and trip contacts to indicate “oil temperature high” and “filter clogged”.

N. Where electrical motors are provided with sleeve bearings, the machine bearings should have the end-float that is not less than minimum limits specified in Table 4. The running motor magnetic centre shall not shift from either side of the geometric centre by more than 20% of the total end-float. To facilitate the assembly of driven equipment and sleeve bearing motors, the motor *Supplier* should:

N.1. Indicate, on the motor outline drawing, the minimum machine rotor end play in millimetres, and,

N.2. Mark the rotor end play limits on the machine shaft with indelible lines for the two limits and magnetic centre. The magnetic centre line should be provided with a sharp marker from the bearing end cap or dust seal cover, and dimensions of the centre line to the bearing end-cap or dust seal cover shall be recorded and marked on the motor.

3.4.5.5.4. Water Cooled Bearings

A. The water supply and quality conditions, along with supply and drain pipe interface dimensions, shall be given in Technical Schedule-A, if the requirement is for a replacement motor.

B. If both bearings require water cooling, each bearing shall have one water pipe connection for the cooling water inlet and another pipe connection for discharge. These inlet and discharge

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connections shall be piped to common headers for interfacing with the *Employer*'s service water system.

C. The water supply and outlet pipes shall be electrically insulated from the bearing housing. The cooling coil plugs and couplings for the water supply and outlet shall ensure that water leaks, from any source, do not ingress the oil reservoir.

D. Unless otherwise specified in Technical Schedule A, the cooling coil material shall be 90/10 copper/nickel and the cooling coil connections must have brazed or welded joints both inside and outside of the oil reservoir.

E. Threaded or swaged connections on the inlet and discharge pipes of the cooling coil are not allowed. The external inlet and outlet water connections to the oil cooler shall have flanged fittings to minimise the risk of causing stress cracking on the brazed or welded joints.

F. The designed cooling water flow velocity shall be such that erosion and corrosion of cooling tubes is prevented and good heat transfer is promoted.

G. After bearing cooling coils are fitted to the motor, the coils and the cooling water piping shall be hydrostatically tested at a pressure specified in the Technical Schedule A or by the bearing OEM for one hour to check for leaks. The pressure and water flow velocity to simulate conditions in the plant shall be applied throughout the duration of the motor test-running.

3.4.5.5.5. Vertical Motors

A. Motors rated up to 300kW shall have angular contact ball bearings. The tapered roller bearing shall be used for motors rated up to 1000kW or 1500RPM.

B. Where cooling of the thrust bearing on vertical motors is achieved by using a water cooling coil in the bearing oil reservoir, requirements for water cooled bearings in Section 3.4.5.5.4 shall be applicable.

3.4.5.6. Shaft and Coupling

A. Rotor shafts shall withstand the effects of maximum displacement due to unbalanced magnetic pull under the worst combination of air-gap tolerance, specified voltage unbalance, and shaft bending.

B. All step changes on the rotor shaft diameter shall be correctly radiused to minimize stress risers.

C. The rotor shall receive a final balance to ISO 1940, G2.5 balance quality. Balance weight locations shall be such that they can be positively fixed without causing high stresses. All balance weights shall be positively locked using a method that can be verified by visual inspection. Balance weights shall not be attached to ventilating fan blades.

D. Unused shaft extensions shall be enclosed in robust metal covers.

E. When the complete coupling for each motor drive is provided by the supplier of the driven machine, the motor manufacturer shall be responsible for its fitting and balancing. (this should go under services furnished by the *Supplier*)

3.4.5.7. Direction of Rotation

A. Motors shall preferably be bi-directional by interchanging two of the motor power supply leads. Where unidirectional motors are supplied and shaft mounted cooling fans are unidirectional, they shall be capable of running in the reverse direction at no load for up to two hours.

B. An arrow shall be provided on the motor coupling end bearing bracket (or end-shield) to indicate the direction of rotation. Motors with two coupling ends shall have the arrow installed at each end-shield. Motors with bidirectional shaft-mounted cooling fans shall have a bidirectional rotation indication arrow, regardless of the application requirement.

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C. Motors with only one shaft extension shall rotate in a clockwise direction when looking on the drive end, irrespective of the direction of rotation required on site, when L1-L2-L3 (R-W-B) terminals of the supply leads of a phase rotation system rising in that order, i.e. positive sequence supply, are connected to the motor terminals U1-V1-W1 respectively.

D. Motors with double-ended shaft extensions and uni-directional fans shall rotate in the correct direction to suit the motor fan when the L1-L2-L3 (R-W-B) supply with positive sequence supply is connected to its positive sequence winding terminals U1-V1-W1 respectively.

E. The correct rotational direction with the positive sequence supply shall be proven during the motor routine test. Test facilities shall, therefore, be equipped with a phase rotation meter.

3.4.5.8. Stator to Rotor Airgaps

A. Motors equipped with pedestal bearings shall be provided with facilities for measuring the air-gap at four bearing 90º diagonal positions at each end of the motor. If this requirement cannot be met, it shall be clearly stated in the Vendor’s tender along with the method to be used to check that air gaps are uniform.

B. Subject to *Employer* approval, motors with end-shield mounted bearings need not be provided with air-gap measuring facilities provided that the dimensions and tolerances indicated on assembly drawings are adhered to and are such that air-gap measuring facilities are unnecessary.

3.4.5.9. Noise, Vibration and Critical Speeds

A. Noise levels shall not exceed the levels given in SANS IEC 60034-9.

B. Levels of vibration generated within motors when running on their own shall not exceed half the values specified in SANS IEC 60034-14. However, the motor shall be designed to withstand the vibration level imposed upon it by the driven machine as laid down in VDE 2056 for that class of machine. The level of vibration of the driven machine shall be taken as that occurring at the upper limit of the band classified as poor.

C. The motor vibration levels shall not increase by more than 20% between the start of the full-load test and temperature stabilization.

D. The first rotation critical speed of the motor rotor shall not be within 125 % of the rated speed.

3.4.5.10. Rating Plate and Labels

Nameplate data shall be permanently marked on securely attached brass or stainless steel plates. In addition to the nameplate information detailed by SANS IEC 60034-1, the following information must be included on the motor nameplate or on a separate nameplate/s:

A. Make and type of bearings

B. Grade and type of lubricating oil/grease

C. Recommended greasing intervals;

D. Bearing clearances (for sleeve bearings);

E. Bearing fit (for ball and roller bearings);

F. Bearing reference numbers for ball/roller bearings;

G. Bearing metal specifications reference for sleeve bearings;

H. Maximum allowable bearing temperatures;

I. Total rotor end float; with the running position from both ends (DE & NDE);

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J. Whether the motor is uni- or bi-directional and if uni-directional an arrow indication of the direction of rotation. The electrical connections and phase sequence required to achieve a particular sense of rotation;

K. Starting information, i.e. permissible number of starts and intervals between cold and hot starts;

L. Total motor weight and individual weights of the rotor, stator, and removable heat exchanger;

M. Heater rating and connection details;

N. The number of rotor and stator slots;

O. Frame size dimensions in accordance with SANS IEC 60072-2, which shall be in H(A/B/C)D/E format.

The following conditions are applicable to the rating plates:

P. The location of the rating plate that contains the motor identification/serial number shall be at eye level on a motor component that cannot be interchanged with a similar motor, e.g. heat exchanger, fan cowl, cover plates, etc.

3.4.6. Accessories

3.4.6.1. Terminals and Cable Boxes

3.4.6.1.1. General

A. Replacement motor terminals and cable boxes shall be in the same location as that of the existing motor(s) unless otherwise specified in Technical Schedule-A.

B. Terminal boxes and cable boxes shall be provided complete with internal parts and cable glands required to connect the motor for operation.

C. Terminal box lids shall be with “lips” over the terminal box flange, so that the gasket will not be exposed to water and dust.

D. Each motor shall be provided with an earth terminal mounted in an easily accessible position on the motor frame adjacent to the terminal box.

E. The location and size of terminal boxes shall be subject to the mutual agreement between the *Supplier* and *Employer* during the detailed design process. The *Supplier* shall take responsibility for ensuring that the terminal boxes do not restrict the ventilating air flow or interfere with any other motor accessory when mounted in the configuration agreed with the *Employer*.

3.4.6.1.2. Power Connections

A. Motors shall be provided with approved terminating fittings for the required cables. Where a particular type and size of motor is supplied for several different applications, the arrangement of cable terminating fittings shall permit inter-changeability of motors and allow one spare motor to serve for all applications without having to modify the existing cable arrangement.

B. Motors shall have both ends of each winding brought out to terminals.

  B.1. Motors shall have the line ends of the windings brought to one terminal box, and the neutral ends to a separate box. Depending on the type of winding and connection, terminal markings shall be in accordance with SANS IEC 60034-8.

  B.2. Motors that can only have one terminal box shall have all winding terminals appropriately insulated and marked.

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B.3. If it is necessary to connect power supply terminals on both sides of a motor in parallel for either shared current from duplicated supply cables to the motor or alternate cable connection ends;

B.3.1. The star point connection shall be made internally but accessible and easily disconnected with the motor in position for services for motors rated below 1 MW.

B.3.2. Motors rated above 1MW shall be designed to have a third terminal box to enable the required differential protection scheme.

C. Main terminals and motor leads shall be permanently marked with winding identification letters in accordance with SANS IEC 60034-8, e.g. U-V-W and U1-V1-W1, reading from left to right, if horizontally arranged, or top to bottom, if vertically arranged, when facing the terminal box.

D. Internal leads shall be provided with adequate slack to enable inter-changeability for reversing the motor rotation easily. The leads between the motor windings and terminals shall pass through bushes or sealing devices to separate the motor interior from the terminal box(es).

E. The rotational direction and power connections shall be in accordance with the direction of rotation requirement.

3.4.6.1.3. Secondary Connections

A. The connections to temperature measuring devices, current transformers, heaters and other secondary apparatus shall be wired to separate duplicated terminal boxes, one on each side of the motor, to facilitate cabling from either side. The secondary devices shall all be connected to terminals in one box and interconnections shall be provided between these terminals and the duplicated terminals in the second box.

B. All wiring from temperature detectors and all other motor instrumentation shall be brought out to the temperature detector conduit box and suitably identified by wire markers with unique numbers, which shall be in accordance with the marking and labelling section of this specification, unless otherwise specified to the *Supplier* by *Employer*.

C. The lugs used shall be colour coded, where necessary, and be of Lipped Blade type.

D. Terminal strips shall be mounted on DIN rails. The type of terminals used shall be spring-loaded.

E. Secondary terminal boxes shall be fitted with undrilled removable gland plates to accommodate the external cables installed by others.

F. An itemized list or drawing of all internal connections shall be attached to the inside of each conduit box to enable quick identification of all accessories.

G. All secondary terminal boxes shall be clearly labelled to indicate the circuits for which they are provided. Labels shall be of brass or stainless steel with permanent markings, and shall be securely attached to the motor.

H. Where the oil system is provided by others oil inlet and outlet flanges shall be provided on each bearing.

I. Each motor shall be provided with two grounding pads located one on each side of the motor frame.

3.4.6.1.4. Main Terminal Boxes

A. The *Supplier* shall supply the main and neutral terminal box that will accommodate terminations and any accessories such as approved surge suppression units, partial discharge monitoring couplers, and differential protection current transformers as specified in Technical Schedule-A.

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B. To prevent venting from the main terminal box into the motor during a fault in the box, the opening in the stator frame, through which the motor leads pass shall be sealed with fire retardant materials. In addition, the box shall have a blow-out panel or pressure relief feature so that pressure build-up from any phase-to-phase or phase-to-ground faults is relieved. The pressure relief diaphragm shall ensure that the products of the explosion escape in a manner that will not harm personnel in the vicinity.

C. Desiccators shall be fitted with indicator heads visible without removing the terminal box cover.

D. Unless otherwise indicated in Technical Schedule-A, the main and neutral terminal boxes of Draught Group Fan Motors shall be equipped with internal air temperature monitoring devices.

