



GS 112-15

Guidance for Specification 112-15

**ELECTRICAL REQUIREMENTS FOR
VARIABLE SPEED DRIVES**

March 1994

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BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING											
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SCOPE AND PURPOSE This Guidance for Specification identifies the general requirements for variable speed drive controllers and provides for the specification of performance and testing requirements. It is intended for use in buying of variable speed drives for all applications.											
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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 Guidance for Specification

This Guidance for Specification identifies the general requirements for variable speed drive controllers and provides for the specification of performance and testing requirements. It is intended for use in buying of variable speed drives for all applications.

This Guidance for Specification has been written to collate and disseminate information on variable speed drive requirements in response to their use in an increasing variety of applications. Some thought has been given to specialist uses of variable speed drives.

Principal Changes from Previous Edition

Previously issued in December 1992, this document has been revised to correct errors in tables 2 and 3 and includes enhanced testing and documentation requirements. Revision of this document incorporates all elements of proposed GS 112-18 which will not now be issued.

Application

This Guidance for Specification is intended to guide the purchaser in the use or creation of a fit-for-purpose specification for enquiry or purchasing activity.

Text in *italics* is Commentary. Commentary provides background information which supports the requirements of the Specification, and may discuss alternative options. It also gives guidance on the implementation of any 'Specification' or 'Approval' actions; specific actions are indicated by an asterisk (*) preceding a paragraph number.

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.



Specification Ready for Application

A Specification (BP Spec 112-15) is available which may be suitable for enquiry or purchasing without modification. It is derived from this BP Group Guidance for Specification by retaining the technical body unaltered but omitting all commentary, omitting the data page and inserting a modified Foreword.

Feedback and Further Information

Users are invited to feed back any comments and to detail experiences in the application of BP 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

This Specification describes the minimum requirements for the design, manufacture and testing of variable frequency convertor units for driving either synchronous motors or induction motors.

It gives only limited requirements for the materials to be used and principally defines the performance requirements of the drives and the tests to be performed to demonstrate these.

This Specification is written as if for a single drive unit. Where a series or number of drive units/systems are required the requirements shall apply to each drive unit/system.

Specific information will be defined on appropriate data sheets attached to each enquiry or order. These data sheets may also indicate any permissible variations from this Standard.

Where the total scope of purchase is for the convertor unit with the motor and driven piece of equipment, this specification shall be read in conjunction with the motor specification, the driven equipment specification and any supplementary (or functional) specification.

Where a VSD motor-driven equipment purchase is required, an overall specification should be prepared. This specification should reference individual group specifications and details:-

- (a) The appropriate technical specifications for VSD, motor and driven equipment together with any modifications/selections necessary to apply those specifications to the particular.*
- (b) The overall duty for the plant.*
- (c) The starting and any special regimes for the VSD-motor combination. NB This should be within hazardous area certification constraints.)*
- (d) Confirmation of component ratings e.g. Motor matched to 110% of operating range for the driven equipment, VSD exactly matched to motor.*
- (e) The overall noise requirements (if necessary).*
- (f) Critical speed considerations and responsibility of the vendor.*
- (g) Any harmonic study relationships or constraints.*
- (h) Inspection and testing requirements appropriate to the combined equipment.*
- (i) Any special requirements and additional requirements for Electrical Submersible Pump duties.*



1.2 **Quality Assurance**

Verification of the vendor's quality system is normally part of the pre-qualification procedure, and is therefore not specified in the core text of this specification. If this is not the case, clauses should be inserted to require the vendor to operate and be prepared to demonstrate the quality system to the purchaser. The quality system should ensure that the technical and QA requirements specified in the enquiry and purchase documents are applied to all materials, equipment and services provided by sub-contractors and to any free issue materials.

Further suggestions may be found in the BP Group RPSEs Introductory Volume.

2. **GENERAL**

2.1 **Service Conditions**

2.1.1 Service conditions shall be as specified in the Data Sheet.

2.1.2 Equipment to be installed indoors shall be designed for operation in a heated and ventilated substation building, provided by others. Where the interior maximum ambient temperature will not normally exceed 40 °C and the minimum ambient temperature will not normally fall below 5 °C unless otherwise specified.

