



**RP 30-8**

**INSTRUMENTATION AND CONTROL**

**ELECTROMAGNETIC  
COMPATIBILITY  
FOR INSTRUMENTATION AND  
CONTROL SYSTEMS**

**September 1994**

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| <b>BP GROUP RECOMMENDED PRACTICES AND SPECIFICATIONS FOR ENGINEERING</b>                                                                                                                                                                                                                                                                                                                                                                                               |      |                              |                       |     |      |         |             |       |  |  |  |
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| Document Title<br><div style="text-align: center;"> <b>INSTRUMENTATION AND CONTROL<br/>ELECTROMAGNETIC COMPATIBILITY FOR<br/>INSTRUMENTATION AND CONTROL SYSTEMS</b> </div>                                                                                                                                                                                                                                                                                            |      |                              |                       |     |      |         |             |       |  |  |  |
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| <b>SCOPE AND PURPOSE</b><br><br>This Recommended Practice provides information and guidance on the requirements for electromagnetic compatibility when specifying, testing, installing and maintaining equipment for electrical, instrumentation and control systems.<br><br>Its purpose is to ensure that the requirements for electromagnetic compatibility are incorporated during the various stages of design, equipment construction, installation and operation |      |                              |                       |     |      |         |             |       |  |  |  |
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| <b>CUSTODIAN</b> (See Quarterly Status List for Contact)<br><div style="text-align: center;"><b>Control &amp; Electrical Systems</b></div>                                                                                                                                                                                                                                                                                                                             |      |                              |                       |     |      |         |             |       |  |  |  |
| <b>Issued by:-</b><br>Engineering Practices Group, BP International Limited, Research & Engineering Centre<br>Chertsey Road, Sunbury-on-Thames, Middlesex, TW16 7LN, UNITED KINGDOM<br>Tel: +44 1932 76 4067      Fax: +44 1932 76 4077      Telex: 296041                                                                                                                                                                                                             |      |                              |                       |     |      |         |             |       |  |  |  |

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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 Practice

The reason for producing a BP Recommended Practice on electromagnetic compatibility for instrumentation and control systems is that currently there is no single widely accepted relevant document which adequately covers the needs of the BP Businesses.

### 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.

### 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. SCOPE

### 1.1 Introduction

This Recommended Practice provides information and guidance on the specification, testing, installation and maintenance of electrical/electronic instrumentation and control equipment/systems to ensure that the requirements for electromagnetic compatibility are considered during the various stages of design, construction and installation. The document is to be used to ensure that instrumentation and control systems can safely share a common electromagnetic environment.

The aim is to focus on the relevant aspects of international EMC equipment standards and practices and to present methods for determining the limits of electromagnetic energy emission and susceptibility that should be applied so that plant control buildings/equipment rooms/electrical power supplies can be shared and so that cables from different systems can be adjacent.

This Recommended Practice considers electromagnetic compatibility (EMC) with installed systems and includes additional details not provided within the current international EMC equipment standards which are mainly concerned with individual items of equipment and not when equipment is installed as part of a larger system.

Adherence to these requirements is necessary to prevent the degradation of plant safety and reliability that could be caused by the emission of and susceptibility to electromagnetic energy.

*Cognisance has to be taken of the possible susceptibility to electromagnetic interference of each piece of electrical/electronic equipment and its own tendency for causing interference. This document outlines various measures that can be incorporated when specifying equipment and systems and which can be used during installation design to safeguard plant against electromagnetic interference. Various international standards are used to determine the limits of emission and susceptibility to apply; however, compliance with these standards does not necessarily guarantee total compatibility when the installation is complete. The adoption of the design techniques and installation practices presented in this document can be used to take account of the effects of electromagnetic interference and ensure that an overall electromagnetically compatible installation is achieved. The application of this Recommended Practice is required to ensure that the advantages gained by compliance with international standards is not jeopardised by unwanted interactions occurring during installation.*

*The advice provided within this Recommended Practice should be adequate for those engineers acquainted with the subject of EMC. However, general practitioners may have some difficulties and specialist advice may be required. Further guidance can be obtained from the Custodian of this document.*



## 1.2

### Types of Electromagnetic Emission

The definition of the Electromagnetic Environment covers the totality of electromagnetic phenomena. In practical terms this means the strength of the combined electromagnetic field over a spectrum extending from power frequencies to microwaves together with the magnitude of disturbances on mains power supplies due to all causes including switching and induced voltages. Electromagnetic interference energy may be caused by:

- (i) electrostatic discharge (ESD) i.e. from charged personnel and moveable objects

*In most petrochemical installations it is possible for voltages in the range 6 - 10 kV to be generated.*

- (ii) lightning

*The transients induced into wiring systems from lightning strikes can be about 6 kV with rise times of about one microsecond and duration's of about 50 microseconds.*

- (iii) switching transients e.g. on power supplies and generated by other electrical/electronic equipment.

*Transients due to switching operations can be about 2 - 3 kV with rise times of up to 10 nanoseconds and duration's up to 100 nanoseconds.*

- (iv) power frequency harmonics

- (v) power voltage fluctuations

- (vi) radio frequency transmissions produced by one or a combination of electromagnetic fields generated from various sources including radio/radar transmissions

- (vii) conduction emission e.g. along cables i.e. conducted interference and coupling.

These fields all contribute to make up the electromagnetic environment in which plant has to operate reliably and safely. In order to reduce the level of this electromagnetic environment this Recommended Practice recommends emission limits which recognise the industry's standard permitted levels for instrumentation and control systems.

### **1.3 Effects of Electromagnetic Interference**

By their nature, electrical/electronic instrumentation and control systems are susceptible to electromagnetic interference. Sensitive circuits are employed which operate at low energy values. Without protection this could lead to the mis-operation, malfunction or damage of individual components and complete systems. Typical effects might be: Corrupted outputs from thermocouples, amplifiers, spurious operation of trip amplifiers, corrupted signal levels from transmitters, apparent software faults of microprocessor based equipment and disturbance to the stabilised outputs of dc power supplies. Such faults may lead to serious consequences if Category 1 or 2A plant protective control equipment is affected.

In order to reduce the level of susceptibility of equipment/systems from the electromagnetic environment, limits of immunity are specified in this Recommended Practice which recognise the industry standards of acceptable levels of electromagnetic energy in which instrumentation and control equipment must operate.

### **1.4 Installation Practices to Safeguard against EMI**

Installation practices are described in this Recommended Practice which can contribute to the reduction of the effects of EMI when faced with the following situations:-

- (a) Individually specified equipment and/or subsystems of electrical/electronic instrumentation and control equipment are normally combined into larger electrically connected systems, or are located in close proximity to other electrical/electronic equipment. Generation of unwanted interference caused by conduction, mutual coupling or radiation in this situation needs to be avoided and adherence to the installation practices described in Section 3 are required in order to provide protection.
- (b) Cables for various electrical systems are usually installed in close proximity. They are normally run on the same or adjacent cable tray, passed through the same cable transits or mounted on common bulkheads. Installation practices are included in this section to ensure that the EMI produced by this situation is reduced to acceptable levels.
- (c) Power supplies, either primary type electric generators or secondary type supplies using batteries with chargers and possibly invertors are sometimes shared to supply different parts of the same instrumentation and control system, or could be

used to also supply other electrical/electronic equipment forming a part of other independent systems. Adherence to the proven methods of installation described in this section can be used to safeguard against unwanted EMI that could be produced under this situation.

## **2. SPECIFICATION AND SELECTION OF EQUIPMENT**

### **2.1 System Design Considerations**

Electromagnetic Compatibility (EMC) must be given serious consideration in the early planning stages of the overall instrumentation and control system design, when equipment, sub-systems and systems share a common electromagnetic environment (see definition) with other equipment and systems. For each item of equipment, sub-system or system the maximum emission characteristics and minimum levels of susceptibility shall be specified to ensure that the requirements for operability and reliability for the systems are maintained.

The following paragraphs of this section define the recommended limits of emission and susceptibility required to limit and reduce the effects of electromagnetic interference (see definition) to tolerable levels. However, it is the system designer's responsibility to ensure that the limits imposed are adequate and that the operation of the system or systems being designed and specified is satisfactory.

*The EMC characteristics of each piece of equipment or sub-system should be specified to ensure that the levels of emission are limited and that the susceptibility limits are adequate to ensure that there will be no degradation of performance caused by electromagnetic interference for any system sharing a common electromagnetic environment.*

*It should be the responsibility of the system designer to ensure that the limits of emission and susceptibility specified are adequate to comply with the overall requirements for sharing of equipment accommodation, cable routes and electrical power supplies. The proximity of different equipment and cables and the interference present on a common power supply feeds are major considerations when deciding the emission and susceptibility limits that need to be imposed.*

*The following specifications for emission and susceptibility limits are those that are currently imposed by the industry for instrumentation and control equipment. The limits may need to be made more severe or could be relaxed depending on the installation environment. Guidance on the limits to be imposed is contained in each of the following sections as appropriate. The system designer should consider which limits to impose based on an overall EMC control plan that should be drawn up for each installation (see section 3.1)*

A summary of the recommended specification requirements to be imposed on individually manufactured items of equipment, sub-systems

and systems is given in Table 2. The following sections give further details and guidance on the evaluation and interpretation of the limits to be imposed.

## 2.2 Electromagnetic Energy Emission Limits

### 2.2.1 Harmonic Emissions

All equipment operating from an electrical power supply voltage up to 415 volts shall comply with [IEC 1000](#) Part 3 Section 2 and [IEC 555](#) ([EN 60555](#) and [BS 5406](#)) Part 1 and 2 with respect to limits of harmonic currents in accordance with Table I of [IEC 555](#) Part 2

*Reference should be made to [EN 50160](#), [IEC 1000-2-1](#), [IEC 1000-2-2](#), [IEC 1000-2-4](#), [IEC 1000-2-X](#), [IEC 1000-2-Y](#) and [IEC 1000-2-Z](#).*

*Any equipment that operates from an electrical power supply voltage in the United Kingdom over 415 volts shall comply with the Electricity Council Engineering Recommendations [G5/3](#). Reference should also be made to [EN 50160](#), [ANSI Standard: IEEE S519](#), Australian Standard [SAA AS2279 Part 2](#), [IEC 1000-2-X](#), [IEC 1000-2-Y](#) and [IEC 1000-3-4](#).*

*Electrical and electronic equipment are liable to introduce disturbances especially harmonics of the power supply frequency into other systems which share the same power supply system. Such equipment, however, should not adversely affect the system characteristics, the supply voltage, or the performance of any other equipment connected to the power supply system. Provision should be made to limit the disturbing effects and to assist in attaining electromagnetic compatibility.*

### 2.2.2 Voltage Fluctuations

All equipment operating from an electrical power supply up to 415 volts shall comply with [IEC 1000](#) Part 3 Section 3 and [IEC 555](#) ([EN 60555](#) and [BS 5406](#)) Part 1 and 3 with respect to limits of voltage fluctuations as defined in Clause 6.0 of [IEC 555](#) Part 3

*Reference should be made to [EN 50160](#), [IEC 1000-2-1](#), [IEC 1000-2-2](#), [IEC 1000-2-4](#), [IEC 1000-2-X](#), [IEC 1000-2-Y](#) and [IEC 1000-2-Z](#).*

*Any equipment that operates from an electrical power supply voltage in the United Kingdom over 415 volts shall comply with the Electricity Council Engineering Recommendations [P28](#). Reference should be made to [EN 50160](#), Australian Standard [SAA AS2279 Part 4](#), [IEC 1000-2-X](#), [IEC 1000-2-Y](#) and [IEC 1000-3-5](#).*

*Electrical and electronic equipment may produce voltage fluctuations in the power supply systems to which they are connected. A combination of large current variations and high power supply system impedance can cause excessive changes of power supply voltage. Voltage fluctuations produced by an item of equipment should not adversely affect other equipment connected to the same power supply system.*

*If excessive voltage changes are repeated at short intervals of time, objectionable fluctuations of instrumentation functions may be produced within instrumentation and control systems connected to the same power supply system.*

### 2.2.3 Mains Terminal Radio Interference

All equipment shall comply with the Class B mains terminal interference voltage limits as detailed in Table II of [EN 55022 \(BS 6527\)](#) and [VDE 0871](#) as follows:-

| Frequency range<br>(MHz) | Limits [dB (v)] - <a href="#">EN 55022</a> |                     | Limits [dB (v)] -<br><a href="#">VDE 871</a> |
|--------------------------|--------------------------------------------|---------------------|----------------------------------------------|
|                          | Quasi-peak                                 | Average             |                                              |
| 0.01 to 0.15             | Under consideration                        | Under consideration | 79 to 57.5                                   |
| 0.15 to 0.50             | 66 to 56                                   | 56 to 46            | 54                                           |
| 0.50 to 5                | 56                                         | 46                  | 48                                           |
| 5 to 30                  | 60                                         | 50                  | 48                                           |

### 2.2.4 Radiated Interference

All equipment except radio transmitting equipment shall comply with [EN 55022 \(BS 6527\)](#) and shall meet the limits of radiated interference field strength as detailed in Table IV of [EN 55022](#) as follows:-

| Frequency range<br>(MHz) | Quasi-peak limits<br>[dB(v/m)] |
|--------------------------|--------------------------------|
| 30 to 230                | 30                             |
| 230 to 1000              | 37                             |

Note: -  $E \text{ (v/m)} = 10 (E[\text{dB(v/m)}]/20) - 6$

*Any radio transmitting equipment shall comply with the appropriate radio regulatory authority requirements with respect to the generation of radiated radio interference. See BP Group [RP 59-7](#) for further details relating to radio transmission equipment.*

*Low frequency fields may be radiated at the power supply frequency and by any harmonics that could be present. These effects should be observed and precautions taken as necessary so that any susceptible equipment is protected. The maximum transverse psophometrically weighted e.m.f. voltage that is induced into a telephone or data cable pair running adjacent to the equipment should not be greater than 1 mV in accordance with CCITT Directives Volume V1 Section 6.2. (The psophometrically weighted filter used should comply with CCITT Recommendation O.41)*

## 2.3 Electromagnetic Energy Susceptibility Limits

*Electromagnetic energy susceptibility limits for individual items of equipment, sub-systems or systems are defined in [EC 801](#). Parts 1-3 of [EN 801](#) are identical to [BS 6667](#) Parts 1-3 and may be used. [IEC 801](#) Parts 4-6 do not have a BS*

equivalent. [IEC 1000 Part 4](#) is a collection of basic EMC standards which contains the main aspects of [IEC 801](#).

### 2.3.1 General EMC Susceptibility Requirements

All equipment shall comply with the requirements specified in [IEC 801 Part 1](#) ([BS 6667 Part 1](#)) and [IEC 1000 Part 4 Section 1](#), General requirements.

### 2.3.2 Susceptibility to Electrostatic Discharge

All equipment shall comply with [IEC 801 Part 2](#) ([BS 6667 Part 2](#)) and [IEC 1000 Part 4 Section 2](#) and shall meet the severity level requirements specified in Clause 5.0 of [IEC 801 Part 2](#) ([BS 6667 Part 2](#)).

