

Supplementary Specification to IEC 60034-1 High Voltage Three Phase Cage Induction Motors

Public Review Draft

Revision history

VERSION	DATE	PURPOSE
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Acknowledgements

This IOGP Specification was prepared by a Joint Industry Programme 33 Standardization of Equipment Specifications for Procurement organized by IOGP with support by the World Economic Forum (WEF).

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Foreword

This specification was prepared under Joint Industry Programme 33 (JIP33) "Standardization of Equipment Specifications for Procurement" organized by the International Oil & Gas Producers Association (IOGP) with the support from the World Economic Forum (WEF). Companies from the IOGP membership participated in developing this specification to leverage and improve industry level standardization globally in the oil and gas sector. The work has developed a minimized set of supplementary requirements for procurement, with life cycle cost in mind, resulting in a common and jointly agreed specification, building on recognized industry and international standards.

Recent trends in oil and gas projects have demonstrated substantial budget and schedule overruns. The Oil and Gas Community within the World Economic Forum (WEF) has implemented a Capital Project Complexity (CPC) initiative which seeks to drive a structural reduction in upstream project costs with a focus on industry-wide, non-competitive collaboration and standardization. The CPC vision is to standardize specifications for global procurement for equipment and packages. JIP33 provides the oil and gas sector with the opportunity to move from internally to externally focused standardization initiatives and provide step change benefits in the sector's capital projects performance.

This specification has been developed in consultation with a broad user and supplier base to realize benefits from standardization and achieve significant project and schedule cost reductions.

The JIP33 work groups performed their activities in accordance with IOGP's Competition Law Guidelines (November 2014)

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Introduction

The purpose of this specification is to define a minimum common set of requirements for the procurement of high voltage three phase cage induction motors in accordance with IEC 60034-1, Edition 13.0, 2017, Rotating electrical machines – Part 1: Rating and performance for application in the petroleum and natural gas industries.

This specification follows a common document structure comprising the four documents as shown below, which together with the purchase order define the overall technical specification for procurement.



JIP33 Specification for Procurement Documents Supplementary Technical Specification

This specification is to be applied in conjunction with the supporting data sheet, quality requirements specification (QRS) and information requirements specification (IRS) as follows.

IOGP S-704: Supplementary Specification to IEC 60034-1 High Voltage Three Phase Cage Induction Motors

This specification defines the technical requirements for the supply of the equipment and is written as an overlay to IEC 60034-1, following the IEC 60034-1 clause structure. Clauses from IEC 60034-1 not amended by this specification apply as written to the extent applicable to the scope of supply.

Modifications to IEC 60034-1 defined in this specification are identified as Add (add to clause or add new clause), Replace (part of or entire clause) or Delete.

IOGP S-704D: Data Sheet for High Voltage Three Phase Cage Induction Motors

The data sheet defines application specific requirements, attributes and options specified by the purchaser for the supply of equipment to the technical specification. The data sheet may also include fields for supplier provided information attributes subject to purchaser's technical evaluation. Additional purchaser supplied documents may also be incorporated or referenced in the data sheet to define scope and technical requirements for enquiry and purchase of the equipment.

IOGP S-704Q: Quality Requirements for High Voltage Three Phase Cage Induction Motors

The QRS defines quality management system requirements and the proposed extent of purchaser conformity assessment activities for the scope of supply. Purchaser conformity assessment activities are defined through the selection of one of four generic conformity assessment system (CAS) levels on the basis of evaluation of the associated service and supply chain risks. The applicable CAS level is specified by the purchaser in the data sheet or in the purchase order.

IOGP S-704L: Information Requirements for High Voltage Three Phase Cage Induction Motors

The IRS defines the information requirements, including contents, format, timing and purpose to be provided by the supplier. It may also define specific conditions which invoke information requirements.

The terminology used within this specification and the supporting data sheet, QRS and IRS follows that of IEC 60034-1 and is in accordance with ISO/IEC Directives, Part 2 as appropriate.

The data sheet and IRS are published as editable documents for the purchaser to specify application specific requirements. The supplementary specification and QRS are fixed documents.

The order of precedence (highest authority listed first) of the documents shall be:

- a) regulatory requirements;
- b) contract documentation (e.g. purchase order);
- c) purchaser defined requirements (data sheet, QRS, IRS);
- d) this specification;
- e) IEC 60034-1.

1 Scope

Add new subclause

1.1 General

This specification amends and supplements IEC 60034-1, Edition 13.0, 2017 for the design, materials, fabrication and testing of high voltage AC squirrel cage induction motors for petroleum, chemical and other severe-duty industry applications.

Add new subclause

1.2 Motors included in scope

Included in the scope of this specification are electric motors that:

- are of a form-wound stator coil a.c. squirrel cage induction type;
- have a rated power 185 kW or greater;
- have a rated voltage above 1 kV or are form-wound with a rated voltage below 1kV;
- have 2, 4, 6 or 8 poles;
- are air- or water-cooled;
- have rolling element or sleeve bearings;
- are for single-speed use or are converter-fed.

Add new subclause

1.3 Motors excluded from scope

Excluded from the scope of this specification are electric motors that are:

- wire-wound rated at a voltage below 1 kV;
- submersible, subsea, canned or hermetically sealed motors;
- d.c. motors;
- synchronous motors (including permanent magnet motors).

Add new subclause

1.4 Extended use of this specification

This specification may be used as a basis for the purchase of electric motors which are outside the immediate scope of this specification, with those clauses that remain relevant for motors of a similar construction and cooling method, such as:

- motors with 10 poles or more;
- induction generators.

Those parameters which are outside the scope of this specification are subject to agreement between the purchaser and the manufacturer.