In order to keep below an internal room temperature of 40°C in a mild climate it may be necessary to employ air conditioning or air chiller units. It has been discovered that the air blower units fitted are not always sufficient to counteract the heat produced by the drives, especially where a number are housed in the same substation. An outside summer ambient of 22°C or above has been known to cause indoor temperatures in excess of 40°C where six units are housed together and ventilation is by air blower.

2.1.3 Equipment to be installed outdoors shall be designed for operation across the maximum and minimum site ambient temperature range of 40°C and -5°C unless otherwise specified.

2.1.4 The vendor shall provide details at the time of quotation listing the heat generated by all indoor equipment across the full operating range of the VSD.

2.2 **Reliability and Operational Life**

2.2.1 **The vendor shall include a listing of the MTBF (mean time between failures) and the MTTR (mean time to repair) of all the major components of the motor drive system and shall also give the overall MTBF of the motor drive system.**



2.3 Environmental Protection

- 2.3.1 Equipment for mounting indoors shall be provided with an overall degree of protection IP 22 to IEC 529 unless otherwise specified.
- 2.3.2 Equipment for outdoor installation shall be provided with an overall degree of protection IP 55 to IEC 529 unless otherwise specified.

2.4 Hazardous Area Certification

- 2.4.1 Where a motor is to be used in a hazardous area it must comply with the appropriate national requirements. The certification of the motor shall be suitable for the power supply delivered by the Variable Speed Drive. Unless indicated otherwise on the Data Sheets the vendor shall provide the necessary certification by a National Certifying Authority.
- 2.4.2 The rating plate of the motor shall be stamped with the appropriate temperature class to which the motor is certified when supplied by the VSD.

Where the VSD is a retrofit to an existing motor and the motor is installed in and certified for use in a hazardous area, a responsibility for ensuring safety shall be identified.

The holder of this responsibility shall ensure that sufficient analysis/testing is available in support of the hazardous area certification.

Regardless of the machine location, the additional heating effect of the VSD on the motor shall be identified and a maximum motor rating obtained.

2.5 Mode of Operation

The VSD shall have the capability to deliver sequential starting and loading duties without restriction. Where the VSD, motor and driven equipment form one contract, the mode of operation will be specified in the project specification and will include start, run-up and stop requirements.

2.6 Rating

- 2.6.1 The VSD shall be rated to continuously supply 100% of motor full load current.
- 2.6.2 The VSD shall be able to deliver 110% of the maximum equipment load (mechanical load) for a minimum period of 60 seconds. Refer to project specification for maximum loading.
- 2.6.3 The drive system shall be capable of delivering 150% of motor rated torque for the duration of start up.



Concerns which must be satisfied are:-

- (i) *Minimisation of overdesign. e.g. With the motor rated to 110% of driven equipment nominal rating, the VSD should not require further over-rating.*
- (ii) *At start up there must be sufficient torque capacity to overcome stiction. e.g. Typically 150% motor full load torque would be satisfactory.*

Where these concerns are not relevant or are not suitably covered by this specification, the project specification should address other specific requirements.

2.7 Acoustic Noise

The following shall apply unless otherwise stated in the project specification:-

- 2.7.1 Equipment for installation indoors shall be so designed that the sound pressure level at 1 metre from the equipment surface shall not exceed 65 dB(A) under any load and/or frequency condition within the operating range of the VSD.
- 2.7.2 Equipment for installation outdoors, shall have a sound pressure level at 1 metre from the equipment surface not exceeding 80 dB(A) under any load and/or frequency condition within the operating speed range of the VSD.

Where VSD's are installed outdoors close to operator working areas the use of the 'Indoor' criteria should be considered.

2.8 Critical Speeds

The VSD shall include the facility to be programmed to run rapidly through and avoid operating at any of the complete rotating equipment train (i.e. motor and drivenload) critical speeds.

