

Electromagnetic compatibility for industrial-process measurement and control equipment —

Part 3: Method of evaluating susceptibility to radiated electromagnetic energy

[IEC title: Electromagnetic compatibility for industrial-process
measurement and control equipment Part 3: Radiated
electromagnetic field requirements]

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- Electricity Supply Industry in England and Wales
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- Institution of Gas Engineers
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National foreword

This Part of BS 6667 has been prepared under the direction of the Industrial-process Measurement and Control Standards Committee. It is identical with IEC Publication 801-3:1984 *“Electromagnetic compatibility for industrial-process measurement and control equipment — Part 3: Radiated electromagnetic field requirements”* published by the International Electrotechnical Commission (IEC).

Part 1 and Part 2 of this British Standard have been published simultaneously with this Part. Part 1 is a general introduction and Part 2 is a method for evaluating susceptibility of industrial-process measurement and control equipment to electrostatic discharge.

Terminology and conventions. The text of the International Standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

In Figure A.3 and Figure A.4 the comma has been used as a decimal marker. In British Standards, as elsewhere in the text of the International Standard, a full point on the baseline is used as the decimal marker.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 18, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This part is applicable to the susceptibility of industrial-process measurement and control instrumentation to radiated electromagnetic energy. It additionally establishes severity levels and the required test procedures.

2 Object

The object of this part is to establish a common reference for evaluating the performance of industrial-process measurement and control instrumentation when subjected to electromagnetic fields such as those generated by portable radio transceivers (walkie-talkies) or any other device that will generate continuous wave radiated electromagnetic energy.

NOTE Test methods are defined in this part for measuring the effect that electromagnetic radiation has on the equipment concerned. The simulation and measurement of electromagnetic radiation is not adequately exact for quantitative determination of effects. The test methods defined are structured for the primary objective of establishing adequate repeatability of results at various test facilities for qualitative analysis of effects. These differences shall be taken into account when verification testing is conducted.

3 General

Most electronic equipment is in some manner affected by electromagnetic radiation. This radiation is frequently generated by the small hand-held radio transceivers that are used by operating, maintenance and security personnel. The susceptibility of industrial-process measurement and control instrumentation to the radiation of the hand-held transceiver is the primary concern of this part.

However, other sources of electromagnetic radiation are involved, such as fixed station radio and television transmitters, vehicle radio transmitters and various industrial electromagnetic sources.

In addition to the continuous form of electromagnetic energy deliberately generated, there is also spurious radiation caused by devices such as welders, thyristors, fluorescent lights, switches operating inductive loads, etc. For the most part, this interference manifests itself as conducted electrical interference and, as such, is dealt with in other parts of the standard. Methods employed to prevent effects from continuous radiation will normally also reduce the effects from these sources.

The electromagnetic environment is determined by the strength of the electromagnetic field (field strength in volts per metre). The field strength is not easily measured without sophisticated instrumentation nor is it easily calculated by classical equations and formulae because of the effect of surrounding structures or the proximity of other equipment that will distort and/or reflect the electromagnetic waves.

4 Definitions/Terminology

4.1

antenna

a transducer which either emits radio frequency power into space from a signal source or intercepts an arriving electromagnetic field, converting it into an electrical signal

4.2

broad-band emission

an emission having a spectral energy distribution sufficiently broad, uniform, and continuous for the response of the measuring receiver in use, not to vary significantly when tuned over a specified number of receiver impulse bandwidths

4.3

conducted emission

desired or undesired electromagnetic energy which is propagated along a conductor. Such an emission is called "conducted interference" if it is undesired

4.4

continuous waves (C.W.)

electromagnetic waves, the successive oscillations of which are identical under steady-state conditions, which can be interrupted or modulated to convey information

4.5

degradation

in susceptibility specification testing, degradation is an unwanted change in the operational performance of a test specimen. This does not necessarily mean malfunction or catastrophic failure. The E.M.I. test specification generally requires stating the criteria for degradation of performance

4.6

dipole

an antenna consisting of a straight conductor (usually not more than a half-wavelength long), divided at its electrical centre for connection to a transmission line

4.7**electromagnetic compatibility (E.M.C.)**

E.M.C. is the ability of equipment to function satisfactorily in its electromagnetic environment without introducing intolerable disturbances to that environment or to other equipment

4.8**electromagnetic interference (E.M.I.)**

E.M.I. electromagnetic disturbance which manifests itself in performance degradation, malfunction, or failure of electrical or electronic equipment

4.9**electromagnetic wave**

the radiant energy produced by the oscillation of an electric charge characterized by oscillation of the electric and magnetic fields

4.10**emission**

electromagnetic energy propagated from a source by radiation or conduction

4.11**far field**

that region where the power flux density from an antenna approximately obeys an inverse square law of the distance

for a dipole this corresponds to distances greater than $\lambda/2\pi$ where λ is the wavelength of the radiation

4.12**field strength**

the term “field strength” shall be applied only to measurements made in the far field. The measurement may be of either the electric or the magnetic component of the field and may be expressed as V/m, A/m or W/m²; any one of these may be converted to the others

NOTE For measurements made in the near field the term “electric field strength” or “magnetic field strength” shall be used according to whether the resultant electric or magnetic field, respectively, is measured.