2 Normative references

Add to clause

API 541:2014, *Form-wound Squirrel Cage Induction Motors—375 kW (500 Horsepower) and Larger*

API RP 686:2009, *Recommended Practice for Machinery Installation and Installation Design*

API STD 670, *Machinery Protection Systems*

IEC 60034-2-1:2014, *Standard methods for determining losses and efficiency from tests (excluding machines for traction vehicles)*

IEC 60034-2-3, *Specific test methods for determining losses and efficiency of converter-fed AC motors*

IEC 60034-5, *Degrees of protection provided by the integral design of rotating electrical machines (IP code) – Classification*

IEC 60034-6, *Methods of cooling (IC Code)*

IEC 60034-7, *Rotating electrical machines - Part 7: Classification of types of construction, mounting arrangements and terminal box position (IM Code)*

IEC 60034-8:2014, *Terminal markings and direction of rotation*

IEC 60034-9:2007, *Rotating electrical machines - Part 9: Noise limits*

IEC 60034-14:2018, *Mechanical vibration of certain machines with shaft heights 56 mm and higher – Measurement, evaluation and limits of vibration severity*

IEC 60034-15, *Impulse voltage withstand levels of form-wound stator coils for rotating a.c. machines*

IEC TS 60034-25, *AC electrical machines used in power drive systems – Application guide*

IEC 60034-27-1, *Off-line partial discharge measurements on the winding insulation*

IEC 60034-27-3, *Dielectric dissipation factor measurement on stator winding insulation of rotating electrical machines*

IEC 60034-27-4, *Measurement of insulation resistance and polarization index of winding insulation of rotating electrical machines*

IEC 60034-18-1, *Rotating electrical machines – Part 18-1: Functional evaluation of insulation systems – General guidelines*

IEC 60034-18-42, *Partial discharge resistant electrical insulation systems (Type II) used in rotating electrical machines fed from voltage converters – Qualification tests*

IEC 60072-2, *Dimensions and output series for rotating electrical machines Part 2: Frame numbers 355 to 1000 and flange numbers 1180 to 2360*

IEC 60079-0, *Explosive atmospheres – Part 0: Equipment – General requirements*

IEC 60079-1, *Explosive atmospheres - Part 1: Equipment protection by flameproof enclosures "d"*

IEC 60079-2, *Explosive atmospheres – Part 2: Equipment protection by pressurized enclosure "p"*

IEC 60079-7, *Explosive atmospheres – Part 7: Equipment protection by increased safety "e"*

IEC 60085, *Electrical insulation – Thermal evaluation and designation*

IEC 60423:2007, *Conduit systems for cable management – Outside diameters of conduits for electrical installations and threads for conduits and fittings*

IEC 60751, *Industrial platinum resistance thermometers and platinum temperature sensors*

IEC 61800-4:2003, *Adjustable speed electrical power drive systems Part 4: General requirements - Rating specifications for a.c. power drive systems above 1 000 V a.c. and not exceeding 35 kV*

IEC 62262, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

ISO 281, *Rolling bearings - Dynamic load ratings and rating life*

ISO 1680, *Acoustics - Test code for the measurement of airborne noise emitted by rotating electrical machines*

ISO 5753-1:2009, *Rolling bearings — Internal clearance — Part 1: Radial internal clearance for radial bearings*

ISO 5593:2019, *Rolling bearings - Vocabulary*

ISO 12944-1, *Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 1: General introduction*

ISO 12944-2, *Paints and varnishes – Corrosion protection of steel structures by protective paint systems – Part 2: Classification of environments*

ISO 21940-11, *Mechanical vibration - Rotor balancing - Part 11: Procedures and tolerances for rotors with rigid behaviour*

ISO 21940-32, *Mechanical vibration - Rotor balancing - Part 32: Shaft and fitment key convention*

NEMA MG 1, *Motors and Generators*

3 Terms and definitions

Add new term

3.34

converter-fed motor

electric motor fed from a frequency converter independent of whether it is specifically designed for converter supply or whether it is an *electric motor* which is designed originally for main supply

Note 1 to entry: This definition is taken from IEC TS 60034-25 and for the purposes of this specification, replaces the term electrical machine with the term motor and removes reference to IEC 60034-12.

[SOURCE: IEC TS 60034-25: 2014, 3.5, modified: Note 1 to entry added and other modifications indicated in italics]

Add new term

3.35

D-end

drive end of a *motor*, that end of the *motor* which accommodates the shaft end

Note 1 to entry: This can also be expressed as DE.

Note 2 to entry: This definition is taken from IEC 60050-411 and for the purposes of this specification, replaces the term "machine" with the term "motor".

[SOURCE: IEC 60050-411: 1996, 411-43-36, modified: Note 1 to entry added and other modifications indicated in italics]

Add new term

3.36

N-end

non-drive end of a *motor*, that end of the *motor* opposite to the drive end

Note 1 to entry: This can also be expressed as NDE.

Note 2 to entry: This definition is taken from IEC 60050-411 and for the purposes of this specification, replaces the term machine with the term motor.

[SOURCE: IEC 60050-411: 1996, 411-43-37, modified: Note 1 to entry added and other modifications indicated in italics]

Add new term

3.37

notified body

organization designated by a European Union country to assess the conformity of equipment for use in potentially explosive atmospheres before being placed on the market

Note 1 to entry: These bodies carry out tasks related to conformity assessment procedures set out in the applicable legislation, when a third party is required.

Note 2 to entry: The European Commission publishes a list of such notified bodies.

Note 3 to entry: Notified bodies can certify to European Directive 2014/34/EU.

Add new term

3.38

certification body

organization having successfully completed the IECEx assessment process and approved to operate within the IECEx Certified Equipment Scheme

Add new term

3.39

form-wound winding

winding consisting of coils or bars which are preformed to shape, insulated and substantially completed before they are inserted into their final places

Note 1 to entry: Coils or bars are usually wound with rectangular conductors.

[Source IEC 60034-18-1:2010, 3.1.8]

Add new term

3.40

maximum continuous operating speed

highest rotational speed at which the motor, as-built and tested, is capable of continuous operation, expressed as revolutions per minute [rpm]

Add new term

3.41

minimum continuous operating speed

lowest rotational speed at which the motor, as-built and tested, is capable of continuous operation, expressed as revolutions per minute [rpm]

5 Rating

5.5 Rated output

5.5.3 Motors

Replace first sentence with

The motor rated output is the mechanical power available at the shaft and shall be expressed in kilowatts (kW).

6 Site conditions

6.4 Minimum ambient air temperature

Delete subclause 6.4

Add new subclause

6.8 Degree of ingress protection

6.8.1

For exterior locations, motors shall have a minimum degree of ingress protection of IP55, in accordance with IEC 60034-5.

NOTE For interior locations, the requirement for a degree of ingress protection lower than IP55 may be specified.

6.8.2

A condensation drain hole with a removable plug shall be provided at the motor enclosure low point, when mounted at the designated orientation.

