DEP SPECIFICATION

# SYNCHRONOUS AC MACHINES (AMENDMENTS/SUPPLEMENTS TO IEC 60034-1 AND IEC 60034-14)

DEP 33.65.11.31-Gen.

February 2012

**DESIGN AND ENGINEERING PRACTICE**

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# PART I INTRODUCTION

## 1.1 SCOPE

This DEP specifies requirements and gives recommendations for three-phase, air-cooled, synchronous AC machines, and their excitation systems and auxiliary equipment, and is based on IEC 60034-1 and IEC 60034-14.

Part III of this DEP amends, supplements and deletes various clauses of IEC 60034-1 for all synchronous machines, both motors and generators, with ratings of 1250 kVA and higher. Part III follows the clause numbering of 60034-1 for easy reference. These machines shall, where relevant, also comply with the clauses of other parts of IEC 60034.

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

Part IV of this DEP amends, supplements and deletes various clauses of IEC 60034-14. Part IV follows the clause numbering of IEC 60034-14 for easy reference. All clauses of IEC 60034-14 not modified by this DEP remain valid as written

The specific requirements for the motors that form part of A.C. Variable Speed Drive Systems (VSDS) are included in this DEP. For the total VSDS specification, reference is made to DEP 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 DEP and DEP 33.65.40.31-Gen.

This is a revision of the DEP of the same number dated June 2007; see (1.5) regarding the changes.

## 1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

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This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall 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 could be more stringent than in this DEP, 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 DEP 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 DEP 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.

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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 that initiates the project and ultimately pays for it. 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.

## 1.4 CROSS-REFERENCES

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

## 1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated June 2007. The following are the main, non-editorial changes.

As the original text is now split between this document and an informative document and there have been significant changes to the content, this version of the DEP should be treated as a new document. As a consequence, there is no attempt to try and identify major changes between this DEP and its original source document.

## 1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal http://sww.shell.com/standards and on the main page of the DEPs DVD-ROM.

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# PART II GENERAL

## 2.1 GENERAL REQUIREMENTS AND STATEMENT OF COMPLIANCE

### 2.1.1 General requirements

Part III of this DEP is written as amendments and supplements to IEC 60034-1. Wherever reference is made to IEC 60034-1, it shall be understood to mean IEC 60034-1 as amended/supplemented by this DEP.

For ease of reference, the clause numbering of IEC 60034-1 has been used throughout Part III of this DEP.

Clauses in IEC 60034-1, which are not mentioned in this DEP, shall remain valid as written.

Part IV of this DEP is written as amendments and supplements to IEC 60034-14. Wherever reference is made to IEC 60034-14, it shall be understood to mean IEC 60034-14 as amended/supplemented by this DEP.

For ease of reference, the clause numbering of IEC 60034-14 has been used throughout Part IV of this DEP.

Clauses in IEC 60034-14, which are not mentioned in this DEP, shall remain valid as written.

### 2.1.2 Manufacturer compliance

The Manufacturer of the machine(s) and its ancillary equipment shall confirm that the equipment fully complies with the quotation and the whole system is properly designed, constructed and suitable for the specified duty.

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 DEP and the requisition.

Tolerances shall be in accordance with this DEP 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 continuous uninterrupted operation for periods of at least 6 years. However, within this six-year period, periods of running may alternate with idle periods of up to 6 months. Re-greasing of bearings or replenishment of lube oil, if required, shall be possible with the machine in operation. Rolling element bearings are exempted from the expected lifetime requirement.

NOTE: The requirement for replenishment of the lube oil during operation may be waived by the Principal if a similar machine is installed as a spare for the same operational duty.

## 2.3 PRE-ORDERING MEETING

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

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## 2.4 STUDIES

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

## 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 IC 6A6A1, the Manufacturer shall list the power consumption of these devices in the quotation.

## 2.6 GENERAL DESIGN FEATURES

### 2.6.1 Degree of protection (IP)

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 44 |
| | | outdoor installation | IP 54 |
| | Terminal boxes and bearing housings | | IP 55 |
| Offshore installations | Machine, auxiliaries, terminal boxes and bearing housing. | | IP 56 |

The enclosure of the machine shall be equipped with a normally open drain hole in accordance with IEC 60034-5 to IP44. Attention shall be paid to the correct location of the drain hole, especially for vertical motors.

NOTE:
1) This clause is not applicable to Ex ‘d’ machines.
2) The certification of explosion-protected machines (according to the relevant part of IEC 60079) shall not be invalidated by this open drain hole. A certified drain plug may be provided.
3) Drain holes for IP68 motors are not required.