In this field region the relationship between the electric and magnetic field strength and distance is complex and difficult to predict, being dependent on this specific configuration involved. Inasmuch as it is not generally feasible to determine the time and space phase relationship of the various components of the complex field, the power flux density of the field is similarly indeterminate.

4.13**frequency band**

a continuous range of frequencies extending between two limits

4.14**induction field**

the predominant electric and/or magnetic field existing at a distance, $d < \lambda/2\pi$, where λ is the wavelength

4.15**isotropic**

having properties of equal values in all directions

4.16**monopole**

an antenna consisting of a straight conductor (usually not more than one-quarter-wavelength long) mounted immediately above, and normal to, an imaging (ground) plane. It is connected to a transmission line at its base and behaves, with its image, like a dipole

4.17**polarization**

a term used to describe the orientation of the electric field vector of a radiated field

4.18**radiated emission**

radiation and induction field components in space

4.19**radiation**

the propagation of a signal or interference from a source other than by conduction

4.20**radio environment**

the combined effect of the radio emissions that are created at any given location by normally operating authorized transmitters. It has the dimension of field strength and varies with frequency band, geographical location and time

4.21**radio-frequency interference (R.F.I.)**

R.F.I. used interchangeably with E.M.I. E.M.I. is a later definition which includes the entire electromagnetic spectrum, whereas R.F.I. is more restricted to the radio-frequency band, generally considered to be between 10 kHz and 10 GHz

4.22**shielded enclosure**

a screened or solid metal housing designed expressly for the purpose of isolating the internal from the external electromagnetic environment
the purpose is to prevent outside ambient electromagnetic fields from causing performance degradation and to prevent emission from causing interference to outside activities

4.23**stripline**

parallel plate transmission line to generate an electromagnetic field for testing purposes

4.24**spurious radiation**

any undesired electromagnetic emission from an electrical device

4.25**susceptibility**

the characteristic of electronic equipment that results in unwanted responses when subjected to electromagnetic energy

4.26**sweep**

a continuous traverse over a range of frequencies

4.27**transceiver**

the combination of radio transmitting and receiving equipment in a common housing

5 Severity levels

Frequency band: 27 MHz to 500 MHz

Level	Test field strength (V/m)
1	1
2	3
3	10
x	Special
NOTE x is an open class.	

6 Selection of test methods

The test methods contained in this part are the usual methods employed in conducting E.M.I. radiated susceptibility tests, and because of the magnitude of the field strengths generated, they shall be conducted in a shielded room in order to comply with various national and international laws prohibiting interference to radio communications. In addition, since most test equipment used to collect data is sensitive to the local ambient electromagnetic field generated during the execution of the susceptibility test, the shielded enclosure provides the necessary "barrier" between the equipment under test (E.U.T.) and the required test instrumentation. Care needs to be taken to ensure that the interconnection cabling penetrating the shielded enclosure adequately attenuates the conducted radiated emission and preserves the integrity of the E.U.T.'s signal and power responses.

6.1 Shielded enclosures

The use of a shielded enclosure has always caused a high degree of controversy during the development of any E.M.I. standard. Specifically, the issue of standing waves and the resultant potential for erroneous results have been intensively discussed.

In comparing the available alternative methods (anechoic chambers, transverse electromagnetic (T.E.M.) cells, mode-stirred chambers, open antenna ranges, stripline), the use of shielded enclosures was retained because it is the most efficient means of performing radiated measurements that is in widespread use.

Since most occurrences of susceptibility are relatively broad band, a qualitative analysis of data will in most cases be quite adequate. If a radiated field peaks at 150 MHz, causing a malfunction in the operation of electronic equipment, the equipment will most likely malfunction at 145 MHz or 155 MHz or anywhere near 150 MHz when tested in a different shielded room. For devices which are narrow-band (i.e. a low level internal oscillator), radiated field nulls at the location of the equipment under test and at the frequency of the oscillator may provide an apparent negligible influence when in fact the equipment may be susceptible. The wide excursions of field strengths are greatly alleviated by the use of one or more monitoring antennae near the test sample. As peaks and nulls are encountered, the field strength can be readjusted to the required level. The influence of standing waves can be additionally controlled by the geometry of the enclosure, the removal of non-required objects in the enclosure, and partial anechoic shielding.