Add new subclause

6.9 Degree of impact protection

The motor enclosure and terminal boxes shall have a minimum degree of protection against harmful external mechanical impacts of IK08 in accordance with IEC 62262.

7 Electrical operating conditions

7.2 Form and symmetry of voltages and currents

7.2.1 AC motors

7.2.1.1

Add to subclause

Single-speed motors shall be rated to operate on a supply voltage with the specified power supply quality.

Add to subclause

For converter-fed motors, the winding system shall comply with IEC 60034-18-42.

7.5 Voltage (peak and gradient) withstand levels

Replace fourth paragraph with

Where sample coils have been specified, testing shall comply with IEC 60034-15.

8 Thermal performance and tests

8.1 Thermal class

Replace first paragraph with

The motor insulation system shall be thermal class 155 (F) in accordance with IEC 60085 without exceeding thermal class 130 (B) temperature limits at the motor rated output at maximum ambient air temperature.

NOTE: Where the application requires motor insulation thermal class 180 (H) in accordance with IEC 60085 without exceeding class 155 (F) limits at the motor rated output at maximum ambient air temperature, this may be specified.

Add to subclause after first paragraph

For converter-fed motors, the total losses including additional losses within the operating load envelope due to a non-sinusoidal power supply shall not cause thermal class 130 (B) temperature limits to be exceeded.

8.6 Determination of winding temperature

8.6.1 Choice of method

Delete second and third paragraphs

8.6.2 Determination by resistance method

8.6.2.3 Correction for stopping time

8.6.2.3.2 Short stopping time

Short stopping time shall be determined by the following steps.

- Obtain initial resistance reading after stabilization of the measuring device and within 120 seconds of switching off power.
- Take additional readings at 30 second intervals over a five minute period following the first reading.
- Calculate the resistance value at the time of switching off power by means of extrapolation.
- Use the resistance value at the time of switching off power to confirm the winding temperature at the time of switching power off.

NOTE Resistance readings to be measured between the same windings for all readings.

Delete Table 6

8.6.2.3.3 Extended stopping time

Delete subclause 8.6.2.3.3

9 Other performance and tests

9.1 Routine tests

Replace subclause with

Add new subclause

9.1.1 General

9.1.1.1

Routine tests shall be performed on all motors at the factory of the manufacturer.

9.1.1.2

The motor shall be completely assembled with the exception of components which are not significant for the testing.

9.1.1.3

Shims used during testing shall be in accordance with API RP 686, 5.4.2.4.

9.1.1.4

A "soft feet" check shall be made prior to any running test in accordance with API 541, 6.3.1.6.

Add new subclause

9.1.2 Motors with sleeve bearings

9.1.2.1

Factory tests shall be carried out with the lube oil grade, inlet temperature and flow rate specified as per site conditions.

9.1.2.2

During the vibration severity test, the lube oil temperature and pressure shall be varied through the specified operating range from minimum to maximum.

9.1.2.3

The following data shall be plotted during coast, prior and post heat run test and vibration severity test, covering the speed range from motor trip to 400 rpm:

- synchronous (one per revolution) vibration amplitude;
- overall vibration amplitude;
- phase angle versus speed.

9.1.2.4

The contact between the shaft journal and the bearing bore shall be a minimum of 80 % of the axial length and symmetrical, with no edge loading or metal transfer between the shaft and the bearing.

9.1.2.5

Where bearing disassembly, modification or replacement is required during testing, previous motor tests shall be repeated so revised bearing configuration can be assessed.

9.1.2.6

Shaft vibration displacement at any filtered frequency below running-speed frequency shall not exceed 2,5 μm p-p or 20 % of the measured unfiltered vibration displacement, whichever is greater.

9.1.2.7

Shaft vibration displacement at any filtered frequency above running-speed frequency shall not exceed 12,5 μm p-p.

9.1.2.8

Shaft vibration displacement filtered at running-speed frequency (run-out compensated) shall not exceed 80 % of the unfiltered specified limit.

9.1.2.9

The magnitude of the vectorial change in the 1X vibration (where vibration cpm equals motor rpm) on the shaft and bearing housings, when operated at running speed after the overspeed tests, shall not exceed 10 % of the unfiltered specified vibration limits.

Replace Table 16 with Tables 16A, 16B and 16C

Add new table

Table 16A – Minimum routine tests for single speed motors assembled and tested in the factory of the manufacturer

Number	Test description	Reference standard	Routine / Type ^a	Motors with a rated power less than 400 kW	Motors with a rated power 400 kW to 2 000 kW	Motors with a rated power greater than 2 000 kW
1	Air-gap measurement between stator and rotor		Routine	Yes	Yes	Yes
2	Measurement of ohmic resistance of stator winding referred to 20 °C	IEC 60034-1 Section 9	Routine	Yes	Yes	Yes
3	Insulation resistance and polarization index of stator windings - pre test	IEC 60034-27-4	Routine	Yes	Yes	Yes
4	Check of phase sequence, direction of rotation and terminal markings	IEC 60034-8 Section 6.7	Routine	Yes	Yes	Yes
5	No-load losses and current test at rated frequency ^b	IEC 60034-1 Section 9	Routine	Yes	Yes	Yes
6	No-load characteristic (saturation curve) at rated frequency		Type	No	Yes	Yes
7	Locked rotor current test		Routine	No	Yes	Yes
8	Locked rotor torque test		Type	No	Yes	Yes
9	Heat run test at full load	IEC 60034-1 Section 8	Type	Yes	Yes	Yes
10	Performance test at rated frequency at 100 %, 75 % and 50 % load ^c	IEC 60034-2-3	Type	Yes	Yes	Yes
11	Vibration severity test at no-load (for the whole operating speed range) ^{d,e,f}		Routine	No	Yes	Yes
12	Overspeed test	IEC 60034-1 Section 9	Routine	No	Yes	Yes

