



RP 12-11

**ELECTRICAL SYSTEMS AND
INSTALLATIONS - MOTORS**

July 1996

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BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING											
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SCOPE AND PURPOSE BP Group RP 12 series specifies BP general requirements for electrical systems, equipment, materials and installations. This document (BP Group RP 12-11) specifies requirements for the selection and application of electric motors. The recommendations apply to both onshore and offshore installations. This document co-ordinates the best practice found in a range of local, national and international references and details appropriate measures where a choice of solution is required.											
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FOREWORD

Introduction to BP Group Recommended Practices and Specifications for Engineering

The Introductory Volume contains a series of documents that provide an introduction to the BP Group Recommended Practices and Specifications for Engineering (RPSEs). In particular, the 'General Foreword' sets out the philosophy of the RPSEs. Other documents in the Introductory Volume provide general guidance on using the RPSEs and background information to Engineering Standards in BP. There are also recommendations for specific definitions and requirements.

Value of this Recommended Practice

This Recommended Practice provides guidance on the application of national and international documents and gives additional guidance not contained in these documents. This document refers to local, national and international Standards which are widely applicable. Codes and Standards of the country where the equipment is manufactured or operated should also be considered where they can be used to achieve an equivalent technical solution. In any case, compliance must be achieved with applicable statutory and local regulations.

Application

Text in *italics* is Commentary. Commentary provides background information which supports the requirements of the Recommended Practice, and may discuss alternative options.

This document may refer to certain local, national or international regulations but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this document to ensure compliance for the specific application.

Principal Changes from Previous Edition

This Recommended Practice is a revision of BP Group CP 17 Part 11 - Motors, which was last issued in June 1989. It has been generally updated and re-formatted to the way forward format and includes additional material giving guidance on recent developments.

Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP Group RPSE's, to assist in the process of their continuous improvement.

For feedback and further information, please contact Standards Group, BP International or the Custodian. See Quarterly Status List for contacts.



1. INTRODUCTION

1.1 Scope

BP Group RP 12 series specifies BP general requirements for electrical systems, equipment, materials and installations

This document (BP Group RP 12-11) specifies requirements for the selection and application of electric motors. The recommendations apply to both onshore and offshore installations.

2. DESIGN REQUIREMENTS

2.1 Motor Type and Specification

- 2.1.1 Motors should be cage induction type, started direct-on-line wherever possible and comply with BP Guidance for Specification [GS 112-4](#) (High-voltage) or [GS 112-3](#) (Low-voltage).

Direct on line started cage induction motors represent the lowest cost and simplest arrangement for the vast majority of applications. It should be noted that motor designs can achieve a starting current ratio down to and below three times full load current and this feature should be exploited to avoid use of assisted start techniques which would increase the cost and complexity and have an adverse effect on reliability.

- 2.1.2 D.C. motors should only be used in special applications such as certain variable speed drives or where the required speed/torque characteristic can only be provided by a d.c. motor.

there are no specific requirements for d.c. motors as their use is invariably of a special nature. reference should be made to [IEC 34](#) or [IEC 349](#) for general requirements.

- 2.1.3 Synchronous motors should only be used in either of the following circumstances:

- (a) For certain variable speed drive applications which dictate the use of a synchronous motor. Further guidance on electric variable speed drives may be found in BP Group [RP 12-12](#).
- (b) For the purpose of system power factor correction where it is more economic than using capacitors. Further guidance on power factor improvement may be found in BP Group [RP 12-3](#).



This Recommended Practice while specifically intended to apply to induction machines may also be generally applied to synchronous machines. Reference should also be made to IEC 34.

2.2 Co-ordination of Voltages and Outputs

2.2.1 Induction motors should be allocated to system voltages that result in the most economic application. The following guide shown in Figure 1 gives an indication but wide variations are possible for each application.

Economic selection of outputs will depend on the voltage levels available. A large LV motor started via an assisted start method may provide a more economic solution if the next available voltage is 11kV for example, or the most economic method may be supplying a 3.3kV motor from 11kV via a unit transformer.

Rated Voltage U_N (kV)	Minimum Output (kW)
$1 < U_N \leq 3.3$	160
$3.3 < U_N \leq 11$	1000

Figure 1

2.3 Motors for Use in Hazardous Areas

2.3.1 A number of mechanisms have been identified as capable of causing incendive sparking in motors where the current 'construction' or 'use' standards do not address the measures required to mitigate or remove their effect.