2.9 Harmonics

- 2.9.1 The vendor shall provide, at the time of tender, a full harmonic analysis of both the input load current and the output voltage at full load and at the operating points where the greatest distortion occurs.
- 2.9.2 In the event that the levels of harmonic current exceed those given in the tables of Appendix C, then the vendor shall propose means by which these levels can be achieved.
- 2.9.3 The vendor shall guarantee that the levels of harmonic distortion quoted at the time of tender shall not be exceeded by the equipment once in service.



- 2.9.4 Any harmonic filtration equipment supplied shall be switched out of service when the drive system is not operating.

In general, the harmonic content of load current should satisfy the following criteria:-

- (a) *No damaging resonances shall occur on the system.*
- (b) *No interference problems which lead to malfunction shall be apparent.*
- (c) *No legislative requirements shall be infringed.*
- (d) *No equipment Certification (for hazardous areas) shall be infringed.*
- (e) *No overloads shall occur as a result of harmonics.*

Appendix C contains limits for any single variable speed drive which are based on UK Electricity Supply Authority requirements (Electricity Council Recommendation (G5/3). These are considered generally acceptable within the UK or elsewhere when applied to load currents for individual VSDs. Where numerous VSDs installed or where the point of common coupling with a supply authority is remote, these may be relaxed by BP provided the other criteria listed above are met.

Where the harmonic question proves complex (e.g. significantly large number of VSDs) it is recommended that a harmonic analysis be performed and the results form part of the project specification and performance guarantee.

3. EQUIPMENT

3.1 Electronic Component Enclosures

- 3.1.1 Enclosures housing electronic components shall be installed indoors. Such enclosures shall be free standing, flush fronted of a uniform design.

The number of cooling fans installed should be based on the size and criticality of the drive. On small VSDs (less than 30 kW) a single fan would normally be expected where for high voltage or critical drives duplicated fans should be specified.

- 3.1.2 The circuitry contained in electronic component enclosures shall comply, where applicable, with [IEC 146](#).

- 3.1.3 No component mounted on the exterior wall of an enclosure shall be less than 750 mm or more than 1800 mm above floor level.

Care should be taken to ensure that components are mounted in or on electronic component enclosures in accordance with recommendations of the component manufacturers.



- 3.1.4 All enclosure doors and removable panels shall be designed to prevent unauthorised entry and shall require the use of keys or special tools to gain access.
- 3.1.5 Exposed parts within the LV compartments of the convertor which have to be accessible during normal operating of the VSD for measuring, adjusting, resetting, etc., shall, when the door is open, have an enclosure to a degree of protection of at least IP 20.
- Measures shall be taken to ensure that all other HV and LV compartments cannot be opened unless all components in the compartments are electrically isolated from the supply and earthed.
- 3.1.6 Enclosures shall preferably be air cooled. Where forced cooling is to be provided the manufacturer shall include:-
- (a) Forced cooling failure alarm.
 - (b) Air filters.
- The number of fans included in the design needs to be agreed with the supplier. Account of the reliability and redundancy of fans together with criticality of drives system should be made.*
- * 3.1.7 Where water cooling is to be employed the system shall be approved by BP.
- 3.1.8 HV busbars, where fitted, should be fully insulated. The insulation material shall withstand without damage the effects of carrying the maximum short circuit current.
- The need to insulate LV busbars, where fitted, should be agreed with the manufacturer. The preference is for phase and neutral busbars to be individually covered throughout their length. The insulation material shall withstand without damage the effects of carrying the maximum short circuit current.*
- 3.1.9 Busbars shall be marked for identification purposes and all joints and connections shall be corrosion protected and secured in such a way as to prevent loosening.
- 3.1.10 Requirements for termination racks, termination chambers and gland plates should be discussed with the manufacturer.
- The following items require consideration:-*
- (a) provision for support of external cables
 - (b) cable bending radii

- (c) *point and direction of cable entry*
- (d) *segregation of HV, LV and control cables*
- (e) *segregation of terminals carrying different voltages*
- (f) *gland plates preferably undrilled*
- (g) *eddy current/hysteresis effects of single core cables on glandplates.*

3.1.11 Where necessary, terminals shall be provided with test links or facilities to carry out diagnostic testing.

3.1.12 Equipment earthing in/on electronic component enclosures shall be such that all metal work, cable gland plates and component or sub-assembly chassis are bonded to the earth bar which shall have a minimum cross section of 16 mm² or half the size of the main power cable conductor whichever is the larger, and shall be connected at each end to a copper external protective conductor sized as above.

