



RP 12-13

**ELECTRICAL SYSTEMS AND
INSTALLATIONS
CABLES, CABLE SYSTEMS AND
WIRING**

July 1996

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SCOPE AND PURPOSE The BP Group RP 12 series, specifies BP general requirements for electrical systems, equipment, materials and installations. This document identifies the recommended requirements for the selection, application and installation of power cables for use on systems up to 33 kV including associated cables for the purpose of control, indication and protection. The document covers both onshore and offshore applications.											
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Issued by:- Engineering Practices Group, BP International Limited, Research & Engineering Centre Chertsey Road, Sunbury-on-Thames, Middlesex, TW16 7LN, UNITED KINGDOM Tel: +44 1932 76 4067 Fax: +44 1932 76 4077 Telex: 296041											

CONTENTS

Section	Page
1. INTRODUCTION.....	1
1.1 Scope	1
2. CABLE SYSTEM DESIGN.....	1
2.1 Voltage Rating of Cables	1
2.2 Current Carrying Capacity	1
2.3 Short-Circuit Rating	4
2.4 Voltage Drop	5
2.5 Computer-aided Design of Cable Systems.....	6
2.6 Documentation	7
3. SELECTION OF CABLES	7
3.1 Approved Cable Types	7
3.2 Cables for Use Onshore	8
3.3 Cables for Use Offshore.....	9
3.4 Cables for Special Fire Risk Areas	10
3.5 Use of Mineral Insulated Copper-Sheathed Cable	11
3.6 Environmental Considerations.....	12
4. CABLE INSTALLATION METHODS AND MATERIALS.....	12
4.1 Methods of Installation	12
4.2 Cable Routing.....	14
4.3 Underground Cable Systems.....	15
4.4 Above Ground Cable Systems.....	15
4.5 Cable Grouping and Segregation.....	21
4.6 Cable Jointing and Termination.....	21
FIGURE 1	23
Power Cable Selection Chart: Onshore Installations.....	23
FIGURE 2	24
Power Cable Selection Chart: Offshore Installations	24
APPENDIX A.....	25
DEFINITIONS AND ABBREVIATIONS	25
APPENDIX B.....	26
LIST OF REFERENCED DOCUMENTS.....	26



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 document identifies the recommended requirements for the selection, application and installation of power cables for use on systems up to 33 kV including associated cables for the purpose of control, indication and protection. The document covers both onshore and offshore applications.

Application

Text in italics is commentary. Commentary provides background information which supports the requirements of the Recommended Practice, 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.

Principal Changes from Previous Edition

Generally updated and reformatted.

Feedback and Further Information

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

The BP Group RP 12 series specify BP general requirements for electrical systems, equipment, materials and installations. This document specifies the requirements for the selection, application and installation of power cables for use on systems up to 33 kV including associated cables for the purpose of control, indication and protection.

Note that this document has limited applicability where US practices and standards are used.

2. CABLE SYSTEM DESIGN

2.1 Voltage Rating of Cables

The voltage designation or rating, Eo/E, should be selected from the standard ratings given in the relevant cable standard, e.g. 600/1000V, 1900/3300V, etc., and shall be appropriate to the type of system and the earthing arrangements.

Guidance on the choice of an appropriate standard voltage rating is given in [BS 6346](#), [BS 6480](#) and [IEC 183](#).

2.2 Current Carrying Capacity

2.2.1 Cables shall be sized to operate within their current carrying capacity as determined by the maximum continuous temperature of the insulation, see Table 1.

Several factors are involved in the sizing of conductors and whilst continuous current capacity is paramount, others such as voltage drop and ability to carry short circuit currents must not be neglected.

The continuous current carrying capacity of a cable is dependent on the way heat generated in the conductor, insulation and metallic components is transmitted through the cable and then dissipated from its external surface. The conductor temperature is taken as the reference datum for the cable. A notional maximum cable rating can then be calculated from the permissible temperature rise from a standard base ambient to the maximum temperature that the particular type of insulation will withstand. The maximum temperature is fixed which is commonly the limit for the insulation material, without undue ageing, for a reasonable maximum life.

2.2.2 In assessing the size of conductor required for a given design current the following factors shall be taken into account:

- (i) Ambient temperature
- (ii) Grouping and proximity to other loaded cables



- (iii) Method of installation
- (iv) Thermal conductivity of the medium in which the cable is installed.
- (v) Thermal conductivity of the cable constituents.

The basic source document for calculating cable current ratings is [IEC 287](#) 'Electric Cables - Calculation of Current Rating' which provides in great detail the theory and mathematical treatment for most situations. The following are the most commonly used sources of information on cable current carrying capacity:-

- (a) *The IEE Wiring Regulations for Electrical Installations. This covers cables of all standard types up to 1 kV. The ratings quoted are based on a ambient temperature of 30 degC (compared to the normal of 25 degC) - and thus lead to lower quoted ratings. Only 'in air' , i.e. not buried, installations are considered.*
- (b) *ERA Technology Ltd specialise in methods of calculation and practical work for verification. They are a recognised authority and have produced many publications . Report [ERA 69-30](#) provides ratings in Part 1 for paper insulated cables up to 33kV, in Part 3 for PVC insulated cables up to 3.3kV and in Part 5 for thermoset insulated cables up to 3.3kV.*
- (c) *Manufacturers' catalogues.*
- (d) *Other sources exist for more specialised installations. Cables for ships are based on an ambient temperature of 45 degC with somewhat lower maximum temperatures for continuous operation than permitted elsewhere. Ratings are provided in the IEE Recommendations for the Electrical and Electronic Equipment of Mobile and Fixed Offshore Installations.*

In general, these documents provide tabulated figures for cables installed in air, in ducts and buried directly in the ground. Factors have then to be applied to obtain the actual rating for the individual conditions. The references quoted provide these factors for variations in ambient or ground temperature, depth of laying, thermal resistivity of soil and mutual heating due to cables being installed close together.

2.2.3 If the load is intermittent it may be possible to use a cable with smaller sized conductors.

This would require specific attention and detailed calculation in accordance with [IEC 853-1](#). [ERA document 69-30](#) pt IV (89-0094) dated July 1989 gives further guidance on the subject together with additional examples.

It should be noted that no advantage can be taken of loads which fluctuate on a daily cycle when cables are installed in air. This is because the conductor temperature of such cables responds rapidly to any change in load.

2.2.4 The design current, I_d , shall be determined as follows:

- (a) Circuits supplying single fixed loads
 I_d = rated current of the load.

