Another EMC resource
from EMC Standards

Complying with the EMC Directive, 2004/108/EC

Helping you solve your EMC problems

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Complying with the EMC Directive, 2004/108/EC

for

Owners/operators of "Fixed Installations"

and for

Suppliers of equipment/systems intended for "fixed installations"

and for

Architects, Consultants and M&E Contractors

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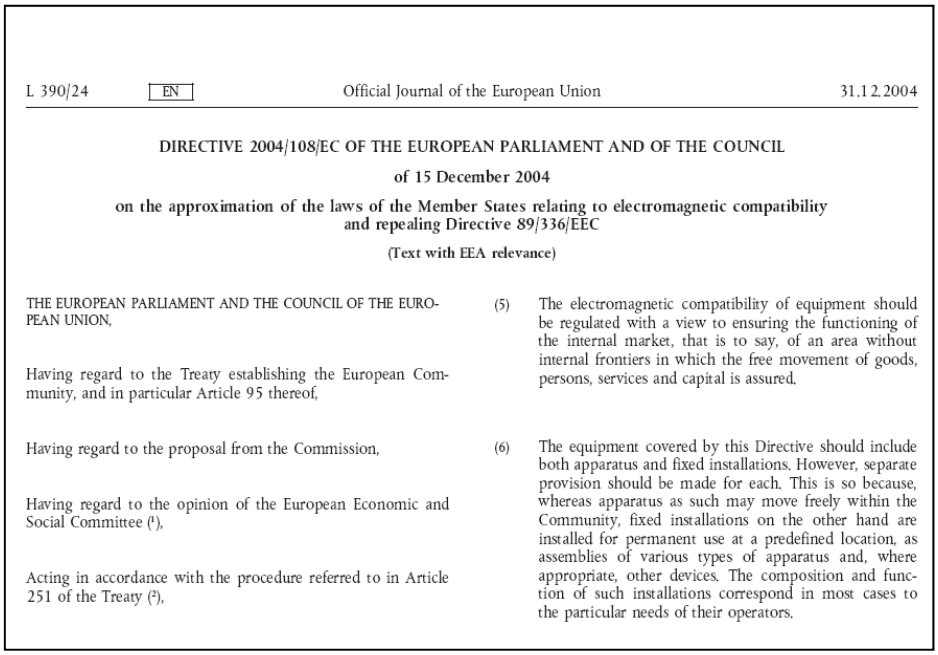
1 Introduction to the new EMC Directive: 2004/108/EC

This section is based upon the following documents:

a) The 2nd Edition of the EMC Directive: 2004/108/EC [1] see Figure 1
b) The EC's official Guide to 2004/108/EC [8]
c) The UK's EMC Regulations 2006: SI 2006 No. 3418 [4] see Figure 2
d) The BERR Guide to the UK's 2006 EMC Regulations [9]
e) The EC's 'Blue Guide' [10]



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DIRECTIVE 2004/108/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 15 December 2004

on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC

(Text with EEA relevance)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 95 thereof,