3.1.13 Nameplates and labels shall be provided detailing all information required by [IEC 146](#) in addition to the following:-

- (a) Order Number
- (b) Date of Order
- (c) Item Number
- (d) Order Placed By
- (e) Cooling Method
- (f) Operating Voltage
- (g) Operating Current

Labels shall be engraved, embossed or otherwise formed so as to be permanent.

Labels shall be fitted to identify the following:-

- (a) The function of the total assembly of equipment.
- (b) Each control switch or push button.
- (c) Each indication lamp.



- (d) Each component part of the equipment.
- (e) Each fuse.
- (f) Each position of selector switches.
- (g) Each instrument.

3.2 Electronic Components

- * 3.2.1 Electronic components shall be of assessed quality either to [BS 9000](#) or to an equivalent standard which shall be subject to BP's approval.
- 3.2.2 All components such as thyristors, diodes, switching devices, protection relays, instruments, instrument transformers, fuses and fuse holders shall be individually identified by means of permanent labels marked with rating and other essential information as required. On withdrawable type units, identification labels shall be mounted on both fixed and withdrawable parts.
- 3.2.3 Enclosure mounted semiconductor devices, capacitors, resistors, and any other electronic components shall be rated for a surrounding air temperature of 5°C to 50°C or the maximum predicted temperature within the enclosure (assuming maximum ambient temperature), whichever is the greater.
- 3.2.4 For high voltage applications galvanic isolation between control circuitry and solid state power switching devices shall be incorporated.
- 3.2.5 Any device incorporating secondary supplies (e.g. batteries) to retain memory shall be clearly identified and full details provided.

3.3 Power Transformers and Line Reactors

- 3.3.1 Power transformers and line reactors shall be specified and supplied in accordance with the requirements of BP Group [GS 112-5](#).

Where a drive is for use with an ESP, a variable frequency step up transformer is often required on the output. The transformer is made non-standard by the requirement for an output operating frequency range around 30-70 Hz and a secondary voltage range around 1000V to 3600V with tapings at 100V steps. Despite the non-standard nature of this transformer, it must comply with BP Group [GS 112-5](#).

- 3.3.2 Power transformers and line reactors designed for location indoors shall be of the enclosed, encapsulated, dry-type design.



- 3.3.3 Power transformers and line reactors designed for location outdoors shall be of the liquid-immersed type filled with mineral oil insulating liquid, naturally cooled.
- 3.3.4 Power transformers and line reactors shall be of the sealed tank design; incorporating liquid temperature indicators, pressure/vacuum bleeder devices, and pressure relief valves.
- 3.3.5 All transformer protective devices shall be fitted with changeover contacts for alarm/trip duty.
- 3.3.6 Power transformers and line reactors shall be continuously rated and shall incorporate sufficient derating to allow for the drive system operating range of frequencies, harmonics and voltages.
- 3.3.7 Main terminal boxes shall be of the air filled, phase insulated type suitable for terminating heat-shrink or factory-made fully insulated cable terminations.
- 3.3.8 Power transformers on the output of VSDs feeding ESPs require voltages to be changed on a relatively frequent basis.

It is therefore preferable that these tap changing facilities be readily accessible without the need to remove covers or drain insulating fluid.