Circuits supplying two or more final sub-circuits should be rated in accordance with the total connected load but may, where justified, be subjected to application of diversity factor. (See item (c) below).

- (b) Radial circuits supplying socket outlets
 I_d = rated current of the socket outlet.

- (c) Incoming feeders to switchboards and sub-distribution panels.
 I_d = maximum current associated with peak design production with an additional 10% contingency.

This is consistent with the requirements of [RP 12-3](#). It is important to note that the maximum current should account for appropriate application of diversity factors. Such allowances require the judgement of a qualified electrical engineer with knowledge of the operational requirements of the plant. Further guidance is given in [RP 12-3](#).

Typically, where switchboards are fed by transformers, the incoming cables are sized to the rating of the transformer. Where there are no infeed transformers to the switchboard or sub-distribution panel, then the infeed cables are sized to the rating of the incoming switch or busbar (whichever is the smaller).

2.2.5 Where cables are laid in mixed groups of different types, sizes and loading, the group rating factor of each cable should be calculated or assessed for each cable, taking into consideration the thermal effect of all the other cables of the group. [IEC 287](#) provides the mathematical basis for determining individual cables ratings when installed in mixed groups. Reference should be made to [ERA Report 74-29](#).

The question of rating factors applicable to mixed groups of cables has been investigated by the ERA (Report [No.84-0172](#)). If the group rating factors given in the IEE Wiring Regulations and ERA Report 69-30 are applied to a mixed group of cables, the larger cables tend to be oversized and the smaller cables undersized. The degree of error will depend on the group configuration, and it is not possible to give precise guidance. However, published group rating factors should obviously be treated with caution in such cases.

2.2.6 For 3 phase, 4 wire circuits, multicore cables the neutral conductor should be no smaller than 50% of the size of the phase conductors. Reduced sizing of neutral conductors should not be applied where there is likely to be serious load imbalance, significant harmonic distortion in normal service or in any circuit where the load is predominately discharge lighting.

For most 3 phase, 4 wire circuits, multicore cable applications the neutral conductor is sized the same as the phase conductor. There are potential cost and weight savings to be derived by specifying reduced size neutral conductors and these should be considered.

Where single core cables are used, the neutral conductor(s) may have a reduced cross-section appropriate to the expected value of neutral current, and above stated restrictions.

2.3 Short-Circuit Rating

2.3.1 The short time maximum current carrying capacity of the cable should be considered with regards the current/time characteristics of the circuit protection device to ensure that cables do not suffer damage due to overheating under maximum through fault conditions.

In some cases, particularly where cables are protected by non-current limiting circuit breakers, the cable size is determined by the magnitude and duration of the maximum through fault current, rather than by the continuous current capacity or voltage drop constraints.

2.3.2 The minimum cross-sectional area should be assessed from the following formula:

$$A = \frac{I\sqrt{t}}{K} \text{ mm}^2$$

where, A = Cross sectional area of the conductor (mm²)
 I = Short circuit current (amps)
 t = Total fault clearance time (seconds)
 K = Constant dependent on the type of conductor, the insulations, and the initial and final temperatures.

Values of K for various types of insulation in contact with copper conductors are given in Table 1.

Table 1 Maximum Permitted Conductor Temperatures and Values of K for Various Insulants (Copper Conductors)

Insulation	Cable Types	Maximum Working Temp T1 deg C	Final temp at end of short circuit T2 deg C	Value of K for temps T1 and T2
Paper	Up to 6.6kV single and multicore	80	160	108
Paper	11kV and 15kV single and 3 core screened	70	160	115
Paper	22kV and 33kV single and 3 core	65	160	118
PVC	Up to 185 sqmm	70	150	109
PVC	240 sqmm and above	70	130	95
EPR	All types	85	220	134
XLPE	All types	90	250	143

The values of K given in Table 1 assume that the cable is operating at its maximum current carrying capacity. If this is not the case, the true value may be determined from the formula:

$$K = 225.7 \sqrt[n]{\log_n \frac{234.5 + T_2}{234.5 + T_1}}$$

where T_1 = initial temperature of conductor (C)
 T_2 = final temperature of conductor (C)

2.4 Voltage Drop

2.4.1 Cables shall be sized so that the maximum voltage drop between the supply source and the load when carrying the design current does not exceed that which will ensure safe and efficient operation of the associated apparatus, or 5% of nominal voltage, whichever is lower.

The supply source will be the switchboard or MCC upstream of the load, at which the voltage can be adjusted. This adjustment can be made either by changing taps on the incoming transformers or through AVRs of directly connected generators. In

the majority of cases the load will be connected directly to the supply source through a single cable. However there will be cases where the load is fed from a sub-circuit and in such cases there may be two interposing cables between the load and the supply source. In such cases the permissible voltage drop of 5% needs to be accounted for from the supply source through the two series connected cables to the load terminals.

The maximum cable length for a low-voltage motor of given rating may be calculated from the following formulae:-

$$L_s = \frac{V_s 1000}{1.73 I_s (R \cos \phi_s + X \sin \phi_s)}$$

$$L_r = \frac{V_r 1000}{1.73 I_r (R \cos \phi_r + X \sin \phi_r)}$$

The maximum route length is the lesser of these two lengths.

R	= Cable resistance	ohms/kM
X	= Cable reactance	ohms/kM
L	= Maximum cable length (m)	
V	= Maximum cable volt drop (V)	
I	= Motor current (A)	
ϕ	= Motor power factor	

Subscripts r and s refer to running and starting values of the above parameters respectively.

- 2.4.2 Cables shall be sized so that during motor starting, voltages throughout the network shall not fall by more than 20% of nominal values.

Further explanation is given in [RP12-3](#), section 4.5.

- 2.4.3 For high-voltage motors, the voltage drop along the cable to the motor due to the load current shall not exceed 3.25% of nominal voltage during normal running at full load.

The total voltage drop through the distribution network to the terminals of high voltage motors under the worst conditions of supply is not normally a limiting factor unless very long cables are installed between starter and motor. A maximum cable volt drop of 3.25% with motor full load current should normally satisfy the criteria stated in 2.4.2 for starting conditions.

2.5 Computer-aided Design of Cable Systems

Computer-aided design methods may be used to solve problems of cable sizing, route allocation and traywork design, provided that accepted criteria are used consistent with this RP and that the resulting design is both technically adequate and economical.

2.6 Documentation

The documentation requirements for the cable system design shall be agreed with the design contractor.