Number	Test description	Reference standard	Routine / Type ^a	Motors with a rated power less than 400 kW	Motors with a rated power 400 kW to 2 000 kW	Motors with a rated power greater than 2 000 kW
13	Measurements of shaft voltage at no-load		Routine	Yes	Yes	Yes
14	Determination of magnetic centre (where sleeve bearings are provided)		Routine	No	Yes	Yes
15	Sleeve bearing inspection (where sleeve bearings are provided)	9.1.3	Routine	No	Yes	Yes
16	SPM recording (where rolling element bearings are provided)		Routine	Yes	No	No
17	Withstand voltage test	IEC 60034-1 Section 9	Routine	No	Yes	Yes
18	Insulation resistance and polarization index of stator windings - post withstand voltage test	IEC 60034-27-4	Routine	No	Yes	Yes
Auxiliary devices						
19	Functional tests of all auxiliary devices		Routine	Yes	Yes	Yes
20	Withstand voltage tests on RTDs, space heaters and insulated bearings where applicable		Routine	Yes	Yes	Yes
21	Insulation resistance tests on RTDs, space heaters and insulated bearings where applicable		Routine	Yes	Yes	Yes
Air to water heat exchangers						
22	Hydrostatic pressure test of heat exchanger tubing	As per design code ^g	Routine	Yes	Yes	Yes
^a A type test shall be performed on a single motor only, where a number of identical motors are being purchased as a batch. ^b No stabilization of temperature required for measurement of no-load losses. ^c Performance test to include determination of power factor, efficiency, current balance and slip. ^d Contract vibration sensors shall be used, forming the basis for acceptance. ^e For rolling element bearings, test facilities shall include the capability to continuously monitor, display, record, and print vibration speeds. ^f For sleeve bearings, test facilities shall include the capability to continuously monitor, display, record, and print vibration displacements and phase, vibration spectra, Bode plots and shaft orbits. ^g Heat exchanger design code to be confirmed by supplier.						

Add new table**Table 16B – Minimum routine tests for converter-fed motors assembled and tested in the factory of the manufacturer**

Number	Test description	Reference standard	Routine / Type ^a	Motors with a rated power less than 400 kW	Motors with a rated power 400 kW to 2 000 kW	Motors with a rated power greater than 2 000 kW
1	Air-gap measurement between stator and rotor		Routine	Yes	Yes	Yes
2	Measurement of ohmic resistance of stator winding referred to 20 °C	IEC 60034-1 Section 9	Routine	Yes	Yes	Yes
3	Insulation resistance and polarization index of stator windings - pre test		Routine	Yes	Yes	Yes
4	Check of phase sequence, direction of rotation and terminal markings		Routine	Yes	Yes	Yes
5	No-load losses and current test at rated frequency ^b	IEC 60034-1 Section 9	Routine	Yes	Yes	Yes
6	No-load losses and current test at minimum continuous operating frequency	IEC 60034-1 Section 9	Routine	No	Yes	Yes
7	No-load losses and current test at maximum continuous operating frequency	IEC 60034-1 Section 9	Routine	No	Yes	Yes
8	No-load characteristic (saturation curve) at rated frequency		Type	No	Yes	Yes
9	Heat run test at rated torque and rated frequency	IEC 60034-1 Section 8	Type	Yes	Yes	Yes
10	Heat run test at maximum torque at minimum continuous operating frequency	IEC 60034-1 Section 8	Type	No	Yes	Yes
11	Heat run test at maximum torque at maximum continuous operating frequency	IEC 60034-1 Section 8	Type	No	Yes	Yes
12	Performance test ^c at rated frequency at 100 %, 75 % and 50 % load	IEC 60034-2-3	Type	Yes	Yes	Yes
13	Performance test ^c at min cont. operating frequency at 100 %, 75 % and 50 % torque	IEC 60034-2-3	Type	No	Yes	Yes

Number	Test description	Reference standard	Routine / Type ^a	Motors with a rated power less than 400 kW	Motors with a rated power 400 kW to 2 000 kW	Motors with a rated power greater than 2 000 kW
14	Performance test ^c at max cont. operating frequency at 100 %, 75 % and 50 % torque	IEC 60034-2-3	Type	No	Yes	Yes
15	Vibration severity test at no-load (for the whole operating speed range) ^{d,e,f}		Routine	Yes	Yes	Yes
16	Overspeed test	IEC 60034-1 Section 9	Routine	No	Yes	Yes
17	Measurements of shaft voltage at no-load		Routine	No	Yes	Yes
18	Determination of magnetic centre (where sleeve bearings are used)		Routine	No	Yes	Yes
19	Sleeve bearing inspection (where sleeve bearings are used)	9.1.3	Routine	No	Yes	Yes
20	SPM recording (where rolling element bearings are provided)		Routine	Yes	No	No
21	Withstand voltage test	IEC 60034-1 section 9	Routine	Yes	Yes	Yes
22	Insulation resistance and polarization index of stator windings - post withstand voltage test	IEC 60034-27-4	Routine	Yes	Yes	Yes
Auxiliary devices						
23	Functional tests of all auxiliary devices		Routine	Yes	Yes	Yes
24	Withstand voltage tests on RTDs, space heaters and insulated bearings where applicable		Routine	Yes	Yes	Yes
25	Insulation resistance tests on RTDs, space heaters and insulated bearings where applicable		Routine	Yes	Yes	Yes
Air to water heat exchangers						
26	Hydrostatic pressure test of heat exchanger tubing	As per design code ^g	Routine	Yes	Yes	Yes

Number	Test description	Reference standard	Routine / Type ^a	Motors with a rated power less than 400 kW	Motors with a rated power 400 kW to 2 000 kW	Motors with a rated power greater than 2 000 kW
^a	A type test shall be performed on a single motor only, where a number of identical motors are being purchased as a batch.					
^b	No stabilization of temperature required for measurement of no-load losses.					
^c	Performance test to include determination of power factor, efficiency, current balance and slip.					
^d	Contract vibration sensors shall be used, forming the basis for acceptance.					
^e	For rolling element bearings, test facilities shall include the capability to continuously monitor, display, record, and print vibration speeds.					
^f	For sleeve bearings, test facilities shall include the capability to continuously monitor, display, record, and print vibration displacements and phase, vibration spectra, Bode plots and shaft orbits.					
^g	Heat exchanger design code to be confirmed by supplier.					