E. Horizontal motors smaller than 355 frame size, may be fitted with terminal boxes that allow cable entry from any one of four positions, 90 apart, on top of the motor. A spreader/adaptor box, and cable gland or removable gland plate, shall be provided to accommodate the cable and cable tails.

F. Motors of frame size 355 and above shall be fitted with terminal boxes on both sides. Unless otherwise approved, motors shall be delivered with the cable boxes or gland plates fitted to the right hand terminal box when viewed from the drive end. The opposite terminal box shall be complete with a neutral connection and all fittings and shall be totally enclosed.

G. Cable tail support bars within the terminal boxes shall be made from non-hygroscopic insulating material.

H. Where the electrical supply to a motor is provided through fuses or a similar current-limiting device the terminals shall be enclosed in a moisture-proof box sealed with gaskets and arranged to prevent warping of the lid when secured.

I. Motors with an electrical supply provided through devices with no current limiting capability, shall have terminal boxes capable of withstanding an internal fault and through fault of 45 kA, symmetrical for not less than 0.25 s. The terminal boxes shall be the totally enclosed, phase-insulated type, sealed to exclude moisture and dust from internal air circuits and from outside. The terminal boxes and covers shall be fabricated from mild steel plate and all joints shall be flanged and sealed with neoprene gaskets or similar material.

J. Live parts inside the terminal boxes and disconnecting chambers shall be fully insulated with a self-vulcanizing insulating tape or heat shrink material. Natural rubber shall not be used.

K. The dimensions of terminal boxes and cable boxes shall be adequate for accommodating the sizes and types of cable specified. The design of the terminal box shall permit the removal of the motor without the need to disturb the termination or bend the cable appreciably.

3.4.6.1.5. Auxiliary Terminal Boxes

A. Two duplicate separate conduit boxes, suitably identified, shall be provided, one for the termination of temperature detector leads and the other for the termination of heater leads on the opposite sides of the motor. These boxes shall be constructed so that the conduit entrance may be made at the top, bottom or either side of the box.

B. The heater terminal boxes shall be supplied with suitable nameplates giving the heater rating, voltage, and connection details.

3.4.6.2. Differential Protection Current Transformers

A. All motors with power rating above 1MW are required to have differential protection current transformers (CT) fitted in the neutral terminal box.

   A.1. CTs fitted by the motor manufacturer shall meet SANS IEC 60044-1 requirements.

   A.2. Class PX (sometimes referred to as Class X) CTs shall be used.

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A.3. The Turns Ratio, Secondary Winding Resistance, Knee Point Voltage and magnetizing current shall be determined by the *Supplier* in conjunction with the *Employer*. The CT characteristics shall be based on the protection scheme, protection functions and the circuit load requirements

B. Where Switchgear side CTs are already installed, motor side CTs shall match the existing CTs. It is preferable that the motor terminal side CTs are of the same manufacturer and design as the breaker terminal side CTs.

C. Where Switchgear does not yet have differential protection enabled, motor side CTs that meet the above requirements shall still be installed in the neutral terminal box.

D. Motors rated above 1MW shall, therefore, not have internal and inaccessible neutral terminations. Motors that require either duplicated or parallel line terminal boxes shall, therefore, be designed to have a third terminal box to house the required differential protection scheme.

E. Marking of CT terminations shall be in accordance with SANS IEC 60034-8.

3.4.6.3. Partial Discharge Couplers

A. Motors used for applications whose unavailability can lead to direct load loss, such as Draught Group Fans and Electric Feed Pumps, and with ratings equal to or greater than 6.6 kV and 1 MW, shall be supplied with proven instruments for measuring on-line partial discharge activity.

B. When required in Technical Schedule-A, only the Eskom approved partial discharge couplers shall be installed for stator partial discharge measurements.

3.4.6.4. Surge Arresters

The surge withstands capability levels for windings are specified under general requirements for stator winding insulation. Due to the unpredictable nature of surge magnitudes and rise times, however, all motors shall be supplied with surge protection devices to slope back the rise time of incoming surges for even distribution across the entire winding. Unless otherwise specified in Technical Schedule A, the following requirements for surge arrestors shall be adhered to:

A. They shall be installed at or within 1000 mm of motor line terminals.

B. Only service proven devices, with replacement units readily available in South Africa, shall be installed.

C. Single phase units are preferable three-phase units.

D. Units that can remove a failed surge arrestor from the circuit and provide unit failure notifications through a set of dry contacts are preferable.

3.4.6.5. Temperature Detectors

The *Employer* shall specify, in Technical Schedule-A, the number and type of embedded temperature detectors (ETDs) to be installed in identified motor components. Unless otherwise specified in Technical Schedule A, the following requirements shall be adhered to:

A. Each bearing shall be supplied with pockets and inserts with a temperature detector in the most heavily loaded area, either on the stationary race of the rolling element bearing or within 3 mm of the white metal of a sleeve or tilting pad bearing. Bi-directional motors with sleeve bearings shall thus have two pockets per bearing. All inserts shall be spring-loaded to ensure contact between the thermocouple or PT100 and the base of the pocket. A locking device shall be provided to ensure that the insert does not work loose.

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B. The stator winding shall have PT100, either 3-wire or 4-wire, RTDs embedded in the hottest part of each phase winding. Where the hottest part of the winding is not in the middle of the core section, at least one additional PT100 RTD shall be embedded in the middle of the slot between coils of each phase. The minimum number of RTDs embedded in the stator shall be:

B.1. Two (2) detectors per phase for motors rated below 800 kW,

B.2. Three (3) detectors per phase for motors rated 800 kW and above.

C. Winding RTDs shall be evenly distributed around the stator. A drawing showing the location of identified RTDs shall be provided by the *Supplier*.

D. Motors rated above 1000 kW and with a primary cooling air that is circulated in a closed circuit shall be provided with the primary coolant cold and hot air temperature detectors. The number of these ETDs shall be equal to the number of primary cooling and hot air circuits, respectively. PT100, either 3-wire or 4-wire, ETDs are the preferred type.

E. Motors whose failure leads to direct load loss, e.g. Draught Group Fan and Boiler Feed Pump motors shall have the main and neutral terminal boxes supplied with internal air temperature detectors.

F. The *Supplier* shall connect all ETDs to the Temperature Detector Terminal Box’s marked terminal strips with shielded leads.

G. The *Supplier* shall inform the *Employer* of the required alarm and trip settings for the components monitored by the ETDs.

H. The stator winding RTDs shall only be used for monitoring and alarming, and not for tripping the motors to avoid load loss due to nuisance trips.

3.4.6.6. Space Heaters

A. All motors shall be equipped with space heaters to operate on 220VAC. Selection of the space heater shall be such that its surface temperature is low enough to minimise the risk of igniting bearing oil or other inflammable materials that might come in contact with it. This is achieved by connecting heaters such that their operating voltage is one-half their rated voltage. For the specified 220VAC supply, therefore, each motor shall be equipped with two 220V rated heaters connected in series.

B. The heaters shall have sufficient capacity to raise and maintain the motor internal temperature to the range between 5ºC and 10°C above ambient to protect the motor against moisture due to condensation during extended shutdown periods. It is approximated that 955W per 1-Ton of motor mass is sufficient to maintain the motor frame temperature at 5ºC above ambient still air. The *Supplier* shall be responsible for determining the heater capacity. The *Supplier* shall, at own cost, replace heaters that are found to generate heat that raises and maintains motor frame temperature outside of the specified range.

C. The mounting location of space heaters shall be such as to ensure heat contact with the core frame near the underside/lower-part of the motor frame. To minimise risk of insulation damage by either direct radiation or flames from ignited inflammable materials, heaters shall not be mounted on the stator windings and too close to the motor end-windings. The heaters shall be easily accessible and replaceable through the motor housing with the motor in its installed position and without the need for dismantling the motor.

D. The flat-strip type heaters are preferable as they can be mounted flat against the metal frame. The type of heaters to be fitted shall, if different from the preferable type, have to be approved by the *Employer* during the design freeze phase.

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E. Connections shall be brought out to a separate Heater Terminal Box in accordance with the requirements for auxiliary terminal boxes and the heating element and terminals shall be guarded to prevent accidental contact by maintenance or other personnel. If specified in Technical Schedule-A, space heaters shall also be installed in the main motor terminal box.

F. The anti-condensation heating is only allowed to be operated when the motor is off, before the stator winding temperature drops to within 5 °C of ambient temperature. The *Employer* shall, therefore, ensure that space heaters are connected through an auxiliary switch on the motor control circuitry so that they will be energised when the motor is de-energised and its winding temperature has dropped to within $T_{ambient}$ + (5-to-10)°C, and de-energised when the motor is energised.

G. The heater terminal box shall be equipped with a RED 220 V pilot lamp that should light up when the heater is energised. The pilot lamp shall be mounted on the immovable terminal box cover for effortless visualisation.

3.4.6.7. Corrosion Protection and Paint Finishes

It must be noted that, as per IEC 60721-2-1, most Eskom Power Plants are located in geographical areas with environmental conditions classified by a combination of two types of climate – Warm Dry and Mild Warm Dry – designated in IEC 60721-2-1 as a 'Moderate' group of climate. There may however be applications whose MV motors are located in areas with a group of climate designated 'World-wide'. There are thus two paint specifications, standard and special paint, for the two designated areas. Table 2 specifies the required thickness for the two paint specifications.

Table 2: Thickness of Paint Finishes

	Standard Paint	Special Paint
Primer on Cast (Dipped) Parts	30 µm	30 µm
Primer on Steel (Sprayed) Parts	60 µm	60 µm
Final Coat	30 µm	60 µm

A. Standard paint, which is suitable for indoors or outdoors undercover installations, shall be applied on motors to be located in the moderate climate group.

B. Special paint, which is suitable for installations that are outdoors with direct exposure to solar radiation and weathering over a wide temperature and humidity range, shall be applied on motors to be located in the world-wide climate group.

C. The required paint finish shall be specified in Technical Schedule A. In the absence of a specification, the standard paint finish shall be de-facto.

Notwithstanding the above requirements, the following shall apply:

D. All metallic surfaces exposed to air, including internal surfaces of terminal boxes, motor frames and heat exchanger shall be treated to prevent corrosion. All metal surfaces shall be treated with – as a minimum – one coat of rust preventing primer and two coats of enamel paint finish.

E. Two-part epoxy type paints are preferred for toughness and durability.

F. All internal and external motor component surfaces shall be prepared for painting and painted in accordance with the paint manufacturer's instructions.

G. All external surfaces shall be finished with an outer coat of enamel of the colour specified in Technical Schedule A of an enquiry document.

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H. Any standard painting procedure that differs from these requirements shall be submitted to Eskom for prior approval.

I. The external paint finish shall be applied only after the completely assembled motor factory acceptance tests have been completed. Prior to shipment, all machined or finished surfaces shall be coated with a suitable protective coating to prevent rusting during shipment, storage and installation.

3.4.6.8. Bearing Oil or Motor Air Coolant

The *Employer* shall provide the following data in Technical Schedule A:

A. Special tube requirements, if any.

B. Coolant grade, if flood lubricated oil bearings, or quality, if bearings and/or air are water cooled.

C. Coolant temperature, flow rate and pressure.

D. Type and/or dimensions of the existing motor inlet and outlet flanges.

The *Supplier* shall provide the following as part of the detailed design data submission:

E. Technical data of the tube/s used for the cooler design.

F. Designed coolant grade, if flood lubricated oil bearings, or quality, if bearings and/or air are water cooled.

G. Designed coolant temperature, flow rate and pressure.

H. Type and dimensions of the motor inlet and outlet flanges.

I. The motor shall be supplied with the complete set of inlet and outlet flanges.

3.5. QUALITY CONTROL AND TESTING

3.5.3. Quality Control

A. The *Supplier* shall hold a valid formal certification confirming full compliance with ISO 9001: 2008. Such certification shall be by a duly IAF accredited independent Quality Management System certification body.