3.4 Controls and Indications

- 3.4.1 VSD functions to be monitored, status indications to be provided, and control switches and pushbuttons to be provided shall be as called for in the Data Sheets.
- 3.4.2 Where the VSD will form part of a VSD - motor - driven equipment contract, the data sheets will further detail the local control requirements in respect of the overall unit.
- * 3.4.3 All local controls and indications for the drive system shall be mounted on a control panel. Where the control panel is not part of the VSD system, the vendor shall detail the arrangements for approval by BP.
- 3.4.4 Where detailed on the Data Sheets, the controls and selectors shall be lockable. Where shrouding is specified on the data sheets, the manner of shrouding shall be arranged to avoid accidental operation.
- 3.4.5 Colours of all indicating lamps shall comply with [IEC 73](#).
- 3.4.6 Where required by the Data Sheets, the VSD shall have an effective speed control system based upon an externally derived setting.



The control arrangement should be discussed and agreed with the manufacturer. Where speed control is part of an automatic process condition, the manner of control should be further specified (e.g. 4-20 mA or 0-10V calibrated control.) Additionally control signals should be suitably segregated and isolated from LV/HV power signals by the use of separated trunking and signed transformer/opto compilers.

- 3.4.7 A programmable logic controller (or similar) based display shall be provided to fulfil monitoring and comprehensive fault diagnostic duties. The following shall be provided along with any supplementary requirements called for as part of the project specification:-

Output frequency
Speed ranges 'locked out'
Ramp time
Start regime settings
Target speed (rpm or Hz as required)

Each tripping function shall have a separate diagnostic output with descriptive text. The vendor shall make available all software documentation and system test data for the controller supplied.

3.5 Protection Devices

- 3.5.1 Protection relays shall comply with [IEC 255](#). Associated current transformers shall comply with [IEC 185](#) and associated voltage transformers shall comply with [IEC 186](#).

- 3.5.2 A master trip relay shall be provided for all VSD's rated 100 kW and above and shall operate when receiving signals for the following conditions, where applicable:-

- (a) Open circuit and short circuit of solid state power switching devices, which could cause a malfunction.
- (b) Overcurrent due to a commutation failure of VSD devices.
- (c) Output overvoltage.
- (d) Output overspeed.
- (e) Output undervoltage.
- (f) Converter and inverter stage, enclosure overtemperature.
- (g) Converter and inverter stage, control circuitry failure.
- (h) Excitation circuit malfunction.

- (i) Under/over excitation.
- (j) Overcurrent protection for the motor shall be effective for any operating frequency within the declared range.
- (k) An earth fault condition on the output.
- (l) Output single phasing.

In addition to the protective arrangement derived from VSD vendor equipment, the master trip relay shall also operate for the following received signals:-

- (i) motor derived tripping conditions where detailed in the project specification.
- (ii) driven equipment derived conditions where detailed in the project specification.
- (iii) process conditions where detailed in the project specification.

3.5.3 VSD's rated less than 100 kW shall be fitted with one of the following:-

- (a) A master trip relay as in 3.5.2 above.
- (b) An electronic micro-processor tripping device with functions as per 3.5.2.

3.5.4 Test blocks shall be provided for secondary injection of protection relays. Primary injection testing for protective relays shall be made possible.

3.6 Alarm Indications

3.6.1 An alarm system shall be provided on each VSD control panel. This alarm arrangement, may be integral with the monitoring and diagnostic arrangement but shall have additional features as follows:-

- (a) A common remote alarm signal given by a fleeting or steady open/closed contact.
- (b) An effective sequence of events system shall be incorporated to indicate the sequence in which the alarms are triggered together with the period between alarms arriving.

3.6.2 Indication shall be provided on the alarm system for operation of all the protection relays and fault conditions in clause 3.5.2. In addition

indication shall be provided for common alarms from d.c. power supplies, forced cooling failure, and any other alarm condition appropriate to the particular motor drive system.

4. EARTHING AND CABLING

4.1 Earthing

4.1.1 The vendor shall provide the control cubicle with an earth stud suitable for connection to an earth bar by a cable with minimum cross-sectional area of 70 mm².

4.1.2 The vendor shall advise BP of the need for any special earthing requirements for any item of the drive system where normal substation earthing practice would not be suitable.

4.2 Cabling

4.2.1 The vendor shall provide for all power and control cabling including the necessary glands and cable lugs for the interconnections between any adjoining electronic equipment enclosures.

