

PETRONAS TECHNICAL STANDARDS

MANUAL

Synchronous AC Machines

(Amendments/Supplements to IEC 60024-1 and IEC 60024-14)

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This revision of PTS **33.65.11.31 – Synchronous AC Machines (Amendments/Supplements to IEC 60024-1 and IEC 60024-14) (February 2011)** has been reviewed and updated to incorporate PETRONAS Lessons Learnt, Best Practice and new information issued by relevant industry code and standards. All updates in the document are highlighted in *italic* font (if any).

The previous version of this PTS **33.65.11.31 – Synchronous AC Machines (Amendments/Supplements to IEC 60024-1 and IEC 60024-14) (February 2010)** will be removed from PTS binder / e-repository from herein onwards.

Document Approval

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PREFACE

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PART I INTRODUCTION

1.1 SCOPE

This PTS specifies requirements and gives recommendations for three-phase, air-cooled, synchronous AC machines, and their excitation systems and auxiliary equipment.

Part III of this PTS gives amendments and supplements to IEC 60034-1:2004 for all synchronous machines, both motors and generators, with ratings of 1250 kVA and higher. These machines shall, where relevant, also comply with the clauses of other parts of IEC 60034.

Part IV of this PTS gives amendments and supplements to IEC 60034-14:2003).

This PTS:

- (i) makes selections from the options given in IEC 60034-1
- (ii) specifies additional or modified requirements considered necessary for the machine to be suitable for operation and maintenance in continuously operating plants.

The specific requirements for the motors that form part of A.C. Variable Speed Drive Systems (VSDS) are included in this PTS. For the total VSDS specification reference is made to PTS 33.66.05.33-Gen.

Electrical machines installed in hazardous areas shall comply with the relevant parts of IEC 60079.

Where a unit transformer is used with the motor, the combination shall comply with this PTS and PTS 33.65.40.31-Gen.

This PTS is a revision of the PTS of the same number dated January 1999; see (1.4) regarding the main changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by PETRONAS the distribution of this PTS is confined to PETRONAS companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them.

This PTS is intended for use in oil refineries, gas plants, chemical plants, exploration and production facilities and supply/distribution installations.

When PTSs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this PTS, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this PTS which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this PTS as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant, authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

Add new clause:

1.3.2 Specific definitions

Air-to-air cooled machine

A closed machine with an integral or machine-mounted heat exchanger, using air as the primary and secondary coolant.

Air-to-water cooled machine

A closed machine with a heat exchanger using air as primary coolant and water as the secondary coolant.

Allowable running-up time (ART)

The time for a machine to complete one start with rated voltage and frequency applied and coupled to a load with the actual running-up characteristics, but with the maximum moment of inertia so that when full speed is reached the most critical part of the machine has reached the highest permissible temperature.

The initial machine temperature is to be its full load working temperature. The coolant temperature is to be the maximum specified.

Certificate of conformity

A certificate stating that the machine complies with the relevant standards for machines for potentially explosive atmospheres.

Critical speed

A finite speed at which resonance exists, regardless of the cause of the resonance.

NOTE: A critical speed can be caused by a number of factors such as electrical/magnetic asymmetry, oil whirl or torsion between shaft components.

Declaration of compliance [IEC 60079-15]

Document issued by the Manufacturer stating that the machine complies with the requirements of IEC 60079-15.

Electromagnetic compatibility (EMC)

The ability of equipment or a system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

Expected lifetime

The expected lifetime of a machine is the time during which the machine remains suitable for the application for which it was made if it is regularly inspected, examined and serviced in accordance with the Manufacturer's instructions, with replacement of lubricants and of parts subject to wear.

High Voltage (HV)

A voltage exceeding 1000 V

Limiting temperature [IEC 60079-7]

The maximum permissible temperature for apparatus or parts, determined by:

- The danger of ignition of the explosive atmosphere
- The thermal stability of the materials used.

The lower of these two temperatures is the limiting temperature.

Requisition

The requisition is:

PTS 33.65.11.93-Gen., Data/requisition sheet for synchronous AC machines

NOTE: Requirements for additional equipment, e.g. power transformers, shall be detailed on specific data/requisition sheets.

Running-up time (RT)

The time for a machine to complete one start with rated voltage and frequency applied and coupled to the actual load.

Self-cooled machine

A machine where the cooling is obtained by means of its own rotation.

Separately cooled machine

A machine where the cooling is obtained by means other than its own rotation.

Turbine-type machine

A cylindrical rotor machine designed for operation at high peripheral rotor speed.

Vibration severity

The vibration severity is the root-mean-square value of the vibration velocity.

1.5 CROSS-REFERENCES

Where cross-references to other parts of this PTS are made, the referenced section number is shown in brackets. Other documents referenced by this PTS are listed in (Part V).

PART II GENERAL

2.1 STATEMENT OF COMPLIANCE

By submitting the quotation the Manufacturer is deemed to comply with this PTS and the requisition. If the Manufacturer has any deviations, concerning both requirements and recommendations, these shall be identified in writing at the time of quotation.