*Severity level 3 is considered to apply to most installations, however, the electrostatic discharge susceptibility severity level for IEC 801-2 may be relaxed or made more onerous dependent of the most realistic installation and environmental conditions used. The severity level chosen can be selected from the installation and environmental levels outlined in Clause 5 of IEC 801-2 as follows:-*

| Severity Level | Relative humidity as low as (%) | Installation | Environment        | Derived Maximum voltage (kV) |
|----------------|---------------------------------|--------------|--------------------|------------------------------|
|                |                                 | Anti-static  | Synthetic (Static) |                              |
| 1              | 35                              | Yes          |                    | 2                            |
| 2              | 10                              | Yes          |                    | 4                            |
| 3              | 50                              |              | Yes                | 8                            |
| 4              | 10                              |              | Yes                | 15                           |

*For materials, such as wood, concrete, ceramic, vinyl and metal, the severity level should not be greater than severity level 2. However, further guidance on this aspect can be obtained from the Custodian of this document.*

### 2.3.3 Susceptibility to Radiated Electromagnetic Energy

All equipment shall comply with [IEC 801 Part 3](#) ([BS 6667 Part 3](#)) and [IEC 1000 Part 4 Section 3](#) and shall meet the severity level requirements as specified in Clause 5.0 of [IEC 801 Part 3](#) ([BS 6667 Part 3](#)).

*The severity level chosen can be selected from the installation and environmental levels outlined in Clause 5 of [IEC 801-3](#) as follows:-*

| Severity Level | Test field strength (Volts/metre) @ 1 metre |
|----------------|---------------------------------------------|
| 27 to 500 MHz  |                                             |
| 1              | 1                                           |
| 2              | 3                                           |
| 3              | 10                                          |

|   |         |
|---|---------|
| X | Special |
|---|---------|

The severity level and frequency band for [IEC 801-3](#) must be specified and selected in accordance with the electromagnetic radiation environment in which the equipment and/or system being specified will be exposed when finally installed.

The following severity level classes are the levels listed in Clause 5 of [IEC 801-3](#), they are considered as general guidelines for the selection of the appropriate radiation levels to be tested:-

- Level 1: Low level electromagnetic radiation environment, such as levels typical of local radio/television stations located at more than 1 km and levels typical of low power transceivers.
- Level 2: Moderate electromagnetic radiation environments, such as portable transceivers that can be relatively close to the equipment but not closer than 1 metre.
- Level 3: Severe electromagnetic radiation environments, such as levels typical of high power transceivers in close proximity to the control equipment.
- level X: Open class for situations involving very severe electromagnetic radiation environments. The level is subject to negotiation between the user and manufacturer or as defined by the manufacturer.

For further guidance a range of typical values of electromagnetic energy field strengths that may be present from various sources of radio frequency equipment are given in Table 3 of this Recommended Practice.

The most onerous of these situations occurs when handportable radios are anticipated to be used in close proximity to equipment. [IEC 801-3](#) Appendix A para A5 and Figure A3 gives guidance on the average electromagnetic field strengths likely to be experienced from these devices. Field strengths can be a maximum of 3.5 times greater than those indicated in Figure A of [IEC 801-3](#) e.g. A field strength of 55 volts/metre may be produced if a one watt handportable radio is held 10 cm from the equipment.

It is unlikely that the severity level chosen will be less than Level 2. However, further guidance on this aspect can be obtained from the Custodian of this document when specifying actual frequencies and field strength levels. Further information is given in Section 5 of this Recommended Practice, maintenance and operation.

All equipment shall comply with IEC 801 Part 4 and IEC 1000 Part 4 Section 4 and shall meet the severity level requirements specified in accordance with Clause 5 of IEC 801 Part 4.

*The severity level chosen can be selected from the installation and environmental levels outlined in Clause 5 of IEC 801-4 as follows:-*

| Severity Level | Open circuit voltage    | + 10%                                           |
|----------------|-------------------------|-------------------------------------------------|
|                | On power supply<br>(kV) | On I/O signal, data and<br>control line<br>(kV) |
| 1              | 0.5                     | 0.25                                            |
| 2              | 1                       | 0.5                                             |
| 3              | 2                       | 1                                               |
| 4              | 4                       | 2                                               |
| X              | Special                 | Special                                         |

*The immunity tests given in IEC 801-4 are correlated with the levels in Clause 5 of IEC 801-4 in order to establish a performance level for the environment in which the equipment is expected to operate.*

*For I/O lines, control, signal and data lines use half the test voltage values applied on power supply lines.*

*Based on common installation practices, the recommended selection of severity levels for EFT/B testing according to the requirements of the electromagnetic environment, is given in IEC 801-4 as follows:-*

#### **Level 1: Well-protected environment**

*The installation is characterised by the following attributes:-*

- (i) suppression of all EFT/B in the switched control circuits;
- (ii) separation between power supply lines (a.c. and d.c.) and control and measurement circuits coming from other environments belonging to higher severity levels;
- (iii) shielded power supply cables with the screens earthed at both ends on the reference ground of the installation, and power supply protection by filtering.

*A computer room may be representative of this environment.*

*The applicability of this level to testing of equipment is limited to the power supply circuits for type tests, and to the earthing circuits and equipment cabinets for field tests.*

### **Level 2:**

*The installation is characterised by the following attributes:-*

- (i) partial suppression of EFT/B in the control circuits which are switched only by relays (no contactors);*
- (ii) separation of all the circuits from other circuits associated with environments of higher severity levels;*
- (iii) physical separation of unshielded power supply and control cables from signal and communication cables.*

*A control room or terminal room of industrial and electrical plants may be representative of this environment.*

### **Level 3: Typical industrial environment**

*The installation is characterised by the following attributes:-*

- (i) no suppression of EFT/B in the control circuits which are switched only by relays (no contactors);*
- (ii) poor separation of the industrial circuits from other circuits associated with environments of higher severity levels;*
- (iii) dedicated cables for power supply, control, signal and communication lines;*
- (iv) poor separation between power supply, control signal and communication cables;*
- (v) availability of earthing system represented by conductive pipes, ground conductors in the cables trays (connected to the protective earth system) and by a ground mesh.*

*The area of industrial process equipment, the power plants and the relay room of open air H.V. substations may be representative of this environment.*

### **Level 4: Severe industrial environment**

*The installation is characterised by the following attributes:-*

- (i) no suppression of EFT/B in the control and power circuits which are switched by relays and contactors;*
- (ii) no separation of the industrial circuits from other circuits associated with environments of higher severity levels;*
- (iii) no separation between power supply, control, signal and communication cables;*
- (iv) use of multicore cables in common for control and signal lines.*

The outdoor area of industrial process equipment, where no specific installation practice has been adopted, of power stations, open air H.V. substation switchyards and gas insulated switchgear up to 500 kV operating voltage (with typical installation practice) may be representative of this environment.

#### **Level X: Special situations to be analysed**

The minor or major electromagnetic separation of interference sources from equipment circuits, cables, lines etc., and the quality of the installations may require the use of a higher or lower environmental level than those described above. It should be noted that equipment lines of a higher severity level can penetrate a lower severity environment.

It is unlikely that a severity level above Level 2 will be needed for a majority of BP installations. However, further guidance on this aspect can be obtained from the Custodian of this document.

### 2.3.5

#### **Susceptibility to Surge**

All equipment shall comply with IEC 801 Part 5 (DRAFT) and IEC 1000 Part 4 Section 5 and shall meet the severity level requirements as specified in Clause 5 of IEC 801 Part 5 .

The severity level chosen can be selected from the installation and environmental levels outlined in Clause 5 of IEC 801-5 as follows:-

| <b>Severity Level</b> | <b>Open circuit test voltage <math>\pm 10\%</math><br/>(kV)</b> |
|-----------------------|-----------------------------------------------------------------|
| 1                     | 0.5                                                             |
| 2                     | 1                                                               |
| 3                     | 2                                                               |
| 4                     | 4                                                               |
| X                     | Special                                                         |

The following extract from IEC 801-5 (Draft) gives guidance on the selection of severity levels for IEC 801-5:-

**Level 0: Well protected electrical environment, where all incoming cables are provided with overvoltage (primary and secondary) protection.**

This electrical environment often exists within a special room.

The units of the electronic equipment are interconnected by a well designed earthing system, which is not essentially influenced by the power installation or lightning.

The electronic equipment has the power supply of its own. Surge voltage may not exceed 25 V.

**Level 1: Partly protected electrical environment where all incoming cables to the room are provided with overvoltage (primary) protection.**



*The units of the equipment are well interconnected by an earth line network, which is not essentially influenced by the power installation or from lightning.*

*The electronic equipment has its power supply completely separated from the other equipment.*

*Switching operations can generate interference voltages within the room.*

*Surge voltage may not exceed 500 V.*

**Level 2: Electrical environment where the cables are well separated, even at short runs.**

*The installation is earthed via separate earth line to the earthing system of the power installation which can be essentially subjected to interference voltages generated by the installation itself or by lightning. The power supply to the electronic equipment is separated from other circuits, mostly by a special transformer for the power supply.*

*Non-protected circuits are in the installation, but well separated and in restricted numbers.*

*Surge voltage may not exceed 1 kV.*

**Level 3: The installation is earthed to the common earthing system of the power installation which can be essentially subjected to interference voltages generated by the installation itself or by the lightning.**

*Current due to earth faults, switching operations and lightning in the power installation may generate interference voltages with relatively high amplitudes in the earthing system. Protected electronic equipment and less sensitive electric equipment are connected to the same power supply network. The I/O cables can be partly as outdoor cables, but close to the earthing/grounding network.*

*Unsuppressed inductive loads are in the installation and usually no separation of the different field cables. Surge voltage may not exceed 2 kV.*

**Level 4: Electrical environment where multi-wire cables are used for both electronic and electric circuits.**

*The installation is connected to the earthing system of the power installation which can be subject to interference voltages generated by the installation itself or by lightning.*

*Currents in the kA range due to earth faults, switching operations and lightning in the power supply installation may generate interference voltages with relatively high amplitudes in the earthing system. The power supply network can be the same for both the electronic and the electric equipment. The I/O cables are running as outdoor cables even to the high voltage equipment.*

*A special case of this environment is when the electronic equipment is connected to the telecommunication network within a densely populated area.*

*There is no systematically constructed earthing network outside the electronic equipment, the earthing system consists of pipes, cables etc. only.*

*Surge voltage may not exceed 4 kV.*

**Level 5: Electrical environment for electronic equipment connected to telecommunication cables and overhead power lines in non densely populated area.**

*Outside the electronic equipment there is no wide spread earthing system (exposed plant). The interference voltages due to earth fault (currents up to 10 kA) and lightning (currents up to 100 kA) can be extremely high.*

*All these cables and lines are provided with overvoltage (primary) protection.*

**Level X: Special conditions to be agreed upon by manufacturer and customer.**

*It is unlikely that a severity level above Level 2 will be needed for a majority of BP installations. However, further guidance on this aspect can be obtained from the Custodian of this document.*

## 2.3.6

### Susceptibility to Conducted Radio Frequency Disturbances

All equipment shall comply with [IEC 801](#) Part 6 (DRAFT) and [IEC 1000](#) Part 4 Section 6. and shall meet the severity level requirements specified in accordance with Clause 5 of [IEC 801](#) Part 6.

*The severity level chosen can be selected from the installation and environmental levels outlined in Clause 5 of IEC 801-6 as follows:-*

| <b>Severity Level</b> | <b>Voltage Level (EMF)<br/>(V)<br/>0 Hz to 230 MHz</b> |
|-----------------------|--------------------------------------------------------|
| 1                     | 1                                                      |
| 2                     | 3                                                      |
| 3                     | 10                                                     |
| X                     | Special                                                |

*The test severity levels shall be selected in accordance with the electromagnetic radiation environment to which the equipment may be exposed when finally installed. The consequences of failure should be borne in mind in selecting the severity level to be applied. A higher level should be considered if the consequences of failure are large.*

*If the equipment is to be installed at only a few sites, then an inspection of the local RF-sources will enable a calculation of field strengths likely to be encountered. If the powers of the sources are not known it may be possible to measure the actual field strength at the location(s) concerned.*

*For equipment intended for operation in a variety of locations, the following guidance extracted from [IEC 801-6](#) (Draft) may be used in selecting the test level to be applied.*



The following classes are related to the levels listed in clause 5 of [IEC 801](#) Part 6 severity levels. They are considered as general guidelines for the selection of the appropriate levels:-

**Level 1: Low level electromagnetic radiation environment.**

Levels typical of local radio/television stations located at more than 1 km and levels typical for low power transceivers.

**Level 2: Moderate electromagnetic radiation environment.**

Low power portable transceivers (typical less than 1 W rating) are in use, but with restrictions on use in close proximity to the equipment. A typical commercial environment.

**Level 3: Severe electromagnetic radiation environment.**

Portable transceivers (2 W and more) are in use relatively close to the equipment but not less than 1m. High power broadcast transmitters are in close proximity to the equipment. A typical industrial environment.

**Level X:**

X is an open level which might be negotiated and specified in the dedicated equipment specifications.

The severity levels are related to the severity levels of the radiated field test in [IEC 801-3](#), by assuming an active antenna height for the receiving antenna network of 1 metre.

It is unlikely that the severity level chosen will be less than Level 2 for a majority of BP installations. However, further guidance on this aspect can be obtained from the Custodian of this document.

### 2.3.7 Susceptibility to Harmonics

All equipment shall comply with [EN 61000-4](#) Part 7, [IEC 1000](#) Part 4 Section 7 and [IEC 1000](#) Part 4 Section X.

Reference should be made to the relevant sections of [EN 55024](#), [IEC 1000](#) and [EN 50082](#) for guidance.

All equipment shall comply with IEC 1000 Part 4 Section 8 and shall meet the severity level requirements specified in accordance with Clause 5 of IEC 1000 Part 4 Section 8.

*The severity level chosen can be selected from the most realistic installation and environmental conditions outlined in Clause 5 of IEC 1000-4-8 as follows:-*

| <b>Level</b> | <b>Magnetic Field Strength<br/>A/m</b> |
|--------------|----------------------------------------|
| 1            | 1                                      |
| 2            | 3                                      |
| 3            | 10                                     |
| 4            | 30                                     |
| 5            | 100                                    |
| x            | special                                |

*The test severity level shall be chosen according to:-*

- *the electromagnetic environment;*
- *the proximity of the disturbances sources to the equipment concerned*
- *the compatibility margins*

*Based on common installation practices, a guide for the selection of test levels for magnetic fields testing may be the following:-*

**Level 1: Environmental levels where sensitive device using electron beam can be used.**

*Monitors, electron microscope, etc., are representative of these devices.*

*Note: 90% of the computer screens are submitted to only 1 A/m. However, screens located near source of disturbance such as transformers or power lines shall withstand higher level to be set by product committees (other measures can be necessary like moving screens away from these sources).*

**Level 2: Well protected environment.**

*The environment is characterised by the following attributes:-*

- *absence of electrical equipment like power transformers that may give rise to leakage fluxes;*
- *areas not subjected to the influence of H.V. sub-stations may be representative of this environment.*

**Level 3: Protected environment.**

*The environment is characterised by the following attributes:-*

- electrical equipment and cables that may give rise to leakage fluxes or magnetic field;
- proximity of earth conductors of protection systems;
- M.V. circuits and H.V. bus-bars far away (a few hundred metres) from equipment concerned.

Commercial areas, control building, field of not heavy industrial plants, computer room of H.V. sub-stations may be representative of this environment.

#### **Level 4: Typical industrial environment.**

The environment is characterised by the following attributes:-

- short branch power lines as bus-bars, etc.;
- high power electrical equipment that may give rise to leakage fluxes;
- ground conductors of protection system;
- M.V. circuits and H.V. bus-bars at relative distance (a few tens of metres) from equipment concerned.