2.3.2 The mechanisms identified are:

- (a) Circulating currents in the non active parts of unit construction machines such as the frame and enclosure panels caused by stray magnetic fields producing sparking at the joints between those parts where a reliable electrical connection does not exist.
- (b) Discharge activity on the windings of high voltage machines during starting, exacerbated by contamination by salt laden atmospheres.
- (c) Discharge activity in the airgap between rotor and stator related to rotor current density during starting.

The mechanisms shown above were identified by experimental work carried out following a number of incidents where ignition of hydrocarbons occurred. The work was carried out by or on behalf of the UK Department of Energy (DEn), members of the rotating electrical machines association (REMA) and the UK Health and Safety Executive (HSE). The DEn issued a series of safety notices which applied to offshore installations only but their recommendations were endorsed and

adopted by the HSE in the HSE offshore safety notice SN 17/90. The HSE are now responsible for ensuring safety related legislation is implemented both onshore and offshore. The recommendations made by the HSE include measures to avoid the introduction of hydrocarbons into the inside of motor enclosures and to avoid the occurrence of incendiary sparking. It is envisaged that the recommendations will eventually be incorporated into the appropriate codes and standards but until this is achieved the HSE recommendations should be followed.

2.3.3 Requirements for New Machines

HSE recommendations which should be followed are summarised here in (a) - (e) for all new installations:

- (a) Motors of voltage 3kV a.c. and above of protection Type p, Type e and Type N should incorporate measures to remove the possibility of gas ingress from common systems by separation of compressor seal oil and motor lube oil systems for gas compressor drives.
- (b) Manufacturers recommendations should be followed in respect of circulating currents in the non active parts of unit construction motors. This will probably involve the fitting of bonding straps. This will apply to Type e and Type N motors and for the external parts of Type p motors not protected by the pressurisation concept.
- (c) Type e motors rated above 3kV a.c. should not be selected for use in Zone 1 hazardous areas.
- (d) Type N motors rated above 11kV a.c. should not be selected for use in Zone 2 hazardous areas.
- (e) Type e and Type N motors rated above 3kV a.c. up to 11kV a.c. situated in Zone 2 hazardous areas should not be started if there is the possibility of a potentially explosive atmosphere within the motor enclosure.

It is not appropriate to select offhand a Type p motor for Zone 2 applications between 3kV and 11kV as this type of protection has significant cost and operational restriction penalties. To meet the requirements of paragraph (e) above a Type e or Type N motor should be provided with facilities to purge the machine with inert gas or clean air following the release of flammable gas or vapour.

Depending on operational restrictions, including availability for restart, the purging may be achieved in a number of ways. This may be from portable gas bottles, a temporary connection to an inert gas/air supply, by periodic purging from a permanent supply, or by continuous purging.

At this time BSI and CENELEC working groups are working towards the development of type tests for Type e and Type N machines to determine if their method of construction is truly non sparking. If this work is successful it is likely that these tests will be incorporated into appropriate standards and a relaxation of the requirement of paragraph (e) above will be made. It has now been agreed by the IEC Technical Subcommittee 31J on Classification of Hazardous Areas and Installation Requirements that the non sparking requirements of Type N machines should also apply during starting (previously this was by agreement between manufacturer and purchaser) and this will be included in the next revision of the appropriate part of IEC 79.

2.3.4 Requirements for Existing Machines Offshore

HSE recommendations which should be followed are summarised here in (a) -(e) for existing installations offshore:

- (a) Motors of voltage 3kV a.c. and above of protection Type p, Type e and Type N should incorporate measures to remove the possibility of gas ingress from common systems by separation of compressor seal oil and motor lube oil systems for gas compressor drives.
- (b) Manufacturers recommendations should be followed in respect of circulating currents in the non active parts of unit construction motors. This will probably involve the fitting of bonding straps. This will apply to Type e and Type N motors and for the external parts of Type p motors not protected by the pressurisation concept.
- (c) Type e motors rated above 3kV a.c. situated in Zone 1 hazardous areas should be pressurised. Where it is not practicable to upgrade the motor to the full requirements of Type p protection then it may be sufficient to take measures to ensure flammable gas is excluded from the motor enclosure by maintaining an overpressure within the motor enclosure.
- (d) Type N motors rated above 11kV a.c. situated in Zone 2 hazardous areas should be pressurised. Where it is not practicable to upgrade the motor to the full requirements of Type p protection then it may be sufficient to take measures to ensure flammable gas is excluded from the motor enclosure by maintaining an overpressure within the motor enclosure.
- (e) Type e and Type N motors rated above 3kV a.c. up to 11kV a.c. situated in Zone 2 hazardous areas should not be started if there is the possibility of a potentially explosive atmosphere within the motor enclosure. Procedures should be written to ensure the motor enclosure does not contain a potentially

explosive atmosphere following a gas release within the area in which the motor is operating.