The following is a guide of typical requirements:-

- (i) Design dossier including basis of cable sizing together with specimen calculations. This dossier should normally form part of the permanent records of the site.
- (ii) Cable routing diagrams.
- (iii) Constructional details of cable traywork and cable tray support systems.
- (iv) Cross sections of cable routes showing the actual arrangement of cables, and separation distances.
- (v) Interconnection diagrams showing the cable numbers, the core identification numbers and equipment terminal numbers.
- (vi) Cable and cable cutting schedules.
- (viii) Cable gland schedule.

3. SELECTION OF CABLES

3.1 Approved Cable Types

3.1.1 Power cables shall have annealed stranded copper conductors and should normally be selected from the types listed below, subject to their being suitable for the application and operating environment.

Type

- A PVC insulated, extruded PVC inner sheath, galvanised steel wire armoured, PVC outer sheath, to [BS 6346](#) or similar national standard.
- B As above, with the addition of a lead sheath over the inner extruded PVC sheath and an additional extruded PVC bedding between the lead sheath and the armour. This type can also be to [EEMUA Publication 133](#).
- C Flame retardant cable to [GS 112-12](#).
- D EPR insulated, CSP inner sheath, galvanised steel or copper alloy braid armour, CSP outer sheath, to [BS 6883](#), [IEC 92-3](#) or similar national standard.
- E Fire resistant cable to [GS 112-12](#).
- F PVC or elastomer insulated wiring cables in accordance with [BS 6004](#) and [BS 6007](#) or similar national standard respectively, for use in conduit/trunking or as earthing conductor.

- G EPR or XLPE insulated, galvanised steel wire or tape armoured, PVC outer sheath, in accordance with IEC 502.
- H Mineral insulated copper sheathed cable (MICC) in accordance with BS 6207: Part 1, or similar national standard.
- J Paper insulated, mass-impregnated non-draining, lead covered steel wire or tape armoured, PVC outer sheath, to BS 6480: Part 1, or similar national standard.

3.1.2 Unarmoured cables may be used if confined to control rooms or other internal areas, provided that adequate mechanical protection is provided by other means.

3.1.3 Cables for use in areas classified as hazardous shall incorporate non-hygroscopic fillers in the interstices between the cores. Where a void would otherwise occur at the centre of the cable, this shall also be filled, to make a substantially solid cross section. The fillers may be applied as an integral part of the extruded bedding.

3.1.4 No PVC cable should be installed at temperatures lower than 0 degC unless special low temperature grade PVC has been specified, in which case installation at ambient temperatures down to -10 degC may be possible.

Most insulating and sheathing materials stiffen to some extent as their temperature is progressively reduced. PVC shows this effect more markedly than do the rubbers or polyethylene. Once installed, PVC is quite satisfactory at temperatures down to -30 degC if protected from violent impact. However, the general duty compounds will shatter if bent violently, or particularly if struck hard at temperatures below freezing point. PVC compounds specially formulated for low temperatures show a marked improvement in this situation. PVC insulated and / or sheathed cables which have been stored at temperatures below freezing point should be allowed to stand for at least 24 hours at a temperature above 10 degC before they are handled for installation. Rubber cables are less susceptible to low temperature damage, for example EPR cables can withstand reasonable bending down to -40 degC. CSP stiffens as the temperature is reduced below 0 degC but will not shatter from impact above -35 degC. It is advisable to allow CSP sheathed cables which have been subjected to low temperatures, time to warm up before they are handled.

3.2 Cables for Use Onshore

3.2.1 Cables for use onshore shall be selected in accordance with the Selection Chart, Figure 1.

3.2.2 Cables laid in the ground shall have an appropriate lead sheath if there is a possibility of the cables coming into prolonged contact with hydrocarbon or other organic solvents due to spillage, etc.

The need for lead sheathing arises because hydrocarbons degrade PVC (and other plastics and rubbers) and will cause electrical failure. The hydrocarbons of concern include crude, refined products, fuels, light oils, solvents and others. For saturated hydrocarbon areas such as old refineries there is no substitute for lead covered cables to be assured of reliable life expectation.

Where cables are buried and not subjected to significant hydrocarbon exposure, then lead sheaths will not be required. Such locations can easily exist within refineries such as gas treatment / handling locations. In such locations hydrocarbon contamination is limited and product spills will evaporate rapidly.

- 3.2.3 Short runs of single core cable may be unarmoured but where armouring is required, it shall consist of aluminium wire or strip.

- 3.2.4 New substations located within processing areas such as refineries or oil terminals should have their lowest level (e.g. bottom of trench) elevated from the outside grade level.

Hydrocarbon products have entered cables beneath the sheath and have degraded the PVC to form a liquid substance which migrates along the cables. (Because the PVC is associated with the outer sheath the lead covering does not provide protection against this phenomenon.) In the past, the substance has migrated to the ends of the cable and leaked out into the substation building. The problem is considered to be mainly a housekeeping issue, although with substantial deposits entering a building there is a danger of vaporisation into flammable products.

For existing buildings the problem can be alleviated by cutting back the cable sheaths outside of the building to allow the substance to leak out prior to migration into the building.

The elevated designs for new substations will ensure that there will be no hydrocarbons entering the building due to either cable migration or rainwater seepage.

3.3 Cables for Use Offshore

- 3.3.1 Cables for use on offshore installations shall be selected in accordance with the Selection Chart Figure 2 .

UKOOA publication "Guidelines for Instrumentation, Power and Control Cables for Fixed and Mobile Production Facilities" provides complimentary guidance to [BS 6883](#), covering the general and detailed construction of elastomeric cables. This document provides a subset of the innumerable option combinations in order to standardise on a coherent family of cables aimed at satisfying the majority of instrumentation, power, telecommunication and control applications.

Where possible, cables should be selected from those specified in the UKOOA document.

- 3.3.2 Cables shall be flame retardant, at least to the standard of [IEC 332-3](#).



IEC 332-1 and BS 4066 Part 1 specify a flame retardancy test on a single wire or cable under laboratory conditions. A more onerous test method which more closely simulates a practical fire situation is given in IEC Standard 332-3.

- 3.3.3 Cables for 'general purpose' use offshore should normally be Type C. For small projects requiring limited quantities, Type D shall be used where economical or expedient.

'General purpose' means any application other than one calling for a fire resistant cable.

- 3.3.4 Where an armour is required for single core cables it shall consist of a phosphor bronze wire braid complying with IEC 92-3.

