DEP SPECIFICATION

ELECTRICAL MACHINES - CAGE-INDUCTION TYPES (AMENDMENTS/SUPPLEMENTS TO IEC 60034-1 AND IEC 60034-14)

DEP 33.66.05.31-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 electrical machines of the cage-induction type. It applies to both induction motors and induction generators.

IEC 60034-1 shall apply to all induction machines. Induction machines shall, where relevant, also comply with the clauses of other parts of IEC 60034.

(Part III) of this DEP gives amendments and supplements to IEC 60034-1 (11th edition, 2010-10). Clauses shall apply to all machines except where the heading identifies that they apply to low voltage machines only or to high voltage machines only.

(Part IV) gives amendments and supplements to IEC 60034-14 (edition 3.1, 2007-03).

This DEP:

(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 minimum performance requirements specified in this DEP refer to constant speed operation and direct-on-line starting of the machines.

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 the IEC 60079 series of publications.

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

This DEP is a revision of the DEP of the same number dated June 2007; see (1.4) regarding the main changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

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

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 may 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 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.

1.3.2 Specific definitions

Term	Definition
Air-to-air cooled machine	A closed machine with 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 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	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.
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.
Frame-surface cooled machine	A closed machine with its surface cooled by means of surrounding medium.
Fouling Resistance	A measure of the ultimate additional resistance to heat transfer caused by deposits on and corrosion of the heat transfer material surface.
High Voltage (HV)	A voltage exceeding 1000V.
Limiting temperature (IEC 60079-7)	The maximum permissible temperature for machines, or parts of machines, determined by: • The danger of ignition of the explosive atmosphere. • The thermal stability of the materials used.
Low voltage (LV)	A voltage not exceeding 1000 V.

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Term	Definition
Offshore installation	An installation located near open saliferous water, e.g., platforms, jetties, floating production storage and offloading vessels (FPSO).
Requisition	The requisition is one of the following: • DEP 33.66.05.93-Gen., Data/requisition sheet for electrical machines, LV cage induction motors. • DEP 33.66.05.94-Gen., Data/requisition sheet for electrical machines, HV cage induction motors. NOTE: Requirements for additional equipment, e.g., power transformers, will be detailed on specific data/ requisition sheets.
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.
Self-cooled machine	A machine where cooling is effected by means of its own rotation.
Separately-cooled machine	A machine where cooling is effected by means of other than its own rotation.
Stalling time	The time taken for any part of the machine, when it is energised at rated voltage and in the stalled condition, to be heated up from the temperature reached under full load and maximum coolant temperature conditions to the highest temperature which does not impair its subsequent performance.
Starting load torque	The torque required by the load over the starting period from zero speed to load speed. The starting torque includes, if applicable, compression torque and bearing friction torque.
Time t_E	The time tE is the lesser of the times defined below: • For the AC windings, when carrying the locked rotor current with the motor in the stalled condition, to be heated up from the temperature reached under full load and maximum coolant temperature conditions to the limiting temperature. • For any other part of the machine in stalled condition, and with the AC windings carrying the locked rotor current, to be heated up from the temperature reached under full load and maximum coolant temperature conditions to the limiting temperature.
Vibration severity	The vibration severity is the root-mean-square value of the vibration velocity.

1.4 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.

1.5 CROSS-REFERENCES

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

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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 STATEMENT OF 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.

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 HV 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 and the Manufacturer and, if necessary, other parties shall execute these studies at a mutually agreed time.

2.5 EFFICIENCY AND LIFE-CYCLE COST

The minimum values for efficiency and power factor shall be as given in (Part III, Annex D and Annex E, respectively).

For machines which require separately driven auxiliary devices, e.g., ventilators, oil pumps, the Manufacturer shall list the power consumption of these devices in the quotation.

The Principal may decide to select the motor based on the total annual cost. This will be stated in the requisition. (Part III, Annex F) gives the calculation method and a calculation example.

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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:

Land installations	IP54 for the machine and auxiliaries IP55 for the terminal box and bearing housings
Offshore installations	IP56 for the machine, auxiliaries, terminal boxes and bearing housings
Submerged electric motors and electric drives of seal-less pumps	IP68 for the applicable parts

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 be air cooled with methods of cooling IC 4A1A1, IC 5A1A1 or IC 6A1A1 in accordance with IEC 60034-6.

- If specified in the requisition, air-to-water, self-cooled machines with method of cooling IC 8A1W7 in accordance with IEC 60034-6 shall be supplied
- 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.

2.6.3 Type of construction and mounting

Unless otherwise specified, the type of mounting for standard machines shall be either IM B3 (IM 1001), IM B5(IM 3001), IM V1 (IM 3011), or IM V6 (IM 1031) in accordance with IEC 60034-7.

Vertical machines with a downward drive-end shaft shall be provided with a canopy over any upward facing air inlets to prevent entry of water or any other contaminant.

Bearing housings, especially for vertical machines with upwards drive-end shaft, (mounting arrangement IM V3 [IM 3031] and IM V6 [IM 1031] to IEC 60034-7) shall be sealed to prevent water entry to the machine via the shaft. Water and dirt collecting on the upper bearing end-shield shall not reduce the performance or lifetime of the machine.

For special applications (e.g., reciprocating compressor drives) an alternative type of mounting may be preferred.

The mounting required will be indicated in the requisition.

Frame sizes shall be in accordance with IEC 60072-1 and IEC 60072-2.