B. The *Supplier* shall maintain an *Employer*-approved quality control and inspection program. This program shall include, but not limited to, the requirements for a Quality Control Plan (QCP) that covers all component inspections, tests, manufacturing procedures, and hold points for the motor contract. An addendum to the QCP shall be the Inspection and Test Plan (ITP), which only shows items/tasks that require input by the *Employer*, e.g. acceptance, approval, inspection, witnessing, and hold point. Manufacturing of the motor shall not start until the *Supplier* receives the *Employer*'s approval of the QCP and ITP.

C. The *Supplier*'s QCP and/or ITP shall include the minimum quality control requirements contained in Appendix J:

D. All materials and parts that are necessary for the motor manufacture shall be new and, including processes, of the best quality and shall be in accordance with the best practice typical to the manufacture of MV electrical motors.

E. Unless otherwise specified or approved by the *Employer* all materials, parts, and processes shall comply with the most recent *Employer*, South African (SANS) and/or International Electro-technical Commission (IEC) standards and certification applicable. Should conflict occur between the standards, the former shall apply, in sequence.

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F. Workmanship shall be in accordance with the best practice to ensure satisfactory operation and service life as described in this specification.

G. During motor manufacture and assembly, component protection and clean conditions shall be practiced to ensure no materials are damaged and foreign materials that would affect motor performance are not left in the motor.

H. Welding shall be undertaken by qualified welders and, where necessary, stress relieving shall be applied prior to machining. No welding, burning in, filling, plugging up or metal deposition to correct defects in any component will be permitted unless agreed to by the *Employer* in writing, following an inspection of the defect by the *Employer* or its authorized representative.

3.5.4. Inspections

A. At any stage during construction and testing, the *Employer* or its authorized representative reserves the right to inspect motors and all their components. By entering into a supply contract with the *Employer*, the *Supplier* therefore, consents the *Employer* or its authorized representative to unlimited access to the *Supplier*'s, including sub-contractors', premises at all reasonable times to the extent necessary to assess compliance with the provisions of this and such other documents as may apply to the procurement of motors. Such inspections shall not relieve the *Supplier* of its obligation or responsibilities under the contract.

B. The *Supplier* shall provide the *Employer* with a complete set of detailed manufacturing drawings that shall be used to assist in the inspection during manufacturing and testing of the motor and its components. These drawings shall be retained at the *Supplier*'s works and returned to them after completion of the contract.

C. The *Supplier* is responsible for managing the requirements of the ITP. The *Supplier* shall notify the *Employer* of its intention to conduct inspections and tests listed in the ITP, giving no less than five working days' notice for the *Employer* to witness the ITP task. The *Employer* reserves the following rights on the QCP and ITP tasks:

   C.1. Request, which shall not be unduly rejected, performing of the test as per the *Employer*'s valid test procedure and/or to the *Employer*'s reasonable satisfaction.

   C.2. Conduct tests/inspections not contained in the QCP and ITP agreed to between the *Employer* and *Supplier*. The costs for such additional test/inspection measurements shall be either for the *Employer*'s account, if the motor manufacturing and/or performance has not deviated from any contract requirement or the *Supplier*'s account if the motor manufacturing and/or performance has deviated from any contract requirement.

   C.3. To instruct the *Supplier* to repeat any task conducted without the required inspection by the *Employer*, at the *Supplier*'s cost.

   C.4. To return, to the *Supplier*'s works and at the *Supplier*' cost, motors despatched to site without the required inspection/s.

D. Manufacturing deviation reports shall be provided to the *Employer* for evaluation and acceptance, which shall not be unduly declined. The *Employer*'s acceptance of a manufacturing deviation does not, in any way, relieve the *Supplier* of its obligation or responsibilities for negative consequence/s of the deviation. Failure to provide full manufacturing deviation reports may, at the *Employer's* discretion; result in the *Employer* rejecting the motors.

E. Type tests shall be witnessed by Eskom and/or an authority, independent of the supplier or contractor.

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3.5.5. Mechanical Component Checks

3.5.5.1. General

Where and when appropriate the following checks shall be performed and results shall be recorded in Technical Schedule C:

A. Forged rotor shafts shall be ultrasonically tested to ensure homogeneity.

B. Where rotor spiders are built-up by welding onto the shaft, the welds shall be X-ray tested, magnetic particle tested and dye-penetration tested before further work is carried out on the built-up shaft.

C. The height of the shaft centre line above the underside of the motor mounting pads or feet shall not vary by more than 1,25 mm from the design value.

D. Where possible, during and after motor assembly, the air gap between the stator and rotor shall be checked with feeler gauges at 4 positions 90° apart and recorded. All four air-gap measurements shall be within ±10% of the average. Corrective action taken to restore air gaps to within this limit and the final values shall be recorded.

3.5.5.2. Mechanical Practices, Checks and Tests during Assembly

Generally all tests and inspections conducted as part of the motor assembly shall be recorded on the motor build report as part of Technical Schedule C. The following general practices shall, as a minimum, be applied:

A. Bolts shall be secured by coating threads with a durable anti-corrosion/anti-seize compound such as Permatex® or Loctite®, or equivalent. All bolts installed during assembly of motor components or motor component attachments shall be tensioned with proper bolt stretch via torque wrench or other acceptable means in accordance with the *Supplier*'s design values.

B. Foreign Material Exclusion (FME) shall be practiced to ensure that no materials that would affect motor performance are left in any part of the machine during assembly.

3.5.5.2.2. *Motors with Ball and Roller Bearings*

Measure the ball and roller bearing clearances and fits as follows:

A. The fit between each bearing inner ring and the shaft and between the bearing outer ring and the bearing housing shall be measured.

B. Motors with deep-grooved ball bearings normally have the outer ring held in a fixed position on its housing. Since rollers can slide axially in the outer race to allow rotor thermal expansion, the outer ring of roller bearing is allowed to accommodate such rotor axial growth. The axial clearance for the roller bearing outer ring must, therefore, be checked and confirmed to be large enough to ensure that contact between the bearing and the housing does not occur because of shaft growth under load.

3.5.5.2.3. *Motors with Sleeve or Tilting Pad Bearings*

The following measurements and checks shall be performed on sleeve and/or tilting pad bearings and the results recorded in Technical Schedule C:

A. All white metal shells shall be tested for adhesion of the white metal to the shell using ultrasonic or another approved method.

B. Check to ensure that the fits between the bearing OD and housing are within the design or following limits;

B.1. For thick shell bearings, unless otherwise specified by the motor manufacturer, such fits

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should be size-for-size to 25.4 – 50.8 µm. tight.

B.2. For thin shell bearings such fits should be size-for-size to 50.8 µm loose.

C. Measure the bearing bore concentricity.

D. Sleeve bearing bore to shaft journal clearances shall be checked. Radial clearances should be within the bearing manufacturer's design range. If this information is not available, the maximum diametrical bearing shaft journal to bearing clearance shall be in accordance with Table 3 below.

Table 3: Sleeve Bearing Clearance Acceptance Criteria

Bearing Journal Diameter [mm]	Minimum Diametral Clearance [mm]	Normal Tolerance Above Minimum Diametral Clearance [mm]
25-to-75	0.101	0.0254
75-to-180	0.002/mm of shaft diameter	0.0508
180-to-250		0.127
250-to-500	0.0005/mm of shaft diameter +0.381	0.127

E. Measure clearances in tilting pad bearings. The bearing manufacturer's or motor *Supplier*'s recommended clearances should be used to determine the acceptability of measured clearances in tilting pad bearings

F. Measure and record white metal bearing lay (contact between sleeve bearing journal and sleeve bearing white metal surface) to verify that there is at least 80% contact between the two surfaces in the axial direction and in the centre portion of the bearing. Bearing scraping shall not be used to meet this criterion, but the shaft must be re-aligned if the bearing bore concentricity is within specifications.

G. Measure shaft-to-bearing housing seal clearance values. The manufacturer's acceptance values shall be adhered to and recorded in Technical Schedule C. In the absence of the OEM's acceptance values, the acceptance criteria of 50.8 to 101.6 µm greater that the bearing diametrical clearance shall be used by the *Employer*.

3.5.5.3. Mechanical Checks and Tests after Assembly

After motor assembly the total axial end float of the rotor in the bearings shall be measured and recorded in Technical Schedule C. The following are specific requirements for rotor end float:

A. If the measured end-float is less than the minimum value given in Table 4, modifications shall be made to restore rotor end float to the minimum specified value. Details of these modifications shall be recorded.

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Table 4: Sleeve Bearing End Float Acceptance Criteria

Motor Rating [kW]	Number of Poles	Minimum Total End Float [mm]
Below 200	2	6
200-to-375	2	10
375 and below	4 and above	6
Above 375	All speeds	10

B. The end float for motors with sleeve and tilting pad guide bearings shall be in accordance with the motor *Supplier*'s design value.

C. Shaft end float limits of sleeve or tilting pad guide bearing motors shall be marked with a light indelible groove on the shaft and indicator on the housing to show its normal free running position. The end-float on either side of the magnetic centre shall be so co-ordinated with the coupling maximum end float that shaft thrust against bearing cheeks shall not damage the motor in any way.

Measure and record the shaft extension total indicator run-out of all motors. These run out measurements must be within the following limits and recorded in Technical Schedule C:

D. 0.025 mm for shaft extensions that are below 45 mm in diameter

E. 0.038 mm for shaft extensions that are above 45 mm in diameter.

3.5.6. Static Electrical Tests

3.5.6.1. Stator Coil Tests

All coils installed in the stator shall have interturn insulation surge/impulse tested in accordance with IEEE Std 522, while tests conducted on sample coils shall be conducted in accordance with SANS IEC 60034-15.

A. The impulse generator used shall, therefore, be capable of generating impulses with peak values in excess of 50 kV and front rise times of 0.1 to 0.2 μs. The test voltage and wave shape of the impulse wave shall be subject to the *Employer*'s approval.

B. Coils that have not been resin impregnated shall be tested with the impulse level that is no higher than 75% of that specified for fully cured coils.

C. Coil inter-turn insulation surge/impulse withstand capability tests shall, as a minimum, be conducted during the following manufacturing steps:

   C.1. Each coil in the winding shall be tested after coil installation, wedging and bracing, but before any connections are made.

   C.2. After all connections are made, but before insulating any coil interconnecting leads--including connections for and between phase groups. Comparisons between individual coils and phase groups shall be conducted at this stage.

D. Two extra coils from the batch for each motor shall be subjected to interturn and groundwall insulation testing, as well as destructive tests to determine interturn and groundwall insulation breakdown voltage levels.

E. For all sample tests, the test specimens shall be selected by the *Employer*, or its authorised Technical Representative, who will witness the tests.

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F. Records of all tests conducted on coil sides shall be held by the *Supplier* for inspection by the *Employer* or its authorised representative.

3.5.6.2. Tan-δ Test

A. Tan Delta tests shall be conducted on each winding insulation by measuring and recording power/dissipation factor and capacitance, while the other two are shorted to ground, for the completely cured windings. An appropriate size 50 Hz AC test unit to provide the required measurements at applied voltage from 20% to 100%, at 20% increments, of motor rated line-to-line voltage shall be utilised. The accuracy of the bridge shall be, at worst, 1%.

B. Test conditions that are to be recorded are; ambient temperature, relative humidity, stator winding temperature, and test voltage at each test point.

C. The characteristics to be calculated and evaluated for each winding are;

C.1. Tan-δ at 20% and 100% of rated voltage,

C.2. The change in Tan-δ (ΔTan-δ) between two incremental points from 20% through to 100%,

C.3. Tan-δ Slope (Tip-up) value from the 20% and 60% voltage points, and

C.4. The change in Capacitance (ΔC) between the 20% and 100% voltage data points.

D. The acceptance criteria are as detailed in Table 5 below:

Table 5: Tan-δ Acceptance Criteria

Characteristic	Acceptable Limit
1. Tan-δ at 20%V_L	≤ 0.01
2. Tan-δ at 100%V_L	≤ 0.03
3. Change in Tan-δ (ΔTan-δ)	≤ 0.006
4. Tan-δ Slope (Tip-up)	≤ 0.006
5. Change in Capacitance (ΔC)	≤ 3%

3.5.6.3. Winding Insulation Resistance Tests

Insulation Resistance tests shall be conducted to check and confirm the integrity of the stator winding insulation. Recorded data shall include IR_{30}, IR_1, and IR_{10}, to calculate DAR and PI on each phase-to-earth, where the neutral point is accessible, and all phases to earth. Table 6 has the specifications for conducting IR tests on MV motors.