3.4 Cables for Special Fire Risk Areas

- 3.4.1 When cable routes are being planned, special fire risk areas shall be avoided as far as possible. Fire risk diagram(s) indicating areas of fire risk and the sources of fire hazard shall be produced.

- 3.4.2 Special fire risk areas shall be determined in accordance with the guidelines in RP 24-1 and RP 24-2.

- 3.4.3 Within a special fire risk area, the following types of circuit shall be fire resistant, i.e. able to continue operating in the presence of a fire of specified temperature and duration.

- (i) Circuits necessary to provide a safe and orderly shutdown of the plant, including essential instrumentation and monitoring circuits.
- (ii) Emergency or 'escape' lighting.
- (iii) Cables essential for the operation of life saving equipment, e.g. fire pumps, fire alarms, evacuation alarms, gas detection, etc.

For most installations, except as required in 3.4.3, fire resistant cables to GS 112-12 should not be specified solely to attempt to keep a plant operating in the event of a fire. In the case of the emergency lighting, a combination of floodlighting and self-maintained luminaires should be used to reduce the amount of cable exposed to fire risk.

- 3.4.4 Depending on the application and the fire withstand requirements, cables shall be Type E. Alternatively, MICC may be used, subject to the restrictions of section 3.5.

Other methods of fire protecting cables, e.g. by cladding and thermal insulation, may be used provided that they have a fire performance at least as good as cables to GS 112-12. Such forms of cable protection invariably reduce the current rating

of the cables and care must be taken to ensure that cable sizing calculations adequately account for this.

- 3.4.5 Cables in special fire risk areas which do not fall into any of the categories of 3.4.3 shall have flame retardant properties in accordance with [IEC 332-3](#).

3.5 Use of Mineral Insulated Copper-Sheathed Cable

- 3.5.1 Mineral insulated copper-sheathed cable (MICC) should in general be restricted to domestic, commercial and light industrial applications such as in offices, accommodation modules, substations, control rooms and workshops. Its inherent, but limited, fire resistant properties can make MICC suitable for essential circuits such as fire alarms, although it may also be used more generally for power, lighting, heating and air conditioning plant.

Although MICC has been used externally both onshore and offshore, it is not particularly suitable and should be avoided. There is no objection to using MICC internally in clean, dry areas such as accommodation modules, where its smaller size and neater appearance are positive advantages.

- 3.5.2 MICC shall not be used in situations where the equipment to which it is connected is subject to vibration or where the cable may need to be disconnected regularly for maintenance. A loop of cable shall be formed just before the gland where MICC is connected to a motor.

- 3.5.3 Where MICC is to be used in a highly inductive circuit, precautions may need to be taken to protect against breakdown due to the high transient voltage which occurs on switching the current off. In such cases, cables shall be protected by suitable surge suppressers across the supply terminals.

Fluorescent or discharge light fittings which incorporate a parallel connected power factor correction capacitor do not need a surge suppresser.

- 3.5.4 MICC used indoors in dry locations may be bare copper sheathed. However, where such cables are used outdoors or where appearance is to be a consideration, they shall have an over sheath of PVC.

3.6 Environmental Considerations

- 3.6.1 Cables shall be constructed with suitable sheathing materials which will withstand exposure to the environment in which they are installed. Wherever possible, however, measures shall be taken to avoid prolonged exposure to conditions which could in the long term produce degradation of the cable. Specific attention shall be given to the following environmental factors:

- (i) Exposure to seawater or salt spray.
- (ii) Exposure to intense heat radiation from the sun or from a flare.
- (iii) Excessively high or low ambient temperatures.

4. CABLE INSTALLATION METHODS AND MATERIALS

Detailed requirements for the installation of cables and wiring are given in [GS 112-1](#). Requirements for the design of cable trenches, road crossings, etc are given in [RP 4-3](#).

4.1 Methods of Installation

- 4.1.1 The following methods of installation may be used in the areas given in 4.1.2, provided they are suitable for the type of cable being used:
- A Directly buried.
 - B Laid in prefabricated concrete troughs, formed concrete or brick service trenches (with or without sand filling) or ducting.
 - C Above ground on trays or ladder-racking.



4.1.2

The methods given in 4.1.1 should be used as follows:

Area	Preferred Method	Notes
Offsites	A or C	Method C shall be used only where use can be made of pipe rack supports, etc
Process Areas	B or C	When using method C attention shall be given to the requirements of 4.2. Method B should be used only in the following:- • within process plant areas where an underground installation has been specified • in paved areas, e.g. around pumping stations Specific attention shall be given to the methods of installation which enable early site paving to be carried out with consequent improvement of access. The method used shall not allow flammable fluids to drain along the cable route.
Within buildings and offshore platforms and on jetties	C	Attention shall be given to the requirements of 4.2.

An analysis of the costs of cable installations for a range of projects has shown that an above ground cabling system is likely to be the least expensive method, where pipe tracks and plant steelwork can be utilised.

Cable distribution methods should be assessed according to the nature of the plant and the nature of the soil structure. Where there are pipe tracks or structural steelwork conveniently placed for running cable ladders or trays throughout a plant, it may be economical to use above ground cabling methods or even a combination of this and cable trench systems. Where there is difficulty in excavating trenches in very rocky areas, the aboveground cabling method is the only sensible choice. Direct burial and concrete trench systems are the best methods of cable distribution in plants which do not lend themselves to above ground cable distribution, but in order to keep down costs concrete trenching should be kept to a minimum.

4.2 Cable Routing

- 4.2.1 Wherever possible, cables installed above ground shall be routed to avoid areas of special fire risk or areas where leakage or spillage of contaminants could occur.
- 4.2.2 Where special fire risk areas cannot be avoided the installation shall comply with section 3.4 of this document.
- 4.2.3 Where duplicate feeders or parallel systems are provided for a given duty, e.g. duty and standby pumps, and the cables are installed above ground in a fire risk area, different routes shall be used wherever practical.
- 4.2.4 The routing of all cables shall be planned concurrently with main pipetracks and vehicle access ways, etc., to provide unimpeded direct routes wherever possible and to make maximum use of overhead pipe tracks and other structures to support cable trays or ladders.
- 4.2.5 Cable routes should minimise the necessity for load bearing road and access way crossings.
- 4.2.6 When planning cable routes, care shall be taken not to obstruct access to or movement of plant.
- 4.2.7 On offshore platforms where large numbers of cables are often installed and space is restricted, specific attention shall be given to cable routing and methods of installation. Main cable routes should be planned in conjunction with other service routings at an early stage of the design, adequate space being allowed for access and for the required bending radii of cables.