Add new table**Table 16C – Special tests to be selected in data sheet as required**

Number	Test Description (selected in data sheet where required)	Reference standard
1	Noise level at no load	
2	Measurement of moment of inertia	
3	Measurement of torque and current as function of speed from standstill to synchronous speed (for single-speed motors)	
4	Measurement of axial shaft displacement	
5	Dielectric dissipation test ($\tan \delta$) on stator windings	IEC 60034-27-3
6	Partial discharge test on complete stator	IEC 60034-27-1
7	Sealed winding conformance test	NEMA MG 1 Part 20
8	Unbalanced response test	API 541 6.3.5.3
9	Bearing housing natural frequency test	API 541 6.3.5.4
Sample coils		
10	Impulse voltage withstand tests of sample coils	IEC 60034-15
11	Dielectric dissipation tests ($\tan \delta$) of sample coils	IEC 60034-27-3
12	Partial discharge test of sample coils	IEC 60034-27-1
NOTE 1 Tests are performed at rated frequency, voltage and speed where applicable.		
NOTE 2 The requirement for the tests listed above can be selected individually.		

9.4 Momentary excess torque for motors

9.4.1 Polyphase induction motors and d.c. motors

Delete seventh paragraph

Table 19 – Overspeeds

Add to table

Item	Motor type	Overspeed
1e)	Converter fed three-phase cage induction motor > 1 000 V ac	1,2 times maximum rated speed or 1,05 times maximum continuous operating speed, whichever is greater

Add new subclause

9.12 Single-speed motor starting, re-starting and re-acceleration

9.12.1 Starting

9.12.1.1

The declared locked-rotor current shall be between 4,5 and 6,5 times the rated current.

NOTE 1 Motors with locked-rotor currents less than 4,5 times the rated current may compromise performance characteristics (such as efficiency, breakdown torque, and rotor thermal stability). Caution should be applied when specifying a motor with a locked-rotor current less than 4,5 times the rated current.

NOTE 2 Where a project specific maximum locked-rotor current is specified, this value will have zero positive tolerance.

9.12.1.2

At 80 % of rated voltage at motor terminals, the motor shall achieve rated speed at rated load without exceeding maximum temperature rise.

9.12.1.3

The torque-speed characteristic of the motor at rated frequency and 80 % rated voltage applied at the motor terminals shall have an accelerating torque margin above the driven load torque-speed curve of at least 10 % of the motor full load torque.

9.12.1.4

Running-up times shall be calculated using inertia values and torque-speed characteristics of the driven equipment.

9.12.1.5

At 80 % of rated voltage at motor terminals, the minimum safe hot stall locked-rotor time shall be five seconds more than the time required to accelerate the specified driven load.

9.12.2 Re-starting

9.12.2.1

Motors shall be capable of withstanding three starts in succession (coasting to rest between starts) from cold conditions.

9.12.2.2

Motors shall be capable of withstanding two starts from hot in succession after running at rated conditions.

9.12.2.3

Motors with a quadratic torque-speed characteristic shall be capable of re-acceleration under full load conditions following a power interruption not exceeding 0,2 seconds.

9.12.2.4

Motors shall withstand re-acceleration with 100 % residual voltage and in total phase opposition to the supply voltage.

9.12.2.5

Motors shall be designed for a minimum of 1 000 starts per year.

9.12.3 Transient air-gap torques

9.12.3.1

The bracing of end windings shall withstand a three-phase short circuit at the motor terminals.

9.12.3.2

The rotor shaft and active iron core systems shall withstand two-phase short circuits.

Add new subclause

9.13 Pulsating stator current

Driven loads requiring variable torque during each revolution shall have inertia to limit the stator current to not exceed 40 % of the motor full load current.

Add new subclause

9.14 Critical speeds

9.14.1

Rigid shaft rotors shall incur the first bending critical speed at least 20 % above the synchronous speed or maximum continuous speed for converter-fed motors.

9.14.2

Flexible shaft rotors shall incur a critical speed separation margin of at least 20 % below minimum operating speed and 20 % above the maximum continuous speed.

Add new subclause

9.15 Motor efficiency

For single-speed and converter-fed motors, compliance with Table 22 shall be confirmed at rated voltage and frequency in accordance with IEC 60034-2-1, Table 2.

Add new table

Table 22 – Motor efficiency

Power rating in kW	2 pole motor efficiency %	4 pole motor efficiency %
185	94.2	94.6
200	94.5	94.7
220	94.7	95.1
250	95.1	95.2
280	95.3	95.4
300	95.4	95.5
315	95.5	95.5
335	95.6	95.6
355	95.7	95.7
375	95.8	95.8
400-500	96.0	96.0
530-570	96.2	96.2
800-950	96.4	96.4
≥1 000	96.5	96.5

Add new subclause

9.16 Noise

9.16.1

Without secondary noise abatement measures, the motor maximum A-weighted sound power level (LWA) at no-load and rated speed shall not exceed the values defined in IEC 60034-9, Table 1.

NOTE IEC 60034-9 Table 1 addresses motors with a power rating up to and including 5.5 MW. For motors with a power rating greater than 5.5 MW, the maximum sound pressure level is specified in the data sheet.

9.16.2

Noise measurements shall be in accordance with ISO 1680.

10 Rating plates

10.1 General

Add new subclause

10.1.1

Rating and marking plates shall be made of 316L stainless steel.

Add new subclause

10.1.2

Rating and marking plates shall be attached to a non-removable part of the motor frame with stainless steel 316L fixings.

Add new subclause

10.1.3

Rating and marking plates shall have information stamped or engraved.

10.2 Marking

Replace list item aa) with

aa) The total mass of the motor.

Add new list item

ee) D-end and N-end bearing type.

Add new list item

ff) Equipment tag number.

11 Miscellaneous requirements

11.1 Protective earthing of motors

Replace fourth paragraph with

Motors shall have at least one ISO metric thread earthing terminal fitted externally on the frame and a means inside the terminal box for connecting a conducting cable sheath.

Add new subclause

11.3 Motor construction

11.3.1 Enclosure

11.3.1.1

Motor enclosures shall be constructed from cast iron or steel.

11.3.1.2

Motors shall have frame dimensions in accordance with IEC 60072 or be of a proven design with a service record of at least 10 000 hours.

11.3.1.3

Where provided, fan covers shall be constructed from ferrous metal.

11.3.1.4

Motors shall be provided with frame mounted lifting lugs or lifting eye bolts.

11.3.1.5

Foot mounted motors frame size 400 and above shall be provided with jacking facilities to align the motor with the driven equipment.

11.3.1.6

Where a corrosivity category of C4 or greater has been specified, external screws, bolts, nuts and washers up to and including a thread diameter of 10 mm shall be made from 316L stainless steel.