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Table 6: Insulation Resistance Test Specifications for New MV Motors

Motor Rated Voltage [V]	Test DC Voltage [V]	Acceptance Values for IR_1		Acceptable PI		Acceptable DAR	
		Min.	Critical	Min.	Critical	Min.	Critical
3 300	2 500	100	16.5	2.0	1.5	1.5	1.25
6 600	5 000	150	33				
11 000	5 000	200	60				

Notes:

1. The motor rated voltage is, by definition, the rated Line-to-Line Voltage of the machine
2. The Polarisation Index, $PI = \frac{IR_{10}}{IR_1}$ and shall be disregarded if the corrected IR_1 is above 5GΩ
3. The Dielectric Absorption Ratio, $DAR = \frac{IR_1}{IR_{30}}$ is the quicker version of PI
4. The critical IR_1 acceptance values (Ω) are calculated from the rated voltage (kV) and specific critical resistance using the equation; $IR_{1-critical} = kV_{rated} \times 5M\Omega/kV$
5. If the measurements are performed at winding temperatures other than 25 °C, the measured value will need to be converted to the reference temperature of 25 °C in order to be able to compare the values with the specified limits. The insulation resistance is reduced by a factor of a half for every 10°C increase in temperature, and it is increased by a factor of two for every 10 °C decrease in temperature.
6. The minimum corrected IR_1 values are applicable to all phases-to-earth (entire winding) on windings with insulation that consists of glass backed mica paper bonded with epoxy resin. Minimum IR_1 on one phase-to-earth, with the other two phases earthed, should be double that of the entire winding.

A. Winding insulation resistance shall be considered “UNACCEPTABLE” if the measured values for IR_1 and PI are below the minimum values specified in Table 6.

3.5.6.4. Winding Resistance Test

A. Measure the three line terminal-to-terminal stator winding DC resistance values, i.e., R_{UV}, R_{VW} and R_{WU} to confirm that the winding has been correctly connected and insulated. The measured resistances must be corrected to the reference temperature of 25 °C and percentage imbalance ($R_{imb.}$) calculated from the corrected values. Acceptance criteria from the test results are that;

A.1. The corrected values must be equal to the design values, and

A.2. $R_{imb.}$, as determined from $R_{imb.} = \left(\frac{R_{Max.\,Deviation\,From\,Average} - R_{Average}}{R_{Average}} \right) \times 100\%$ does not exceed 1.0%.

B. Motors with either duplicate or parallel winding terminals shall have the winding resistances measured on one terminal box with all internally connected line terminals on the two terminal boxes shorted to each other, e.g. U1-1 shorted to U1-2, with leads between the two terminal boxes. This method of measurement shall prove the correct phasing of internal line terminal connection between the terminal boxes.

B.1. Deviation from winding resistances measured without external terminal short circuiting and/or imbalance above acceptance criterion is indicative of incorrect phasing on internal line terminations

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3.5.6.5. Locked Rotor Test

This test shall be conducted when the motor winding temperature is within 5°C of ambient temperature.

A. All measurements of Power Input, Voltage, Current, and Torque shall be taken simultaneously.

B. A three phase locked rotor test shall be conducted only on the motor that is being type tested. With the shaft locked, a variable three phase power is supplied to induce rated full load current and the input power and torque is measured either directly or approximated from the equation;

$$T = \frac{8.69\left(P_1 - P_w - P_{fe}\right)}{n_s}$$

where; T is torque, in N·m,

P_1 is the input power to stator, in W,

P_w is the stator I^2R loss, in W, at the test current,

P_{fe} is the stator iron loss in W, at test voltage

n_s is the motor synchronous speed

C. Single phase locked rotor test shall be conducted on all induction motors. Single-phase power of rated voltage and frequency shall be applied to any two of the three-phase machine line terminals, and current and power input measurements recorded. The values obtained must be compared with those measured on a duplicate unit that has been subjected to a type test three-phase locked rotor test.

C.1. With a three-phase machine, the line current should be approximately 86% and the power input (P_1) approximately 50% of the corresponding values obtained with three-phase locked rotor test on a duplicate motor.

3.5.6.6. Accessory Tests

A. Space heater/s shall have the following tests conducted;

A.1. The insulation resistance (IR_1) with respect to the motor frame must be checked to exceed a value of 10 MΩ when measured at 100 V DC.

A.2. Total heater element resistance at the heater terminals in the auxiliary terminal box.

B. The bearing insulation resistance shall be measured, with a 500 VDC megohmeter, on a stationary motor either during assembly or with the motor completely assembled. Bearing insulation can also be checked while the motor is running during a no-load test. Acceptance criteria for bearing insulation is:

B.1. Insulation resistance ≥ 1 MΩ, or

B.2. Shaft voltage (shaft end to shaft end) ≤ 100 mV for rolling element bearings, and

B.3. Shaft voltage ≤ 200 mV for sleeve bearings, whichever is applicable.

3.5.7. Performance Tests

3.5.7.1. General Requirements

A. One of the first motors of each group of identical motors shall be given a Type Test and a Routine Test to prove compliance with the quoted performance.

B. Additional motors for the same application shall be type tested if any one of the following is true;

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B.1. The *Employer* has placed a different order

B.2. The design has been modified for whatever reason

B.3. The period of manufacture between the previous motor/group exceeds two months

B.4. The routine test results differ from that of the type tested motor by more than ± 5%.

C. Procedures for the routine and type tests shall be in accordance with either SANS IEC 60034-1 and 60034-2-1 or IEEE Std 112.

D. Test results shall be reported on *Employer* form/s in accordance with test certificate requirements.

E. The acceptable performance testing methods are illustrated in Table 7, which provides the list in the order of preference.

Table 7: Acceptable Performance Testing Methods for MV Motors

Test	Motor Rating	Preferred Method	1st Alternative	2nd Alternative
Losses	All	Separate Losses		Total Losses
Stray Load Loss	All	Indirect	Direct	Assumed
Loading	P < 800 kW	Actual Loading	Actual Loading Only	
	0.80 ≤ P ≤ 5 MW		Primary-superimposed Equivalent	Actual loading to ≥ 50%, and extrapolate to 100%
	P > 5 MW		Primary-superimposed Equivalent	Reduced Voltage
Temperature Rise (ΔT)	All	Resistance & ETD	Resistance	ETD
Specified Temperature for efficiency tests	P ≤ 5 MW	ΔT + 25°C	Specified temperature for the duplicate motor, determined as per preferred method	
	P > 5 MW	ΔT + 25°C	Duplicate motor's	Design Temperature Rise, by Resistance Method, Plus 25°C
Efficiency	P < 800 kW	Dynamometer Loading with Torque Measurement (IEEE Method B)	Dual Supply – Back to Back test (IEEE Method C)	Dynamometer Loading without Torque Measurement (IEEE Method E)
	0.80 ≤ P ≤ 5 MW	Direct Methods (excl Eh-star)	IEEE Method E or equivalent	Calibrated Equivalent Circuit Method (IEEE Method E/F)
	P > 5 MW	Direct Methods	IEEE Method E/F or equivalent	Equivalent Circuit Method (IEEE Method F)

F. The method of performing the required tests, if different from the *Employer* preferred method/s shall be agreed upon with *Employer* prior to the issuing of a purchase order. If the *Supplier* cannot comply with the preferred test method requirements, it should be so stated in the tender together with details as to intended tests. Failure by the *Supplier* to declare, in the tender, inability to conduct the required tests using the *Employer* preferred test methods may result in the *Employer*

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commissioning motor tests at any *Employer* preferred test facility, which shall be for the *Supplier*'s account.

G. If results obtained on routine tests on a particular motor differ significantly from those obtained on the complete tests on its prototype, the *Employer* may require that the motor be given a complete Type Test to determine the extent to which the motor differs from its prototype.

3.5.7.2. Electrical Checks and Tests Prior to Test-run

The following electrical tests/measurements shall be performed on the motor after assembling and prior to the no-load test-run to be witnessed by the *Employer's* Technical Contact. These tests shall also be witnessed by the *Employer's* Technical Contact and recorded on the pre-run test data section of the Routine Test Certificate.

A. Stator Winding Resistance and percentage imbalance;

B. Stator Winding IR, DAR, and PI,

B.1. If the measured and corrected IR_1 and calculated PI are less than specified critical limit values, the windings must be dried prior to motor testing. If the measured values are within 120% of critical acceptance criteria, the motor may be energised for test-running and the insulation resistance tests subsequently checked at the completion of the test-run.

B.2. Unless otherwise specified in the Contract, the acceptance criteria for the motor to be delivered, regardless of other test results, is that IR_1 and PI test results must exceed minimum acceptable values of Table 6.;

C. Space Heater and winding ETD IR tests and functional checks;

D. Bearing RTD/Thermocouple Functional Checks;

E. Bearing insulation IR (if applicable);

F. Rotational direction with supply phases L1, L2, and L3 connected to U1, V1, and W1. When viewed from DE, the direction of rotation shall be clockwise.

G. Locked rotor.

3.5.7.3. Test Power Supply and Instrumentation Quality

Due to the effect of power supply quality on the electrical machine performance, it is essential that a suitable source of power and careful measurement with accurate instrumentation are employed for correct data and performance to be obtained. The test facility shall therefore have the power supply source and instrumentation that is capable of meeting the following requirements throughout the test duration;

A. The harmonic distortion coefficient, THD, shall not exceed 0.05.

B. The voltage unbalance shall not exceed 0.5%.

C. The frequency shall be within ±0.5% for routine test, and ±0.1% for performance test of motor rated frequency. The power supply frequency range is, therefore, limited to 49.75-to-50.25 Hz for routine test, and 49.95-to-50.05 Hz for performance test.

D. Variations in frequency during a test shall not exceed 0.33% of the average frequency.

E. Power supply quality shall be monitored, and automatically controlled throughout the test duration. The supply conditions shall be recorded throughout the tests, and such records must form part of the motor test record.

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F. The accuracy of instrumentation used to measure test data shall be in accordance with SANS IEC 60034-2-1 requirements.

G. The capabilities of vibration measurement instruments shall include the following;

G.1. Can measure displacement, velocity, acceleration, and phase.

G.2. The software must be able to convert the vibration time waveform between acceleration and velocity.

G.3. Minimum zoom factor of 10 to enable high-resolution spectral analysis. The analyser shall therefore be able to permit time period (maximum frequency) settings of 12 000 CPM (200 Hz) for 1 600 lines of resolution by machine speed.

G.4. Log amplitude scale

G.5. Wide frequency response range of 0 Hz – 20 kHz, as a minimum, for standard vibration measurements. To reliably detect all calculable rolling element bearing defect frequencies, high-frequency vibration analysis instruments that have a frequency response range of 25 kHz – 36 kHz are required.

G.6. Plots that can be produced include;

G.6.1. Time waveforms

G.6.2. Plots of overall vibration amplitudes

G.6.3. Vibration amplitudes in specific frequency bands

G.6.4. Trend plots

G.6.5. Bode plots

G.6.6. Vibration spectrum and overall vibration in one measurement

H. Recording of run test data shall be computerised and automatically transferred from the measuring instrument onto the test report, without human interference.

3.5.7.4. Routine Test Run

All new motors shall be ran uncoupled with either the half-key or coupling fitted at rated frequency and voltage in accordance with SANS IEC 60034-2-1 to determine constant losses and other performance parameters.

A. The routine test run shall be conducted with the motor completely assembled.

B. Bearings shall be lubricated and cooled as they are designed to be in service, i.e. flood lubrication system and

C. Snapshot measurements that are to be recorded every 15-minutes, with the first set as soon as the motor testing power supply requirements are met, are;

C.1. Input power,

C.2. Line voltages,

C.3. Line currents,

C.4. Shaft speed,

C.5. Supply frequency,

C.6. Bearing temperatures and bearing coolant inlet and outlet temperature, and

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C.7. Winding temperature from the highest reading ETD, and winding coolant inlet and outlet temperatures.