2.3.5 Requirements for Existing Machines Onshore

In accordance with the requirements of the HSE Information Document HSE 498/12 a hazard analysis and risk assessment should be carried out for Type e and Type N motors operating in potentially explosive atmospheres to determine if remedial measures are appropriate.

A document prepared by EEMUA giving guidance on how such an assessment should be conducted is 'A Guide to Risk Based Assessments of in situ Large Ex'e' and Ex'N' Machines Publication No. 181'.

The remedial measures indicated following the assessment may include:

- (a) Motors of voltage 3kV a.c. and above of protection Type p, Type e and Type N should incorporate measures to remove the possibility of gas ingress from common systems by separation of compressor seal oil and motor lube oil systems or by installing degassing equipment, for gas compressor drives.

Neither the HSE document nor the EEMUA guide mention Type p machines but they should be included in any assessment in this context.

- (b) Manufacturers recommendations should be followed in respect of circulating currents in the non active parts of unit construction motors. This will probably involve the fitting of bonding straps. This will apply to Type e and Type N motors and for the external parts of Type p motors not protected by the pressurisation concept.

Neither the HSE document nor the EEMUA guide mention Type p machines but they should be included in any assessment in this context.

- (c) Type e motors rated above 3kV a.c. situated in Zone 1 hazardous areas should be pressurised. Where it is not practicable to upgrade the motor to the full requirements of Type p protection then it may be sufficient to take measures to ensure flammable gas is excluded from the motor enclosure by maintaining an overpressure within the motor enclosure.
- (d) Type N motors rated above 11kV a.c. situated in Zone 2 hazardous areas should be pressurised. Where it is not practicable to upgrade the motor to the full requirements of Type p protection then it may be sufficient to take measures to ensure flammable gas is excluded from the motor enclosure by maintaining an overpressure within the motor enclosure.

- (e) Type e and Type N motors rated above 3kV a.c. up to 11kV a.c. situated in Zone 2 hazardous areas should not be started if there is the possibility of a potentially explosive atmosphere within the motor enclosure. This may be achieved by either;
 - (i) written procedures to ensure the motor enclosure does not contain a potentially explosive atmosphere following a gas release within the area in which the motor is operating or
 - (ii) modification of the motor to ensure a purge of the internal volume with uncontaminated air after a known release of flammable gas or vapour and before starting or
 - (iii) pressurising the motor enclosure continuously with clean air to ensure that flammable gases can not enter and create a flammable gas/air mixture.

2.4 Motor Re-acceleration

- 2.4.1 Where automatic re-acceleration systems are used, the motor design should be compatible with the proposed reconnection time with regard to the capability of the shaft and coupling system to withstand the high transient torques produced if the supply is out of phase with the residual voltage at the motor terminals, when the motor is reconnected.

In general, no special provisions will be required in the motor design if the residual voltage has fallen to below 0.25 per unit of the system voltage assuming full anti-phase at the time of reconnection. It is therefore possible to determine the minimum reconnection time if open circuit time constant of the motor is known. Further guidance on re-acceleration schemes is provided in [RP 12-6](#) or [RP 12-7](#).

2.5 Cooling

- 2.5.1 The method of cooling should normally be in accordance with [IEC 34-6](#), the following arrangements accommodate the majority of applications.
- 2.5.2 The optimum arrangement for motors up to around 1 MW is totally enclosed fan cooled (TEFC) where the internal cooling air is a closed circuit with air being moved by internal shaft mounted fans or by rotor action, and the external cooling air forced along the outer surface of the frame via an external shaft mounted fan. In this case the correct IEC code to specify this method of cooling is IC 01 41.

- 2.5.3 For larger air cooled motors where external surface cooling is not thermally efficient then a closed air circuit air cooled (CACA) concept is adopted where the external cooling air is forced through an integral or machine mounted heat exchanger by an external shaft mounted fan. In this case the correct IEC code to specify this method of cooling is IC 01 51 for an integral heat exchanger or IC 01 61 for a machine mounted heat exchanger.

Machine mounted shell and tube heat exchangers should be specified in accordance with an appropriate design standard such as the 'Tubular Exchanger Manufacturers Association' (TEMA) Standards.

- 2.5.4 Closed air circuit water cooled machines (CACW) may be specified where cooling water is economically available and specific advantages are appropriate such as low noise or lower weight and a more compact machine. In these machines an air/water heat exchanger is mounted on the top of the motor and water is circulated by a separate pump or from a pressurised water system, the IEC code is IC W37 A81.