11.3.1.7

Where a corrosivity category of C4 or greater has been specified, external screws, bolts, nuts and washers with a thread diameter greater than 10 mm shall be hot dip galvanized.

11.3.1.8

Where a corrosivity category of C4 or greater has been specified, grease nipples shall be made from 316L stainless steel.

11.3.1.9

Motors with a frame size 630 and above shall have removable covers for inspection of the air-gap in at least three positions, 90° apart.

11.3.1.10

The motor shall be free of structural resonances on its permanent foundation with a safety margin of at least 20 % within the operating speed range for one and two times electrical motor power frequency.

11.3.1.11

The motor shall be free of structural resonances on its permanent foundation with a safety margin of at least 20 % within the operating speed range for one and two times mechanical rotating frequency.

11.3.1.12

For motors with sleeve bearings, there shall be no structural resonances between 40 % and 60 % of the operating speed range.

11.3.2 Windings

11.3.2.1

Windings shall be of a form wound global fully vacuum pressure impregnated (VPI) construction.

11.3.2.2

The stator winding system, including connections and terminal lead extensions, shall be supported, wedged or braced to prevent insulation cracking.

11.3.2.3

Conductors connected between stator coils and terminals bushings shall allow movement of the stator during start up and thermal expansion.

11.3.2.4

Connections in end windings, coils and conductors to the terminal box shall be either crimped and brazed or crimped and soldered.

NOTE Crimped only connections are not permitted.

11.3.2.5

Coils shall be insulated by mica tape.

11.3.2.6

Stator coils and terminals shall have uniform insulation levels throughout the entire winding length.

11.3.2.7

For motors with a rated voltage of 3 kV and above, windings shall be provided with an anti-corona protection system in the slot of the coil.

11.3.2.8

For motors with a rated voltage of 5 kV and above, field stress grading tape shall also be used for anti-corona protection.

11.3.3 Rotor

11.3.3.1

The shaft shall be made of one-piece, heat-treated steel.

11.3.3.2

Where shaft keys are provided, rotors shall be balanced with a half-key fitted in the shaft key-way in accordance with IEC 60034-14 and ISO 21940-32.

11.3.3.3

Rotors with rigid shaft characteristics shall be balanced in accordance with ISO 21940-11 to meet the limits of the maximum vibration magnitude specified, in accordance with IEC 60034-14, Table 1.

Note: For converter-fed motors, the maximum vibration magnitude is applicable throughout the defined speed range.

11.3.3.4

Rotors with flexible shaft characteristics shall be balanced in accordance with ISO 21940-12 to meet the limits of the maximum vibration magnitude specified, in accordance with IEC 60034-14, Table 1.

Note: For converter-fed motors, the maximum vibration magnitude is applicable throughout the defined speed range.

11.3.3.5

Rotor shaft ends shall be provided with an ISO metric threaded hole to facilitate coupling and rolling element bearing removal.

11.3.4 Fan

11.3.4.1

Where a corrosivity category greater than C3 has been specified, aluminium fan impellers shall not be provided.

11.3.4.2

Where fan balancing is required, fans external to the stator frame end shields shall be individually balanced prior to fitting to the rotor shaft.

11.3.4.3

Fan impellers external to the stator frame shall be keyed to the rotor shaft.

11.3.4.4

Unidirectional fans shall be provided with an engraved arrow permanently indicating the direction of rotation.

11.3.5 Terminal box

11.3.5.1

Terminal boxes shall be constructed from steel with a minimum nominal thickness of 3 mm.

11.3.5.2

Threaded cable glands shall have a metric thread in accordance with IEC 60423, Table 1.

11.3.5.3

Cable entries shall be fitted with blanking devices to maintain the ingress protection rating of the motor during transportation and storage.

11.3.5.4

Where single core line conductor cable entries have been specified, gland plates and transit frames shall be of a non-magnetic material.

11.3.5.5

For converter-fed motors, provisions for 360° high frequency earthing shall be provided where cables enter the terminal box.

11.3.5.6

For converter-fed motors, conductive gaskets shall be provided.

11.3.5.7

Where winding partial discharge monitoring is specified, the partial discharge sensing elements shall be located in the line conductor terminal box.

11.3.5.8

Where a star point terminal box is specified it shall be located on the opposite side of the motor from the line conductor terminal box.

11.8.5.9

Space shall be provided for the installation of current transformers to facilitate differential protection in the star point terminal box.

11.3.5.10

For terminal boxes that are not Ex db, a diaphragm shall be incorporated in the terminal box to relieve pressure caused by an electrical breakdown.

11.3.5.11

The pressure relief diaphragm shall be arranged so that in the event activation, the discharge is directed away from locations where personnel are normally present.

11.3.5.12

The pressure relief diaphragm shall be made of corrosion-resistant material or shall have corrosion-resistant plating or treatment applicable for the specified environmental conditions.

NOTE It is expected that the pressure relief diaphragm air deflector shall have corrosion resistance properties comparable to the motor enclosure surface protection system.

11.3.5.13

Where the termination system is not fully insulated, a connection point on each phase and earth terminal shall be provided for the attachment of the portable earthing device specified.

11.3.5.14

Terminal box covers with a mass greater than 25 kg shall be provided with hoisting attachments or shall be vertically hinged.

11.3.5.15

Auxiliary terminal box cables shall be bottom entry.

11.3.6 Bushings and terminations

11.3.6.1

Line conductor bushings or post insulators shall be polyurethane resin or epoxy casting resin.

11.3.6.2

Bushings and insulators shall be able to withstand the dynamic and thermal effects of the maximum prospective short circuit current specified in the data sheet for at least 0,2 seconds.

11.3.7 Bearings

11.3.7.1 General

11.3.7.1.1

Bearings shall be grease lubricated rolling element bearings or oil lubricated sleeve bearings.

11.3.7.1.2

Sleeve bearings shall be used when the product of rated power in kW and speed in revolutions per minute (rpm) is greater than 4.0×10^6 .

NOTE If standard motor or driven equipment use rolling element bearings, these may be proposed.

11.3.7.1.3

A minimum of one 3-wire Pt-100 temperature detector shall be provided per bearing.

11.3.7.2 Bearing insulation

11.3.7.2.1

The N-end bearing shall be electrically insulated from the rotor shaft.

11.3.7.2.2

Where the D-end and N-end bearings are insulated, a shaft grounding system shall be provided at the D-end of the rotor shaft.