D. The test run shall be long enough to allow the motor to reach stability, which is when bearing temperatures and no-load losses have reached equilibrium. Motor stability shall therefore be considered reached when, at two successive 30 minute intervals;

D.1. The no-load power input at the same voltage varies by not more than 3%, and

D.2. The change in bearing temperatures (ΔT), taking coolant temperature changes into account, is within 1°C.

E. Cold and hot motor horizontal, vertical, and axial vibration measurements shall be taken on both bearing housings.

E.1. For time waveform analysis, standard resolution measurements shall be taken on all directions with the vibration analyser set to 1600 lines of resolution and maximum frequency to at most 30 kCPM (500 Hz). The direction that exhibits the highest standard resolution vibration on either end shall have high resolution measurements taken with the analyser set to no less than 3200 lines of resolution and maximum frequency to at most 12 kCPM (200 Hz).

E.2. Cold vibration levels shall be taken within five minutes of the motor being started. Other vibration measurements must be taken at 30-minute intervals until thermal stability has been reached.

E.3. Hot vibrations measurements shall be conducted when stability has been attained.

E.4. Acceptance criteria for bearing vibrations with the new motor solidly bolted to the floor include the following;

E.4.1. Overall vibration levels shall not exceed;

E.4.1.1. 1.8mm/s for 2-pole motors

E.4.1.2. 1.5mm/s for 4-pole motors

E.4.1.3. 1.0mm/s for 6-pole motors

E.4.1.4. 0.8 mm/s for 8-pole motors

E.4.1.5. 0.6mm/s for 10-pole motors

E.4.1.6. 0.4mm/s for 18-pole motors.

E.4.2. The change between cold and hot vibrations shall not exceed 15%.

E.4.3. Vibration spectra for rolling element bearings shall not show any bearing defect frequencies being emitted.

E.4.4. Electrical defects are not acceptable.

F. The acceptance criteria for bearing temperature rise when the motor has reached stability are;

F.1. For Ball and Roller Bearings;

F.1.1. 35°C on motors with 4 or more poles

F.1.2. 40°C for 2 pole motors.

F.2. For Sleeve and Tilting Pad Bearings;

F.2.1. 45°C for vertical motors when measured by the ETD on thrust pads,

F.2.2. 30°C for on motors with shaft diameter less than 70 mm,

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F.2.3. 40°C for 2 and 4-pole motors with shaft diameter between 70 and 100 mm,

F.2.4. 30°C for 6-pole and slower motors with shaft diameter between 70 and 100 mm,

F.2.5. 45°C for 2 and 4-pole motors with shaft diameter between above 100 mm,

F.2.6. 35°C for 6-pole and slower motors with shaft diameter above 100 mm,

G. Other measurements and checks that shall be conducted and recorded during the rated frequency and voltage test run are;

G.1. Shaft Voltage,

G.2. Bearing oil and grease leaks,

G.3. Rotor magnetic centre for horizontal motors with sleeve or tilting pad bearings. Requirements for the magnetic centre include; position

G.3.1. The location of the shoulder on the rotor, relative to a fixed point on the on the DE bearing bracket, when the motor is running on magnetic centre, shall be indicated by a nameplate attached to the motor DE end-shield above the bearing. Such a nameplate shall describe the dimensions it provides, e.g. Magnetic centre = Shaft Shoulder at 200mm from bearing bracket.

G.3.2. The magnetic centre line should be provided with a sharp marker from the bearing bracket.

G.3.3. The running motor magnetic centre shall not shift from either side of the geometric centre by more than 20% of the total end-float. An example is that the magnetic centre on a 10 mm end-float shall be within 2 mm of the geometric centre (5 mm). If this limit is exceeded, the cause shall be investigated and corrected.

H. No-load loss separation test shall be conducted after all required measurements at rated voltage and stability have been recorded. Recording of winding temperature, average line voltage and current, and power input at rated frequency and at voltages ranging from 120% of rated voltage down to the point where further voltage reduction increases the current.

I. To end the test-run, the following measurements shall be conducted during the motor rundown when it has been de-energised;

I.1. The run-down time for 2-pole motors shall be recorded and abnormal values resolved to the *Employer*'s approval.

I.2. The total end-float for horizontal motors with sleeve bearings.

J. Electrical tests that are to be conducted on a hot motor after the test run are;

J.1. Stator winding Insulation Resistance, Dielectric Absorption (DA), Polarization Index (PI) before and after the following test,

J.2. Stator AC or DC Hi-pot.

J.3. DC Step Voltage Test (if requested)

K. On completion of the bearing run, the sleeve bearings shall be opened up for inspection to verify that there is at least 80% contact between the journal and the white metal surface in the axial direction in the centre portion of the bearing. Bearing scraping shall not be used to meet this criterion.

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3.5.7.5. Type Test

A. The motor shall be loaded, as per preferred loading method, to 25%, 50%, 75%, 100%, 115% and 130% of rated capacity to determine the efficiency at each load point. The loading shall be in descending order, i.e. from highest to lowest load points.

B. The motor efficiencies shall be determined with the machine at the specified temperature.

C. The temperature test shall be conducted on a motor loaded to 100% of its rated capacity.

D. Type tests shall consist of the following measurements/calculations:

D.1. Stator winding temperatures;

D.2. Efficiency and power factor from 25 per cent to 125 per cent load, in 25 per cent increments;

D.3. Rated load slip;

D.4. Rated load stator winding and bearing temperature rises;

D.5. Three-phase locked rotor current and torque;

D.6. Speed/torque and speed/current characteristics; and

D.7. Vibration at full load.

E. The permissible temperature rise for all motors shall be in accordance with limits specified in the Thermal Class section. The final temperature and the slip or speed at the reduced voltage shall be recorded. Where it is not possible to load a motor fully in the works, the *Employer* may accept the "mixed frequency" method of temperature rise testing provided the manufacturer can justify the results obtained by this method. A partial load test may also be used subject to the same stipulation. If approved, the temperature rise test may be done on site.

F. The stator winding temperature used to calculate the rated load temperature rise shall be determined from both the rated test resistance method (the Resistance Method), and the directly measuring ETDs (the ETD Method). Both methods shall yield temperature rise within acceptable limits for the specified Thermal Class for motor acceptance.

G. For fault-withstanding terminal boxes as specified in the terminal boxes clause, test certificates shall be submitted to show that a prototype terminal and cable box assembly complete with all attachments has been type tested under internal short-circuit conditions and that the pressure relief diaphragm ruptured, protecting the terminal box from serious distortion. The certificates shall also show that a through-fault current test was made to demonstrate that the complete assembly is capable of handling the short-circuit current without damage. The fault current for these tests shall be 45 kA for a duration of not less than 0,25 s.

3.5.7.6. Test Certificates

A. Before the motors can be delivered, type/performance test certificates shall be submitted to the *Employer* for approval. These certificates shall show measured and/or calculated figures of efficiency, power factor, current and slip versus kW load (from 25% to 125% of rated load, in 25% increments) at rated voltage.

B. Routine test and static test certificates for all motors shall be submitted to the *Employer* within one month of delivery.

C. Motor test results shall be recorded on the *Employer* standard forms in Appendix E and Appendix F. *Suppliers* may use their own standard report forms, but the forms must be amended or supplemented, as needed, to clearly and completely cover any reporting items required by the *Employer* standard forms. Use of *Supplier* standard forms shall be approved by the *Employer's* Technical Contact.

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D. The *Supplier*'s test reports shall include the results of all tests performed, whether the tests are specifically required herein or not.

3.6. Storage, Packing and Shipping

Motors shall be prepared for shipment and storage as follows:

A. Motors shall not be delivered without agreement of readiness to receive them. Motors delivered without such approval may be returned at the *Supplier*'s expense for later delivery at no extra cost to the *Employer*.

B. Release for shipment of each motor shall be made after all tests and inspections have been completed and the *Employer* has approved the motor test results required in the section labelled Test Certificates.

C. The motor preparation shall be suitable for indefinite indoor storage from the time of shipment in a manner requiring no disassembly prior to operation. The preparation for shipment shall include the following items:

C.1. All machined or finished surfaces shall have a protective coating applied to them to prevent rusting.

C.2. After being thoroughly drained and cleaned, internal areas of bearings and all auxiliary equipment in oil lubrication systems using carbon steel shall be coated with suitable oil soluble rust preventive.

C.3. Flanged openings shall be provided with metal closures at least 6.00mm thick with synthetic gaskets.

C.4. Threaded openings shall be provided with steel caps or solid steel plugs.

C.5. Lifting points or lugs shall be clearly marked. The motor's centre of gravity shall be located in the centre of lifting points. If the centre of gravity is not located centrally between the lifting points, the hoisting hook must be positioned above the centre of gravity.

C.6. The motor shall be mounted on a rigid skid or base suitable for handling by forklift, truck, or crane. The total motor weight shall be clearly marked on the packaging.

C.7. The rotor shall be blocked to prevent axial and radial movement.

C.8. The space heater terminal box shall be accessible without disturbing the shipping package and shall be suitably tagged for easy identification.

C.9. Each motor packaging shall be properly identified with securely affixed, corrosion-resistant metal tags indicating the *Employer* Order Number and motor description, and *Supplier*'s serial number. This is similarly applicable to all materials shipped in separate crate/s.

C.10. Motors shall be transported and hoisted in a position corresponding to their mounting position.

C.11. The motor shall be shipped to the *Employer* in an enclosed truck or be covered by a tarpaulin if an open truck is used. Covers or tarpaulins used to protect the equipment against the weather must not make contact with the motor surfaces. Wooden spacer blocks shall be placed between the motor and such covers for adequate air circulation.

C.12. The *Supplier* shall provide the *Employer* with instructions necessary to preserve the integrity of the storage preparation after the equipment arrives at the job site.

D. Unless otherwise indicated by the *Employer*, motors shall be stored in accordance with the Eskom Electric Motor Storage Specification 240-56360387. The following instructions for motor storage in a suitable storage facility shall, however, have to be included in the motor package:

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D.1. Directions on any unpacking to be done once the motor arrives at its storage facility, e.g. removal of drain plugs

D.2. Directions on how frequently the shaft should be rotated and the number of rotations it is to be given if the motor is placed in storage.

D.3. Bearing re-lubrication interval together with the method of lubrication and the quantity, type and grade of lubricant to be used.

D.4. Frequency of stator winding insulation resistance measurements to verify they remain dry and clean while the motor is in storage.

D.5. Any specific storage instructions for the motor.

3.7. Installation and Commissioning

Whenever the installation and commissioning is undertaken, the following requirements shall be applicable.

3.7.1. General

A. The *Supplier* shall re-establish the full warranty period, from the date of installation, if the following installation and commissioning requirements are met for motors installed within 12-months of delivery:

A.1. Mechanical visual inspection of the motor exterior by the *Employer.*

A.2. Prior to the motor being transported from storage to its installation position and prior to power connections being made, Insulation Resistance tests shall be conducted to check and confirm serviceability.

A.2.1. New motors shall be considered “NOT READY FOR SERVICE” if the measured and corrected IR_1 and calculated PI are below the critical values specified in Table 6, and the windings will have to be dried prior to installation/commissioning.

A.2.2. If the measured values are within 120% of acceptance criteria, the motor may be commissioned and the insulation resistance tests subsequently checked to have improved after 1-month of operation but within 3-months prior to the effective warrantee period expiring.

B. If the motor has to be commissioned 12-months or more after despatch, the *Supplier* shall re-establish the full warranty period, from installation, if the following requirements, in addition to the above, are met prior to test-running:

B.1. Motors are visually inspected for possible damage on, where possible; partially exposed windings; and sleeve bearings.