4.2.2 Within enclosures, all low voltage and control wiring shall be physically segregated from medium and high voltage cabling and busbars by use of separate compartments or earthed metal barriers. All wiring within the enclosures shall carry an indelible, easily noticeable identification which shall be clearly shown on the wiring/schematic diagrams. Paper labels, easily removable ferrules or printed labels with erodible ink are unacceptable.

4.2.3 Analogue control cables shall be screened and segregated from all other cables.

4.2.4 All external cabling shall be via terminal blocks. No more than two wires shall be connected to any one terminal. Terminations connected directly to printed circuit boards are not acceptable.

5. INSPECTION AND TEST

5.1 Inspection

* 5.1.1 The vendor shall allow for inspection visits by BP or their appointed agents both at the vendor's premises and at the vendor's sub-supplier's premises, during all stages of manufacture. The procedure for such visits shall be agreed between the vendor and BP prior to any order being placed.



5.2 Testing

5.2.1 Type and routine testing of all components and the complete drive system shall be carried out in accordance with this specification, the project specification and all referenced standards.

5.2.2 The vendor shall provide a schedule of tests to demonstrate compliance with this specification, the project specification and all reference standards.

It is recommended that the schedule of tests for the components and complete systems be agreed with vendor prior to order placement. This should cover where and how each of the components and complete systems are to be tested, together with the identification of tests to be witnessed by BP or its representative.

5.2.3 All routine and type tests carried out on the drive system at the vendor's premises and on the major components of the drive system at their respective manufacturer's premises shall be witnessed as required by BP or its representative. The vendor shall give BP two working weeks notice of the date, time and location of these tests.

Where tests are to be witnessed, drawings relating to the equipment should be available on the day of the test and should correspond to the apparatus as built.

5.2.4 Where major components of the complete drive system are not of the vendors manufacture, these shall undergo agreed type and routine tests at their respective manufacturers premises prior to the test requirements of clause 5.2.5.

5.2.5 The vendor shall provide for the drive system to be completely assembled and wired for testing at suitable premises. These tests shall include a full string test up to and including the full load condition with the actual motor and, where feasible, the mechanical load.

It is recommended that the following tests be performed on the complete drive system:-

- (a) *Insulation tests.*
- (b) *Preliminary light load tests.*
- (c) *Check of auxiliary devices.*
- (d) *Temperature rise (heat soak) test under maximum running load and make ambient temperature for 8 hours.*
- (e) *Output voltage tolerance.*
- (f) *Output frequency tolerance.*



- (g) *Harmonic content of input and output waveforms at maximum running load at minimum operating speed, at 50% operating speed, at full speed, and at any intermediate speed where harmonics reach a maximum.*
- (h) *Efficiency at maximum running load at minimum operating speed, at 50% operating speed, and full speed.*
- (i) *Check of the co-ordination of protective devices.*
- (j) *Voltage dip test to demonstrate the ability of the drive system to ride through a voltage disturbance.*
- (k) *Full functional test.*
- (l) *Noise test covering the full range of operating conditions.*
- (m) *Vendors routine tests where not covered by this schedule.*

The harmonic content, efficiency, full functional, and voltage dip tests shall be performed with the motor connected in circuit.

5.2.6 The vendor shall provide and include for test certificates for all tests performed.

6. DOCUMENTATION

6.1 The following documents shall be submitted:-

- (a) General arrangement drawings showing main dimensions, weights, arrangement of components and the minimum space required for correct installation, operation and maintenance.
- (b) Foundation plan showing location and details of foundation bolts.
- (c) Cable entry and termination arrangements.
- (d) Electrical schematic and wiring diagrams.
- (e) Completed Data Sheets.
- (f) Installation, operation and maintenance instructions.
- (g) All software documentation associated with plc or other microprocessor equipment provided.
- (h) Test reports and test certificates.
- (i) Overall MTBF and MTTR calculations.