Fields of heavy industrial and power plants and the control room of H.V. sub-stations may be representative of this environment.

#### **Level 5: Severe industrial environment.**

The environment is characterised by the following attributes:-

- conductors, bus-bars or M.V., H.V. lines carrying tens of kA;
- Ground conductors of the protection system;
- proximity of M.V. and H.V. bus-bars;
- proximity of high power electrical equipment.

Switchyard areas of heavy industrial plants, M.V., H.V. and power stations may be representative of this environment.

#### **Level x: Special environment.**

The environment is characterised by the following attributes:-

The minor or major electromagnetic separation of interference sources from equipment circuits, cables, lines etc., and the quality of the installations may require the use of a higher or lower environmental level than those described above. It should be noted that the equipment lines of a higher level can penetrate a lower severity environment.

It is unlikely that a severity level above Level 3 will be needed for a majority of BP installations. However, further guidance on this aspect can be obtained from the Custodian of this document.

### **2.3.9**

#### **Susceptibility to Pulse and Magnetic Fields**

All equipment shall comply with IEC 1000 Part 4 Section 9 and should meet the severity level requirements specified in accordance with Clause 5.0 of [IEC 1000 Part 4 Section 9](#).



The severity level chosen can be selected from the most realistic installation and environmental conditions outlined in Clause 5 of IEC 1000-4-9 as follows:-

| <b>Level</b> | <b>Magnetic Field Strength<br/>A/m</b> |
|--------------|----------------------------------------|
| 1            | n.a.                                   |
| 2            | n.a.                                   |
| 3            | 100                                    |
| 4            | 300                                    |
| 5            | 1000                                   |
| x            | special                                |

The test severity level shall be chosen according to:-

- the electromagnetic environment;
- the proximity of the disturbances sources to the equipment concerned
- the compatibility margins

Based on common installation practices, a guide for the selection of test levels for magnetic fields testing may be the following:-

**Level 1: Test not applicable to this environment where sensitive devices using electron beam can be used** (monitors, electron microscope, etc., are representative of these devices).

**Level 2: Well protected environment.**

Test not applicable to this environment because the areas concerned are not subjected to the influence of lightning and initial transient fault current.

Residential, office, hospital protected areas far away from earth conductors of lightning protection systems may be representative of this environment.

**Level 3: Protected environment.**

The environment is characterised by the proximity of earth conductors of lightning protection systems and metallic structures.

Commercial areas, control building, field of not heavy industrial plants provided with lightning protection system or metallic structures in the proximity, computer room of H.V. sub-stations may be representative of this environment.

**Level 4: Typical industrial environment.**

The environment is characterised by the ground conductors of the lightning protection system or structures.

Fields of heavy industrial and power plants and the control room of H.V. sub-stations may be representative of this environment.

### **Level 5: Severe industrial environment.**

*The environment is characterised by the following attributes:-*

- conductors, bus-bars or M.V., H.V. lines carrying tens of kA;
- ground conductors of the lightning protection system or high structures like the line towers carrying the whole lightning current.;

*Switchyard areas of heavy industrial plants, M.V., H.V. and power stations may be representative of this environment.*

### **Level X: Special environment.**

*The environment is characterised by the following attributes:-*

*The minor or major electromagnetic separation of interference sources from equipment circuits, cables, lines etc., and the quality of the installations may require the use of a higher or lower environmental level than those described above. It should be noted that the equipment lines of a higher level can penetrate a lower severity environment.*

*It is unlikely that a severity level above Level 3 will be needed for a majority of BP installations. However, further guidance on this aspect can be obtained from the Custodian of this document.*

## **2.3.10**

### **Susceptibility to Damped Oscillatory Magnetic Fields**

All equipment that is likely to be installed in H.V. sub-stations shall comply with [IEC 1000](#) Part 4 Section 10 and should meet the severity level requirements specified in accordance with Clause 5 of [IEC 1000](#) Part 4 Section 10.

*The severity level chosen can be selected from the most realistic installation and environmental conditions outlined in Clause 5 of IEC 1000-4-10 as follows:-*

| <b>Level</b> | <b>Magnetic Field Strength<br/>A/m</b> |
|--------------|----------------------------------------|
| 1            | n.a.                                   |
| 2            | n.a.                                   |
| 3            | 10                                     |
| 4            | 30                                     |
| 5            | 100                                    |
| x            | special                                |

*The test severity level shall be chosen according to:-*

- the electromagnetic environment;
- the proximity of the disturbances sources to the equipment concerned
- the compatibility margins

*Based on common installation practices, a guide for the selection of test levels for magnetic fields testing may be the following:-*



**Level 1: Test not applicable to this environment where sensitive devices using electron beam can be used** (monitors, electron microscope, etc., are representative of these devices).

**Level 2: Well protected environment.**

Test not applicable to this environment class because the areas concerned are not subjected to the influence of switching of H.V. bus-bars by isolators.

Shielded areas of industrial installations and H.V. sub-stations may be representative of this environment.

**Level 3: Protected environment.**

The environment is characterised by M.V. circuits and H.V. bus-bars switched by isolators far away (a few hundred metres) from equipment concerned.

Computer room of H.V. sub-stations may be representative of this environment.

**Level 4: Typical industrial environment.**

The environment is characterised by M.V. circuits and H.V. bus-bars switched by isolators at relative distance (a few tens metres) from equipment concerned.

Field of heavy industrial and power plants and the control room of H.V. sub-stations may be representative of this environment.

**Level 5: Severe industrial environment.**

The environment is characterised by the following attributes:-

- proximity of M.V. and H.V. bus-bars switched by isolators;
- proximity of high power electrical equipment.

Switchyard areas of heavy industrial plants, M.V., H.V. and power stations may be representative of this environment.

**Level X: Special environment.**

The environment is characterised by the following attributes:-

The minor or major electromagnetic separation of interference sources from equipment circuits, cables, lines etc., and the quality of the installations may require the use of a higher or lower environmental level than those described above. It should be noted that the equipment lines of a higher level can penetrate a lower severity environment.

It is unlikely that a severity level above Level 4 will be needed for a majority of BP installations. However, further guidance on this aspect can be obtained from the Custodian of this document.

2.3.11

Susceptibility to Voltage Fluctuations



All equipment shall comply with [IEC SC 77B](#), [IEC 1000](#) Part 4 Section 11 and [IEC 1000](#) Part 4 Section Y.

*Reference should be made to the relevant sections of [EN 55024](#), and [EN 50082](#) for guidance.*

*Until [IEC SC 77B](#) and [IEC 1000-4-11](#) are published equipment shall comply with [EN 50093](#), i.e. Basic immunity standard for voltage dips, short interruptions and voltage variations, as follows:*

(a) Voltage Variations

*The test shall be performed on the equipment d.c. power input terminals and the performance of the equipment under test shall not be impaired when test levels of  $Unom \pm 10\%$  in accordance with [EN 50093](#) are used.*

(b) Voltage Dips and Interruptions

*The tests shall be performed on the equipment a.c. power input terminals and the performance of the equipment under test shall not be impaired when the following test levels are used in accordance with [EN 50093](#) as follows:-*

- (i) *A voltage dip corresponding to a reduction of the supply voltage of 30 % for 10 mS, and*
- (ii) *A voltage dip corresponding to a reduction of the supply voltage of 50 % for 100 mS, and*
- (iii) *A voltage interruption corresponding to reduction of the supply voltage of greater than 95 % for 5000 mS*

2.3.12 Susceptibility to Oscillatory Waves

All equipment shall comply with [IEC 1000](#) Part 4 Section W.

2.3.13 Susceptibility to Continuous Conducted Disturbances

All equipment shall comply with [IEC 1000](#) Part 4 Section Z.

**2.4 EMC Emission and Susceptibility Testing and Acceptance**

2.4.1 Factory Testing

The manufacturer shall demonstrate that a representative configuration of the equipment, sub-system or system required is capable of meeting the test requirements described in Sections 2.2 and 2.3 above. Tests should have been carried out by the manufacturer on individual items of equipment or assembled sub-systems with all ancillary items and

interconnecting cables connected and tested in accordance with the test procedure and conditions specified.

A certificate confirming compliance to the tests shall be prepared for each item of equipment or sub-system tested, giving details of all test equipment used with type and calibration details, the test configuration arrangement, the test site used and the name of the testing authority.

*A test certificate should be issued by each manufacturer or sub-system supplier to certify that a representative item of the equipment or sub-system complies with the requirements specified above. In most cases it is not practical to obtain a test certificate for a completely assembled system and the system designer should ensure that each item of equipment and sub-system are adequately specified to meet the overall EMC requirements ( see Sections 2.1 and 3.1)*

## 2.4.2

### Installation Testing

#### (a) Site Testing

The EMC test specifications described in Sections 2.2, 2.3 and 2.4 above are often inappropriate due to the size of the system and tests may need to be carried after installation to verify that electromagnetic compatibility is achieved.

In addition it may be necessary to carry out EMC testing at the installation site to verify that the standard of installation is adequate and that the installation has not degraded the required performance caused by insufficient attention to EMC installation practices.

It is the system designer's responsibility to determine what additional testing will be required at the installation site to verify that the EMC requirements are satisfactory.

*The 'bulk current injection' and 'mode stirring' test methods defined in [UK Defence Standard 59-41](#) should be used to verify EMC requirements at the installation site.*

#### (b) Tests with Radios

*The main radiation threat is often handportable and vehicle mounted radios (see comments in Section 2.3.3 and Table 3) and it has been usual practice to carry out on-site testing with portable radios in order to determine if the equipment is susceptible to the types of radios being used. However, this is only worthwhile where the equipment manufacturer has confirmed that the particular piece of equipment is not susceptible to the level of radio frequency radiation that is being generated (see Table 3).*

*Extreme caution must be taken when using the results of this type of testing. The tests carried out during commissioning are normally limited*

to specific points around the equipment and only cover the range of radio frequencies and output powers specific to the portable radios used at the time of testing. In order to allow portable radios to be used in close proximity to instrumentation and control equipment more extensive testing that is verified by the manufacturer will need to be carried out, and this is only considered worthwhile where the use of portable radios close to the equipment is essential for maintenance or operational purposes.

Where the manufacturer has verified that the equipment meets the requirements of [IEC 801-3](#) to a severity level appropriate to the level of radio frequency radiation to be used - see Table 3 (for vhf and uhf handportable radios this should be typically 20 volts/metre at one metre) then the equipment may be tested after the completion of installation as follows:-

Each handportable radio transmitter typical of the type or types to be used, shall be operated at as many locations around the equipment as possible with the midpoint of the antenna no more than 100 mm from all parts of the instrumentation and control equipment under test. The performance of the instrumentation and control equipment under test shall not be impaired or degraded. The tests should be carried out with all cabinet doors open and covers removed to simulate maintenance activities.

In addition it may be necessary to test for the effects of other radio transmitter antennas that may be mounted close the equipment being installed. See Table 3. The possible effects of mobile radios fitted in vehicles should be considered where equipment is installed adjacent to plant control building walls that are alongside a road or driveway.

## 2.5 Mandatory Standards

The standards listed above in paragraphs 2.2 and 2.3 each define specific requirements for particular needs in the electromagnetic environment. However, the EC issued a Directive ([89/336/EEC](#)) as amended by Directive [92/31/EEC](#), which has been implemented in the UK by the EMC Regulations (Statutory Instrument [SI 1992/2372](#)). This came into force on the 28 October 1992, and allows for a transition period until 31 December 1995. During the transition period, manufacturers of electrotechnical products can either conform to the Directive (and apply the 'CE' Mark) or can comply with existing regulations in force in the Member States in which the product is to be placed on the market (i.e. national regulations which were in force on 30 June 1992).

All equipment and systems used in the EU must meet the requirements specified in [European EMC Directive No. 92/31/EEC](#).

The Directive applies to all electrical and electronic appliances, including equipment and systems, containing electrical and/or electronic components, which are liable to cause electromagnetic disturbance or whose performance is liable to be affected by such disturbance (Article 2.1). The Directive specifies that products must be so constructed that they do not generate an excessive level of electromagnetic emission and that they should have sufficient immunity in order to not be susceptible to electromagnetic radiation. The Directive requires that

apparatus to which it applies should comply with the protection requirements set out in Article 4 of the Directive:

- (a) the electromagnetic disturbance it generates does not exceed a level allowing radio, telecommunications and other electrical apparatus to operate as intended; and
- (b) the apparatus has an adequate level of intrinsic immunity to electromagnetic disturbance to enable it to operate as intended.

Manufacturers of non-radio communications equipment can comply with the EMC Directive in one of two ways as follows:-

- (a) Self-certification in accordance with harmonised European standards.  
A manufacturer does not have to produce a test report to self-certify a product, but must have reasonable evidence to prove compliance if required to do so. However, as a word of caution, the UK regulations allow a manufacturer to determine the electromagnetic environment, such that tests do not have to be carried out. e.g. the manufacturer can just state that his equipment must only be used in an isolated environment.
- (b) By compiling a 'Technical Construction File' which describes the equipment and the procedures used to ensure conformity. It should also include a technical report or certificate from a competent notified body.

Manufacturers of radio communications equipment must comply with the EMC Directive by obtaining a EC type-examination certificate from an authorised notified body.

Compliance with 'harmonised standards' may not be sufficient to specify and select equipment to meet BP's requirements and it will be necessary to define equipment and systems in accordance with the details given in Sections 2.1 to 2.4 of this Recommended Practice.

[EN 60555 \(BS 5046\)](#) and [EN 55022 \(BS 6527\)](#) are considered to be 'harmonised standards'. However, depending on the type of equipment/system and the country in which the equipment is being used, other standards detailed in Appendix B and listed as follows should be consulted:-

#### UK

|                                           |                                      |
|-------------------------------------------|--------------------------------------|
| <a href="#">BS 613</a>                    | <a href="#">BS 5394 (CISPR 15)</a>   |
| <a href="#">BS 727 (CISPR 16)</a>         | <a href="#">BS 5406 (IEC 555)</a>    |
| <a href="#">BS 800 (CISPR 14)</a>         | <a href="#">BS 5602 (CISPR 18)</a>   |
| <a href="#">BS 833 (CISPR 12)</a>         | <a href="#">BS 5783</a>              |
| <a href="#">BS 905 (CISPR 13&amp; 20)</a> | <a href="#">BS 6201 (IEC 384-14)</a> |
| <a href="#">BS 1597</a>                   | <a href="#">BS 6299 (CISPR 17)</a>   |
| <a href="#">BS 2316</a>                   | <a href="#">BS 6345 (CISPR 15)</a>   |
| <a href="#">BS 4727</a>                   | <a href="#">BS 6651</a>              |
| <a href="#">BS 4809 (CISPR 11)</a>        | <a href="#">PD 6485 (CISPR 9)</a>    |
| <a href="#">BS 5049 (CISPR 18)</a>        | <a href="#">3G 100</a>               |
| <a href="#">BS 5260</a>                   |                                      |

## Germany

Legal regulations for interference control are enforced by the Fernmeldetechnisches Zentralamt (FTZ) which is the Central Telecommunications Office of West German Ministry of Posts and Telecommunications. The standards are developed by the Association of German Electrical Engineers in co-ordination with the German Institute for Standardisation (DIN). Each standard has a similar VDE and DIN number; the VDE designation only is listed below. When importing equipment into West Germany, VDE/DIN approval must be obtained; the one which is of major importance is [VDE 0871](#)

[VDE 0565](#)

[VDE 0871](#)

[VDE 0873](#)

[VDE 087](#)

[VDE 0874](#)

[VDE 0875](#)

[VDE 0876](#)

## USA

FCC, [Docket 20780](#) Part 15 sub-part J. (The FCC is a US Government Agency responsible for communication allocation and control. [Docket 20780](#) contains standards regarding electromagnetic compatibility; in particular Part 15, sub-part J, which relates to radiated and conducted emissions from digital equipment.)