2.6 Construction and Mounting

- 2.6.1 Motors complying with BP Group [GS 112-3](#) or [GS 112-4](#) should be designated by codes (Code II) specified in accordance with [IEC 34-7](#). Typical arrangements are as follows.

For horizontal foot mounted motors the normal method is IM 1001 which provides for end shield mounted bearings. An alternative for pedestal mounted bearings is IM 7211 and for vertical flange mounted machines the normal designation can be IM 3011 which provides for a shaft vertically downwards, two end shield mounted bearings and the flange on the end shield.

All designations for the method of construction should be confirmed by the driven equipment vendor.

2.7 Service and Operating Conditions

- 2.7.1 Motors should generally be designed for the following operating conditions:

- (a) Altitude not exceeding 1000 m above sea level.
- (b) Ambient air temperature not exceeding 40°C.
- (c) Cooling water temperature not exceeding 25°C

Where the site is considered to be subject to less onerous climatic conditions, project specific conditions may be applied.

Consideration should be given to advantage being taken of lower ambient temperatures with respect to agreeing a higher temperature rise with the manufacturer if this offers significant advantages in the motor design.

2.8 Noise

2.8.1 All terms and definitions used in evaluating and stating noise data should be in accordance with BP Group [RP 14-1](#). Alternatively, such measurements and calculations may be carried out by other standard noise test procedures. The manufacturer should provide full details of the test procedure for approval by the purchaser.

Examples of test procedures are [IEC 34-9](#), [BS 4999 Part 109](#) and [EEMUA Publication No. 140](#).

2.8.2 Unless lower noise limits are required at a particular location, the maximum sound pressure level at or beyond 1m from the surface of any motor driven plant shall not exceed 85dB(A) when operating at rated voltage, speed and no load.

2.8.3 To comply with reduced noise requirements manufacturers may modify their normal design. Acceptable modification may be achieved by one, or a combination of the following methods:

- (a) In the case of general purpose motors, by using a frame size larger than the normal size for a particular motor rating.
- (b) Modifying the fan design including the use of a unidirectional fan. In this case this shall be identified on the external surface of the motor.
- (c) Providing acoustic treatment to the fan cover, fan inlet cover or other parts of the motor.

Modification of a standard design will probably be reflected by an increase in price. The cost implications of different noise levels shall be identified by the manufacturer. In particular project noise specifications, it may be possible to accept a higher noise from certain motors, and this shall be assessed on an individual basis.

2.9 Winding and Cable Terminations

2.9.1 Motor Instrumentation Wiring and Cabling

Instrumentation such as winding temperature sensors, pressure sensors and vibration monitoring associated with an electric driver shall be segregated from power electrical circuits. This shall include wiring and cabling within the motor casing, junction boxes and external field wiring.



Where such equipment is connected to the main plant instrumentation for display and alarm purposes, the motor sensor installation and wiring shall be segregated to satisfy any hazardous area certification requirement of the plant instrumentation system.

2.9.2 Low Voltage Induction Motors

For motors complying with BP Group [GS 112-3](#) specific attention should be given to the following requirements:

- (a) [EEMUA Publication No. 132](#) specifies the terminal box position to be on the left hand side when viewed from the non-drive end, with bottom cable entry. Alternative arrangements should be specified if required by the purchaser.
- (b) Cable entries should remain sealed to IP 55 until cable connections are made at site.
- (c) Motors installed in areas classified as hazardous and provided with more than one cable entry, may not use all the cable entries. The decision as to which entry to use will be made at site when cable connections are completed. To ensure unused cable entries remain sealed with an appropriately stopper plug, it is a requirement of BP Group [GS 112-3](#) that all entries shall be fitted with appropriate seals at manufacture, so that only the requisite seal(s) is removed at the time of site cable connections.

Where the choice of cable entry is unambiguous it may be appropriate to seal the cable entry with a temporary plug which would be replaced with a suitable cable gland on installation.

2.9.3 High Voltage Induction Motors

Due to the wide variety of cable types and explosion protection concepts found in installations, complete standardisation of terminal arrangement for high-voltage motors is not feasible. It is recognised that assets in different locations may have standardised on particular types of termination embodying acceptable requirements of explosion protection, fault capability and fault/pressure relief. Where no acceptable standardisation exists it is recommended that one of the following types of termination is provided from the various types shown in Appendix C:

- (a) Type 1 - Phase Separated Pressure Containing. This type of terminal box should only be applied to Type d motors which have certification requiring a Type d terminal arrangement.