PART 1 TO BE COMPLETED BY PURCHASER				
A	CONTRACTUAL INFORMATION			
1	Delivery Site			
2	Job Name/Job No.			
3	Equipment Name			
4	Order No.			
5	Item No./Tag No.			
B	INCOMING SUPPLY DETAILS			
6	Frequency	50 Hz		
7	Mains Power Supply	V ph Wire	V ph Wire	Neutral Earthed
8	Aux. Power Supply	V ph Wire	V ph Wire	Neutral Earthed
9	Voltage Tolerance	+/- 6%		+ % - %
10	Frequency Tolerance	+/- 1%		+ % - %
11	Cables	Power		Control
	Function			
	Type			
	No. of Cores			
	Conductor Cu/Al			
	Core Size mm ²			
	Entry From			
	From			
	To			
	Remarks			

DATA SHEET (SHEET 1 OF 4)

VARIABLE SPEED DRIVES



C	ENVIRONMENT			
12	VSD Location	Indoor		
	Temperature Max. Min.	40°C 5°C		
	Max. Relative Humidity	% at °C		
13	Ambient Condition	Outdoor		
	Temperature Max. Min.	40°C -5°C		
	Max. Relative Humidity	% at °C		
	Altitude	Under 1000m		
	Atmospheric Contaminants	Salt Laden		
14	Hazardous Area Certification Responsibility Of	Vendor		Purchaser
15	Number of Cooling Fans	1	2	
D	CONTROLS, SELECTORS AND INDICATIONS			
16	Controls	On Front Panel Of VSD	Remote	S-Shrouded L-Lockable
	Power On/Off (Controls remote circuit breaker)	Yes/	No/	S
	Start/Stop	Yes/	Yes/	S
	Speed Setting	Yes/	Yes/	L

DATA SHEET (SHEET 2 OF 4)
VARIABLE SPEED DRIVES



17	Selectors-Located	On VSD	Remote
	Loc/Rem for Start/Stop	Yes/	No/
	Loc/Rem for Speed Control	Yes/	No/
	Hand/Auto for Start/Stop	No/	Yes/
	Hand/Auto for Speed Control	No/	Yes/
18	Indications Required	Power On	
		Running/Stopped	
		System Healthy/Faulty	
E	DRIVEN EQUIPMENT		
19	Type (Description)		
	Contractual Relationship		
F	SYSTEM DIAGRAM (Cable route lengths should be specified where appropriate)		

DATA SHEET (SHEET 3 OF 4)
VARIABLE SPEED DRIVES



PART 2 TO BE COMPLETED BY PURCHASER/MANUFACTURER (delete as appropriate)				
G	MOTOR DETAILS			
20	Type	Induction		Synchronous
	Voltage			
21	Location	Outdoor		
	Hazardous Area (BS 5345)	Zone 1	Zone 2	Non-Hazardous
	Group	IIB		
	Temperature	T3		
	Enclosure	IP 55		
	Dust Hazards	None		
22	Operating Parameters	Speed Range		rpm
		Starting Torque (Full Volts)		Nm
		Full Load Torque		Nm at pu Slip
		Power Rating (Full Load Max. Ambient Conditions)		kw at p.f.
		Torque Characteristic		
23	Input Power Factor 100%; 75%; 50% Fl			
24	Heat Generated	kw at 100% load kw at 75% load kw at 50% load		
25	Special Requirements	None		

**DATA SHEET (SHEET 4 OF 4)
VARIABLE SPEED DRIVES**



DEFINITIONS AND ABBREVIATIONS**Definitions**

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

routine test: test carried out on each drive system or part thereof.

type test: test carried for a particular make, design or build of equipment.

Abbreviations

BS	British Standard
ESP	Electrical Submersible Pump
HV	High Voltage
IEC	International Electrotechnical Commission
IP	Ingress Protection
LV	Low Voltage
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
UK	United Kingdom
VSD	Variable Speed Drive



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.