All performance values laid down in the pre-ordering meeting or quotation (whichever is the later) shall be regarded as maximum or minimum values as applicable.

These values shall also be guaranteed by the Manufacturer under the most arduous conditions specified in this PTS and the requisition.

Tolerances shall be in accordance with this PTS and the relevant IEC publications. All the equipment forming part of the order shall be tested individually and in combination at the Manufacturer's works to prove their capability and compliance with the specification and the performance data.

The Manufacturer shall comply with regulatory requirements applicable to the equipment for the location in which it will be installed; see also (Part I-1.2).

If any one of the components or the whole system does not comply with the specification and any agreed amendments, the Manufacturer shall rectify and re-test the machine(s) within a mutually agreed time.

2.2 LIFETIME AND RELIABILITY

The machine and all individual items forming part of it, including, if applicable, the unit transformer shall have an expected lifetime of at least 20 years. They shall be suitable for at least 6 years cumulative. Within each cumulative 6 year period, there may be idle periods for inspection and maintenance of up to 4 months cumulative.

Unless otherwise stated in the requisition, the machine Manufacturer shall include provisions for condition monitoring where relevant in order to maximize intervals between maintenance.

The unit transformer of the machine, if applicable, shall comply with this PTS and PTS 33.65.40.31

2.3 PRE-ORDERING MEETING

If deemed necessary by one of the parties involved, a pre-ordering meeting shall be arranged to define clearly the overall scope of supply, individual responsibilities and test methods.

2.4 STUDIES

For large machines one or more specific studies and/or reviews may be required. Detailed information shall be given by the Principal in the specification. The Principal and the Manufacturer and, if necessary, other parties shall execute these studies at a mutually agreed time.

Examples of studies/reviews that may be specified are:

- SAFOP (Safety and Operability study – electrical focus)
- HAZOP (Hazard and Operability study – process focus)
- IPF (Instrumented Protected Function study)
- SRCM (Shell Reliability Centred Maintenance study)
- Design Assurance Review
- Transient torque analysis

2.5 EFFICIENCY

High voltage synchronous machines shall have efficiencies not less than the following:

2-pole:	98.0 %
4-pole:	97.5 %

These values are related to full load operation at the power factor specified in the requisition, and include the power consumption of the excitation system.

For machines which require separately driven auxiliary devices, like ventilators for method of cooling IC6A6A1, the Manufacturer shall list the power consumption of these devices in the quotation.

2.6 GENERAL DESIGN FEATURES

2.6.1 Degree of protection

The minimum degree of ingress protection, in accordance with IEC 60529, shall be as follows:

			Minimum degree of protection
Land installations	Machine and auxiliaries	indoor installation	IP 23
		outdoor installation	IP 54
	Terminal boxes and bearing housings		IP 55
Offshore installations	Machine, auxiliaries, terminal boxes and bearing housing.	indoor installation	IP 23
		outdoor installation	IP 55
	Terminal boxes and bearing housings		IP 55

NOTE: For large machines installed outdoors, especially low speed machines, a lower degree of protection, e.g. IP 44, may be acceptable if approved by the Principal. Terminal boxes and bearing housings shall always have a degree of protection of at least IP 55.

2.6.2 Methods of cooling

Unless otherwise specified, machines shall have air-to-air, self-cooling with cooling method IC 5A1A1, IC 6A1A1 or IC6A1A6 in accordance with IEC 60034-6.

Air-to-water, self-cooled machines shall be supplied with cooling method IC 8A1W7 in accordance with IEC 60034-6.

Separately cooled machines may be supplied only for special applications and only with the approval of the Principal. Attention shall be paid to the sparing of auxiliaries of separately cooled machines.

The cooling air for the exciter shall be taken from the cooling air circuit of the machine (cooling method IC 3A1 in accordance with IEC 60034-6), except that for larger exciters where the above cooling method is no longer practical, exciter cooling shall be independent of the main machine cooling. In the latter situation the exciter cooling method shall be IC 6A1A1 or IC 8A1W7 in accordance with IEC 60034-6.

The coolers shall be pressure-tested at 1.5 times the maximum working pressure for 15 minutes to demonstrate the withstand capability. If the water pressure in the cooler is controlled by a valve or pressure-reducing device connected to a water supply of higher

pressure than the working pressure of the cooler, the cooler shall be designed for the higher pressure, and tested at 1.5 times the higher pressure value.

Ventilation and cooling facilities shall be designed such that hot exhaust air is not directed over the bearing houses.

The Principal shall submit to the Manufacturer the relevant data regarding the cooling water.

PART III AMENDMENTS/SUPPLEMENTS TO IEC 60034-1:2004

In this part, clauses of IEC 60034-1:2004 are amended or supplemented, or new sections are added. Clauses of IEC 60034-1:2004 that are not mentioned shall remain applicable as written.

3 TERMS AND DEFINITIONS

For additional definitions refer to (Part I, 1.3)

4 DUTY

4.1 DECLARATION OF DUTY

Add to this clause:

Periods of running may alternate with idle (standstill) periods of maximum six months. At the end of such an idle period the machine shall be suitable for another running period without requiring additional inspection.