- (b) Type 4 - Phase Insulated Pressure Relieving. This type of terminal box is recommended for the majority of applications as it is available for all normal types of cable and all explosion protection concepts. It can also be applied to general purpose industrial motors.
- (c) Type 5 - Moulded Rubber Connectors. This terminal arrangement is recommended for use on very high fault level systems using polymeric cables.

A number of terminal box designs or terminal arrangements provide for the use of moulded rubber connectors. These generally will have been designed for use with polymeric cables or PVC insulated cables, with individually screened cores and conductor insulation of specified minimum/maximum thickness. Where external cables are to be terminated and connected by this means, cable dimensions shall be consistent with the connector to be provided by the motor manufacturer.

Other types as detailed in Appendix C should be considered if they offer significant benefits.

The types shown in Appendix C are not exhaustive and an arrangement to suit a specific application may be agreed between the purchaser and manufacturer.

2.9.4 Testing of Terminal Boxes

For motors complying with BP Group [GS 112-4](#), terminal boxes are required to have been type tested for fault conditions. Manufacturers should provide test documentation to confirm the requirements have been met.

Suitable tests are identified in [EEMUA Publication No. 132](#), Appendix 2. The type tests in this document are for three phase through faults and single phase to earth faults in the terminal compartment. Protection of the terminal box for the type test shall either be category A, a fault energy limiting device whose characteristic is comparable to that specified by the purchaser, or by category B, a circuit-breaker arranged to disconnect the supply 0.25 seconds after fault energisation. If test results show a disconnection time less than 0.25 seconds, this may be acceptable if this time is greater than the actual disconnection time at the installation.

2.10 Bearings and Lubrication

- 2.10.1 Motors with self-contained bearing lubrication may be unable to meet the 26000 hours of continuous operation referenced in BP Group [GS 112-4](#). In which case consideration should be given to the economic implications of either using forced lubrication to achieve a continuous operating period of 26 000 hours, or a reduction in the continuous operating period. The manufacturer shall specify the maximum guaranteed continuous operating period applicable to self-contained bearing lubrication, where this is less than 26 000 hours.



2.11 Balancing

- 2.11.1 Where a manufacturer offers proposals which differ from the recommendations of [ISO 11342](#), it is recommended that for flexible rotors, these include as a minimum, corrective balancing carried out in three planes and at speeds up to full rated speed.

Flexible rotors are those whose critical speed(s) are less than the full load speed of the motor.

2.12 Environmental Protection.

2.12.1 Anti-Condensation

It is a general requirement that anti-condensation heaters should not be required for any machine. However, where this requirement cannot be met, the manufacturers advice for each specific application should be considered. Related factors such as heater operating indication, power supply, switching and labelling for safety and isolation or restrictions on hazardous area certification should be addressed.

Use of modern non-hygroscopic insulation materials generally obviate the need for anti-condensation heaters but manufacturers may recommend their use for motors in exposed locations or where excessive thermal cycling occurs.

2.12.2 Painting

The manufacturer standard paint finish for a particular application will normally be acceptable.

Guidance is given in BP Group [GS 106-2](#) on paint finishes.

2.12.3 Weatherproofing

Silicon based greases are normally used for the coating of fixing bolts and flanges of Type d machines. However the use of such greases may be prohibited by certain offshore inspection agencies on the basis that silicon can inhibit the operation of gas detectors with catalytic elements.

[BS 5345:Part 3](#) has guidance on selection of grease or other methods of weatherproofing for equipment flanges, in particular where Type d machines are to be used in offshore installations.

2.12.4 Drain Holes

BP Group [GS 112-3](#) and [GS 112-4](#) specifies that, where a drain hole is to be provided, it shall be at the lowest point of the stator. For those motors for use in areas classified as hazardous, it shall be sealed with a

certified device. It should be noted that in [IEC 34-7](#) the manufacturer shall make suitable arrangements for drainage holes to meet the IP class in all positions indicated by the IM designation of the motor.

2.13 Speed

- 2.13.1 The motor speed and the driven unit speed shall preferably be selected to match, provided the result is a practical and efficient driven machine.

The use of two pole motors above 5.0 MW rating should be subject to a detailed technical assessment and the advice of rotating machine technical experts should be sought.

- 2.13.2 Where the driven unit design parameters result in a more practicable efficient or economic solution at a speed higher than two pole speed then the preference is to use a four pole machine with up-speed increasing gearbox, provided the step-up ratio is still suited to single stage parallel shaft gearing.

2.14 Built-in Temperature Detection

- 2.14.1 It is not expected that winding temperature detection should be necessary for LV machines.