B.2. Ball and roller bearings shall be re-greased;

B.3. Sleeve bearings, if not force fed, shall have lubrication oil replaced with new oil; and

B.4. Manual shaft rotation prior to energising. If no roughness is felt when the shaft is rotated by hand, the bearings will be considered acceptable. If the bearings fail or exhibit the symptoms of brinelling during the guarantee period they shall be replaced by the *Supplier*, which shall be for the *Supplier*’s account, and without delay.

C. For motors commissioned 12-months or more after despatch, the general installation and commissioning requirements to re-establish the full warranty period from installation, shall be conducted by the *Supplier.* The *Employer* shall give the *Supplier* at least 5-days’ notification of installation and commissioning dates. The *Employer* reserves the right to conduct the installation and commissioning requirements without the *Supplier,* if the *Supplier* fails to provide necessary resources on the intended date of installation and commissioning.

D. If the *Employer* deems the motor to be “READY FOR SERVICE” after the minimum required tests and inspections, the *Supplier* shall re-establish the full warranty period from installation.

E. If the *Employer* deems the motor “NOT READY FOR SERVICE” after the minimum required tests and inspections, the *Supplier* shall conduct necessary remedial tasks to re-establish the full warranty period from installation, which shall be for the *Employer*’s account. Any remedial task shall be conducted in accordance with the *Employer’*s specification/procedure or, if not specified, the *Supplier*’s specification/procedure. The *Supplier*’s procedure shall be applied after the *Employer* approval, which shall not be unreasonably declined. If the remedial tasks include motor dry-out, such shall be in accordance with the Motor Drying specification below.

3.7.2. Installation

The following requirements are applicable when MV motors are erected:

A. Remove any shipping braces/brackets that may be in place before installation

B. Sufficient packets to accommodate the dimensional tolerances shall be provided in appropriate locations to allow for adjustments in height.

C. Before the base-frame or bed-plate holding-down bolts are grouted in, the motor shall be lined up and the bolts properly centred in the hole of the bed-plate,

D. When aligning the motor and its base-frame or bed-plate the bolts holding the motor to the base frame or bed-plate shall be centralised in the motor holding-down bolt holes.

E. The unused shaft extension of a double-ended shaft motor shall be covered with approved rust preventer when the motor is commissioned.

F. The cross section of the ground conductor shall be in accordance with SANS IEC 60204-1 installation and erection regulations.

3.7.2.1. Alignment

A. After erection, the alignment of the half-couplings between the motor and the driven machine shall be measured. In the case of a pedestal bearing motor, the air-gap clearances between the rotor and the stator shall also be measured. A record shall be kept of these figures and they shall be submitted to Eskom’s site representative for his approval.

B. The motor manufacturer or his representative shall, at no extra charge to Eskom, satisfy himself that the alignment and air-gap clearances are acceptable and he shall be present and assist with motor related aspects when the driven machine and its auxiliary plant is commissioned.

3.7.2.2. Electrical Tests

A. Uncoupled test run in the correct rotational direction. The shortened test-run shall be conducted after motor alignment to driven load. The motor shall be test ran at rated voltage and frequency for at least 15-minutes, during which the following measurements are recorded as base values and for analysis:

A.1. Cold bearing vibrations;

A.2. Current on each phase;

A.3. Supply line voltages and frequency; and

A.4. Shaft rotational speed.

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B. Motors with horizontal sleeve bearings or limited end-float roller bearings shall be run uncoupled from loads to ensure that they rotate at the axial positions indicated on their shafts and that their rotors are free to move to either side of these positions. Particular attention shall be paid to ensure that the free running positions and the rotor end-floats are within the axial movements allowed by the flexible couplings.

3.7.2.3. Terminal Connections

Make power cable connections, and ensure that;

A. the contact surface is clean and bright, and is protected with a suitable anti-corrosion agent, e.g. acid-free Vaseline.

B. the flat and spring washers are located under the bolt head, if applicable.

Before closing any of the terminal boxes, check that;

C. the cables are connected in accordance with the terminal diagram inside the terminal box cover.

D. the inside of the terminal box is clean and free of any cable pieces.

E. the cable glands are firmly tightened, and are suitable regarding the degree of protection,

F. type of cable routing, permissible cable diameter etc., and have been mounted in full compliance with the specifications and regulations.

G. the connecting cables are laid in an open arrangement, and the cable insulation cannot be damaged.

H. any cable entries which are not used are sealed and the plugs are tightly screwed in (i.e. so that they can only be removed using the suitable tools).

I. all of the seals/gaskets and sealing surfaces of the terminal box are in a good condition.

J. for screw terminals, ensure that all of the terminal screws have been firmly tightened (this also applies to terminals which may not be used)

3.7.2.4. Uncoupled Test Run

All motors shall be inspected and test-ran after installation but prior to coupling to driven load. The run-time must be at least 15 minutes, but preferably either 1-hour or until bearing temperatures stabilise. The following checks shall be made during the uncoupled test-run:

A. **Motor direction** – Check shaft rotational direction

B. **No load current –** Check and record the no load current at the correct rotational direction

C. **Vibration –** Vibration levels at no load and vibration analysis.

D. **Bearing condition** – Check bearing temperature at no load.

E. **Ventilation system and stator rubs** – Check winding temperature at no load.

3.7.3. Commissioning

After assembling the motor in line with technical requirements and before commissioning the system, check that:

A. the motor has been assembled and aligned properly.

B. the motor is connected up in accordance with the specified direction of rotation.

C. the bearings have been re-greased (depending on model). Rolling-contact bearing motors which have been in storage for more than 2 years must be re-greased.

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D. any supplementary motor monitoring devices and equipment have been correctly connected and are functioning.

E. that if bearing thermometers are fitted, the bearing temperatures are checked during the initial run of the motor and the values for warning and switch-off are set on the monitoring device.

F. the minimum insulation resistance values and the minimum air gap values are satisfied.

G. that the grounding and equipotential bonding connections have been correctly made.

H. any bearing insulation which may be present has not been bridged.

I. if the second end of the shaft is unused, its feather key has been secured so that it cannot fall out and the open shaft end is covered.

J. all separately driven fans fitted are ready for operation and have been connected such that they rotate in the direction specified.

K. the flow of cooling air is not impeded.

3.7.4. Motor Drying

Motors that do not have a thermosetting resin insulation system and whose polarisation index (PI) and insulation resistance (IR_1) are lower than the specified minimum values of Table 6 shall be dried-out before such motors are connected to the supply. Low IR_1 measurements on motors with thermosetting resin insulation system cannot be solved by drying out; therefore, such motors shall be deemed not ready for service and the *Supplier* shall, at own cost, determine and resolve the cause of low resistance value. Requirements for the dry-out process on applicable insulation systems are as follows:

A. Equipment and personnel to do the drying-out shall be provided by the *Supplier*.

B. The drying-out process shall be to supply sufficient heat to the windings to produce a winding temperature not greater than 90°C when measured by winding ETDs and 85°C on observable coil surfaces for Class F and Class H insulation systems.

C. The motor shall be sufficiently open to promote escape of moisture from the enclosing motor frame. Removable heat exchangers shall, therefore, be removed during the dry-out process. Use of forced-air draft electric fans or blower is advisable where feasible.

D. It is critical that the applied heat does not create vapour pressure build up that can cause damage such as rupturing to the winding insulation. This shall be achieved by ensuring that the rate of winding temperature rise is limited to;

    D.1. 10°C per hour for the motor that has been dampened by moisture pick-up from the atmosphere; or

    D.2. 5°C Per hour for the motor that has been dampened by being thoroughly soaked with water.

E. Progress of the dry-out shall be checked and plotted in sequence as follows:

    E.1. Insulation resistance measurements, which may be conducted at lower test voltages than specified in Table 6 to avoid puncturing a wet insulation, and winding temperature readings shall be taken regularly every half hour from the start of the dry-out until the motor attains an even winding temperature that shall not exceed the maximum level of either 90°C or 85°C indicated above.

    E.2. With even temperature attained, the insulation resistance and winding temperature measurements shall thereafter be taken every hour. Winding temperature, which shall be kept constant/steady at even temperature, shall be used to correct the measured IR_1.

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E.3. The time vs. corrected IR_1 characteristics shall be plotted to assess the point at which the motor is dried out. The graph, with the *Supplier*'s recommendations, shall be submitted to the *Employer*'s representative for acceptance before the dry-out is terminated.

E.4. The dry-out should be considered complete if the previously benchmarked dry insulation resistance is reached and successive IR_1 measurements show stability. Use of benchmark dry IR_1 is necessary to avoid false interpretation of the dry-out curves when stability appears to be reached at below normal IR_1 values due to entrapped moisture or local hot spots that result in IR_1 sharply rising once moisture is released. A compromise consideration, if the dry-out duration is too long, may be to deem the dry-out as complete when successive IR_1 measurements show constant resistance that is higher than the minimum acceptance value in Table 6.

F. Failure of the *Supplier* to achieve approval of the dry-out shall entitle Eskom to reject the motor concerned.

G. The method to be adopted for generating heat shall be, in the order of preference, either;

G.1. The internal warming method, which produces heat in the winding conductor where it is most effective in driving out moisture. A suitable and adjustable voltage source shall be used to circulate up to rated current through the windings. To limit temperature rise to safe levels specified above, the voltage shall be adjusted such that the initial current is low and increased gradually until the desired even winding temperature is reached.

G.2. The external warming method, which produces heat by means of either; space heaters located in and around the machine, or; oven heating. Where oven dry-out is necessary, the clean hot air in the oven shall be forced through the motor by an electric fan or blower. The air temperature in the oven shall be monitored, recorded and controlled not to exceed 105°C. The motor winding temperatures shall also be monitored, recorded, and fed back to the oven control system to not exceed 90°C. The time stamped record of the oven dry-out process shall be kept and provided to the *Employer* for record keeping.

H. Any motor that fails as a result of being commissioned in a damp condition shall be repaired at the expense of the *Supplier*, provided the *Employer* had notified the *Supplier* and the motor had, in accordance with installation requirements, been found to be ready for service.

3.8. MARKING, LABELING AND PACKAGING

A. All device symbols and terminal markings shall be in accordance with SANS IEC 60034-8.

B. Terminations for temperature measuring devices shall be:

B.1. PT100 wires/cores are to be labelled at the termination point, in the format; (RTD Number) (R) (RTD Terminal Number) (Winding Number), e.g. 1R11 for the 1st terminal of RTD No:1 in Winding No:1 (U-Phase) , and 6R23 for the 2nd terminal of RTD No:6 in Winding No:3 (W-Phase). The RTD terminal number shall be the same for wires connected to the same terminal on RTDs with more than two-wires, e.g. four-lead PT100 devices.

B.2. Bearing thermocouples whose termination cores and lugs shall be colour coded to denote polarity and be labelled; (Bearing Location (1=DE & 2=NDE)) (TC) (Polarity (1=Positive & 2=Negative)), e.g. 1TC1 for the DE Positive terminal and 2TC2 for the NDE Negative terminal, etc.

3.9. SPARES

A. Each design shall have a completely serviceable spare motor.

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B. Additional spare motors for designs whose application unavailability results in direct load loss shall be provided. This provision may be in the form of shared additional spares with other Eskom Power Station/s.

C. All motors with friction type bearings, e.g. sleeve bearings, must have a spare set of serviceable bearings in storage.

D. The quantity of items in storage shall be such that no load loss of more than 100MW may persist for more than one day, once a year, i.e. 2,400 MWh.