5 RATING

5.5.2 AC generators

Add to this clause:

The required generator rating, speed and power factor shall be stated in the requisition.

All insulation materials shall be class F, as defined in IEC 60034-18. The rating of the machine offered by the manufacturer shall be based on a class B temperature rise for all parts of the machine windings (stator, rotor and exciter).

The Manufacturer shall provide advice regarding the optimum generator rating with respect to the prime mover capabilities and the specified operating and site conditions.

5.5.3 Motors

Add to this clause:

The required motor rating, speed and power factor shall be stated in the requisition.

All insulation materials shall be class F, as defined in IEC 60034-18. The rating of the machine offered by the Manufacturer shall be based on a class B temperature rise for all parts of the machine windings.

6 SITE OPERATING CONDITIONS

6.1 GENERAL

Add to this clause:

Machines shall be suitable for use in a saliferous, sulphurous and dusty atmosphere. Condensation, solar radiation and wind loading shall be taken into account.

The machines shall normally be installed outdoors without shelter with a common base plate on the foundation. The area classification according to IEC 60079-10 shall be stated in the requisition or appertaining documentation.

The Manufacturer shall assume a background vibration severity level of 0.4 mm/s at the bearings of the machines.

Machines installed on mobile and fixed offshore installations shall also be capable of absorbing shocks of twice the acceleration of free fall ($2 \times g_n$) when running or standing idle. If indicated in the requisition, machines shall be earthquake-proof in accordance with the local requirements.

Other equipment, e.g. unit transformers and excitation control cabinets, installed on mobile and fixed offshore installations shall not be affected by vibration and shock. The equipment for these applications shall be tested according to IEC 61892-3:1999, item 9 of table 9.

If a transformer forms part of the supply package then it shall normally be located outside the substation building in a non-hazardous area according to IEC 60079-10.

Unless specified differently in the requisition, operating conditions shall be as stated in IEC 60034-1, amended as follows:

- maximum ambient air temperature	40 °C
- mean ambient air temperature (over 24 h period)	35 °C
- minimum ambient temperature	-15 °C
- maximum relative humidity	100 %
- maximum altitude	1000 m

6.4 MINIMUM AMBIENT AIR TEMPERATURE

Add to this clause:

The minimum ambient temperature of machines in the categories a) to e) inclusive shall not be limited to 0 °C. For those machines the Principal shall state the minimum ambient temperature in the requisition.

NOTE: Special measures (e.g. heating) may be required.

6.5 WATER COOLANT TEMPERATURE

Replace this clause by:

The temperature of the water at the inlet to the heat exchanger shall not exceed 30 °C. The minimum cooling water temperature is 5 °C.

Add new clause:

6.8 ADDITIONAL DESIGN DATA FOR AIR-TO-WATER COOLED HEAT EXCHANGERS

In the quotation stage, the Principal shall provide the Manufacturer with information about the cooling water available.

The following design data shall apply:

- maximum cooling water outlet temperature	37 °C
- maximum temperature rise for cooling water	7 K
- maximum static water pressure	8×10^5 Pa
- minimum static water pressure	3×10^5 Pa
- minimum cooling water velocity in tubes	1 m/s
- fouling resistance	$0.52 \times 10^{-3} \text{ m}^2 \cdot \text{K/W}$

NOTE: Guideline for fouling resistance are referred to in PTS 31.21.01.31 and PTS 20.21.00.31.

7 ELECTRICAL OPERATING CONDITIONS

7.1 ELECTRICAL SUPPLY

Add to this clause:

The nominal system voltage and frequency shall be indicated in the requisition.

During normal system operation and under steady-state conditions, the voltage at the motor terminals shall not deviate from nominal voltage by more than 5 % and the system frequency shall not deviate from the nominal frequency by more than 2 %. Where these values differ from the above, e.g. at offshore facilities, this shall be stated in the requisition.

The AC power supply shall be symmetrical and sinusoidal, although the input voltage may be subject to transients resulting in short term voltage excursions between 80 % and 110 % of nominal, and to voltage interruptions during system short circuits. Transient high frequency voltages of up to 2 kV may also be superimposed on the input voltage as a consequence of system switching operations.

The requisition shall state the maximum and minimum prospective short circuit current at the terminals of the motor.

Synchronous generators shall be suitable for:

- island operation; and
- parallel operation with other generators; and
- parallel operation with an external grid.

Details regarding the parameters of the external grid and/or other generators operating on the system shall be made available by the Principal.

7.2 FORM AND SYMMETRY OF VOLTAGES AND CURRENTS

Add to this clause:

For specific installations, e.g. offshore facilities, the expected harmonic distortion may be more severe than stated in IEC 60034-1. These requirements shall be specified by the Principal in the requisition.

7.2.2 AC generators

Add to this clause:

When tested on open circuit and at rated speed and voltage, the wave-form of the line-to-line terminal voltage shall be sinusoidal with a relative harmonic content not exceeding 3 % for generators with ratings up to 5 MVA and 1.5 % for generators with ratings exceeding 5 MVA.