[MIL-STD-461C](#)

[MIL-STD-462](#)

[MIL-STD-463](#)

[MIL-STD-469](#)

[ANSI C16](#)

[ANSI C63](#)

[ANSI C68](#)

[ANSI C95](#)

## International

[IEC 50](#)

[IEC 96](#)

[IEC 106](#)

[IEC 478](#)

[IEC 533](#)

[IEC 555](#)

[IEC 654](#)

[IEC 801](#)

[CISPR 10](#)

[CISPR 11](#)

[CISPR 12](#)

[CISPR 13](#)

[CISPR 14](#)

[CISPR 15](#)

[CISPR 16](#)

[CISPR 17](#)

[CISPR 18](#)

[CISPR 19](#)

[CISPR 20](#)

[CISPR 21](#)

[CISPR 22](#)

[CISPR 23](#)

[CISPR 24](#)

## 3. INSTALLATION OF EQUIPMENT

### 3.1 Installation Design

Electromagnetic Compatibility (EMC) should be given serious consideration in the early planning stages of an installation to ensure that equipment accommodation, power supplies and cable routes can be economically shared without compromising the operability or safety of the plant being controlled. By observing certain practices as outlined in this Recommended Practice it is possible to co-locate equipment, sub-systems and systems in the same electromagnetic environment so they

can share equipment rooms, common power supply systems and cable supports.

For each item of equipment or system the emission characteristics and levels of susceptibility should be stated and detailed in a control plan. Table 1 is provided as an installation design aid so that the various likely causes of emission and susceptibility from the individual items of equipment, sub-systems and systems can be evaluated. Table 1 should be completed for individual items of equipment or systems as applicable.

*The information obtained from Table 1 should be used to ensure that equipment, sub-systems and systems are only physically separated and supplied from independent power supply systems where necessary. Equipment, sub-system and system suppliers should be made aware of the requirement to limit EM emissions and increase EMI immunity in order that more economic use can be made of the environment where equipment and systems are to be installed.*

Equipment manufacturers and system suppliers shall demonstrate that the EMC requirements for the installation are given consideration during the system design. Manufacturers should be requested to state their reservations.

*Manufacturers should be advised that the most effective way to prevent EMI is by careful design i.e:-*

- (i) *Keep signal lines separate and run them at right angles to one another - when possible.*
- (ii) *Backplane wiring should be point-to-point and not cabled.*
- (iii) *Signal lines, if they must be loomed, should preferably be shielded or, at least, should be twisted pairs.*
- (iv) *Cables with very thick insulation which have a low dielectric constant (high voltage cable) will reduce coupling between conductors.*
- (v) *Sheet metal, wire screen and mesh, and the braid of co-axial cable make excellent electrostatic shields; a twisted pair is more susceptible to capacitive pick-up than co-axial cable but is better than a single lead. A magnetic shield can usually provide an electrostatic shield. However, the converse, only applies when there is a high permeability metal shield at low frequencies or a complete current path at high frequencies.*
- (vi) *Electrostatic shielding, such as that provided by the braid of a co-axial cable, reduces capacitive coupling by providing a conductor at ground potential between two signal lines.*
- (vii) *Local shielding and/or filtering should be provided where EMI sensitive equipment is installed in the same compartment as equipment which is likely to produce EMI.*

Cables likely to be affected by interference should be separated in accordance with Section 3.4 and, where necessary, protected by screening (see Section 3.5) and/or filtering (see Section 3.3.1). Such cables should be identified in accordance with Section 3.4.

## **3.2 Equipment Location and Screening**

### **3.2.1 Separation**

#### **(a) Equipment Location**

Where it is not possible to adequately limit the level of electromagnetic emissions or increase the immunity of installed equipment the most effective means of reducing the effects of radiated emission is to locate the installed equipment away from possible sources of emission. The field strength of radiated emissions is inversely proportional to the distance from the source and a doubling of the separation distance therefore quarters the field strength at the equipment.

*Ideally, instrumentation and control equipment should be sited in a specifically provided room in order to safeguard against possible EMI. However, miniaturisation of equipment and systems makes the possibility of co-locating equipment in common areas more likely than before and the provision of separate rooms adds unnecessary costs. It is therefore more beneficial to limit the effects of EMI by increasing equipment immunity or by reducing the level of the emissions at the source. Where this is not possible then a room or rooms should be designated that are as far away as possible from other electrical/electronic equipment and other major sources of interference.*

*The room should be constructed as a continuous conducting envelope with the openings reduced to a minimum. Only cables, pipes, etc. essential to the equipment should penetrate the bulkheads. All such metallic pipes, screened cable, etc. should be bonded to the bulkheads, and unscreened cables should be fitted with suppressers. If a room cannot be provided specifically and exclusively for equipment then the space provided should be as far away as possible from all sources of interference.*

#### **(b) Cable Separation**

Cables run internally within equipment cabinets which are connected to EMI emission free equipment are not necessarily free from residual radio frequency currents. These cables should therefore be either screened or separated by distance (as identified in section 3.4) from cables connected to equipment that is known to be sensitive to interference (as identified by the control plan). Cables of known sensitive circuits should be separated from adjacent power cables even if the power circuit has been filtered. However, where equipment has adequate EM

immunity, cables should be grouped together whenever possible. See Sections 3.4 in this Recommended Practice for guidance on cable grouping and separation distances.

### 3.2.2 Equipment Cabinet Screening

*Guidance on equipment cabinet construction is contained in the IEE's [Recommendations for Electrical and Electronic Equipment in Mobile and Fixed Offshore Installations, Appendix D Section D4\(4\) and IEC 1000 Part 5 Section 2.](#)*

*Some of this information is repeated here for clarity together with additional information to aid explanation.*

#### (a) Radiated Interference

Radiated interference should be reduced through the use of an earthed, screened enclosure. The screening can be provided by a combination of cable screening and metal enclosures, however, it must be continuous. Any gap in the screening will allow radiation to enter the equipment. To prevent this all screening must be continuous and effectively bonded. Entry glands must be manufactured from conductive materials and must provide an effective seal. All cable screens must be continuous and bonded to the enclosure (see Section 4.4.2). The means used to bond and earth the screening must be designed to have a low impedance at the frequencies of the transmissions, and corrosion products must not be allowed to increase the resistance of metal to metal joints. (See Section 4 on Earthing and Bonding).

*Screening is the only practical method of suppressing radiated disturbances and should be provided to prevent radiation from potential sources of interference, as well as to protect susceptible equipment. Screening reflects or absorbs the electromagnetic waves from the source, with the absorbed portion attenuated as it passes through the metal screens or, alternatively, the interfering sources induce currents in the screening barrier which oppose the external field.*

*Screens of high conductivity such as copper, aluminium or silver offer good screening against high impedance fields but are not effective against low frequency magnetic fields. At audio frequencies, screening against magnetic fields is obtained by using high permeability material.*

*Screens designed to contain disturbances are dependent primarily on their attenuation of all radiated energy entering the walls of the screen since reflection will have little or no effect. It is this absorption loss through the walls that reduces the magnitude of the field, therefore, attenuation is a function of screens thickness. In the far field materials with high conductivity and low permeability are more effective.*

*In general the effectiveness of a screen is proportional to its conductivity, thickness and permeability. At low frequencies it is preferable to use a ferrous material in order to obtain the advantage of permeability but at high frequencies conductivity is of greater importance, and copper or aluminium should be used.*

(b) Equipment Cabinets are required to exclude or confine EMI, and the construction should meet the following requirements:-

(i) The d.c. resistance between any two points on the cabinet casing or between the cabinet and main structure, should be not greater than 0.01 ohms. Non-conducting housings, e.g. plastic are required to be coated by a continuous conducting layer, e.g. metal foil, preferably during manufacture.

See Section 4 for further guidance and explanation.

(ii) All metallic conduits, pipes, cable screens, etc., should be bonded at their point of entry to the cabinet, preferably by a bonding gland giving circumferential contact. If a bonding strap has to be used, it is essential for it to be of the absolute shortest length and connected to the cabinet at the point of entry.

(iii) Where the performance of a pipe system, e.g. water pipes with thermal lagging, could be impaired by the presence of an electrical bond, other means such as the enclosure of the pipe in a screened trunking and RF sealed at the points of exit and entry, should be considered.

(iv) All equipment cabinet doors, windows (gauze covered or otherwise opaque to RF), hatches, inspection plates, etc., should be RF sealed by a continuous bond around their perimeter.

*A continuous bond is one where good electrical contact is achieved throughout its length. Such a bond may be achieved by the use of copper or bronze 'weatherstrip'.*

(v) All power supply cables entering and terminating in a screened compartment which are not bonded at the point of entry, should pass through an appropriate EMI filter at that point. See Section 3.3.

### 3.3 Power Supplies and Filters

#### 3.3.1 Filter Units and Components

*For guidance on the installation of filters see [IEE document on Recommendations for Electrical and Electronic Equipment of Mobile and Fixed Offshore Installations Appendix D Section D4 \(7\)](#).*

Electrical and electronic equipment are liable to introduce disturbances into other systems that share the same power supply system. Such equipment, however, should not adversely affect the system characteristics, the supply voltage, or the performance of any other equipment connected to the power supply system. Provision should be made to limit the disturbing effects and to assist in attaining electromagnetic compatibility.

*EMI may be reduced on equipment power supply terminals by the use of one or all of the following:*

- (i) Capacitors connected between the line terminals of equipment to provide a low impedance path for radio frequency interference currents, and at the same time to maintain a high impedance path at power frequencies. The asymmetrical current may similarly be directed by means of capacitors between line and earth. The suppression performance of any capacitor will depend very much on the method of installation. In particular it is important that the lengths of the leads are kept to a minimum.*
- (ii) Inductors provide a series impedance to symmetrical and asymmetrical radio frequency interference currents. They are particularly useful on direct current power supplies.*
- (iii) Combinations of capacitors and inductors*
- (iv) Isolating transformers: consideration should be given to using an isolating iron-cored transformer with an earthed metallic screen between windings.*

*Note: The suppression of EMI, produced from single-phase equipment, by the techniques listed above, generally presents no difficulties, but the suppression of three-phase systems that use rectifiers, thyristors or similar switching devices may cause large unbalanced earth currents to flow, thereby producing interference at low frequencies. All thyristor and similar control devices require special consideration from the interference aspect and it is essential that any equipment containing thyristors is selected and designed with this in view.*

All components and filter units used for electromagnetic interference suppression shall comply with [BS 613](#).

- (a) The following aspects should be considered when specifying and selecting filters*
  - (i) Filter manufacturers data usually refers to performance when tested in accordance with [MIL-STD-220](#) - which means the data is*

valid only if the filter is connected between 50 ohm source and load impedance.

- (ii) *Mismatched filters can cause resonant voltage peaks in the region of the design cut off frequency which may lead to a significant increase in the noise voltage over a narrow frequency band. This can be overcome by the inclusion of additional resistance in the series arm of the filter although this will also change the slope of the attenuation curve above cut-off.*
  - (iii) *EMI filters normally shunt the unwanted noise signals directly to the 'earthed' structure. The RF impedance between structure and signal return (OV) then becomes a significant factor in the overall circuit response.*
  - (iv) *Line filters do not work efficiently in the presence of a significant amount of common mode noise. Therefore, the inclusion of an overall cable loom screen over individually unscreened filtered wires can effectively nullify the filters and may even increase the common mode interference seen by the rest of the system.*
  - (v) *The choice of the 'best' filter for a particular application entails detailed analysis of the source, load and OV-structure impedances of every circuit associated with the cable loom to be filtered.*
  - (vi) *The filter compartment must be carefully designed otherwise the filter effectiveness will be compromised by interwiring crosstalk.*
- (b) *Attention should be paid to the following when installing filter units and suppression components:-*
- (i) *The suppression components should be housed in a metal container and it is essential that a good metal-to-metal contact is made between the container and the frame of the equipment being suppressed.*
  - (ii) *It is essential that the case of a filter is adequately earthed, otherwise the filter may be ineffective, and may even become the source of interference.*
  - (iii) *The suppression unit should be situated as near as possible to the source of interference and, if it is sited adjacent to the equipment, the suppression unit should be bonded to the equipment by the shortest possible bonding strap.*
  - (iv) *All earthing and bonding connections should be clean and free from paint, grease and rust, and contact between dissimilar metals should be avoided.*
  - (v) *Suppressed and unsuppressed cables should be well separated. Connections made inside the suppression unit should be short in order to avoid coupling loops.*

### 3.3.2

### Measures Relating to Electrical Machinery and Appliances



Radio frequency terminal voltages of electrical machines and appliances should comply with the requirements of [BS 1597](#) and [EN 55022 \(BS 6527\)](#).

*Measures for the suppression of internal combustion engines employing electric ignition are given in [CISPR 12 \(BS 833\)](#) and although [CISPR 12](#) does not cover the frequency range of [BS 1597](#) and [EN 55022 \(BS 6527\)](#), the guidance may be of assistance.*

*On power systems where convertors of large rating are incorporated, it may be feasible to suppress harmonics generated by the convertors at source. In order to attenuate these effects on sensitive equipment, consideration should be given to motor generator sets placed in the distribution system to supply such equipment. The motor generator sets should be sited in a separate screened compartment, care being taken to ensure adequate separation of input and output cabling.*

### 3.4 Separation of Cables

Where it is not possible to electromagnetically screen cables in accordance with Section 3.5 below, cables shall be separated in accordance with the following guidelines:

*The following information assumes that all cables are armoured for protection purposes and that the reason for separation is purely to reduce the effects of electromagnetic coupling. The IEE Wiring Regulations (i.e. [BS 7671](#) and the IEE recommendations for offshore installations) should be referred to in order to determine alternate methods of protection when cable separation is not possible and cables are not armoured, e.g. by using earthed metallic barriers.*

*Guidance on the separation of cables to reduce mutual coupling is contained in the [IEE Recommendations for Electrical and Electronic Equipment for Mobile and Fixed Offshore Platforms](#), Appendix D Section D4(2). However, the relevant information has been extracted in the details that follow together with additional information and explanation.*

- (a) Mains cables (not screened), carrying up to 250V should not be grouped with sensitive cables.

*Cables carrying low level signals which are adjacent to power cables must be screened. See Section 3.5.*

*For mains cable separations using 440V and above refer to BP Group RP 30-1 para 4.13.4.*

- (b) Small pulse cables, digital-data cables and databus cables (not screened), should be separated from all other cables by at least 50 mm and from fluorescent tubes by at least 75 mm. Preferably, these cables should be run separately from each other also by at least 50 mm.

*It is often not practical to maintain the separation distances specified above over an entire cable length and it is preferable if cables are screened. See Section 3.5 for further guidance on cable screening.*

- (c) Cables carrying high level impulses are liable to cause interference over a wide frequency band to adjacent sensitive cables, and such cables should be separated from other sensitive cables. Special precautions are necessary in the cables connected to digital computers. See Section 3.4.
- (d) Crossovers, where made at right angles, may have the separation distance at the crossover reduced by 75% of the foregoing values.