### 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 IC 6A1A6 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. In that case, attention should be paid to the sparing of auxiliaries of separately cooled machines.

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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 water 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.

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## PART III AMENDMENTS/SUPPLEMENTS TO IEC 60034-1

### 3 Terms and definitions

*Add new clauses:*

**3.34 Air-to-air cooled machine**

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

**3.35 Air-to-water cooled machine**

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

**3.36 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.

**3.37 Certificate of conformity**

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

**3.38 Critical speed**

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

**3.39 Declaration of compliance** [IEC 60079-15]

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

**3.40 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.

**3.41 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.

**3.42 High Voltage (HV)**

A voltage exceeding 1000 V.

**3.43 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.

**3.44 Requisition**

The requisition is:

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

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

**3.45 Running-up time (RT)**

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

**3.46 Self-cooled machine**

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

**3.47 Separately cooled machine**

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

**3.48 Turbine-type machine**

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

**3.49 Vibration severity**

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

## 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 Rated output

#### 5.5.2 AC generators

*Add to this clause:*

The required generator rating, expressed in Volt Amperes (VA), power factor and speed will 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 expressed in Watt (W), power factor and speed will 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.

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## 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 will 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 x $g_n$) 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 should not be affected by vibration and shock. The equipment for these applications shall be tested according to IEC 61892-3, item 10 of Table 4.

If a transformer forms part of the supply package, then it will 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 will 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 will 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

At the quotation stage, the Principal will provide the Manufacturer with the chemical and physical properties of the available cooling water together with its on-site treatment.

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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 | $8 \times 10^5$ Pa |
| - minimum static water pressure | $3 \times 10^5$ Pa |
| - minimum cooling water velocity in tubes | 1 m/s |
| - fouling resistance | $0.52 \times 10^{-3}$ $m^2$.K/W |

NOTE: For further guidance on fouling resistance reference is made to DEP 31.21.01.30-Gen.

## 7 Electrical operating conditions

### 7.1 Electrical supply

*Add to this clause:*

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

During normal system operation and under steady-state conditions, the voltage at the motor terminals will not deviate from nominal voltage by more than 5 % and the system frequency will not deviate from the nominal frequency by more than 2 %.

The AC power supply will 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.

Where these values differ from the above, e.g., at offshore facilities, this shall be stated in the requisition.

The requisition will state the maximum and minimum prospective short-circuit current at the terminals of the machine.

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 will 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 will 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.

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### 7.2.3 Synchronous machines

*Add to this clause:*

During operation under these conditions the maximum permissible winding temperature rise may be exceeded by maximum 5 K.

### 7.3 Voltage and frequency variations during operation

*Add to this clause:*

Generators connected to the grid via a unit transformer shall be capable of supplying their rated output (kVA) at rated speed and power factor and at voltage and frequency variations for zone A of Figure 11. Machines directly coupled to the grid shall be capable of supplying their rated output at rated speed and power factor at voltages ranging from +10 % to –10 % of the rated value.

In cases of continuous operation at the extreme voltage limits specified above, the maximum permissible winding temperature rise may be exceeded by maximum 10 K.

The output voltage of generators shall be adjustable between +10 % and -10 % of the rated value. Adjustment shall be possible during normal operation.

### 7.4 Three phase a.c. machine operating on unearthed systems

*Add to this clause:*

The machines shall be suitable to operate for periods of up to 8 hours on an unearthed system with an earth fault on one phase. The total operating time in this condition will not exceed 125 hours per year.

*Add new clause:*

### 7.6 Machine neutral earthing

The requirements for machine neutral earthing will be advised by the Principal in the requisition. For motors, neutral earthing is required only if a unit transformer is installed. Reference is made to (11.15).

If applicable, the equipment required for neutral earthing of the machine including enclosure will form part of the order.

## 8 Thermal performance and tests

### 8.9 Measurement of bearing temperatures

*Add to this clause:*

The bearing temperature rise measured by ETD, fitted in the bearing housing, shall not exceed 55 K at the end of the heat run.

For sleeve bearings with forced lubrication, the lubricating oil temperature rise with the minimum allowable oil flow shall not exceed 28 K at the end of the heat run. However, the oil temperature shall never exceed 82°C. For oil ring lubricated bearings, the sump temperature shall not exceed 82°C.

## 9 Other performance and tests

### 9.1 Routine test

*Add to this clause:*

Reference is made to the routine test requirements as stated in (16.4.3) and (16.5.3).

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