BS 5345	Code of practice for selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres
BS 9000	General requirements for a system for electronic components of assured quality
IEC 73	Coding of indicating devices and actuators by colours and supplementary means
IEC 146	Semiconductor convertors
IEC 185	Current transformers
IEC 186	Voltage transformers
IEC 255	Electrical relays
IEC 529	Degrees of protection provided by enclosures (IP code)
BP Group GS 112-5	Transformers and Reactors



**PERMITTED LIMITS OF HARMONIC CURRENTS
MEASURED AT THE INPUT TO SINGLE VARIABLE SPEED DRIVE**

**TABLE 1
POWER SYSTEMS UP TO 440V**

HARMONIC NUMBER	2nd	3rd	4th	5th	7th	11th	13th	17th	19th
Percentage of Rated Motor RMS Current (%) * Motors Rated up to 132 kW	20.9	14.8	9.6	24.3	17.4	8.3	7.0	2.6	2.6
Percentage of Rated Motor RMS Current (%) * Motors Rated 132 kW to 275 kW	10.0	7.1	4.6	11.7	8.4	4.0	3.3	1.3	1.3
Permitted Total System Harmonic Currents (A)	48	34	22	56	40	19	16	6	6

NOTE: HARMONIC CURRENTS FROM A DRIVE GREATER THAN 275 kW SHALL NOT EXCEED THE PERMITTED TOTAL SYSTEM HARMONIC CURRENTS

**TABLE 2
POWER SYSTEMS 2 kV TO 4.16 kV**

HARMONIC NUMBER	2nd	3rd	4th	5th	7th	11th	13th	17th	19th
Percentage of Rated Motor RMS Current (%) * Motors Rated up to 900 kW	16.2	11.1	7.1	17.3	12.7	6.6	5.6	2.0	2.0
Percentage of Rated Motor RMS Current (%) * Motors Rated 900 kW to 1850 kW	7.9	5.4	3.5	8.4	6.2	3.2	2.7	1.0	1.0
Permitted Total System Harmonic Currents (A)	32	22	14	34	25	13	11	4	4

NOTE: HARMONIC CURRENTS FROM A DRIVE GREATER THAN 1850 kW SHALL NOT EXCEED THE PERMITTED TOTAL SYSTEM HARMONIC CURRENTS



TABLE 3
POWER SYSTEMS 6 kV TO 13.8 kV

HARMONIC NUMBER	2nd	3rd	4th	5th	7th	11th	13th	17th	19th
Percentage of Rated Motor RMS Current (%) * Motors Rated up to 1500 kW	7.9	4.9	3.7	6.1	4.9	4.3	3.7	1.2	0.6
Percentage of Rated Motor RMS Current (%) * Motors Rated 1500 kW to 3000 kW	4.0	2.4	1.8	3.0	2.4	2.1	1.8	0.6	0.3
Permitted Total System Harmonic Currents (A)	13	8	6	10	8	7	6	2	1

NOTE: HARMONIC CURRENTS FROM A DRIVE GREATER THAN 3000 kW SHALL NOT EXCEED THE PERMITTED TOTAL SYSTEM HARMONIC CURRENTS

PERMITTED TOLERANCE +10% OF TABULAR VALUES APPLIED TO A MAXIMUM OF 2 HARMONICS



SPECIAL REQUIREMENTS FOR VSD UNITS FOR USE WITH ESPs

VSDs for use with ESPs are a special case with several requirements which affect only this type of VSD. These requirements are listed below:-

- (a) Voltage boost ability on start-up. This is required to overcome the large voltage drop on start up caused by the lengths of downhole cable involved.
- (b) Variable settings for starting frequency to give variable starting torque. A frequency range of 2-3 Hz; up to 20 Hz is usually made available.
- (c) Overload capability to compensate for a different load for a specified time (say, 150% for 3 seconds) to cope with variation in fluid viscosity.
- (d) The VSD should have a built in electronic control of motor rotation to avoid the need for physical disconnection and reconnection of cables should rotation have to be reversed.
- (e) The VSD should be equipped with a keypad into which control parameters are entered and a digital readout. A sequential event memory is useful as a diagnostic aid.
- (f) The following should be adjustable from the keyboard:-

Starting frequency

Operating frequency

Max. and min. set frequencies

Ramp rate

Overcurrent protections levels

Underload protection levels (to prevent ESP operating with downthrust)