In order to ensure that both initial installations and retrofit cabling achieves an acceptable EMC standard, such cables should be permanently identified after installation by identification at the ends and, as far as is practicable, when entering or leaving compartments.

### 3.5

#### Screening of Cables and Connectors

*Guidance on the screening of cables and connectors is contained in the IEE Recommendations for Electrical and Electronic Equipment for Mobile and Fixed Offshore Platforms, Appendix D Section D4(5) and IEC 1000 Part 5 Section 2. Some of this information is repeated in the following details. However, further information and explanation is added. Details of the earthing of screened cables is contained in Section 4.4.2.*

Where it is not possible to obtain adequate separation between cables in accordance with Section 3.4 above, screened cables shall be used to provide an efficient means of confining radio frequency energy to the conductor system, and to also protect the conductors from the effects of external fields.

*In selecting screened cables for a particular duty the following conditions should be observed:-*

- (a) *The 'lead' and 'return' conductors of all circuits employing single-core cables should be fixed as close to one another as possible.*
- (b) *A single isolated conductor with a screen earth at a single point is protected only against electric fields. The screen has no effect on the magnetic component.*
- (c) *Wherever possible the 'lead' and 'return' conductors of a circuit should use twisted pairs so that the two ('lead and return') conductors are as close together as possible. If conductors are surrounded by an overall screen earthed at a single point, protection from electric fields is achieved and the effects of magnetic fields are minimised by the balancing of closely coupled conductors.*

- (d) *All coaxial cables should be terminated with their characteristic impedance and with the screen as the return conductor to provide protection from both electrostatic and magnetic fields.*
- (e) *Cables carrying low level signals from transducers, thermocouples, etc., that are adjacent to unscreened power cables and are longer than three metres should be treated as exceptionally sensitive circuits and double screening may be required, trunking is not satisfactory. Runs should be kept as short as practicable. In the case of sensing devices with output less than 10 V consideration should be given to the use of preamplifiers as close to the sensing device as possible.*
- (f) *Screwed or clip-on connectors should be used with discretion, since the inefficient screening of the connector assembly can nullify the efforts spent in screening interconnecting cables.*
- (g) *Cables other than those feeding services in a screened radio room should preferably not be installed in a radio room. Cables which have to pass through a screened radio room should be screened throughout their length within the room, which should be bonded to the screening of the room at the points of entry and exit.*
- (h) *In practice, imperfections in the conducting screen and the effects of unwanted earths could modify the efficiency of screening techniques.*
- (i) *Screening provided by metallic trunking is doubtful and is only effective if the number of joints is kept to a minimum.*

#### **4. EARTHING AND BONDING**

Full details of the requirements for earthing and bonding of instrumentation and control systems are contained in BP Group [RP 30-1](#) Section 5 and BP Group [RP 12-16](#). The following details provide additional recommendations and guidance with respect to reducing the occurrence and effects of EMI caused by inadequate earthing and bonding and are supplementary to the information contained in BP Group [RP 30-1](#) and BP Group [RP 12-16](#).

Further guidance on earthing and bonding is contained in the [IEE Recommendations for Electrical and Electronic Equipment for Mobile and Fixed Offshore Platforms](#) in Part 2 Section 2 and Appendix D Section D4(6) and [IEC 1000](#) Part 5 Section 1.. Some of this information is repeated here for clarity. However, other information and explanation is added.



## 4.1 Use of Earthing and Bonding

### 4.1.1 'Safety' Earth

It is generally necessary to earth electrical equipment for the purpose of reducing radio interference. With few exceptions (provided by wiring regulations) all accessible metal parts of an electrical installation will be earthed for reasons of electrical safety. In addition, certain suppression devices, screening, metal trunking or conduit should be earthed. All earthing connections should be protected from corrosion and accidental damage. Connections to cable braids are particularly liable to damage or deterioration. However, it should be noted that a satisfactory 'safety' earth will not necessarily provide a satisfactory 'signal' earth.

*If the removal of a 'safety' earth reduces interference the equipment should not be left in this interference-reduced but unsafe condition and the following causes should be investigated:-*

- (a) *Because of circulating currents a voltage may exist across a discontinuity in a screening cabinet or compartment. This voltage may be sufficient to cause current to flow through another compartment to which it is connected (thus causing interference), the conducting path being via the screens of the interconnecting cables, the equipment cabinet or compartment walls and earth, i.e. the structure. Removal of an earth connection may effectively open-circuit this conducting path and reduce interference.*
- (b) *The earth connection of a receiver plus the self-capacitance of its case to earth may form a parallel resonant circuit. Removal of the earth connection could increase signal and reduce interference because the self-capacitance may provide a lower impedance to earth. Additionally, there may be an external noise signal injected in series with the earth lead. Under these circumstances removal of the earth connection will reduce interference. This effect can occur independently or in association with the resonant effect.*

### 4.1.2 Bonding to Reduce EMI

Bonding is the provision of a reliable low impedance electrical connection between metal parts. It is applied where normal electrical connections may be unreliable.

*Electrical bonding is a fixed union between two metallic surfaces, resulting in a low-impedance connection. It should be made so that there is no disparity between parts of a structure, and that RF currents are not likely to flow more in one part of the structure than in another.*

*All electronic equipment metal work should have a continuous low impedance path to earth. If the inductance of a bonding strap exceeds 0.025 mH, the effectiveness of the bond is reduced. A good bond has its mating surfaces clean of any anodic film, grease, oil, paint, etc.*

*Bonds should be of sufficient cross-sectional area to carry any current densities that may develop and should be held in place with a nut and bolt.*

*Bonding by means of jumpers is not considered satisfactory unless no other practical method can be utilised.*

*Stranded bonding braid should never be used for bonding when RF currents are involved. A significant danger of interstrand sparking exists.*

*Bonding is frequently employed to provide a low impedance return path for the noise currents to the frame or housing of the equipment producing them, and joints between metal surfaces in the paths of the currents should be efficiently bonded. Bonding may be carried out by directly bolting together component parts or by means of bonding strips. A good bond will be obtained, for example, when the casing or housing of a suppresser unit is bolted directly to the casing or frame of the equipment to be suppressed or to the metal structure adjacent to the equipment. The abutting surfaces should be cleaned of all paint or other protective covering down to the bare metal. The bond so made should then be covered with a protective coating to prevent corrosion. The method of attachment should ensure that abutting surfaces remain securely bonded.*

No bond should have a resistance exceeding 0.01 ohms

*Bonding to a metal structure or an immersed metal plate is also referred to as 'earthing'.*

*Bonding at bulkheads and joints must be of a high quality and the use of inspection hatches and other apertures should be avoided if possible.*

## 4.2

### General Requirements for Equipment Earthing

Each unit of electrical equipment should have its own individual earth taken to the main earthing terminal or offshore installation structure. In the case of an offshore structure the earthing bond may be achieved by direct metallic contact with the structure and equipment mounted in a manner that gives sufficient contact with the general mass of the offshore installation structure does not normally require additional earth bonds. However, all earth connections and bonds shall meet the requirements of the [IEE Wiring Regulations](#) and the [IEE Regulations for the Electrical and Electronic Equipment of Mobile and Fixed Offshore Installations](#). Requirements for earthing and bonding of equipment in hazardous areas shall comply with [BS 5345](#).

*Metal frames or enclosures of apparatus mounted in direct contact with the steel structure or hull of an offshore installation will normally exhibit a low resistance to the main earthing terminal and no supplementary bonding should be necessary if the supplies to the apparatus and their protection arrangements are in accordance with Table 2.1 of the [IEE regulations for the Electrical and Electronic Equipment of Mobile and Fixed Offshore Installations](#).*

The use of busbar earthing arrangements should be avoided.

The earthing strap should be solid, as short as is practicable and of low inductance. It should be assembled using washers of diameter equal to the width of the strap using suitable lock nuts and the whole assembly should provide a d.c. resistance of less than 0.01 ohms. After a d.c. resistance check, the whole assembly should be painted or otherwise preserved against corrosion. The use of a conductive paste smeared on all contact faces will help to ensure a lasting low resistance contact.

The earth strap should not be attached to the equipment using any of the bolts, or other parts, of shock or anti-vibration mountings.

*Return paths are a means for coupling voltage transitions from one circuit into others. A chassis, frame or bus is not a zero impedance path. If high current flows the voltage drop can reach levels high enough to affect logic circuits. A more common problem resulting from the use of a frame as a common earth occurs when the return-path voltage drop is conducted into the input circuit of an amplifier.*

*When using frame earths, extra care must be taken to ensure that impedances will not increase through the development of oxide films or corrosion in bolt-joined members. Joints should be welded or soldered if possible. Earthing points must be designed into the frame taking into consideration all of the above factors.*

### 4.3 Choice of Bonding Materials

Where the metallic composition of the equipment differs from that of the structure, care should be taken in the selection of the bonding strap to minimise possible ill effects of contact potentials.

*Bonds should be made between the same metal types. When different metals are bonded they should be close together in the electro-chemical series to prevent corrosion. If two metals widely spaced in the series are bonded, such as aluminium and copper, there will be a continuous ion stream with an accompanying decomposition of the aluminium as it gradually goes into solution. If two such metals must necessarily be bonded, the bond should be carefully maintained and easily accessible for replacement. Corrosion at one or both interfaces can render the bond ineffective in a short time. The bonding strap should ideally be compatible with both metals.*

*Bonding strap materials which are considered suitable are copper or aluminium (see table below). In the case of the latter, it is essential to ensure that the contact surfaces are oxide free, and that they are coated with a thin layer of conducting paste before assembly to seal the joint and provide a large contact area.*

| <b>Equipment or Structure</b> | <b>Aluminium Strap</b> | <b>Tinner Copper Strap</b> |
|-------------------------------|------------------------|----------------------------|
| Stainless Steel               | Zinc plated washer     | Direct                     |
| Aluminium                     | Direct                 | Aluminium washer           |
| Steel                         | Direct                 | Direct                     |
| Copper                        | Zinc plated washer     | Direct                     |

*Conductive metal finishes on the equipment cabinet or structure such as ALACHROME, IRIDITE, TRIDURAL, and protective coatings such as silver plate are satisfactory to achieve effective bonding, but most other finishes are non-conducting and destroy the low impedance path.*

## **4.4 Cable Earthing**

### **4.4.1 Earthing of Screened Cables**

The efficiency of a cable screen is critically dependent upon the method of earthing. It is difficult to generalise on the principles of the earthing of cable screens, but as a guide it can be assumed that cables carrying currents at frequencies less than 10 MHz should be earthed only at the amplifier end, whereas cables carrying current frequencies greater than 10 MHz should be earthed in as many places as possible. Cables carrying currents at frequencies between these ranges may require single or double point earthing; usually cables shorter than one-eighth of the radio frequency wavelength need single point earthing and longer cables need double point earthing. The screening of all cables should be continuous from end to end.

*The precise earthing requirements for screened cables cannot be defined for all cases in advance and some site testing will sometimes be necessary to achieve the best arrangement. Generally the maximum distance between earthing points should not exceed 1/8th of the wavelength of the maximum susceptible operating frequency. If the screen is grounded at one end only it could behave as a radio frequency receiving antenna and may act as an effective pick-up for any locally radiated fields.*

The following guidelines should be followed:-

- (a) Power cables (a.c. and d.c.) - Earthed at both ends or as near to the ends as possible. Intermediate earths may be necessary and may already be unavoidably present.
- (b) Analogue signal cables - Earthed at one end.
- (c) Digital signal cables - Earthed at one end if carrying less than 10 MHz.
- (d) Radio frequency cables - Where the cable is less than 1/8th wavelength long at the highest frequency of the interference spectrum, it shall be earthed at one end only. For longer lengths the cable should be earthed at both ends and, if necessary, at frequent regular intervals, 1/8th wavelengths, along its length.

*A screen around a wire which is grounded at one point does not reduce the induced EMF unless the frequency is high enough (say 50 kHz) for eddy currents in the screen to act as a cancelling influence.*

*Joining the screen to OV (not Earth) at both ends gives some protection against inductive pick-up. Better immunity is provided by a twisted pair in which the signal line is twisted with another line joined to OV at both ends, thereby subjecting both wires to the same field. This, however, will not be the same when screened or coaxial cable is used. A twisted pair is less effective than a screened cable against electric field interference. An ideal solution is to use a screened twisted pair with one line joined to OV at both ends and the screen joined to Earth at one end only. Whichever method is chosen, the practice of connecting both ends of the screen to OV must be used with caution.*

#### 4.4.2 Earthing of Cable Armour and Conduit.

In the absence of specific instructions to the contrary, metallic conduit and metallic armoured sheaths of cables (not part of a screen) should be earthed and bonded to any adjacent cable sheaths or conduit at the ends and also at as many intermediate points as practicable, such points being well distributed and readily accessible. The metal saddles, clips or other devices which hold metal sheathed cables in place should be a good fit, to prevent movement of the cables relative to one another or to the clip even under heavy vibration.

*If the armoured sheath or conduit is grounded at one end only it could behave as a radio receiving antenna and may act as an effective pick-up for any locally radiated fields.*

All cabling which enters a structure from an area that is within 10 metres from a radar antenna or within 10 metres of a high power MF/HF radio transmitting antenna (see Table 3), should be screened or run in a metal conduit. The screen or conduit should be earthed at the point of entry from the open area. Bonding joints should be watertight and protected from corrosion.

The metallic armours of flexible power cables should be earthed close to the point where they are connected to the supply and bonded to the metalwork of the appliance to which they are connected.

#### 4.4.3 Earthing of Spare Pairs

Where spare pairs exist in multi-cable runs or within multicore cables they should normally be isolated and either taped back or adequately terminated at each end. Alternatively, it may be possible to achieve a better EMC environment by connecting them in parallel with pairs already in use. Earthing of spare pairs at one or both ends is not normally advisable or necessary but may be appropriate in particular cases where there is a high risk of contact with 'working' circuits. In these circumstances other more appropriate insulation/separation protection should be considered.

*On some installations it has been the practice to terminate all the unused spare pairs and cores that exist in a multi-cable run so they can be used at a later date. This practice is acceptable from an EMC point of view and does not cause any additional EMC hazard. However, the earthing of spare pairs and cores could cause an unwanted source of electromagnetic interference by acting as an unintentional receive antenna and it is preferable if spare pairs and cores in a multipair/multicore cable are not earthed. Where the spare pairs and spare cores are contained within a cable that is used for intrinsically safe circuits and these spare pairs and cores are terminated but not earthed then attention should be paid to the danger of electrostatic charging. In this case adequate insulation of the spare pairs and cores must be achieved so that separation from working intrinsically safe circuits is obtained. The aim of the insulation rules imposed for 'working' intrinsically safe circuits is to maintain separation from other circuits, and these rules are adequate to avoid the risk of electrostatic charging from spare pairs and spare cores that are terminated but not earthed. i.e. [BS 5345](#) recommends the mechanical and electrical characteristics for cables carrying intrinsically safe circuits and how they should be terminated, and these recommendations should be complied with.*

#### **4.5 Protection Against Lightning**

Full details concerning the requirements for the protection of structures against lightning are contained in [BS 6651](#) and BP Group [RP 12-16](#). Details of the requirements for the protection of instrumentation and control equipment against lightning are contained in BP Group [RP 30-1](#) Section 5.7.