On offshore platforms, the designer should aim to minimise the total amount of intermodule cabling and thus reduce the offshore hook-up time.

Intermodule cabling can be reduced by, for example, the provision of local substations in each module, by optimum use of multicore cables, and by the use of distributed control systems.

To minimise the amount of cable pulling and termination required offshore, consideration should be given to the use of joints, plug and socket connections and pre cabled racks or looms for the intermodule cables.

Consideration should also be given to the possibility of utilising the under floor spaces within or between modules for routing main runs of cable. This may be preferable to high level overhead cable trays or ladders to avoid congestion with other services.



4.3 Underground Cable Systems

4.3.1 Underground cables shall be laid in accordance with [GS 112-1](#).

4.3.2 Cables shall be arranged in layers with a minimum of 25mm of clean sand or riddled soil between each layer. The minimum number of layers should be used, preferably not exceeding three. Adjacent cables within the same layer may be laid touching, thermal conditions permitting.

It is important to ensure that the cable rating calculations reflect the installation, particularly with regards to group derating factors. Calculations in the past have stated a separation of the cables from each - however in reality the cables were bunched together and physically touching.

4.3.3 Cable trenches in areas accessible to vehicles shall be covered with reinforced concrete slabs. Prefabricated cable troughs shall be closed using prefabricated concrete covers.

Details of the constructions of cable trenches are given in [RP 4-3](#).

4.3.4 The depth of concrete cable trenches and prefabricated concrete troughs should not normally exceed 750 mm.

4.3.5 Prefabricated concrete troughs should normally be buried in the ground so that the top of the cover is 150 mm above grade level.

However, on rocky terrain or where excavation costs would be excessive, troughs may be laid on the surface.

4.3.6 Cables under roads, railways and, where necessary, under pipetracks shall be run in either concrete encased or similar ducts.

4.3.7 Wiring conduit buried in the ground or in trenches will not be permitted.

4.4 Above Ground Cable Systems

4.4.1 Above ground cables shall be installed in accordance with [GS112-1](#).

4.4.2 Cables shall be protected as required against mechanical damage, chemicals, excessive temperatures and fire.

4.4.3 Cable support systems shall be provided for all main routes.

Single cables to push-button stations, luminaires, earthing points, etc, may be clipped direct to the surface with suitable fixing devices.

4.4.4

The choice of materials for cable trays and ladders shall depend on the severity of the environment and the design life of the installation. As a minimum requirement, they shall be heavy duty mild steel hot dipped galvanised to [BS 729](#) or similar national standard. For corrosive environments, deep galvanised Corten 'A' steel or Type 316 516 'marine' grade stainless steel are acceptable materials. GRP may be used where weight saving is an important factor.

The choice of materials and finish for cable tray and ladder should be determined by consideration of the environment in which it is to be installed and the required life of the installation.

Hot-Dip Galvanised Mild Steel

The length of time for which steel is protected by galvanising is directly proportional to the thickness of the galvanised coating. [BS 729](#) : 1971 stipulates a minimum average zinc coating of 335 g/m² of surface area (approximately 47 microns thick) for cable ladder made from 1.5 or 1.6 mm steel, or 460 g/m² (approximately 64 microns thick) for 2.0 mm steel.

Table 2 is derived from information published by the Galvanisers' Association and gives a guide to the rate of corrosion of a zinc coating in different types of atmosphere.

Table 2 Corrosion Rate of Zinc in Outdoor Atmospheres

Site	Type of Atmosphere	Corrosion Rate microns/year	Estimated Life of 460g/sqm Zinc Coating - Years
Llanwrtyd Wells	Rural	2.3	25
Calshot Hants	Marine	3.3	18
Motherwell Scotland	Industrial	4.6	13
Woolwich Kent	Industrial	4.1	14

Notes:

The estimated coating lives have been calculated on the assumption that 10% of the original zinc remains when rusting of the basis steel begins, which has been demonstrated for coatings of reasonable uniformity.

A 460 g/m² coating has an average thickness of 65 microns.



The increased corrosion rate in industrial environments is mainly due to the presence of sulphur dioxide dissolved in moisture, forming sulphurous acid, which hastens the removal of the zinc from the steel. Although the acidic, industrial type of atmosphere is not present in the North Sea, the conditions that do exist are obviously more severe than the marine environment in Hampshire. Twelve years is considered a reasonable expectation for the life of cable ladder galvanised in accordance with the British Standard, installed in locations outside the splash zone.

It is important to note that the thickness of a galvanised coating varies over the total surface of the equipment, a fact which the national standards mentioned allow for by defining the average coating weight, rather than the coating depth which is a point measurement. Therefore corrosion may be expected in some areas of the tray or ladder within a shorter period than the estimated 12 years, but in general the steel should remain intact for this period of time.

Corten 'A' Steel

Corten 'A' steel with a galvanised finish has been used increasingly in severely corrosive environments as a cheap alternative to stainless steel. It has an inherently greater strength than mild steel and is highly resistant to corrosion even in an ungalvanised state. The high silicon content of Corten 'A' steel gives it the ability to attract more zinc than mild steel during the galvanising process. Some manufacturers can offer deep galvanised Corten 'A' steel ladder/tray with an average coating weight of 900 g/m², or more if required.

With a zinc coating of approximately twice the thickness required by [BS 729](#), the protective life will be approximately doubled.

Stainless Steel

Stainless steel is the most corrosion resistant ferrous material but is very expensive compared with hot dipped galvanised mild steel and deep galvanised Corten 'A' steel. Type 316 stainless steel has superior resistance to sea water and can be used in contact with a wide range of alkaline solutions. However, stainless steel may be attacked by certain acids. When using stainless steel care must be taken to avoid preferential corrosion which can occur in some metals which may come into contact with stainless steel.

Glass Reinforced Plastic (GRP)

GRP ladders, used for some time in the USA, have a good strength-to-weight ratio, are corrosion resistant and can be cut and drilled easily on site, making installation easier. However, this material is highly susceptible to mechanical damage and if cut or drilled, needs to be painted with a polyurethane resin to prevent the ingress of moisture and subsequent capillary action causing splitting, particularly in temperatures below freezing. A GRP ladder can also become charged with static electricity although it can be given an anti static surface coating complying with [BS 5958](#).

There is some fire risk associated with this type of material, particularly on long vertical runs.