There are applications where this may be desirable or necessary however. Such cases may be a particularly large LV motor, or where hazardous area certification demands such use. These hazardous area conditions may apply to Type e motors, for certain designs of canned motor employing a Type s concept or for motors for use with variable speed drives which may employ Type d or Type N concepts.

2.15 Condition Monitoring

- 2.15.1 The maintenance philosophy of a Project or asset may require condition monitoring to be carried out on motors. This may involve any of the following.

- (a) Vibration monitoring which may be implemented by installed non contacting or accelerometer type detection systems, or by regular measurements taken by hand held equipment. If the latter method is to be utilised then provision should be made for suitable measuring positions to be available.

The commentary in [GS 112-3](#) gives guidance on the provision of measurement positions.

- (b) Monitoring of the stator insulation system which may be implemented by continuous or regular monitoring via permanently installed Rogowski coils or by monitoring infrequently during shutdowns via temporarily installed coils.

Also, insulation quality may be monitored by carrying out tan delta measurements off line, in this case a 'signature' should be obtained during initial testing of the completely wound machine stator at the manufacturers works.

- (c) Monitoring of the stray fields via search coils to detect rotor eccentricities or rotor bar failures. Provision may be required for the location of the search coils.

3. TESTING

3.1 Heat Run

3.1.1 It may not be possible for large machines to be tested at full load at rated voltage and frequency due to limitations in manufacturers test equipment. In this event a number of options are available as follows:

- (a) A test at rated voltage and frequency but at the highest load possible. The temperature rise at full load can be estimated from an assessment of the losses at the reduced load.

This method is quite accurate if the test load is near full load.

- (b) A test at a reduced frequency (say 50Hz for a 60Hz machine) but the voltage to frequency ratio of the design machine maintained such that the machine flux is correct and the design full load current flowing.

This method tends to produce a temperature rise greater than the actual rise for the correct voltage and frequency as the reduced cooling at the lower speed has more effect than the reduction in core losses due to the lower frequency.

- (c) A test using a modulated frequency know as 'continuously varying frequency' (CVF), in which no load machine is connected and the load is simulated by continuously accelerating and decelerating the motor and hence causing an rms current equal to full load current to be drawn.

This method is not favoured as the dynamic behaviour of the rotor causes inaccurate vibration levels to be generated.

3.2 Torque Speed Curve

3.2.1 Measurements are usually only taken to allow the locked rotor torque and the pull out torque to be determined, but it is often important to determine the torque at intermediate points on the torque/speed curve,

as this is nearly always the most important region. It is possible to determine the average torque over a speed range by measuring speed versus time during a motor start and calculating the torque knowing the motor inertia, the voltage should be measured and corrections made to account for voltage reduction.

3.3 Locked Rotor Current

- 3.3.1 If there is a maximum locked rotor current specified for a large machine due to voltage drop limitations in the power system to which the motor is to be connected then it will be important to determine the locked rotor current accurately. The variation of current with voltage is not linear under locked rotor conditions due to saturation in some regions of the magnetic circuit and hence a linear extrapolation from the highest test voltage gives a lower current than would be expected under full voltage conditions. A logarithmic extrapolation of current should be made therefore from two reduced voltage test points, with the highest voltage as high as possible.

DEFINITIONS AND ABBREVIATIONS**Definitions**

Standardised definitions may be found in the BP Group RPSEs Introductory Volume.

Abbreviations

BS	British Standard
BSI	British Standards Institution
CACA	Closed Air Circuit Air Cooled
CACW	Closed Air Circuit Water Cooled
CENELEC	European Committee for Electrotechnical Standardisation
CVF	Continuously Varying Frequency
DEn	Department of the Environment
EEMUA	Engineering Equipment and Materials Users Association.
HSE	Health and Safety Executive
IEC	International Electrotechnical Commission.
ISO	International Organisation for Standardisation.
LV	Low Voltage
PVC	Polyvinyl Chloride
REMA	Rotating Electrical Machines Association
TEFC	Totally Enclosed Fan Cooled

LIST OF REFERENCED DOCUMENTS

A reference invokes the latest published issue or amendment unless stated otherwise.

Referenced standards may be replaced by equivalent standards that are internationally or otherwise recognised provided that it can be shown to the satisfaction of the purchaser's professional engineer that they meet or exceed the requirements of the referenced standards.