NOTE A shaft grounding system may be provided at the N-end of the rotor shaft if an insulated coupling has been specified.

11.3.7.3 Sleeve bearings

11.3.7.3.1

Sleeve bearing liner replacement shall be possible without disassembly of coupling or motor parts.

11.3.7.3.2

Sleeve bearings shall be of a split construction for ease of assembly.

11.3.7.3.3

Naturally lubricated sleeve bearings shall be provided with an oil level indicator.

11.3.7.3.4

For force lubricated sleeve bearings a flow indicator shall be provided.

11.3.7.3.5

Sleeve bearings with a ring lubricating system shall allow visual inspection of the oil ring operation while the motor is running.

11.3.7.3.6

Sleeve bearings shall be spherical seated and self-aligning.

11.3.7.3.7

The magnetic centre and the limits of permissible shaft axial movement shall be permanently marked on the rotor to facilitate observation of the rotor position relative to these marks at all times.

11.3.7.3.8

Each sleeve bearing shall be provided with two non-contacting proximity probes in accordance with API 670.

11.3.7.3.9

Sleeve bearing oil temperature shall not exceed 80 °C.

11.3.7.3.10

Sleeve bearings shall not require jacking oil prior to motor starting.

11.3.7.4 Rolling element bearings**11.3.7.4.1**

Grease lubricated rolling element bearings lubrication intervals shall be 4 000 hours or greater for horizontal motors and 2 000 hours or greater for vertical motors.

11.3.7.4.2

Rolling element bearings shall be C3 type in accordance with ISO 5753-1, Table 1, Group 3.

11.3.7.4.3

Horizontally mounted motor bearings shall have a minimum L10h bearing design lifetime of 50 000 hours in accordance with ISO 281 when the defined radial and axial load values are not exceeded.

11.3.7.4.4

Vertically mounted motor bearings shall have a minimum L10h bearing design lifetime of 40 000 hours in accordance with ISO 281 when the defined radial and axial load values are not exceeded.

11.3.7.4.5

Motors with rolling element bearings and a rated power of less than 400 kW shall be provided with one stainless steel SPM (shock pulse monitoring) nipple per bearing.

11.3.7.4.6

Motors with rolling element bearings and a rated power equal to or greater than 400 kW shall be provided with one accelerometer per bearing.

11.3.7.4.7

Where accelerometers are not provided, the motors shall have two clearly marked positions, X and Y, at each bearing housing with a flat surface for mounting of a magnetic portable accelerometer.

11.3.7.4.8

Rolling element bearings shall be greased, packed and equipped with double (metallic) shields or double (rubber) seals according to ISO 5593: 2019, Figure 2, Figure 8 or Figure 44.

11.3.7.4.9

Relubrication of bearings shall be possible whilst the motor is in operation.

11.3.7.4.10

A synthetic base oil grease with structural stability in the presence of water shall be used in rolling element bearings.

11.3.8 Space heaters

11.3.8.1

The space heater shall be rated for operation at the heater supply a.c. voltage specified.

11.3.8.2

Space heaters shall maintain the surface temperature of the stator windings at not less than 5 K above ambient air temperature to maintain the integrity of the insulation system at minimum ambient air temperature.

11.3.8.3

A dedicated space heater terminal box shall be provided for the space heater terminals.

11.3.8.4

A label shall be fixed externally to the terminal box containing the heater terminals, warning that heater terminals may be live when the motor is isolated.

Add new subclause

11.4 Mounting

11.4.1 Mounting arrangement

Motors shall have one of the mounting arrangements confirmed in Table 23, in accordance with IEC 60034-7.

Add new table

Table 23 –Mounting arrangement

Mounting arrangement	Designation
Horizontal shaft, foot mounted motors with one cylindrical shaft extension	IM B3 (IM 1001)
Horizontal shaft, foot mounted motors with one conical shaft extension	IM B3 (IM 1003)
Horizontal shaft, flange mounted motors with one cylindrical shaft extension	IM B5 (IM 3001)
Vertical shaft, foot mounted motors with one cylindrical shaft extension	IM V6 (IM 1031)
Vertical shaft, flange mounted motors with one cylindrical shaft extension	IM V1 (IM 3011)
Vertical shaft, foot mounted motors with one flanged shaft extension	IM V6 (IM 1035)
Vertical shaft, flange mounted motors with one flanged shaft extension	IM V1 (IM 3015)

11.4.2 Vertically mounted motors

Vertically mounted motors with a downward facing drive-end shaft shall be provided with a canopy over any upward facing air inlets.

11.4.3 Mounting surfaces and alignment

11.4.3.1

Frame mounting surfaces shall be machined to at least a finish of 6 μm arithmetic average roughness (Ra).

11.4.3.2

Mounting surfaces shall be machined within a flatness of 40 μm per linear meter of mounting surface.

11.4.3.3

Frame mounting surfaces shall be in the same horizontal plane within 125 μm .

11.4.3.4

The upper machined or spot faced surface shall be parallel to the mounting surface.

11.4.3.5

Different mounting planes shall be parallel to each other within 0,17 mm per meter.

11.4.3.6

The mounting planes on a horizontal motor shall be parallel to a horizontal plane through the bearing centreline within 0,17 mm per meter.

11.4.3.7

The mounting surface on a vertical motor shall be machined perpendicular to the motor's centreline.

11.4.3.8

The mounting surface on a vertical motor shall not deviate from the perpendicular plane by more than 0,17 mm per meter.

11.4.3.9

Hold down or foundation bolt holes shall be drilled perpendicular to the mounting surfaces of the motor.

11.4.3.10

Hold down or foundation bolt holes shall be machined or spot faced to a diameter of at least two times that of the bolt hole.

11.4.3.11

Hold down or foundation bolt holes shall be 13 mm larger in diameter than the hold down bolt.

11.4.3.12

Load bearing washers shall remain in 360° contact with the mounting faces when the machine is aligned in its extreme position where the bolt is touching one side of its clearance hole.

11.4.3.13

Frame supports shall be provided with two vertical pilot holes for the installation of alignment dowels.

Add new subclause

11.5 Methods of cooling**11.5.1 Cooling method**

Motors shall have one of the cooling methods confirmed in Table 24, in accordance with IEC 60034-6.