4. AUTHORISATION

This document has been seen and accepted by:

Name	Designation
	Rev 1 Document Approved by TDAC ROD 16 July 2013
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5. REVISIONS

Date	Rev.	Compiler	Remarks
October 2012	0	PJ Khumalo	New document on new template. Split MV motor specification from LV motor requirements
October 2012	0.1	PJ Khumalo	Updated to style template by C Bunce
October 2012	0.2	PJ Khumalo	Removed appendices that have normative forms created and refined document
October 2012	0.3	PJ Khumalo	Draft Document for Comments Review
November 2012	1	PJ Khumalo	Final Document for Authorisation and Publication
October 2014	1.1	PJ Khumalo	Correct numbering and naming of some hyperlinks updated
October 2014	2	PJ Khumalo	Final Document Rev 2 for Authorisation and Publication
March 2017	2.1	M. Manyage	Update to the signatory page, first draft
May 2017	3	M. Manyage	Final Document Rev 3 for Authorisation and Publication

6. DEVELOPMENT TEAM

The following people were involved in the development of this document:

Name	Business Unit
Gert Brink	Arnot Power Station - EPE
Dr Marubini Manyage	Generation Business Unit
Verwy Fourie	Eskom Generation

7. ACKNOWLEDGEMENTS

This document contains information from the following sources:

A. Electric Power Research Institute - EPRI

B. South African National Standards - SANS

C. The Institute of Electrical and Electronic Engineers - IEEE

D. International Electrotechnical Commission - IEC

E. National Electrical Manufacturers Association - NEMA

F. Siemens H-Compact Manual

G. Actom Electrical Machines

H. ABB

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APPENDIX A: NEW MV MOTOR TECHNICAL SCHEDULE A

Technical Schedule A&B found in Eskom Document 240-54783039

Power Supplies

Motors required must be designed to operate with a 50 Hz power supply equipment parameters in Table A2 and quality in Table A3;

Table A2: Motor Power Supply Switchgear Ratings

Nominal Voltage [V]	Neutral Earthing	Earth fault current [kA]	Symmetrical fault [MVA]		BIL kV peak	50 Hz 60 s voltage withstand [kV]	Clearance & Creepage [mm] *
		Maximum	Maximum	Minimum			
11 000	Resistance	0.3	600	480	95	28	270/200/240
6 600	Resistance	0.3	350	280	75	22	200/130/140
3 300	Resistance	0.3	250	200	45	16	110/70/70

- Line-to-line/line-to-earth/insulator creepage.

Power Quality

Table A3: Quality of Motor Power Supply

	Normal Conditions	Abnormal Conditions	
		Abnormal (Sustained up to 6 h)	Transient (Voltage within ±10 % of nominal for 3 minutes after the transient defined below)
Voltage [% of nominal]	**± 5 %**	**± 10 %**	**1. Complete break for 0.2 s** **2. Voltage down to 75 % of nominal for up to 1s.** **3. Voltage down to 85 % of nominal for up to 60 s.**
Frequency [% of 50 Hz]	**± 2 %**	**+2 % and –3 % for 80 min**	
Simultaneous Voltage & Frequency variations V/f		**1.1 p.u**	
Voltage Unbalance [% of V_2/V_1]	**2 %**	**3 %**	
Waveform [% ΔV_{max} from V_{ph}]		**5 %**	
Harmonic Distortion	• **THD = 5 % of fundamental voltage** • **Voltage waveform can contain harmonic waveforms up to the 100^{th} harmonic** • **The amplitude of any individual component can be up to 1 % of the fundamental component.**		

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APPENDIX B: DEVIATION SCHEDULE

DEVIATION SCHEDULE		
1. Any deviations/modifications/alternatives offered to this standard specification shall be listed below with reasons for the departures. 2. No deviations/modifications/alternatives offered to the specification will be recognized unless listed on this schedule. 3. If no deviations/modifications/alternatives are offered, this schedule must be marked N/A.		
Specification/ Schedule Page number	Specification/ Schedule Clause number	Proposed deviation/modification/alternative

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APPENDIX C: TECHNICAL SCHEDULE C

MANUFACTURED MV MOTOR TECHNICAL DATA SHEET

Item	Description				Value/Data		
1.	Motor Manufacturer (OEM)						
2.	Machine Designed to Drive						
3.	OEM's Reference Code (Series or Serial Number)						
4.	Motor Frame Size	OEM Code					
		H(A/B/C)D/E dimensions as per SANS IEC 60072-2					
		OEM's Outline Drawing Reference Number					
		Eskom Power Station Drawing Reference Number					
5.	Rated Output				[W]		
6.	Service Factor						
7.	Rated Voltage (V_{rated}) / Phases / Frequency				[V]		[Hz]
8.	Full Load Current (FLC)				[A]		
9.	Full Load Speed				[RPM]		
10.	Construction and Mounting, Enclosure, and Cooling Codes (IM, IP & IC)				IM	IP	IC
11.	Stator Winding Insulation Class and Temperature Rise Class						
12.	Thermal Test Winding Temperature Rise (Resistance / ETD Method)				°C	°C	
13.	Stator Winding Insulation Material						
14.	Method of Stator Insulation Impregnation						
15.	Coil Turn Insulation and Description						
16.	Motor Design Life Expectancy at 100% continuous loading				[Years]		
17.	Winding Coil Surge Withstand Capability (Peak Volts / Rise Time)						
18.	Motor Performance	**Load**	**$\theta_{winding} - \theta_{coolant}$**	**Current [A]**	**PF**	**Efficiency**	**Speed**
		Full Load					
		75% Load					
		50% Load					
		Current, Efficiency and PF vs Load Curve Reference					
		Test Method Used to Determine Motor Performance					
19.	Minimum Starting Voltage (V_{min})				[V]		
20.	Locked Rotor Current (100% V_{rated} / V_{min}) [A]						
21.	Locked Rotor Power Factor						
22.	Safe Stall Time (100% V_{rated} / V_{min}) [s]						
23.	Coupled Starting Time (100% V_{rated} / V_{min})						
24.	Time Required between successive Starts (After Start Trip / Load Trip)				[min]	[min]	
25.	Full Load Torque (FLT)				[N·m]		
26.	Locked Rotor Torque / Breakdown Torque						
27.	Torque vs Speed Curve Reference Number						
28.	Shaft Direction of Rotation viewed from DE						
29.	Cooling Fan Design (Directional or Bi-Directional)						
30.	DE Bearing Type and Size						
31.	NDE Bearing Type and Size						
32.	Bearing Lubricant Type and Grade						
33.	Flood Lubricated Bearing Total Oil Flow / Minimum Supply Pressure						
34.	Flood Lubricated Bearing Maximum / Minimum Oil Inlet Temperatures						

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35.	Sleeve Bearing White Metal Grade			
36.	Bearing Lubricant Maintenance Requirement			
37.	Sleeve Bearing Total Run-out			
38.	Full Load Vibration Limit (on Bearing Housing / Shaft)			
39.	Bearing Insulation Location (if fitted)			
40.	First Rotor Critical Speed			
41.	Stator to Rotor Radial Airgap			
42.	Number of Stator Slots			
43.	Number of Rotor Slots			
44.	Anti-Condensation Heater (Total Rating / Voltage / Phases)	[W]	[V]	
45.	Stator Winding Temperature Detector Type and Number per Winding			
46.	Maximum Allowable Stator Winding Temperature	°C		
47.	Bearing Temperature Detector Types and Number Per Bearing			
48.	Maximum Allowable Bearing Temperature	°C		
49.	Stator Winding (Line-to-Line) Resistance at 20°C	Ω		
50.	Stator Resistance @ Standstill (slip = 1)			
51.	Stator Reactance @ Standstill (slip = 1)			
52.	Rotor Resistance @ Standstill (slip = 1)			
53.	Rotor Reactance @ Standstill (slip = 1)			
54.	Stator Resistance @ Full Load			
55.	Stator Reactance @ Full Load			
56.	Rotor Resistance @ Full Load			
57.	Rotor Reactance @ Full Load			
58.	Magnetic Reactance, X_m			
59.	Magnetic Resistance, R_m			
60.	Rotor Inertia, kg.m^2			
61.	Type of Stator Coil Wedges			
62.	Core Material Grade			
63.	Stator Core Rated Flux Density and Volts Per Turn	[T]	[V/Turn]	
64.	Number of Turns/Phase in Series of Stator Winding			
65.	Rotor Inertia, kg.m^2			
66.	Rotor Type			
67.	Rotor Bar Material			
68.	Rotor End-Ring Material			
69.	Heating Time Constant			
70.	Cooling Time Constant			
71.	Winding Temperature Trip Level			
72.	Bearing Temperature Trip Level			
73.	Negative Phase Sequence Current Capability			
74.	Safe Starting Time			
75.	Starting Current vs Time Curve Reference (for 100%, 90% & 80% V_{rated})			
76.	Torque and Current vs Speed Curve Reference (100%, 90% & 80% V_s)			

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APPENDIX D: MOTOR DELIVERY REQUIREMENTS

Item No:	Site	Motor Application	Abbreviated Motor Ratings			Required Delivery Date	Quantity
			Power [kW]	Voltage [V]	No. of Poles		

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APPENDIX E: STANDARD FORM FOR ROUTINE TEST CERTIFICATE

E.1 Motor Identification and Nameplate Data

Motor Manufacturer (OEM): -- Date of Test: --

OEM's Order No: -- Eskom Contract/Order No: --

Motor Serial No: -- Motor Application/Plant: --

Performance Test on S/No: -- Driven Machine: --

Power [W]	Voltage [V]	Current [A]	Speed [RPM]	Frequency [Hz]	Frame Size	Cooling	Enclosure	Insulation	DE Bearing	NDE Bearing	Lubrication
						IC:	IP:	Class:			

E.2 Motor Design Data

T_{start} [%]	I_{stall} [A]	t_{stall} [s]	Hot & Cold Starts/hr		Stator Slots	Rotor Slots	Rotor Bar Material	PF	Efficiency	$X_{\sigma s}$	X_m	$X'_{\sigma r}$	Outline Dimensions $H(A/B/C)D/E$ [mm]

E.3 Pre-run Test Data

Temperatures [°C]			Stator Winding Resistance [mΩ]						Heater [Ω]		Embedded Temperature Detector Continuity/Resistance [Ω]							
$\theta_{ambient}$	$\theta_{winding}$	$\theta_{bearings}$	R_{UV}	R_{VW}	R_{WU}	$R_{LL\text{-}avg}$	R_{imb} [%]	R_{LL} @ 25°C	Htr-1	Htr-2	ETD1	ETD2	ETD3	ETD4	ETD5	ETD6	DE ETD	NDE ETD

3Φ-E Stator Insulation Res. [MΩ]					Winding Temp. Detector Ins. Resistance R_1-E [Ω]						Bearing TD R_1-E [Ω]		Bearing R_1-Shaft		Heater	Air-Gap Measurement [mm]					
R_{30}	R_1	R_{10}	DA	PI	ETD1	ETD2	ETD3	ETD4	ETD5	ETD6	DE TD	NDE TD	DE	NDE			12	3	6	9	Avg
																DE					
																NDE					

E.4.1 No-load Test Data

Duration to Thermal Stability		Supply-Φ Sequence	DE View Shaft Rotation	Measurements Throughout Test									
Start Time	Duration			V_{UV} [V]	V_{VW} [V]	V_{WU} [V]	$V_0 = V_{LL\text{-}avg}$	V_{imb} [%]	I_U [A]	I_V [A]	I_W [A]	$I_0 = I_{av}$	I_{imb} [%]
h	h												

Stability Time	$\theta_{W\text{-}max}$	θ_c	$\Delta_{\theta W}$	P_0 [W]	PF	f [Hz]	RPM	Iron Loss-P_{fe} [W]	Frict &Wind Loss-P_{fw}	Shaft Voltage	
h	°C	°C	°C							DE =	NDE =

Bearing Measurements															Shaft Run-out (Total = DE + NDE)	
	Temperature Measurements at Thermal Stability								Vibration Measurements (rms velocity) [mm/s]						Total:	DE: NDE:
	Meas. Method	$t_{bearing}$	$t_{coolant\text{-}in}$	$t_{coolant\text{-}out}$	$t_{coolant\text{-}rise}$	$t_{bearing\text{-}rise}$	Coolant $_{flow\text{-}rate}$	Coolant $_{pressure}$	V_{cold}	H_{cold}	A_{cold}	V_{hot}	H_{hot}	A_{hot}	Mag-Centre	Run-down Time
DE																:minutes
NDE															Attach vibration spectra & heat-run	:seconds

E.4.2 Reduced Voltage Test Data

Note: From highest to lowest voltage or where further voltage reduction increases current