*Reference should be made to Sections 2.3.5 and 2.3.9 of this Recommended Practice for the effects caused by lightning and the surge and pulse magnetic field immunity levels that are required for instrumentation and control equipment.*

### **5. MAINTENANCE AND OPERATION**

#### **5.1 Electrical Machinery and Power Supplies**

*Normally equipments of this nature are bought-out items and most of the interference suppression should have been carried out by the manufacturers. Typical sources of interference associated with electrical machines are:-*

- (a) Arcing at the brushes (with machines that make use of them).*
- (b) Capacitance and inductance of the field and armature coils form local resonant circuits as multiples of line and commutator frequencies.*
- (c) Discharges of electrostatic energy built up between moving parts. This is particularly true of high speed parts such as between the inner and outer races of ball bearings where the grease or oil film acts as a dielectric (a conductive oil or grease should reduce this effect).*
- (d) Poor concentricity between commutator and bearings causes brush bounce.*

- (e) Too little or too much brush tension.
- (f) Radiation of interference from air vents adjacent to commutator and from plastic covers of brush holders.

*Control of interference can be achieved mainly by filtering supplies. The fitting of fine metal mesh over air vents helps to reduce radiation.*

*Induction motors should be used whenever possible.*

Poor maintenance of electrical equipment is likely to result in an increase in radio interference. The brushes, sliprings, commutators and bearings of rotating machinery should be inspected for abnormal wear and the condition of contactors, plugs, socket outlets, fuse carriers and all terminal connections together with the insulation of all conductors should be maintained at a high standard. During routine maintenance, suppresser components should be visually examined to check that no mechanical damage has occurred and that there is no seepage of impregnant or filling material and that no corrosion has taken place at the bonding point.

If a suppresser or suppresser component is replaced, care should be taken to ensure that the length of the connector and the positions of the connecting wires are altered as little as possible.

Interference from electric machines with brushes normally decreases during a short running-in period of a few hours, during which the brushes 'bed in'. The level then remains fairly constant until the brushes are sufficiently worn to need replacement, when the level of interference may increase. When the brushes are renewed and bedded in, the normal level is usually restored.

## 5.2 Electrical Component Suppression

A luminous discharge lamp which is adequately suppressed in the normal way may cause interference towards the end of its useful life.

*When this occurs the lamp should be replaced but, if this is not immediately practicable, removing and reversing the lamp in its holder may abate the interference. Cleaning the lamp and holder contacts may also effect a temporary cure.*

If suppression equipment is disconnected to enable an insulation test to be carried out or for other purposes, care should be taken to see that it is reconnected as in the original installation.

### 5.3 Earthing, Bonding and Screening

When unusual difficulties are experienced with interference, earth bonds should be checked to ensure that their resistance has not risen above 0.01 ohms.

All covers should be kept in place and all cabinet doors should be kept closed to maintain equipment shielding. Covers should not be modified, a small hole in a cover will allow radiated interference to enter the enclosure.

### 5.4 Use of Handheld Portable Radios

Clear guidelines should be issued, covering the use of portable radio equipment in all plant areas. When drawing up these guidelines, the following should be considered:-

- (a) The criticality of the electronic equipment (i.e. control/monitoring only or safety/shutdown related).
- (b) The different situations under which the equipment may be operating (during on-line maintenance, for example, the panel doors may be open).

The use of hand held radios during on-line maintenance of a shutdown system panel needs to be strictly controlled. The guidelines should be based on available data, which might come from:-

- (a) equipment suppliers' recommendations.
- (b) system evaluation reports, by BP or others.
- (c) trials conducted during system acceptance testing (see Section 2.4.2).
- (d) experience with identical equipment already in use.
- (e) Where test results and/or operating experience are available, they may well permit less conservative guidelines to be produced, than would be the case using only the manufacturers' recommendations.

For equipment already operational and being maintained, records of the susceptibility of the equipment to handheld portable radios can be obtained as follows. The equipment should be taken off-line but be fully assembled and monitored with test signals applied. Hand held radios of the type to be used near the equipment should then be

operated at various locations around the equipment and the effect on the equipment noted. The tests should be carried out with all cabinet doors open and covers removed to simulate maintenance activities. The equipment should be retested when the equipment is installed to ensure that the final arrangement of the equipment is satisfactory. Care must be taken to avoid problems with existing equipment.

*See comments made in Section 2.4.2(b) regarding caution required with results from site testing.*

## **5.5 Isolation of EMC Problem Areas**

For guidance, the 'bulk current injection' and 'mode stirring' test methods defined in [UK Defence Standard 59-41](#) can be used to isolate any suspected EMC problems at the installation site.

*Reference should be made to the techniques described in the following papers for isolation of EMC fault locations:*

- (i) *Fowler EP 'Interference immunity testing requirements' Conference on EMC. IERE Conference Proceedings No. 39 April 1978*
- (ii) *Fowler EP 'Screening measurements in the time domain and their conversion to the frequency domain' Conference on EMC. IERE Conference Proceedings No. 60 September 1984*

## 1. Type of Equipment and/or System

|         |       |              |       |
|---------|-------|--------------|-------|
| Purpose | ..... | Manufacturer | ..... |
| Type No | ..... | Issue State  | ..... |
| Date    | ..... |              |       |

## 2. Electromagnetic Emission Characteristics

### 2.1 Power Supply Terminal Harmonics (ref: [EN 60555-2](#))

| Odd Harmonics  |                         | Even Harmonics |                         |
|----------------|-------------------------|----------------|-------------------------|
| Harmonic Order | Harmonic Voltage Ratios | Harmonic Order | Harmonic Voltage Ratios |
| 3              | .....                   | 2              |                         |
| 5              | .....                   | 4 to 40        |                         |
| 7              | .....                   |                |                         |
| 9 & 11         | .....                   |                |                         |
| 13             | .....                   |                |                         |
| 15 to 39       | .....                   |                |                         |

### 2.2 Power Supply Terminal Voltage Fluctuations (ref: [EN 60555-3](#))

| U/U | P st |
|-----|------|
|     |      |

### 2.3 Power Supply Terminal RF Interference Voltages (ref: [EN 55022](#))

| Frequency(s)<br>[MHz]                                                            | Maximum Level(s)<br>[microvolts or dB(V)] |
|----------------------------------------------------------------------------------|-------------------------------------------|
| 0.1 to 0.5                                                                       | .....                                     |
| 0.5 to 5.0                                                                       | .....                                     |
| 5.0 to 30.0                                                                      | .....                                     |
| Where possible a spectrum analysis of the interfering signal shall be presented. |                                           |

### 2.4 Radiated Interference Field Strengths (ref: [EN 55022](#))

| Frequency<br>[MHz] | Distance from Cabinet<br>[metres] | Maximum Field Strength<br>[dB (µV/m)] |
|--------------------|-----------------------------------|---------------------------------------|
| 0 to 27            | 10                                | .....                                 |
| 27 to 100          | 10                                | .....                                 |
| 100 to 500         | 3                                 | .....                                 |
| 500 to 3,000       | 1                                 | .....                                 |
| 3,000 to 10,000    | 1                                 | .....                                 |
| 30 to 10,000       | 5                                 | .....                                 |

TABLE 1

## ELECTROMAGNETIC COMPATIBILITY CONTROL PLAN DETAILS (Page 1 of 3)



### 3. Electromagnetic Susceptibility Characteristics - maximum levels sustainable without malfunction

#### 3.1 Electrostatic Discharge (ref: [IEC 801-2](#))

|                                          |       |
|------------------------------------------|-------|
| <b>Discharge Current Peak Value (kV)</b> | ..... |
|------------------------------------------|-------|

#### 3.2 Radiated Electromagnetic Energy (ref: [IEC 801-3](#))

| Frequency (MHz) | Sustainable Field Strength at 1 metre from the cabinet (V/m) |
|-----------------|--------------------------------------------------------------|
| 27 to 100       | .....                                                        |
| 100 to 500      | .....                                                        |
| 500 to 3,000    | .....                                                        |
| 3,000 to 10,000 | .....                                                        |

#### 3.3 Fast Transient/Bursts (ref: [IEC 801-4](#))

| On Power Supply Terminals (kV) | On Input/Output Signal, Data and Control Lines (kV) |
|--------------------------------|-----------------------------------------------------|
| .....                          | .....                                               |

#### 3.4 Surge (ref: [IEC 801-5](#))

| On Power Supply Terminals (kV) | On Input/Output Signal, Data and Control Lines (kV) |
|--------------------------------|-----------------------------------------------------|
| .....                          | .....                                               |

#### 3.5 Conducted Interference (ref: [IEC 801-6](#))

| Frequency (MHz) | Field Strength Level(s) Sustainable [Volts or dB(uV)] |
|-----------------|-------------------------------------------------------|
| 0.01 to .150    | .....                                                 |
| 0.150 to 26     | .....                                                 |
| 26 to 230       | .....                                                 |

#### 3.6 Harmonics (ref: [EN 61000-4-7](#))

| Harmonic Order | Maximum Voltage ratio |
|----------------|-----------------------|
| Odd harmonics  | .....                 |
| Even harmonics | .....                 |

#### 3.7 Power Frequency Magnetic Fields (ref: [IEC 1000 4-8](#))

|                                                  |       |
|--------------------------------------------------|-------|
| <b>Magnetic Field Strength Sustainable (A/m)</b> | ..... |
|--------------------------------------------------|-------|

#### 3.8 Pulse and Magnetic Fields (ref: [IEC 1000-4-9](#))

|                                                  |       |
|--------------------------------------------------|-------|
| <b>Magnetic Field Strength Sustainable (A/m)</b> | ..... |
|--------------------------------------------------|-------|

**TABLE 1**

## ELECTROMAGNETIC COMPATIBILITY CONTROL PLAN DETAILS (Page 2 of 3)



**3.9 Damped Oscillatory Magnetic Fields (ref: IEC 1000-4-10)**

|                                                     |       |
|-----------------------------------------------------|-------|
| <b>Magnetic Field Strength Sustainable</b><br>(A/m) | ..... |
|-----------------------------------------------------|-------|

**3.10 Voltage Fluctuations (ref: IEC SC 77B / EN 50093)**

|                                |       |
|--------------------------------|-------|
| Maximum Positive Voltage Ratio | ..... |
| Maximum Negative Voltage Ratio | ..... |

**3.11 Oscillatory Waves (ref: IEC 1000-4-W)**

|                   |       |
|-------------------|-------|
| Waves Sustainable | ..... |
|-------------------|-------|

**3.12 Continuous Conducted Interference ( ref: IEC 1000-4-Z)**

|                          |       |
|--------------------------|-------|
| Sustainable Interference | ..... |
|--------------------------|-------|

**TABLE 1**

**ELECTROMAGNETIC COMPATIBILITY CONTROL PLAN DETAILS**  
**(Page 3 of 3)**



| EMC Disturbance Parameter                  | Recommended Specification Reference                                                                                                                                                                                                                                                       | Recommended Minimum Level of Emission or Susceptibility (see note below) |
|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| <b>Electromagnetic</b>                     | <b>Energy Emission</b>                                                                                                                                                                                                                                                                    |                                                                          |
| Harmonics                                  | <415v: <a href="#">IEC 1000</a> Part 3 Section 2 and <a href="#">IEC 555</a> Parts 1 & 2 ( <a href="#">EN 60555 &amp; BS 5406</a> )<br>or<br>>415v: <a href="#">IEC 1000</a> Part 3 Section 4, <a href="#">IEEE S519</a> and Engineering Council (UK) Recommendation <a href="#">G5/3</a> | Table I                                                                  |
| Voltage Fluctuations                       | <415v: <a href="#">IEC 1000</a> Part 3 Section 3 and <a href="#">IEC 555</a> Parts 1 & 3 ( <a href="#">EN 60555 &amp; BS 5406</a> )<br>or<br>>415v: <a href="#">IEC 1000</a> Part 3 Section 5 and Engineering Council (UK) Recommendation <a href="#">P28</a>                             | Clause 6.0                                                               |
| Mains Terminal Radio Interference Voltages | <a href="#">EN 55022 (BS 6527)</a> and <a href="#">VDE 0871</a>                                                                                                                                                                                                                           | Clause 4.0 Table II                                                      |
| Radiated Radio Interference Voltages       | <a href="#">EN 55022 (BS 6527)</a>                                                                                                                                                                                                                                                        | Clause 5.0 Table IV                                                      |
| <b>Electromagnetic</b>                     | <b>Energy Susceptibility</b>                                                                                                                                                                                                                                                              |                                                                          |
| General Requirements                       | <a href="#">IEC 1000</a> Part 4 Section 1 and <a href="#">IEC 801</a> Part 1 ( <a href="#">BS 6667</a> )                                                                                                                                                                                  | see below                                                                |
| Electrostatic Discharge                    | <a href="#">IEC 1000</a> Part 4 Section 2 and <a href="#">IEC 801</a> Part 2 ( <a href="#">BS 6667</a> )                                                                                                                                                                                  | Severity Level 3                                                         |
| Radiated Electromagnetic Energy            | <a href="#">IEC 1000</a> Part 4 Section 3 and <a href="#">IEC 801</a> Part 3 ( <a href="#">BS 6667</a> )                                                                                                                                                                                  | Severity Level 2                                                         |
| Electrical Fast Transients/Bursts          | <a href="#">IEC 1000</a> Part 4 Section 4 and <a href="#">IEC 801</a> Part 4                                                                                                                                                                                                              | Severity Level 2                                                         |
| Surge Immunity                             | <a href="#">IEC 1000</a> Part 4 Section 5 and <a href="#">IEC 801</a> part 5 (Draft)                                                                                                                                                                                                      | Severity Level 2                                                         |
| Conducted Radio Frequency Disturbances     | <a href="#">IEC 1000</a> Part 4 Section 6 and <a href="#">IEC 801</a> part 6 (Draft)                                                                                                                                                                                                      | Severity level 2                                                         |
| Harmonics                                  | <a href="#">IEC 1000</a> Part 4 Sections 7 and X and <a href="#">EN 61000-4-7</a>                                                                                                                                                                                                         | See text                                                                 |
| Power Frequency Magnetic Fields            | <a href="#">IEC 1000</a> Part 4 Section 8                                                                                                                                                                                                                                                 | Severity level 3                                                         |
| Pulse and Magnetic Fields                  | <a href="#">IEC 1000</a> Part 4 Section 9                                                                                                                                                                                                                                                 | Severity level 3                                                         |
| Damped Oscillatory Waves                   | <a href="#">IEC 1000</a> Part 4 Section 10                                                                                                                                                                                                                                                | Severity level 4                                                         |
| Voltage Fluctuations                       | <a href="#">IEC1000</a> Part 4 Sections 11 and Y and <a href="#">IEC SC7/B</a> (or pr <a href="#">EN 50093</a> )                                                                                                                                                                          | See text                                                                 |
| Oscillatory Waves                          | <a href="#">IEC 1000</a> Part 4 Section W                                                                                                                                                                                                                                                 | See text                                                                 |
| Continuous Conducted Interference          | <a href="#">IEC 1000</a> Part 4 Section Z                                                                                                                                                                                                                                                 | See text                                                                 |