UK Regulatory Documents

- HSE [Offshore Safety Notice SN 17/90, Electric Motors for Use in Hazardous Areas](#)
- HSE [Information Document HSE 498/12, High Voltage Types Ex'N' and Ex'e' Explosion Protected Motors Operating in Potentially Explosive Atmospheres](#)

International Codes or Standards

- [IEC 34](#) Rotating Electrical Machines.
- 34-6 Part 6: Methods of cooling rotating machinery
- 34-7 Part 7: Symbols for types of construction and mounting arrangements of rotating electrical machinery.
- 34-9 Part 9: Noise Limits
- [IEC 349](#) Electric Traction Rotating Machines for Rail and Road Vehicles
- [ISO 11342](#) Methods and Criteria for the Mechanical Balancing of Flexible Rotors

British Codes and Standards

- [BS 4999](#) General requirement for rotating electrical machines.
- Part 109: Specification for noise levels, including test methods.
- [BS 5345](#) Code of Practice for selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosive processing and manufacture).
- Part 3: Installation and maintenance requirements for electrical apparatus with type of protection 'd'. Flameproof enclosure.



BP Group Documents

BP RP 14-1	Guide to Noise Control (Replaces CP 2)
BP RP 12-3	Power System Design (Replaces CP 17 Part 3)
BP RP 12-6	High Voltage Switchgear (Replaces CP 17 Part 6)
BP RP 12-7	Low Voltage Switchgear (Replaces CP 17 Part 7)
BP RP 12-12	Electric Variable Speed Drives (Replaces CP 17 Part 12)
BP GS 106-2	Painting of Metal Surfaces (Replaces BP Group Std 141)
BP GS 112-4	High Voltage Induction Motors (Replaces BP Group Std. 220)
BP GS 112-3	Low Voltage Induction Motors (Replaces BP Group Std. 221)

UK Industry Standards

EEMUA Pub. No. 132	Specification for three-phase cage induction motors.
EEMUA Pub. No. 140	Noise Procedure Specification.
EEMUA Pub. No. 181	A guide to risk based assessments of in situ large Ex'e' and Ex'N' machines
TEMA	Standards of the Tubular Exchanger Manufacturers Association.



TYPES OF HIGH VOLTAGE MOTOR TERMINAL BOX

Type 1 - Phase Separated Pressure Containing Terminal Box

This type of terminal box is suitable for use in areas classified Zone 1 and Zone 2 as it is normally certified Type d, flameproof. A cable sealing chamber is provided attached to the terminal chamber together with intermediate connections for the phase conductors from the cable sealing chamber to the terminal chamber. Compound filling of the cable sealing chamber is normally a requirement of certification.

The terminal box is designed so that protection of the phase conductors against electrical failure within a single compartment terminal box is by insulation and by earthed metal so as to restrict electrical breakdown to an earth fault. Phase-to-phase faults can only occur due to simultaneous earth faults.

Products of an electrical breakdown within the terminal box are completely contained inside the box.

Heat shrink or factory made cable terminations cannot be employed with this type of cable box. Due to its cost and size, it is normally only used where Type d protection is required for the cable termination chamber in addition to Type d protection for the motor enclosure. This type of cable box is suitable for use on motors protected by circuit breakers or fuses and generally on systems whose voltage and fault capacities respectively do not exceed 3.3 kV and 150 MVA or 6.6 kV and 300 MVA.

Type 2 - Phase Segregated Partial Pressure Containing Terminal Box

This type of terminal arrangement is suitable for use in areas classified Zone 1 for which it is certified Type p or Type e, or for use in areas classified Zone 2 for which it is certified Type N or alternatively, Type e or Type p as described for Zone 1. A cable sealing chamber is provided attached to the terminal chamber together with intermediate insulated connections for the phase conductors from the cable sealing chamber to the terminal chamber. Compound filling of the cable sealing chamber may be a requirement of the explosion protection certification and of the certified fault capacity.

The terminal box is designed so that protection of the phase conductors against electrical failure within the terminal box is by insulation and additionally by earthed metallic barriers forming completely distinct individual phase compartments so as to restrict electrical breakdown to an earth fault. Phase-to-phase faults can only occur due to simultaneous earth faults.

Products of an electrical breakdown within the terminal box are either contained inside the box when the fault energy is low, or are released to the inside of the motor when the fault energy is

excessive. Release to the motor interior will be consequent on rupture of an appropriate pressure relieving disc.

Cable sealing using heat shrink type cable seals may be used although the extent to which fault capacities have been tested with this cable sealing method should be examined for each application.

This type of cable box is suitable for use on motors protected by circuit breakers or fuses and on systems whose voltage and fault capacity respectively do not exceed 3.3 kV and 250 MVA, 6.6 kV and 500 MVA, or 11 kV and 500 MVA.