Add new table

Table 24 – Cooling method

Cooling method	Code
Frame surface cooled motors using surrounding medium with self circulation of secondary coolant	IC4A1A1
Motors with an integral heat exchanger using surrounding medium with self circulation of secondary coolant	IC5A1A1
Motors with a machine mounted heat exchanger using surrounding medium with self circulation of secondary coolant	IC6A1A1
Motors with a machine mounted heat exchanger using surrounding medium with self circulation of primary coolant	IC8A1W7

11.5.2 Cooling enclosure

Where provided, motor cooling enclosures shall be of steel construction.

11.5.3 Air to air heat exchangers

A Pt-100 temperature monitoring device shall be provided to monitor heat exchanger outlet air temperature.

11.5.4 Air to water cooling

11.5.4.1

Facilities for high point bleeding and low point draining of the cooling system shall be provided.

11.5.4.2

The heat exchanger shall prevent the entry of water into the motor components, whether by leakage or condensation.

11.5.4.3

Air to water heat exchangers shall have 20 % surplus number of tubes to allow for plugging of leaking tubes over the lifetime of the motor.

11.5.4.4

A cooling water leakage detection system shall be provided.

11.5.4.5

A facility for the collection of coolant leakage with drainage shall be provided.

11.5.4.6

Pt-100 temperature monitoring devices shall be provided to monitor heat exchanger inlet and outlet air temperatures.

11.5.4.7

As a minimum, single copper-nickel tubing shall be provided where fresh water cooling medium has been specified.

11.5.4.8

Double copper-nickel tubing or single titanium tubing shall be provided where a sea water cooling medium has been specified.

11.5.5 Inlet protection

Where a corrosivity category of C4 or greater has been specified, mesh cooling air inlet protection shall be made from 316L stainless steel.

Add new subclause

11.6 Surface finish

11.6.1

For onshore applications, the protective paint system corrosivity category shall be a minimum of C3 in accordance with ISO 12944-2.

11.6.2

For offshore exterior applications, the protective paint system corrosivity category shall be CX in accordance with ISO 12944-2.

11.6.3

The protective paint system durability category shall be a minimum of “medium” in accordance with ISO 12944-1.

Add new subclause

11.7 Temperature monitoring

11.7.1

As a minimum, two 3-wire Pt-100 temperature detectors in accordance with IEC 60751 shall be embedded at the hot spot in each winding.

11.7.2

Temperature monitoring devices shall be wired to a separate terminal box mounted on the motor frame.

11.7.3

The manufacturer shall confirm by calculation if over-voltage surge arrestors are required.

11.7.4

Where surge arrestors are provided, they shall be installed in the temperature monitoring terminal box.

Add new subclause

11.8 Differential protection

Where specified, differential protection star point connections shall be brought out to a dedicated star point terminal box.

Add new subclause

11.9 Bonding

Motors shall have a bonding strap across joints within or between steel main enclosure, bed plate and heat exchanger.

Add new subclause

11.10 Additional requirements for converter-fed motors

11.10.1 General

Converter-fed motors shall comply with IEC TS 60034-25.

11.10.2

The stated continuous motor output ratings for converter-fed motors shall be in accordance with IEC 61800-4, 6.1.3.

Add new subclause

11.11 Lateral vibration analysis

Where specified, lateral analysis shall be carried out for both FAT (rigid workshop floor) and final site conditions (flexible skid or foundation) in accordance with API 541, 4.4.6.2.1.

Add new subclause

11.12 Torsional analysis

11.12.1 Torsional vibration analysis

Where specified, torsional analysis shall be performed in accordance with API 541, 4.4.6.2.2.

11.12.2 Torsional vibration analysis

Where specified, torsional analysis on converter-fed motors shall be performed in accordance with API 541, 4.4.6.2.2 and IEC 61800-4, 9.4.

Add new clause

15 Motors intended for use in potentially explosive atmospheres

15.1 General

15.1.1

Motors for use in potentially explosive atmospheres shall be in conformance with IEC 60079 series.

15.1.2

Motors with an equipment protection level of EPL Ga or EPL Gb or EPL Gc shall be provided with an equipment certificate issued by the specified notified body or certification body.

15.1.3

Motors shall be certified for use in gaseous atmospheres for temperature group T3 as a minimum and for gases in group IIB as a minimum.

15.1.4

Motors shall have one of the protection systems confirmed in Table 25.

Add new table

Table 25 – Protection system

Protection system	International standard
Ex db	IEC 60079-1
Ex db eb	IEC 60079-1 and IEC 60079-7
Ex eb	IEC 60079-7
Ex ec	IEC 60079-7
Ex pxb	IEC 60079-2
Ex pyb	IEC 60079-2
Ex pzc	IEC 60079-2

15.1.5

Motor electrical sub-components shall be certified for the motor explosion protection level.

15.2 Converter-fed motors

Where type test certification is unavailable for the duty of a converter-fed motor, means of temperature control by embedded temperature sensors for limiting the surface temperature of the motor housing shall be provided.

15.3 Flameproof (type Ex db)

15.3.1

On motors with a defined equipment protection level of Ex db eb, terminal boxes shall have an equipment protection level of Ex eb.

15.3.2

A drain fitted with a certified drain plug shall be provided at the motor enclosure low points when mounted at the designated IM orientation.

15.4 Pressurized (type Ex pxb and Ex pzc)

15.4.1

A certified control system for motor pressurization shall be provided to facilitate local control.

15.4.2

The control unit shall provide remote indication output for connection to the end user's integrated system for the 'purge complete' condition.

15.4.3

The control unit shall provide remote indication output for connection to the end user's integrated system for the 'pressurized' condition.

15.4.4

The control unit shall provide remote indication output for connection to the end user's integrated system for the 'pressure fail' condition.

15.4.5

On motors with a defined equipment protection level of Ex pxb, terminal boxes shall have an equipment protection level of Ex eb.

15.4.6

On motors with a defined equipment protection level of Ex pzc, terminal boxes shall have an equipment protection level of Ex ec.

15.5 Increased Safety (type Ex eb and Ex ec)

15.5.1

The acceleration time of the motor shall not exceed 80 % of the t_E time.

15.5.2

A facility for purging the motor with inert gas or compressed air before starting shall be provided.

15.5.3

Where the assessment for possible air gap sparking is required as per IEC 60079-7, 5.2.7.3 method a) shall be applied.

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New Draft