Note: See text for guidance on severity levels

**TABLE 2**

**SUMMARY OF RECOMMENDED EMC SPECIFICATION REQUIREMENTS FOR INSTRUMENTATION AND CONTROL SYSTEMS**



| <b>Transmission Source</b>                                      | <b>Frequency Range<br/>[MHz]</b>        | <b>Radiated Power<br/>[Watts]</b>   | <b>Field Strength<br/>(see notes below)<br/>[Volts/Metre]</b> |
|-----------------------------------------------------------------|-----------------------------------------|-------------------------------------|---------------------------------------------------------------|
| LF/MF Non directional aircraft locator beacon                   | 0.285 to 0.525                          | 100                                 | 3 @ 10 m                                                      |
| MF/HF SSB                                                       | 1.6 to 30                               | 250                                 | 10 @ 10 m                                                     |
| VHF Aeronautical                                                | 118 to 136                              | 10                                  | 2 @ 10 m                                                      |
| VHF Marine                                                      | 154 to 174                              | 25                                  | 3.5 @ 10 m                                                    |
| VHF Marine handportable radio and<br>UHF handportable radio     | 154 to 174<br>and<br>450 to 470         | 1.5                                 | 2 @ 1 m<br>(7 max)                                            |
| VHF/UHF/Cellular vehicle radios                                 | 50 to 960 MHz                           | 25                                  | 3.5 @ 10 m                                                    |
| VHF/UHF handportable radios                                     | 50 to 470 MHz                           | 5                                   | 5 @ 1 m<br>(18 max)                                           |
| Analogue cellular TACS/ETACS (Cellnet/Vodafone) portable radios | 872 to 905<br>and<br>917 to 950         | 1.6 (Class 3) or<br>0.6 (Class 4)   | 2 @ 1 m<br>or<br>1.25 @ 1 m                                   |
| Digital cellular GSM900 (Cellnet/Vodafone) portable radios      | 905 to 915<br>and<br>950 to 960         | 5.0pk(Class 3) or<br>2.0pk(Class 4) | 5 @ 1 m<br>or<br>2.5 @ 1 m                                    |
| Digital cellular DCS1800 (One2One/Microtel) portable radios     | 1710 to 1880                            | 0.25                                | 1 @ 1 m<br>(3.5 max)                                          |
| CT2 private portable radios                                     | 864 to 868                              | 0.01                                | 0.2 @ 1 m<br>(0.6 max)                                        |
| DECT private portable radios                                    | 1880 to 1900                            | 0.2 5                               | 1 @ 1 m<br>(3.5 max)                                          |
| Radio satellite handportable radios                             | 1610 to 1626.5<br>and<br>2483.5 to 2500 | TBA                                 | TBA                                                           |
| Radar (Marine)                                                  | 3,000 or<br>10,000                      | 30,000 or<br>60,000                 | 45 @ 100 m<br>60 @ 100 m                                      |

#### Notes

1. Field strength values are shown at distances from the antenna. For MF/HF radio frequencies the field strength values are based on measurements made in the near field. Field strength values for VHF and above are based on calculations of the far field using conventional antennas. For handportable radios the method described in [IEC 801-3](#) Appendix A5 was used
2. For Radar the field strength values shown are peak values for very short duration pulses lasting from one to four microseconds.

**TABLE 3**  
**TYPICAL SOURCES OF RADIO FREQUENCY RADIATION**  
**(Page 1 of 1)**



## **DEFINITIONS AND ABBREVIATIONS**

### **Definitions**

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

|                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| conducted emission:                  | desired or undesired electromagnetic energy which is propagated along a conductor. Such an emission is called 'conducted interference' if it is undesired.                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| coupling:                            | coupling generally arises in two distinct ways although these may appear in combinations. The first is electric field (or 'electrostatic') pick-up. This is a simple capacitive effect and occurs when a signal line runs close to another. The second type is inductive interference or magnetic/ electromagnetic pick-up. Inductive pick-up is not restricted to interference from inductive items such as transformers, solenoids, etc., but occurs whenever a signal line runs close to a wire. The effect is to generate a series EMF in the line which does not depend on the impedance of the line to ground. |
| electromagnetic compatibility (EMC): | EMC is the ability of equipment to function satisfactorily in its electromagnetic environment without introducing intolerable disturbances to that environment or to other equipment.                                                                                                                                                                                                                                                                                                                                                                                                                                |
| electromagnetic interference (EMI):  | EMI electromagnetic disturbance which manifests itself in performance degradation, malfunction, or failure of electrical or electronic equipment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| emission:                            | electromagnetic energy propagated from a source by radiation or conduction.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| far field:                           | electromagnetic energy which is propagated through space, and eventually decays to zero, is referred to as the radiation field and is predominant in the 'far field'.                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| lighting surge:                      | an electrical discharge between cloud and earth.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |



|                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-----------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| near field:                                                     | energy which surrounds the electric conductor is referred to as the induction field and is predominant in the 'near field' .                                                                                                                                                                                                                                                                                                                     |
|                                                                 | induction fields may be either high or low impedance ( a high impedance is defined as a field whose impedance is higher than the impedance of the dielectric in which it exists). High impedance fields are associated with a voltage source with most of their energy contained in their electric component, while low impedance fields are associated with a current source and most of their energy is contained in their magnetic component. |
| radio-frequency interference (RFI)                              | RFI is often used interchangeably with EMI. EMI is a later definition which includes the entire electromagnetic spectrum, whereas RFI is more restricted to the radio-frequency band, generally considered to be between 10 kHz and 30 GHz.                                                                                                                                                                                                      |
| radio frequency transmission:                                   | radio frequency transmissions are used in communications and measuring systems and cover a wide range of frequencies. Sources of these transmissions are widespread and include transmissions from fixed and portable radios, microwave communications and radar. Spurious radiations occur from items of electrical equipment.                                                                                                                  |
| spurious radiation:                                             | Any undesired electromagnetic emission from an electrical device.                                                                                                                                                                                                                                                                                                                                                                                |
| static electricity discharge, or electrostatic discharge (ESD): | a transfer of electrostatic charge between bodies of different electrostatic potential.                                                                                                                                                                                                                                                                                                                                                          |
| susceptibility:                                                 | the characteristic of electronic equipment that results in unwanted response when subjected to electromagnetic energy.                                                                                                                                                                                                                                                                                                                           |
| the electromagnetic environment:                                | the electromagnetic environment is the combination of electromagnetic fields existing at a given location. These fields may have varying strengths and may cover a wide range of frequencies from power frequencies to radio microwave. The sources of these fields include                                                                                                                                                                      |



radio transmissions, radar, electrostatic discharge, lightning surges, transient noise, conducted interference and the operation of electrical equipment.

transient noise:

transient noise is caused by transient voltages imposed on power supplies due to switching of electrical equipment.

## Abbreviations

|       |                                                                                                                          |
|-------|--------------------------------------------------------------------------------------------------------------------------|
| ATU   | Antenna Tuning Unit                                                                                                      |
| CCITT | International Committee for Telephony and Telegraphy Recommendations                                                     |
| CISPR | Comité International Spécial des Perturbations Radio électriques (International Special Committee on Radio Interference) |
| db    | decibels                                                                                                                 |
| DTI   | Department of Trade and Industry                                                                                         |
| EFT/B | Electrical Fast Transient/Burst                                                                                          |
| EMI   | Electromagnetic Interference                                                                                             |
| EMC   | Electromagnetic Compatibility                                                                                            |
| ERA   | Electrical Research Authority                                                                                            |
| ESD   | Static electricity discharge or electrostatic discharge                                                                  |
| ETSI  | European Telecommunications Standards Institute                                                                          |
| HF    | High Frequency                                                                                                           |
| HV    | High Voltage                                                                                                             |
| MF    | Medium Frequency                                                                                                         |
| NDB   | Non Directional Beacon                                                                                                   |
| RFI   | Radio-frequency Interference                                                                                             |
| SSB   | Single Sideband                                                                                                          |
| UHF   | Ultra High Frequency                                                                                                     |
| VHF   | Very High Frequency                                                                                                      |



## 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 Electrotechnical Commission (IEC)

|                                             |                                                                                                                                                                                         |
|---------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>IEC 50</i>                               | <i>International electrotechnical vocabulary</i><br><i>Part 902: Radio frequency interference</i>                                                                                       |
| <i>IEC 77</i>                               | Electromagnetic environment and compatibility levels for low frequency conducted disturbances and signalling in public power systems.                                                   |
| <i>IEC 96</i>                               | <i>RF Cables</i><br><i>Part 0: Guide to the design of detailed specifications</i><br><i>Part 1: General requirements and measuring methods</i>                                          |
| <i>IEC 106</i>                              | <i>Recommended methods of measurement of radiated and conducted interference from receivers from amplitude modulation, frequency modulation and television broadcast transmissions.</i> |
| <i>IEC 478</i>                              | <i>Stabilised power supplies, d.c. output.</i><br><i>Part 3: Radio frequency interference tests</i>                                                                                     |
| <i>IEC 533</i>                              | <i>Electromagnetic compatibility of electrical and electronic installations in ships.</i>                                                                                               |
| <i>IEC 555</i>                              | The limitation of disturbances in electricity supply networks caused by domestic and similar appliances equipped with electronic devices.                                               |
| <i>IEC 654</i>                              | <i>Operating conditions for industrial process measurement and control equipment.</i>                                                                                                   |
| <i>IEC 801</i>                              | EMC requirements for industrial process control instrumentation.                                                                                                                        |
| <i>IEC 1000</i>                             | Basic EMC Standards                                                                                                                                                                     |
| Part 1: Introduction, terms and definitions |                                                                                                                                                                                         |
| IEC 1000-1-1                                | Applications and interpretation of fundamental terms and definitions (published 1992)                                                                                                   |
| Part 2: The EM Environment                  |                                                                                                                                                                                         |
| IEC 1000-2-1                                | Description of the EM environment for low frequency conducted disturbances and main signalling (published 1991)                                                                         |
| IEC 1000-2-2                                | Compatibility levels for low frequency conducted disturbances and mains signalling (published 1990)                                                                                     |

|         |              |                                                                                                                                                                                                                                       |
|---------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|         | IEC 1000-2-3 | Description of the environment radiated and non-network-frequency-related conducted phenomena (published 1992)                                                                                                                        |
|         | IEC 1000-2-4 | Compatibility levels in industrial plants for low frequency conducted disturbances (approved in voting 1993)                                                                                                                          |
|         | IEC 1000-2-5 | Classification of electromagnetic environments (committee draft for voting)                                                                                                                                                           |
|         | IEC 1000-2-X | Guide to the assessment of emission levels in the power supply of industrial plants as regards the low frequency conducted disturbances (approved in collated comments)                                                               |
| Part 3: | IEC 1000-2-Y | Description of low frequency Limits and Disturbance Levels                                                                                                                                                                            |
|         | IEC 1000-3-1 | General (not yet published)                                                                                                                                                                                                           |
|         | IEC 1000-3-2 | Disturbances caused by equipment connected to the public low-voltage supply system. Limits concerning harmonic currents for equipment having an input current up to 16A and including 16 A per phase (voting ends April 1994)         |
|         | IEC 1000-3-3 | Disturbances caused by equipment connected to the public low-voltage supply system. Limits concerning voltage fluctuations and flicker for equipment having an input current up to and including 16 A per phase (approved for voting) |
|         | IEC 1000-3-4 | Disturbances caused by equipment connected to the public low-voltage supply system. Recommendations for harmonic currents for equipment with rated current exceeding 16 A                                                             |
|         | IEC 1000-3-5 | Disturbances caused by equipment connected to the public low-voltage supply system. Recommendations for voltage fluctuations due to equipment rated current exceeding 16 A or subject to special consent (approved in voting)         |
|         | IEC 1000-3-X | Generic immunity standard for the residential, commercial and light industrial environments (committee draft for voting).                                                                                                             |
| Part 4: |              | Testing and Measuring Techniques                                                                                                                                                                                                      |
|         | IEC 1000-4-1 | Overview of immunity tests (published 1992)                                                                                                                                                                                           |
|         | IEC 1000-4-2 | ESD immunity test (approved in voting)                                                                                                                                                                                                |
|         | IEC 1000-4-3 | Immunity to radiated radio frequency electromagnetic fields (approved in voting). ENV 50140 is based on this document                                                                                                                 |
|         | IEC 1000-4-4 | Electrical fast transient/burst immunity test (approved in voting)                                                                                                                                                                    |

|               |                                                                                                                                                                                            |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IEC 1000-4-5  | Surges (approved in voting). prENV 50142 is based on this document                                                                                                                         |
| IEC 1000-4-6  | Conducted disturbances induced by rf fields immunity test (committee draft for voting). ENV 50141 is based on this document                                                                |
| IEC 1000-4-7  | General guide on harmonics and inter-harmonics measurements and instrumentation for power supply system and equipment connected thereto (published 1991), next edition approved in voting) |
| IEC 1000-4-8  | Power frequency magnetic field immunity test (published 1993).                                                                                                                             |
| IEC 1000-4-9  | Pulse and magnetic field immunity tests (published 1993)                                                                                                                                   |
| IEC 1000-4-10 | Damped oscillatory magnetic field immunity test (published 1993)                                                                                                                           |
| IEC 1000-4-11 | Immunity test for voltage dips, short interruptions and voltage variations in low-voltage power-supply networks (approved in voting)                                                       |
| IEC 1000-4-W  | Oscillatory waves immunity test (approved in voting)                                                                                                                                       |
| IEC 1000-4-X  | Harmonics, inter-harmonics to a.c. power port immunity test (committee draft for comments)                                                                                                 |
| IEC 1000-4-Y  | Immunity test methods for voltage fluctuations, unbalance and variations of the power frequency (approved in voting)                                                                       |
| IEC 1000-4-Z  | Continuous conducted disturbances from d.c. to 150 kHz (approved in voting)                                                                                                                |

#### Part 5: Installation and Mitigation Techniques

|              |                                                                                      |
|--------------|--------------------------------------------------------------------------------------|
| IEC 1000-5-1 | Earthing and cabling (committee draft for comments)                                  |
| IEC 1000-5-2 | Shielding, filtering, protective devices, protection against ESF (not yet published) |

#### ***International Special Committee on Radio Interference (CISPR)***

*CISPR 1 to 6 inclusive have been superseded by CISPR 16.*

*CISPR 10                      Organisation, rules and procedures of the CISPR.*

*CISPR 11                      Limits and methods of measurement of radio interference characteristics of industrial, scientific, and medical (ISM) radio frequency equipment (excluding surgical diathermy apparatus).*

*CISPR 12                      Limits and methods of measurement of radio interference characteristics of vehicle, motor boats, and spark-ignited engine-driven devices.*



|                 |                                                                                                                                                                     |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>CISPR 13</i> | <i>Limits and methods of measurement of radio interference characteristics of sound and television receivers.</i>                                                   |
| <i>CISPR 14</i> | <i>Limits and methods of measurement of radio interference characteristics of household electrical appliances, portable tools and similar electrical apparatus.</i> |
| <i>CISPR 15</i> | <i>Limits and methods of measurement of radio interference characteristics of fluorescent lamps and luminaries.</i>                                                 |
| <i>CISPR 16</i> | <i>CISPR specification for radio interference measuring apparatus and measurement methods.</i>                                                                      |
| <i>CISPR 17</i> | <i>Methods of measurement of the suppression characteristics of passive radio interference filters and suppression components..</i>                                 |
| <i>CISPR 18</i> | <i>Radio interference characteristics of overhead power lines and high-voltage equipment.<br/>Part 1: Description of phenomena. .</i>                               |
| <i>CISPR 19</i> | <i>Guidance on the use of the substitution method for measurements of radiation from microwave ovens for frequencies above 1 GHz.</i>                               |
| <i>CISPR 22</i> | <i>Limits and methods of measurement of radio interference characteristics of information technology equipment.</i>                                                 |
| <i>CISPR 23</i> | <i>Determination of limits for ISM equipment.</i>                                                                                                                   |
| <i>CISPR 24</i> | <i>Draft, Immunity of Information Technology equipment</i>                                                                                                          |