Type 3 - Phase Segregated Pressure Relieving Terminal Box

This type of terminal box is suitable for use in areas classified Zone 1 for which it is certified Type e or Type p as part of the pressurised system of the motor. It is also suitable for use in areas classified Zone 2 for which it is certified Type N or alternatively Type e or Type p as described for Zone 1.

Various arrangements of this type of terminal box provide for its use with paper, plastics or polymeric insulated cables of either single core or three core construction. The associated sealing chamber may be compound filled or can accommodate stress relief cones as appropriate to the type of cable and the installation requirement. Non-magnetic gland plates shall be used when terminating single core cables with current ratings greater than 400A. Intermediate insulated connections for phase conductors from the cable sealing chamber to the terminal are provided and these require specific insulation of the connections to be used when the supply cable is installed.

The terminal box is designed so that the protection of phase conductors against electrical failure within the terminal box is by insulation and additionally by earthed metallic barriers forming completely distinct individual phase compartments so as to restrict electrical breakdown to an earth fault. Phase-to-phase faults can only occur due to simultaneous earth faults.

Products of an electrical breakdown within the terminal box are relieved through a pressure relief diaphragm to the outside of the terminal box. Pressure relief shall be in a location between the motor and the terminal box, designed so that the potential for injury to personnel is minimised for any orientation of the terminal box.

Other arrangements of this type of terminal box provide for use of separable moulded rubber connectors when terminating extruded polymeric or PVC insulated cables. A cable sealing chamber is not required in this case.

Various arrangements of this type of terminal box are suitable for use on motors protected by circuit breakers or fuses, on systems whose voltage and fault capacity respectively do not exceed 3.3 kV and 250 MVA, 6.6 kV and 500 MVA, or 11 kV and 750 MVA.



Type 4 - Phase Insulated Pressure Relieving Terminal Box

This type of terminal box is suitable for use in areas classified Zone 1 for which it is certified Type e either individually or as part of the motor certification, or Type p as part of the pressurised system of the motor. It is also suitable for use in areas classified as Zone 2 for which it is certified Type N or alternatively Type e or Type p as described for Zone 1.

Various arrangements of this type of terminal box provide for its use with paper, plastics or polymeric cables of either single core or three core construction and certain arrangements when used with extruded polymeric or PVC insulated cables, can accommodate separable moulded rubber connectors. An associated cable sealing chamber may be compound filled or can accommodate stress relief cones as appropriate to the type of cable and the installation requirement. Where intermediate insulated connections for the phase conductors are required from the cable sealing chamber to a terminal chamber, specified insulation of the connections shall be used when the supply cable is installed.

The terminal box is designed so that protection of phase conductors against an electrical failure within the terminal box is by insulation such that there are no bare conductors or connectors in the terminal box.

Products of an electrical breakdown within the terminal box are relieved through a pressure relief diaphragm to the outside of the terminal box. Pressure relief shall be in a location between the motor and the terminal box, designed so that the potential for injury to personnel is minimised for any orientation of the terminal box.

This type of terminal box is suitable for use on motors protected by circuit breakers or fuses on systems whose voltage and fault capacity respectively do not exceed 3.3 kV and 250 MVA, 6.6 kV and 500 MVA or 11 kV and 750 MVA.

Type 5 - Moulded Rubber Connectors in Sheet Steel Drip Proof or Ventilated Enclosure

This type of terminal box provides protection against electrical failure by the use of proprietary separable moulded rubber connectors which mount onto matching bushings. Moulded rubber connectors can only be used for the termination of polymeric or PVC insulated cables and therefore this configuration is only suitable when cables of these types are to be employed. The potential for electrical failure is considered sufficiently remote for the construction of the external housing to be limited to the provision of simple mechanical protection without the provision of explosion relief. Such terminal housings may not be adequate for supporting cables and alternative means, such as clamps on surrounding structures, should be provided for this purpose. Various arrangements have been certified Type e, Type p, or Type s, for use in areas classified as Zone 1, or for use in areas classified as Zone 2, Type N or one of the protection types assessed for Zone 1.

Designs have been provided for cables of three core or single core construction, the latter requiring gland plates with non-magnetic features. Depending on the choice of moulded rubber connector, they may be used on motors controlled by circuit breakers on systems whose voltage and fault level can be up to 11 kV 1500 MVA.



Moulded rubber connectors are usually fabricated from ethylene propylene diene modified rubber (EPDM) which can be susceptible to hydrocarbon solvents and chlorinated hydrocarbons. The suitability of this type of termination for a chosen environment should be confirmed before this type of terminal arrangement is selected for any specific application.