Table 3, supplied by B.I.C.C. Vantrunk Ltd., compares the properties and relative costs of the above types of cable ladder:

Table 3 Cable Ladder Comparisons

	Mild Steel Galvanised to BS 729	Corten A Steel, deep galvanised	Stainless Steel, Type 316 516	GRP
Nominal cable carrying capacity for deflection of 15mm over 3m spans based on simple beam support (kg/m)	253	400	400	250
Approx. unit weight per linear metre for 600 mm wide ladder (kg)	8.2	9.0	7.6	5.4
Approx coating weight (g/sqm)	465	915	---	---
Corrosion Resistance 1=Excellent 3=Fair to good, depending on location	3	2	1	1
Resistance to mechanical damage	good	good	good	poor
Relative Cost (cost of galvanised mild steel = 1)	1	1.2	2.25 - 2.66	2.64
Estimated life when installed externally on an offshore platform (not in splash zone)	Up to 12 years	Up to 24 years	Over 24 years	Over 24 years

Note:

A heavier zinc coating can be applied to Corten 'A' steel, giving a proportionately longer life to the system.

4.4.5

The maximum deflection of any cable support system between supports should not normally exceed 1/180 of the span.

The maximum safe load for a cable ladder or tray can be calculated knowing the ultimate strength (yield stress) of the material used. Alternatively, if appearance is considered more important, then the deflection should be kept within visually acceptable limits. In this case a mid-span deflection limit of 1/180 th of the span is the most commonly used criterion for system design. If the deflection is required to be unnoticeable however it should be limited to a maximum of 1/360 th of the span.

Thus the three alternative criteria are:

- (i) *A maximum mid-span deflection of 1/360 th of the span.*
- (ii) *A maximum mid-span deflection of 1/180 th of the span.*
- (iii) *No limit on the deflection, with the maximum load calculated from the minimum yield stress of the material, including a safety factor of, say, 1.5.*

Obviously, a racking system originally designed for a maximum midspan deflection of 1/360 th of the span will have a large margin of spare capacity (in terms of loading) available for future additional cables.

4.4.6 The traywork system designer shall submit calculations setting out the basis of the design. Allowance shall be made, where necessary, for the effects of wind, snow and ice.

4.4.7 Cable trays or ladders which could be walked on or climbed over during cable installation, or subsequently, shall also be capable of supporting a point load of 90 kg at the centre of a span without permanent deformation.

4.4.8 Cable trays or ladders shall be bolted or clamped to supports.

Welding to main structural steel work or drilling into concrete members is only permitted subject to approval by qualified structural engineers. Such drilling or welding of steel or concrete members could weaken the structural integrity of the installation.

4.4.9 Standard prefabricated bends, tees, reducers and other accessories should be used rather than sections fabricated on site from straight sections.

Site fabricated sections tend to be weaker mechanically, and more likely to damage cables by abrasion against burrs. Prefabricated sections will reduce onsite fabrication and installation time.

4.4.10 Cables shall be securely cleated or tied to trays or ladders. Table 4 is the stated requirements of the document "IEE Recommendations for the Electrical and Electronic Equipment of Mobile and Fixed Offshore Installations". Whilst this provides the required clip spacings for offshore platforms, it can be used as a guide for onshore installations.

Table 4 Maximum Spacing of Clips for Securing Cables



Overall Cable Diameter	Wire braid armoured & unarmoured cables	Spiral steel wire armoured cables	Mineral insulated copper sheathed cables (MICC)
Not exceeding 8 mm	200 mm	250 mm	300 mm
Exceeding 8 mm & not exceeding 13 mm	250 mm	350 mm	370 mm
Exceeding 13 mm & not exceeding 20 mm	300 mm	350 mm	450 mm
Exceeding 20 mm & not exceeding 30 mm	350 mm	400 mm	450 mm
Exceeding 30 mm	400 mm	450 mm	----

Notes:

- (i) *The spacings given in this Table are applicable to horizontal runs; for vertical runs they may be increased by 25%.*
- (ii) *Where mineral insulated copper sheathed cables are spaced away from bulkheads, the spacing of clips should be in accordance with column for "Spiral steel wire armoured cables".*

4.4.11 Single core cables making up 3-phase circuits should normally be run in 3-phase trefoil groups, securely clamped together to withstand the mechanical force produced by a short circuit fault. The manufacturer's recommended spacing should be used, supported by evidence of type tests having been performed under short circuit conditions.

Adequate restraint is normally provided by clamps at 1 m spacing on straight runs and 0.5 m spacing on the bends.

4.4.12 Cable ties may be of the following types:

- (i) Nylon (11 or 12).
- (ii) Polypropylene.
- (iii) EVA or PVC coated stainless steel.

For MICC, PVC coated copper saddles shall be used.

EVA or PVC coated stainless steel ties or all-round banding shall be used to provide additional support in special fire risk areas at intervals of about 2m. The reusable types of cable tie are preferred.

Nylon 11 or Nylon 12 ties are preferred to polypropylene ties because of their greater tensile strength. Other types of Nylon (i.e. 6 and 66) are not suitable if they are in contact with galvanised cable trays or ladders.

For further information on cable ties, including cost comparisons, reference should be made to [BP Petroleum Development Engineering Report No. ESR 6229](#).

4.5 Cable Grouping and Segregation

4.5.1 Power and instrument cables should normally be run on separate trays or ladders or in separate trenches or troughs. In a multipurpose cable trench a division wall the full depth of the trench shall be provided.

4.5.2 The spacing between cables shall be sufficient to ensure that any interference with instrumentation control and communications circuits due to the proximity of power cables is insignificant. Recommended minimum spacings are given in [RP 30-1](#).

The minimum separation distances given in [RP 30-1](#) are nothing more than 'rule of thumb' spacings, although they have been successfully applied for many years. In the confined area of, say, an offshore platform it may not be possible to adhere to the recommended distances. Induced voltages are only likely to become significant under conditions of earth fault on the power cable. On this basis, a minimum separation of 300 mm should be adequate for all but the most sensitive low signal level instrumentation circuits.

4.5.3 Auxiliary cables for control, metering and protection of power circuits may be run alongside their associated main power cables.

4.5.4 The horizontal and vertical spacing between adjacent bunches of cable shall not be less than 50 mm.

4.6 Cable Jointing and Termination

4.6.1 The use of joints shall be minimised and the location of all joints should be shown on the appropriate drawings. Joints in cables passing between process and offsite areas should be located in the offsite area.