## **European Committee for Electrotechnical Standardisation (CENELEC)**

|                   |                                                                                                                                                                                                                       |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>EN 50081-2</i> | <i>Electromagnetic compatibility generic emission standard</i>                                                                                                                                                        |
| <i>EN 50082-2</i> | <i>Electromagnetic compatibility generic immunity standard</i>                                                                                                                                                        |
| <i>EN 50093</i>   | <i>Basic immunity standard for voltage dips, short interruptions and voltage variations</i>                                                                                                                           |
| <i>EN 55011</i>   | <i>Limits and methods of measurement of radio interference characteristics of industrial, scientific, and medical (ISM) radio frequency equipment (excluding surgical diathermy apparatus)<br/>-Based on CISPR 11</i> |
| <i>EN 55013</i>   | <i>Limits and methods of measurement of radio interference characteristics of sound and television receivers.<br/>- Based on CISPR 13 (BS 905 pt 1)</i>                                                               |
| <i>EN 55014</i>   | <i>Limits and methods of measurement of radio interference characteristics of household electrical appliances, portable tools and similar electrical apparatus.<br/>- Based on CISPR 14 (BS 800)</i>                  |
| <i>EN 55015</i>   | <i>Limits and methods of measurement of radio interference characteristics of fluorescent lamps and luminaries.<br/>- Based on CISPR 15 (BS 5394).</i>                                                                |



|                                     |                                                                                                                                                                                                                  |
|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">EN 55020</a>            | Measurement of the immunity of sound and television broadcast receivers and associated equipment in the frequency range 1.5 MHz to 30 MHz by the current-injection method.<br>- Based on CISPR 20 (BS 905 Pt 2). |
| <a href="#">EN 55022</a>            | Limits and methods of measurement of radio interference characteristics of information technology equipment.<br>- Based on CISPR 22 (BS 6527).                                                                   |
| <a href="#">pr EN 55024</a>         | Immunity of information technology equipment<br>- Based on IEC 801 and IEC 1000                                                                                                                                  |
| <a href="#">pr EN 50160</a>         | Voltage characteristics of electricity supplied by public distribution systems.                                                                                                                                  |
| <a href="#">EN 60555</a>            | The limitation of disturbances in electricity supply networks caused by domestic and similar appliances equipped with electronic devices.<br>- Based on IEC 555 (BS 5406)                                        |
| <a href="#">EN 60801-2</a>          | EMC requirements for industrial-process measurement and control instrumentation (IEC 801-2).                                                                                                                     |
| <a href="#">EN 61000-4-7</a>        | General guide on harmonics and interharmonic measurements and instrumentation                                                                                                                                    |
| <a href="#">Report No. R110-002</a> | Guide to generic EMC standards.                                                                                                                                                                                  |

#### **European Telecommunications Standards Institute (ETSI)**

[pr ETS RES 0900](#) *Generic EMC European Telecommunication Standard for Radio Equipment.*

#### **British Standards Institution**

|                          |                                                                                                                                                                                                                                   |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">BS 613:</a>  | Specification for components and filter units for electromagnetic interference suppression.                                                                                                                                       |
| <a href="#">BS 727</a>   | Specification for radio-interference measuring apparatus (CISPR 16).                                                                                                                                                              |
| <a href="#">BS 800</a>   | Specification for radio interference limits and measurements for household appliances, portable tools and other electrical equipment causing similar types of interference (CISPR 14).                                            |
| <a href="#">BS 833</a>   | Radio interference limits and measurements for the electrical ignition systems of internal combustion engines (CISPR 12).                                                                                                         |
| <a href="#">BS 905</a>   | Sound and television broadcast receivers and associated equipment: electromagnetic compatibility.<br>Part 1: Specification for limits of radio interference (CISPR 13)<br>Part 2: Specification for limits of immunity (CISPR 20) |
| <a href="#">BS 1597:</a> | Specification for limits and methods of measurement of electromagnetic interference generated by marine equipment and installations.                                                                                              |



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| <a href="#">BS 2316</a> | <i>Radio-frequency cables<br/>Parts 1 and 2<br/>General requirements and tests</i>                                                                                                                                 |
| <a href="#">BS 4727</a> | <i>Glossary of electrotechnical, power, telecommunications, electronics, lighting and colour terms<br/>Part 1: Group 09 Radio interference technology<br/>(IEC 50: Chapter 902)</i>                                |
| <a href="#">BS 4809</a> | <i>Radio interference limits and measurements for radio frequency heating equipment (CISPR 11).</i>                                                                                                                |
| <a href="#">BS 5049</a> | <i>Methods of measurement of radio noise from power supply apparatus for operation at 1 kV and above (CISPR 18).</i>                                                                                               |
| <a href="#">BS 5260</a> | <i>Code of practice for radio interference suppression on marine installations.</i>                                                                                                                                |
| <a href="#">BS 5394</a> | <i>Specification for limits and methods of measurement of radio interference characteristics of fluorescent lamps and luminaries (CISPR 15).</i>                                                                   |
| <a href="#">BS 5345</a> | Use of Electrical Equipment in Hazardous Areas                                                                                                                                                                     |
| <a href="#">BS 5406</a> | The limitation of disturbances in electricity supply networks caused by domestic and similar appliances equipped with electronic devices.                                                                          |
| <a href="#">BS 5602</a> | <i>Code of practice for abatement of radio interference from overhead power lines (CISPR 18).</i>                                                                                                                  |
| <a href="#">BS 5783</a> | <i>Code of practice for handling of electrostatic devices.</i>                                                                                                                                                     |
| <a href="#">BS 6201</a> | <i>Fixed capacitors for use in electronic equipment<br/>Part 3: Specification for fixed capacitors for radio interference suppression.<br/>Selection of methods of test and general requirements (IEC 384-14).</i> |
| <a href="#">BS 6299</a> | <i>Methods of measurement of the suppression characteristics of passive radio interference filters and suppression components (CISPR 17).</i>                                                                      |
| <a href="#">BS 6345</a> | <i>Method of measurement of radio interference terminal voltage of lighting equipment (CISPR 15).</i>                                                                                                              |
| <a href="#">BS 6527</a> | Specification for limits and measurements of radio interference characteristics of information technology equipment (CISPR 22).                                                                                    |
| <a href="#">BS 6651</a> | The protection of structures against lightning.                                                                                                                                                                    |
| <a href="#">BS 6656</a> | <i>Prevention of inadvertent ignition of flammable atmospheres by radio-frequency radiation.</i>                                                                                                                   |
| <a href="#">BS 6657</a> | <i>Prevention of inadvertent initiation of electro-explosive devices by radio-frequency radiation.</i>                                                                                                             |
| <a href="#">BS 6667</a> | EMC requirements for industrial-process measurement and control instrumentation (IEC 801).                                                                                                                         |

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| <a href="#">BS 7671</a> | <i>IEE Wiring Regulations 16th Edition</i>                                                                                                                          |
| <a href="#">PD 6485</a> | <i>Limits of radio interference and leakage currents according to CISPR and National regulations (CISPR 9).</i>                                                     |
| <a href="#">3G 100</a>  | <i>Specification for general requirements for equipment for use in aircraft<br/>Part 4: Section 2: Electromagnetic interference at radio and audio frequencies.</i> |

## **United States Of America**

### **American National Standards Institute (ANSI)**

|                          |                                                                                                                                                                   |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">ANSI C16</a> | <i>Communication and electronic equipment (EMC interest - intermodulation, local oscillator radiation, transient measurement).</i>                                |
| <a href="#">ANSI C63</a> | <i>Radio-electrical co-ordination (EMC interest - measurement techniques regarding noise, signal strength, interference levels, coupling and susceptibility).</i> |
| <a href="#">ANSI C68</a> | <i>High Voltage testing techniques (EMC interest - switching transients, corona).</i>                                                                             |
| <a href="#">ANSI C95</a> | <i>Radio frequency radiation hazards (EMC interest - human exposure to electromagnetic fields)</i>                                                                |

### *Federal Communications Commission (FCC)*

[FCC Docket 20780](#) Part 15 Sub-Part 1  
*Radiated and Conducted Emissions from Digital Equipment*

### **American Defence Standards**

*The US military standards listed below are used virtually throughout the world:*

|                              |                                                                                          |
|------------------------------|------------------------------------------------------------------------------------------|
| <a href="#">MIL-STD-461C</a> | <i>Electromagnetic emission interference characteristics requirements for equipment.</i> |
| <a href="#">MIL-STD-462</a>  | <i>Electromagnetic interference characteristics, measurement of.</i>                     |
| <a href="#">MIL-STD-463</a>  | <i>EMC terminology</i>                                                                   |
| <a href="#">MIL-STD-469</a>  | <i>Radar engineering design requirements, electromagnetic compatibility.</i>             |

### **Institute of Electrical and Electronics Engineers (IEEE) (USA)**

|                           |                                                                                                                                                               |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <a href="#">IEEE S299</a> | <i>Recommended practice for measurement of shielding effectiveness of high-performance shielding enclosures.</i>                                              |
| <a href="#">IEEE S518</a> | <i>Guide for the installation of electrical equipment to minimise electrical equipment to minimise electrical noise to controllers from external sources.</i> |
| <a href="#">IEEE S519</a> | <i>IEEE recommended practices and requirements for harmonic control in electrical power systems. (Recognised as an ANSI standard).</i>                        |

### **Electronic Industries Association (EIA) (USA)**

|                      |                                 |
|----------------------|---------------------------------|
| <a href="#">G-46</a> | <i>Aerospace EMC</i>            |
| <a href="#">R-2</a>  | <i>EMC of consumer products</i> |



## **Society of Automotive Engineers (SAE) (USA)**

|               |                                       |
|---------------|---------------------------------------|
| <i>AE-4</i>   | <i>Electromagnetic compatibility</i>  |
| <i>ESC/SC</i> | <i>EMI standards and test methods</i> |
| <i>EEC/SC</i> | <i>Electromagnetic radiation</i>      |

## **Scientific Apparatus Makers' Association (SAMA)(USA)**

|              |                                                                           |
|--------------|---------------------------------------------------------------------------|
| <i>PMC33</i> | <i>Electromagnetic susceptibility of process control instrumentation.</i> |
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## **Germany, Verband Deutscher Elektrotechniker (VDE)**

|                 |                                                                                                                                                                                                                                                                          |
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| <i>VDE 0565</i> | <i>Specification for RFI suppression devices</i><br><i>Part 1: RFI suppression capacitors</i><br><i>Part 2: RFI suppression chokes</i><br><i>Part 3: RFI interference filters up to 16A</i><br><i>Part 4: RFI suppression capacitors comprising a ceramic dielectric</i> |
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|                 |                                                                          |
|-----------------|--------------------------------------------------------------------------|
| <i>VDE 0871</i> | <i>Limits of radio interference from RF apparatus and installations.</i> |
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*Part 1: Radio interference suppression of RF equipment for industrial, scientific and medical equipment.*  
*100: Data processing equipment and electronic office machines. Limits of interference and measurement methods.*

|                 |                                                                                                                                                              |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>VDE 0873</i> | <i>Measures against radio interference from electrical utility plants and electric traction systems; radio interference from systems of 10 kV and above.</i> |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|

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| <i>VDE 0874</i> | <i>VDE recommendations for measures to be taken for radio interference suppression.</i> |
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|                 |                                                                                                                                               |
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| <i>VDE 0875</i> | <i>Specification for the radio interference suppression of appliances, machines and installations for rated frequencies from 0 to 10 kHz.</i> |
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|                 |                                                                                                                                                                                                                                                                                                                                |
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| <i>VDE 0876</i> | <i>Radio interference measuring apparatus</i><br><i>Part 1: Radio interference receiver with weighted indication and accessories.</i><br><i>Part 2: Disturbance analyser for the automatic assessment of interference produced by switching operations.</i><br><i>Part 3: Current probes for measuring radio interference.</i> |
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|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>VDE 0877</i> | <i>Measurement of radio interference</i><br><i>Part 1: Measurement of radio interference voltages.</i><br><i>Part 2: Measurement of radio interference field strengths.</i><br><i>Part 3: Measurement of radio interference power on leads.</i> |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

*100 Specification for CISPR radio interference measuring apparatus for the frequency range 0.15 to 30 MHz.*

*101 Methods of measuring decoupling factors.*

## **Institution of Electrical Engineers (IEE) (UK)**

*'Recommendations for the electrical and electronic equipment of ships'. Appendix 7 - Recommendations for electromagnetic compatibility aboard ships.*



*'Recommendations for the electrical and electronic equipment of mobile and fixed offshore installations'.  
Appendix D - Electromagnetic compatibility.*

*The International Telegraph and Telephone Consultative Committee (CCITT)*

- (1) *1988 'Blue Book' recommendations*
- (2) *Protection of telecommunications lines against harmful effects from electric power and electrified railway lines. Vol. IV - Danger and Disturbance*

*Fascile IV.4 Specifications for measuring equipment (Rec. O series)*

### **The Electricity Council (UK) - Engineering Recommendations**

*G5/3 Limits for harmonics in the UK electricity supply system.*

*P28 Limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the UK.*

### **Health and Safety Executive**

*Assessment of radio frequency ignition hazards to process plants where flammable atmospheres may occur.  
(Guidance note GS2221) HMSO 1983*

### **Department of Trade and Industry (UK)**

*'Safety precautions relating to intense radio frequency radiation' HMSO 1960*

### **National Radiological Protection Board (NRPB) (UK)**

*'Advice on the protection of workers and members of the public from the possible hazards of electric and magnetic fields with frequencies below 300 GHz. (Consultative Document 1986).*

*Guidance as to Restrictions on Exposures to time-varying electromagnetic fields and the 1988 Recommendations of the International Non-Ionising Radiation Committee (INIRC) (1989) (NRPB-GS11).*

*Board Statement on Restrictions on Human Exposure to Static and Time Varying Electromagnetic Fields and Radiation (1993)*

### **Institute of Petroleum (UK)**

*Recommended practices for radio silence when conducting wireline services involving the use of explosives'.  
Wiley 1984*

### **Ministry of Defence (UK)**

#### **Defence Standard 59-41, Electromagnetic compatibility**

- Part 1 General requirements
- Part 2 Management and planning procedures
- Part 3 Technical requirements, test methods and limits
- Part 4 Open site testing



## Part 5                      Technical requirements for special EMC test equipment

### **Mobile Radio**

*A full list of MPT specifications relating to mobile radio is available from DTI Radio Communications Division, Waterloo Bridge House, London SE1 8UA.*

### **Standards Association of Australia**

**AS 2279**                      *Disturbances in mains supply networks.  
Part 1: Limitations of harmonic caused by household and similar electrical appliances  
Part 2: Limitations of harmonics caused by industrial equipment  
Part 3: Limitations of voltage fluctuations caused by household and similar electrical appliances  
Part 4: Limitations of harmonics caused by industrial equipment*

### **BP Group Documents**

BP Group **RP 12-16**    *Electrical Systems and Installations - Earthing & Bonding  
(replaces BP CP 18 Part 16)*

BP Group **RP 30-1**    *Instrumentation and Control, Design and Practice  
(replaces BP CP 18 Part 2)*

BP Group **RP 59-7**    *Telecommunications - Electromagnetic Compatibility for Manned Offshore Fixed Platforms*