Finally, the qualitative evaluation of any resultant data needs to be assessed in terms of the existing local ambient electromagnetic level and the specific operating frequencies. For example, an equipment's susceptibility at 75 MHz is of no consequence if the operating communication frequency at the equipment site is 450 MHz.

6.2 Anechoic chambers

Anechoic chambers are inefficient at frequencies below 100 MHz. To be effective at 100 MHz, anechoic chambers require absorbers approximately 2 m thick. Above 100 MHz, the use of an anechoic chamber will substantially reduce reflection errors. It is by far the most preferred type of enclosure.

6.3 Stripline circuit

The uniform field produced between the plates of a parallel stripline is a desirable feature in conducting susceptibility measurements.

The parallel stripline specified in MIL-STD-461 and 462 standards is of limited application due to the restricted plate separation (50 cm with maximum object height of 25 cm) and the maximum frequency of operation of 35 MHz. Another design (Groenveld and de Jong) with dimensions of 80 cm × 80 cm × 80 cm has been reported by the Electrical Research Association (E.R.A.) of Great Britain as being usable up to 500 MHz (reference: E.R.A. Report No. 80-135). This part considers only this second apparatus.

This apparatus is potentially usable for small objects (in the order of one-third of the dimensions of the stripline). For objects with larger dimensions, it is possible to have inhomogeneity of the field. Similar problems exist when large equipment is located in small shielding enclosures or anechoic chambers.

NOTE 1 In addition to the test methods described in Clause 6, other methods are in use. Examples of these methods are listed in Appendix A.

NOTE 2 *Field strength measurements* — It is fairly usual to establish the required field strength by utilizing a receiving antenna and subsequently replacing it with the E.U.T. However, it is felt that the time required using this approach is prohibitively expensive, and its relative merits questionable especially when account is taken of the fact that the replacement of the receiving antenna with the E.U.T. distorts the original field. Continuous monitoring of the existing field strength and readjustment of power levels is therefore advocated.

7 Test equipment

The following types of test equipment are recommended:

- 1) Shielded room or anechoic chamber; size adequate to maintain distances specified in Figure 1, page 7.
- 2) Stripline circuit (27 MHz to 500 MHz).
- 3) Signal source: signal generator(s) capable of covering frequency range and having automatic sweep capability of 0.005 octave/s (1.5×10^{-3} decades/s) or slower.
- 4) Power amplifier: to amplify signal and provide antenna drive if signal source is incapable.
- 5) Antennae: signal source
 - a) biconical: 27 MHz to 200 MHz
 - b) conical logarithmic spiral: 200 MHz to 500 MHz
 - c) or any other antenna system capable of satisfying frequency requirements.

6) Field strength monitors

- a) isotropic.

7) Associated equipment to monitor output and to establish operating power and signals for test sample.

NOTE The use of other means of establishing and controlling the field is not ruled out and is acceptable providing the required conditions can be verified.

8 Test set-up

The procedure defined in this part requires the generation of electromagnetic fields within which the test sample is placed and its operation observed. To generate fields that are useful for simulation of actual (field) conditions may require significant antenna drive power and the resultant high field strength levels. To comply with local regulations and to prevent biological hazards to the testing personnel, it is recommended that these tests be carried out in a shielded enclosure or anechoic chamber.

The use of a shielded enclosure, however, creates difficulties in establishing and maintaining the required field strengths due to reflections of the radiated energy from the walls of the enclosure.

These reflections will cause reinforcement (peaks) and cancellation (nulls) to be established within the room. To alleviate the uncertainty regarding the actual field strength present in proximity to the equipment under test, one or more field strength monitors may be required. The size of the shielded enclosure should be commensurate with the size of the equipment under test in order to achieve adequate control over the established field strengths.

All testing of equipment shall be performed in conditions as close as possible to installed conditions. Wiring shall be consistent with the manufacturer's recommended procedures, and the equipment shall be in its housing with all covers and access panels in place, unless otherwise stated.

If the equipment is designed to be mounted in a panel, rack or cabinet, it should be tested in this configuration.

If the wiring to and from the unit is not specified, unshielded twisted-pair wiring shall be used and left exposed to the E.M.R. for a length of 1 m from the point of connection to the E.U.T. After this, the wiring is interfaced with E.M.I. filters and shielded wiring which connects to the test equipment outside the shielded enclosure.