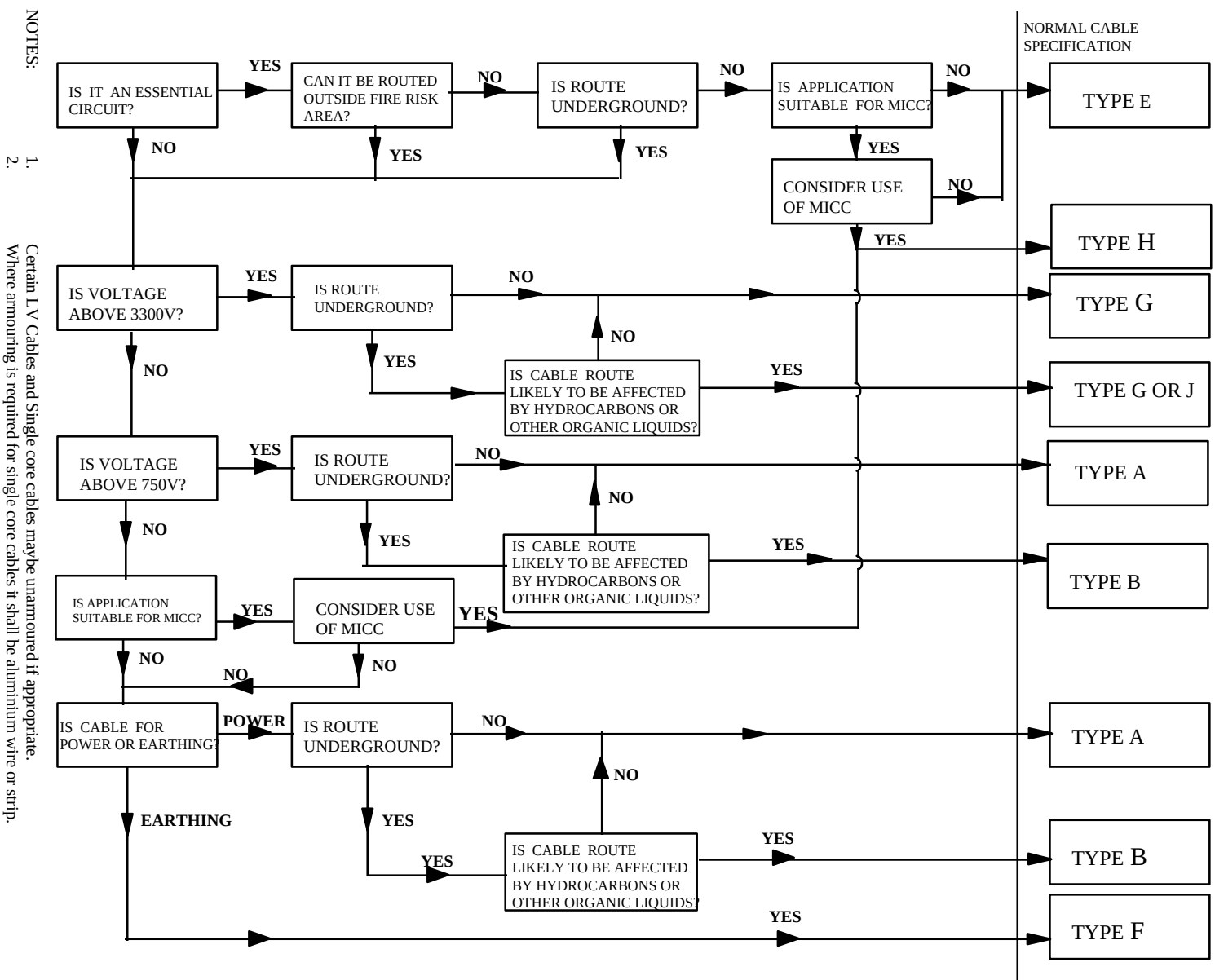
4.6.2 On offshore installations, joints are permitted in the intermodule cables which are preinstalled onshore to minimise the amount of cable pulling offshore. Where joints are used for this purpose, they should be grouped together in a number of jointing areas and identified by their respective cable numbers.

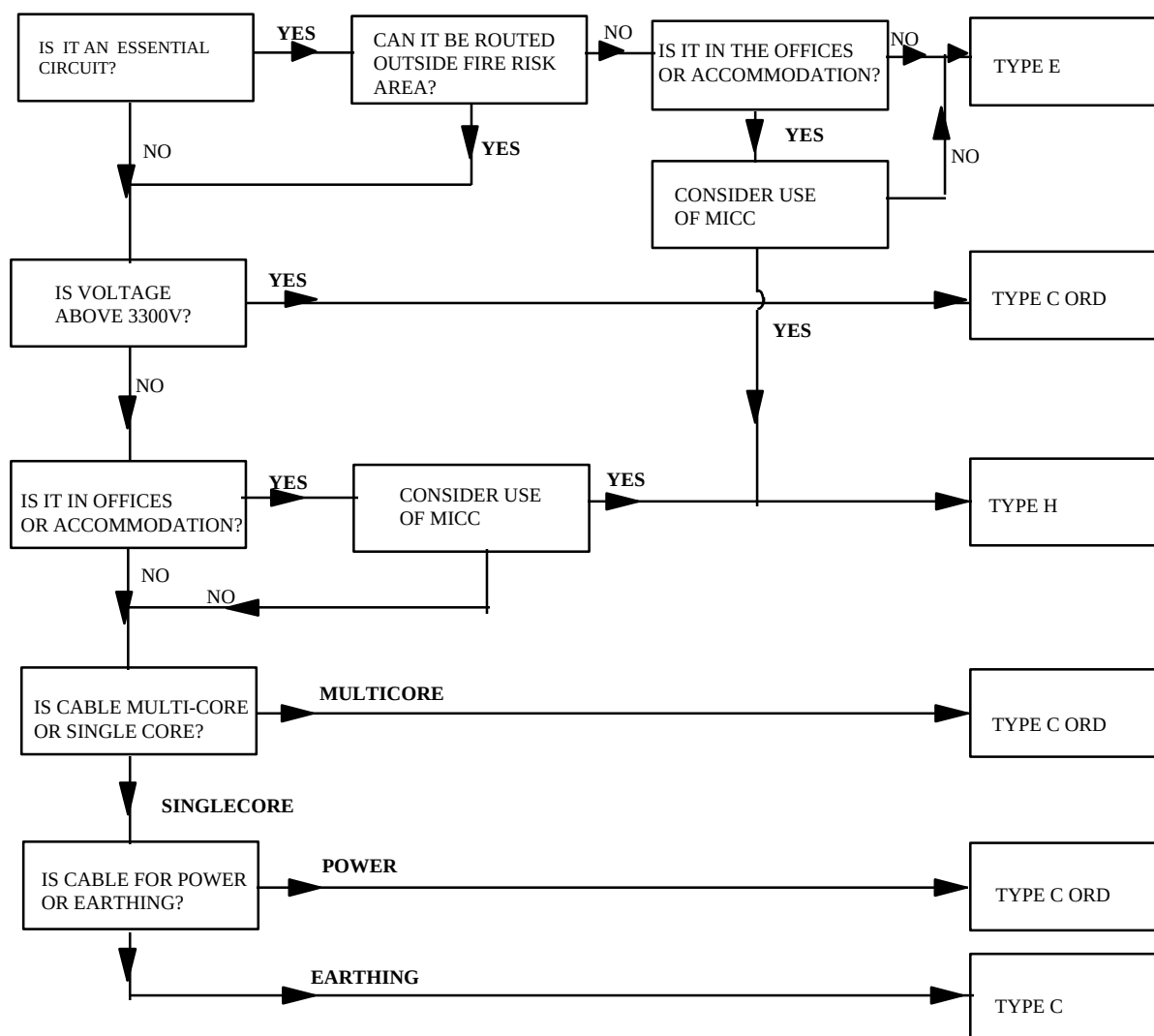
4.6.3 Cable joints shall be in accordance with [RP 12-2](#) when installed in areas classified as hazardous and shall maintain the mechanical and electrical