V_{supply}	θ_0 [°C]	θ_c [°C]	V_{UV} [V]	V_{VW} [V]	V_{WU} [V]	$V_{LL\text{-}avg}$	I_U [A]	I_V [A]	I_W [A]	I_{av} [A]	P_{in} [kW]
120%											
80%											
60%											
50%											
40%											
30%											
20%											

B.6 Calculated Data:	
$P_{s,0}$ [W]	
P_k [W]	
P_{fe} [W]	
P_{fw} [W]	
R_{LL} After 20% Test	

E.5 Locked Rotor Test Data

Note: Machine to be at approximately ambient temperature before test and not increase by more than 5°C

f [Hz]	θ_0 [°C]	θ_a [°C]	V_{UV} [V]	V_{VW} [V]	V_{WU} [V]	$V_{LL\text{-}avg}$	I_U [A]	I_V [A]	I_W [A]	$I_{lr} = I_{av}$	P_{lr} [kW]	T_d [N·m]	f [Hz]	$\theta_{W\text{-}max}$
50														
25														
12.5														
5														

E.6 Test Acceptance

Manufacturer/Repairer Signature: -- Name: -- Date: --

Eskom Representative Signature: -- Name: -- Date: --

Comments/Remarks: --

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APPENDIX F: STANDARD FORM FOR TYPE TEST CERTIFICATE

F.1 Motor Identification and Nameplate Data

Motor Manufacturer (OEM): -- Date of Test: --

OEM's Order No: -- Eskom Contract/Order No: --

Motor Serial No: -- Motor Application/Plant: --

Performance Test on S/No: -- Driven Machine: --

Power [W]	Voltage [V]	Current [A]	Speed [RPM]	Frequency [Hz]	Frame Size	Cooling	Enclosure	Insulation	DE Bearing	NDE Bearing	Lubrication
						IC:	IP:	Class:			

F.2 Motor Design Data

$_{start}$ [%]	I_{stall} [A]	t_{stall} [s]	Hot & Cold Starts/hr		Stator Slots	Rotor Slots	Rotor Bar	PF	Efficiency	$X_{\sigma s}$	X_m	$X'_{\sigma r}$	Outline Dimensions *H(A/B/C)D/E* [mm]

F.3 Pre-test Data

Note: Winding Temperature at beginning of Thermal Test by Resistance Method (θ_0) ≤ 2°C of Coolant Temperature (θ_c), i.e $\theta_0 \leq \theta_c \pm 2$°C [IEC 34-1: 73]

Temperatures [°C]			Stator Winding Resistance [mΩ]					Embedded Temperature Detector Continuity/Resistance [Ω]							
θ_c	θ_0	$\theta_{bearings}$	R_{UV}	R_{VW}	R_{WU}	$R_{LL\text{-}avg}$	R_{LL} @ 25°C	ETD1	ETD2	ETD3	ETD4	ETD5	ETD6	DE_{brng} ETD	NDE_{brng} ETD

F.4.1 Rated Load Test Data

Note: To accept R_{LL} measurements as true load values for Temperature rise by Resistance method, t_1 < 120s for Motors above 150kW

Load %	*Start Time*	θ_0 [°C]	$V_{LL\text{-}avg}$ [V]	V_{imb} [%]	$I_{L\text{-}av}$ [A]	I_{imb} [%]	P_{in} [kW]	PF	*f* [Hz]	RPM	$\theta_{w\text{-}max}$	θ_c [°C]	$\theta_{bearing}$[°C]	Duration	Coolant $_{flow\text{-}rate}$	Coolant $_{pressure}$
100	***h***															

Temperature-rise Test by Resistance Method					
$t_{after\ stop}$ [m:s]		R_{UV} [Ω]	R_{VW} [Ω]	R_{WU} [Ω]	θ_a [°C]
t_1					
t_{1+1min}					
t_{1+2min}					
t_{1+3min}					
t_{1+4min}					
t_{1+5min}					
t_{1+6min}					

Bearing Vibration Measurements (rms velocity) [mm/s]						
	V_{start}	H_{start}	A_{start}	V_{end}	H_{end}	A_{end}
DE						
NDE						
Vibration spectra record attached?			Yes or No			

Shaft Voltage Measurement		
Bearing	*DE*	*NDE*
VAC		
VDC		

Temperature-rise Test by ETD Method						
ETD1	*ETD2*	*ETD3*	*ETD4*	*ETD5*	*ETD6*	Units
						[Ω]
						[°C]

F.6 Calculated Performance Data

Load Point	Efficiency (η)	$\Delta_{\theta w}$ [°C]
50%		
75%		
100%		

F.4.2 Other Load Test Data

Load %	Start Time	θ_0 [°C]	$V_{LL\text{-}avg}$ [V]	V_{imb} [%]	$I_{L\text{-}av}$ [A]	I_{imb} [%]	P_{in} [kW]	PF	*f* [Hz]	RPM	$\theta_{w\text{-}max}$	θ_c [°C]	$\theta_{bearing}$[°C]	Duration	R_{LL} Before 130% Test
130	***h***														
115	***h***														
75	***h***														
50	***h***														R_{LL} After 25% Test
25	***h***														

F.5 Locked Rotor Test Data

Note: Machine to be at approximately ambient temperature before test and not increase by more than 5°C

f [Hz]	θ_0 [°C]	θ_a [°C]	V_{UV} [V]	V_{VW} [V]	V_{WU} [V]	$V_{LL\text{-}avg}$	I_U [A]	I_V [A]	I_W [A]	$I_{lr} = I_{av}$	P_{lr} [kW]	T_d [N·m]	*f* [Hz]	$\theta_{w\text{-}max}$ [°C]
50														
25														
12.5														
5														

F.7 Test Acceptance

Manufacturer/Repairer Signature: -- Name: -- Date: --

Eskom Representative Signature: -- Name: -- Date: --

Comments/Remarks: --

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APPENDIX G: MOTOR VOLTAGES GUIDELINE

Motor voltages will normally be based on the following table, but shall be as specified in Technical Schedule A of an enquiry document. Cable types and sizes shall be as specified in Technical Schedule A.

Rated output	Voltage rating
160 kW to 4 000 kW	3 300 V
or	
All motors above 160 kW	6 600 V
or	
All motors above 4 000 kW	11 000 V/15 000V

It is sometimes more economical for Eskom to use 400 V for motors in the range 160 kW to 200 kW. The above table therefore allows motors up to 200 kW to be supplied at 400 V whereas the range of motors to be supplied at 3 300 V and 6 600 V begins at 160 kW.

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APPENDIX H: MOTOR ENCLOSURES AND COOLING METHODS

Motors likely to be hosed down shall have IP 55 enclosures. Outdoor motors shall have IPW 55 enclosures for hail, snow, fog and dust storms. Cooling methods shall be IC 411 in accordance with SANS 1804 unless otherwise specified.

The following table reflects the usual rating class, type of enclosure, and method of cooling applicable to motors for particular duties.

1	3	4
Motors for	**Type of enclosure**	**Cooling method**
a) Boilers ID, FD and PA fans	IPW 55	Air/air or air/water heat exchangers
b) Turbo-generators CW pumps (in central pump house) CW pumps (outdoor) Condensate extraction pumps	Weather protected NEMA Type II IPW 55 IP 55	Open ventilated Air/air heat exchangers Air/air heat exchangers
c) Coal plant Conveyors Mills	Dust ignition proof Dust ignition proof	IC 411 IC 411
d) Feed pumps	IPW 55	Air/air or air/water heat exchangers

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APPENDIX I: NOTES TO TENDERERS

1. Technical Evaluation

Medium Voltage motors will be technically evaluated based on the following key performance areas:

1.1. New vs. Old Motor Interchangeability

If mechanical and electrical interchangeability is specified as a requirement in Schedule A, the new motor mounting and alignment dimensions shall be evaluated to ensure that the new motor can be installed without any modification to the plant. This criterion is the gatekeeper, i.e., failure of the tendered design to fulfil the required interchangeability should result in the tendered design being found technically unacceptable.

1.2. Accessories

Accessories the motor is to be supplied with must meet or exceed the requirements of Schedule A.

1.3. Design Quality.

The design of the motor must be such that the motor life cycle maintenance costs are minimised.

1.4. Design Performance

With the advent of energy efficiency requirements to reduce auxiliary power consumption in the plant, the design must operate efficiently in service.

1.5. Design Capabilities

For the motor to be serviceable, it has to be capable of providing adequate power and torque under all operating conditions under load.

1.6. Tender Quality, Supplier Profile, and Delivery

Received tender technical documents shall be evaluated for complete fulfillment of the specified scope of work, and this specification. The Supplier technical evaluation score and ranking on the list of approved new MV Motor Suppliers shall also be considered.

2. Adjudication

The adjudication of the preferred design must be based on auditable scoring matrix for each key performance indicator. The scoring system used to evaluate the different tenders should mainly be as follows:

Score	Remarks
0	Non – Compliance – The tender meet does not fulfil specified requirement, and/or information to evaluate is not provided
1	Poor – The tender fulfils some requirements or limited information was provided to fully qualify the response to the requirement
2	Base – specification met
3	Good – specification and some expectations met
4	Best – specification and expectations met or exceeded

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3. Quality Control

The Supplier's QCP and/or ITP shall include the following minimum quality control requirements marked with a **X**:

Plant Walk-down	By all Tenderers during tender phase		By a successful Tenderer during detailed design phase	**X**	Not Necessary			
Detailed Design	During tender phase		By a successful Tenderer only	**X**	*Employer* to review & accept	**X**		
Induction Test	To be witnessed		To include thermal image of brazed coil connections	**X**				
Tan Delta	To be witnessed		Before motor assembly	**X**	After motor assembly		Unnecessary	
Partial Discharge	To be witnessed	**X**	Preferred Test Method	**TVA Probe Analysis**	Before stator fitment into frame	**X**		
Performance Test	To be witnessed	**X**	Preferred Test Method		Number of same design tests	**1**		
Routine Test	To be witnessed	**X**	Bearings to reach thermal stability	**X**	Bearing lay to be inspected after test	**X**		
AC Hi-pot	To be witnessed	**X**	On hot stator windings after Routine / Performance Test	**X**				
Spare Coils	Tests to be witnessed	**X**	Inter-turn Insulation Impulse Voltage Test	**X**	Main Insulation Power Frequency Voltage Test	**X**	Main Insulation Impulse Voltage Test	
	Number of coils	**2**						
Final Inspection	To be witnessed							

4. Penalties For Shortfall In Performance

The following penalties shall be applied should motors fail to meet guaranteed performance:

4.1. Penalty for Shortfall in Output

A motor that fails to produce its rated output shall, at Eskom's discretion, either be rejected outright or accepted with a reduction in the motor price. The following rules shall apply:

A. Where the motor fails to fulfil the guaranteed temperature rise performance, its rating shall be reduced to the motor output where the winding temperature rise satisfies Class B requirements.

B. A motor shall be rejected outright if its drive output is below either the duty point or 90% of guaranteed output, whichever is greater.

C. The motor price shall, as a minimum, be reduced with double the ratio of actual output to guaranteed output if the drive is accepted by Eskom. The formula to be used for determining the minimum percentage by which the contract price shall be reduced shall, therefore, be:

$$\text{Percentage Price Reduction} \geq 2 \times \left(\frac{P_g - P_o}{P_g} \right) \%$$

Where: P_g = Guaranteed Output Rating in kW, and

P_o = Reduced Output Rating in kW

4.2. Penalty for Efficiency and Power Factor

A penalty shall be levied by Eskom for each motor whose performance falls below the guaranteed efficiency and power factor values stated in Schedule B, at 75% Load. The following rules shall apply:

A. The sliding scale formula for determining the efficiency shortfall penalty is **0.5 %** of motor price for every **0.1 %** efficiency drop from the guaranteed motor efficiency, stated in Schedule B, at 75% load.

B. The minimum acceptable performance is 94% or 2% below guaranteed motor efficiency at 75 % load, whichever is greater.

The *Contractor* is expected to make good until minimum performance criteria are met within the reasonable period that is acceptable to the *Employer*.

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