Dimensions of foot-mounted machines and mounting flange dimensions shall be in accordance with IEC 60072-1 and IEC 60072-2.

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PART III AMENDMENTS/SUPPLEMENTS TO IEC 60034-1

In this part, clauses of IEC 60034-1:2010 are amended or supplemented, or new clauses are added. Clauses of IEC 60034-1 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 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.

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), 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.

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

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idle. If indicated in the requisition, machines shall be earthquake-proof in accordance with the local requirements.

Other equipment, e.g., unit transformers, 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 61892-3:1999, item 9 of table 9.

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 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 this will be stated in the requisition.

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

6.5 Water coolant temperature

Replace this clause by:

Where this is not stated on the requisition 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

In the quotation stage, the Principal will provide the Manufacturer with information about the cooling water available and the treatment the water receives to make it suitable for cooling water purpose.

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	0.52×10^{-3} m^2.K/W

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

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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 machine 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.

NOTE: Where a unit transformer is installed the above applies to the supply characteristics at the primary terminals of the transformer.

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

LV motors shall normally protected by short circuit limiting devices, e.g., fuses. The design of the LV motor and its terminal box shall take a fuse or protection device rating of 3 times the motor full load current into account.

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.

7.3 Voltage and frequency variations during operation

Add new clause:

7.3.1 LV machines

Machines shall be suitable for operation on a supply voltage within the limits as specified in IEC 60038.

7.4 Three-phase a.c. machines 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.

8. Thermal performance and tests

8.9 Measurement of bearing temperature

Add to this clause:

For both rolling element and sleeve bearings, the bearing temperature rise as 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

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oil temperature shall not 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).

9.6 Safe operating speed of cage induction motors

Add to this clause:

Motors forming part of an AC Variable Speed Drive System (VSDS) shall comply with DEP 33.66.05.33-Gen.

9.7 Overspeed

Replace the second paragraph of this clause with the following:

Generators above 1000 kW shall be subjected to an overspeed test at 1.2 times rated speed for a duration of 2 minutes. After the overspeed test the rotor balance condition shall be verified to be within the G2,5 limits as specified in ISO 1940-1. If the rotor fails to comply with this requirement the overspeed test may be repeated once after re-balancing, subject to the approval of the Principal.

Add new clause:

9.12 Starting, re-starting and re-acceleration

9.12.1 General

Machines shall be suitable for direct-on-line starting or re-acceleration with any voltage between 80 % and 100 % of the rated voltage applied at the machine terminals.

Motors shall be capable of re-acceleration under full load conditions following a power interruption not exceeding 0.2 s (a quadratic torque-speed characteristic for the driven equipment may be assumed).

- If this requirement cannot be met, and for other driven equipment torque-speed characteristics, the Manufacturer shall provide detailed information regarding the re-acceleration ability of the motor.

HV machines:

- For machines supplied via a dedicated unit transformer, different requirements may prevail. In these situations the design of the machine-transformer combination shall be optimised with respect to the maximum allowable voltage drop at the busbar and the start/restart performance of the machine.

9.12.2 Number of sequential starts

At any voltage between 80 % and 100 % rated voltage, machines (including their unit transformers if applicable) shall be capable of:

- three successive starts with the machine initially at maximum ambient temperature
- two successive starts with the machine initially at full load operating temperature.

Between successive starts the machine may be assumed to decelerate under operating conditions to standstill.

After a cooling period of 30 minutes at standstill, another starting sequence of at least two successive starts shall be possible.

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HV machines:

- For machines with a rated output in excess of 1600 kW, deviations from this requirement may be acceptable. In these circumstances, approval to deviate shall be obtained from the Principal.

9.12.3 Number of starts per year

Machines shall be suitable for one of the duties listed below:

Normal : maximum 1 000 starts per year

Heavy : maximum 3 000 starts per year (e.g., conveyors, drain pumps)

Extra heavy : maximum 20 000 starts per year (e.g., cranes, hoists).

Where applicable, specific attention shall be paid to the design of unit transformers.

The applicable category shall be specified on the requisition.

Add new clause:

9.13 Starting characteristics

9.13.1 Starting current

9.13.1.1 LV machines

The locked rotor apparent power shall comply with IEC 60034-12. However, for machines with a rated output in excess of 55 kW the starting current shall not exceed 7.0 times the rated current of the machine.

9.13.1.2 HV machines

The starting current shall not exceed 6.5 times the rated current of the machine, unless there is a more stringent limitation in the requisition.

9.13.2 Starting performance

9.13.2.1 LV machines

The starting performance shall comply with IEC 60034-12. For driven equipment which exhibits a quadratic torque/speed characteristic, Design N shall apply. For equipment with other characteristics the Manufacturer of the machine shall select a design appropriate to the torque/speed characteristic of the driven equipment.

9.13.2.2 HV machines

The starting performance of cage induction machines at rated voltage shall be not less than the values listed in the table below:

	Poles								
	2			4			6		
Rating (kW)	T_1	T_u	T_b	T_1	T_u	T_b	T_1	T_u	T_b
Up to 250	0.8	0.6	1.8	0.9	0.7	1.8	0.9	0.7	1.8
250 - 500	0.7	0.6	1.8	0.7	0.6	1.8	0.7	0.6	1.8
500 - 1600	0.6	0.5	1.8	0.6	0.5	1.8	0.6	0.5	1.8
Over 1600	*	*	*	*	*	*	*	*	*

T_1 = locked rotor torque

T_u = pull-up torque

T_b = breakdown torque

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