rating of the cable itself. If the cables being jointed are fire resistant or flame retardant, the joint shall also have the same fire performance characteristics.

- 4.6.4 High-voltage cables up to 36 kV should, wherever possible, be terminated using appropriate heat shrinkable or premoulded elastomeric rubber termination kits. Cable termination boxes should preferably be of the air filled type.
- 4.6.5 All cables entering outdoor electrical equipment shall do so via the bottom or side unless the equipment is shielded from the rain or other source of moisture. Cable glands shall maintain at least the same degree of protection against ingress of dust and moisture as the equipment enclosure.
- 4.6.6 Control cables with multi-stranded conductors shall be terminated with pin-ended, crimped ferrules. Terminals shall be of the type which clamps the wire or ferrule and each core shall be terminated in a separate terminal block.
- The correct size of ferrules and crimping tools shall be used and the requirements of [BS 5345](#) should be adhered to.
- 4.6.7 The method of glanding cables which enter certified flameproof enclosures shall comply with the relevant sections of [BS 5345](#).

FIGURE 1





Choice will depend on economic considerations and project standardisation policy.

FIGURE 2

Power Cable Selection Chart: Offshore Installations

DEFINITIONS AND ABBREVIATIONS**Definitions**

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

Abbreviations

AVR	Automatic Voltage Regulator
CSP	Chlorosulphonated Polyethylene
EEMUA	Engineering Equipment and Material Users Association
EPR	Ethylene Propylene Rubber.
ERA	Electrical Research Association.
EVA	Ethylene Vinyl Acetate.
GRP	Glass Reinforced Plastic
IEC	International Electrotechnical Commission.
IEE	Institution of Electrical Engineers.
MC	Motor Control Centre
MICC	Mineral Insulated Copper-sheathed Cable.
PVC	Polyvinyl Chloride.
SI	Système International d'Unités
UKOOA	United Kingdom Offshore Operators Association
XLPE	Cross-linked Polyethylene.

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.

International Standards

IEC 92-3	Electrical Installations in Ships Part 3: Cables (construction, testing and installation).
IEC 183	Guide to the selection of high-voltage cables.
IEC 287	Electric cables - Calculation of current rating
IEC 332-1	Tests on Cables Under Fire Conditions Part 1: Test on a single vertical insulated wire or cable.
IEC 332-3	Part3: Tests on bunched wires or cables
IEC 502	Extruded solid dielectric insulated power cables for rated voltages from 1 kV to 30 kV.
IEC 853-1	Calculation of the cyclic and emergency current rating of cables Part 1: Cyclic rating factor for cables up to and including 18/30 (36) kV

British Standards and Codes

BS 729	Hot dip galvanised coatings on iron and steel articles.
BS 4066: Part 1	Tests on Electric Cables Under Fire Conditions Method of test on a single vertical insulated wire or cable.
BS 5345	Codes of Practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres (other than mining applications or explosive processing and manufacture).
BS 5958	Control of undesirable static electricity
BS 6004	PVC-insulated cables (non-armoured) for electric power and lighting.
BS 6007	Rubber-insulated cables for electric power and lighting.
BS 6207	Copper-sheathed cables with copper conductors.



BS 6346	PVC-insulated cables for electricity supply.
BS 6480	Impregnated paper lead or lead alloy sheathed cables for working voltages up to and including 3kV.
BS 6883	Elastomer-insulated cables for fixed wiring in ships and on mobile and fixed offshore units.

U.K. Industry Standards

EEMUA Publ.133	Underground Armoured Cable Protected against Solvent Penetration and Corrosive Attack.
ERA Report 69-30	Part 1. Sustained current ratings for paper insulated lead sheathed cables to BS 6480 , Part 1, 1969. Part 3. Sustained current ratings for PVC insulated cables to BS 6346 , 1969. Part 4. Calculation of cyclic and emergency current rating for cables laid direct in the ground or in ducts for cables up to and including 19/33 kV Part 5. Sustained current ratings for cables with thermosetting insulation to BS 5467 : 1989 and BS 6724 : 1986.
ERA Report 74-29	A method for calculating ratings for cables in multi-layer groups on trays.
ERA Rep. 84-0172	Tests to determine data for rating cables in randomly laid stacks on tray.
IEE	Wiring Regulations for Electrical Installations
IEE	Recommendations for the Electrical and Electronic Equipment of Mobile and Fixed Offshore Installations.
UKOOA	Guidelines for Instrumentation, Power and Control Cables for Fixed and Mobile Production Facilities

BP Group Documents

RP 4-3	Foundations and General Civil Works
RP 12-2	Electrical Systems and Installations Electrical Equipment in Flammable Atmospheres and Combustible Dusts
RP 12-3	Electrical Systems and Installations



	Power System Design
RP 24-1	Fire Protection - onshore
RP 24-2	Fire Protection - offshore
RP 30-1	Instrumentation
GS 112-1	Electrical Engineering Specification for Materials and Workmanship.
GS 112-12	Requirements for Flame Retardant and Fire Resistant Cables