Having regard to the proposal from the Commission,

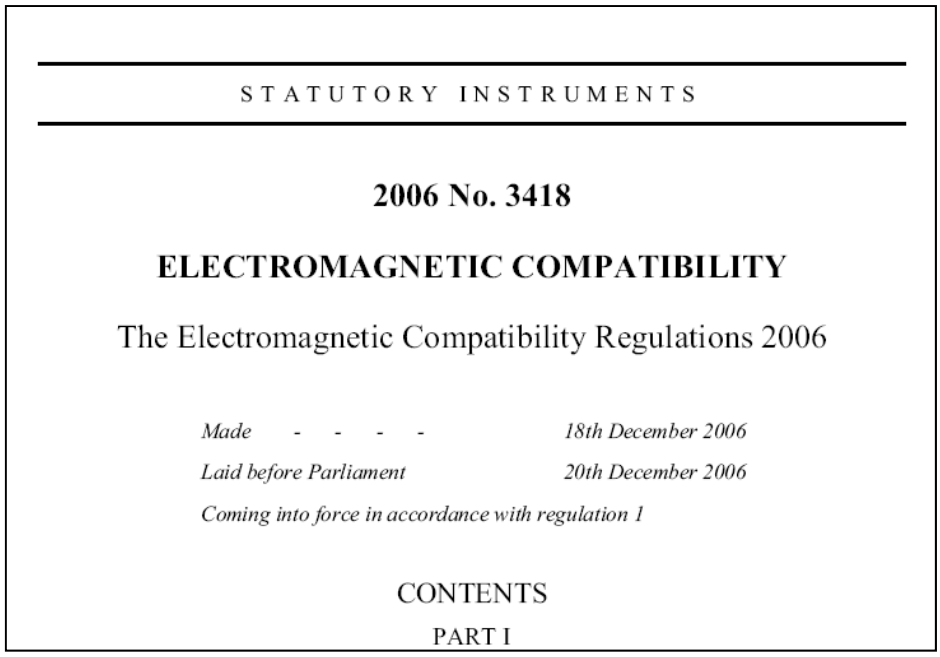
Having regard to the opinion of the European Economic and Social Committee (1),

Acting in accordance with the procedure referred to in Article 251 of the Treaty (2),

(5) The electromagnetic compatibility of equipment should be regulated with a view to ensuring the functioning of the internal market, that is to say, of an area without internal frontiers in which the free movement of goods, persons, services and capital is assured.

(6) The equipment covered by this Directive should include both apparatus and fixed installations. However, separate provision should be made for each. This is so because, whereas apparatus as such may move freely within the Community, fixed installations on the other hand are installed for permanent use at a predefined location, as assemblies of various types of apparatus and, where appropriate, other devices. The composition and function of such installations correspond in most cases to the particular needs of their operators.

Figure 1 The 2nd Edition of the EMC Directive: 2004/108/EC



STATUTORY INSTRUMENTS

2006 No. 3418

ELECTROMAGNETIC COMPATIBILITY

The Electromagnetic Compatibility Regulations 2006

Made - - - - 18th December 2006

Laid before Parliament 20th December 2006

Coming into force in accordance with regulation 1

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PART I

Figure 2 The UK's EMC Regulations 2006: SI 2006 No. 3418

Each EU Member State's national law implementing the EMC Directive is supposed to have the same effect, but the UK's EMC Regulations 2006 go into a lot more detail than 2004/108/EC and make it easier to understand what is actually required.

There was always confusion about how the 1st Edition EMC Directive (89/336/EEC) applied to custom-made (bespoke) equipment, and to systems and installations. It just wasn't written well enough – it was supposed to apply to all electrical/electronic equipment, but its writers only provided compliance details for volume-manufactured equipment sold in shops and through distribution.

Dispelling this confusion was a main aim of the EC's 1997 Guidelines on the EMC Directive, but this was only an official guide and did not did not change the EMC Directive, or the national implementing legislation in the member states.

Since the 1997 Guidelines had no legal force, many organisations (including some government organisations) and companies working in the area of custom equipment, systems and installations chose to ignore them and instead continue with their idiosyncratic interpretations on how they thought 89/336/EEC should apply to them.

Strangely, these interpretations usually resulted in them having to do very little EMC work. And so over the 10 years that 89/336/EEC was in force some very odd views (e.g. that the EMC Directive did not apply at all to installations) and some very incorrect EMC practices (such as the so-called 'CE + CE = CE approach to compliance', see 2.3.4) arose.

The singular absence of enforcement activities targeted at custom equipment, systems or installations did nothing to discourage such views and practices, which became so commonplace and so entrenched that most people working in these areas seemed to assume they were correct interpretations of the Directive.

Setting out a coherent regime for dealing with custom equipment, systems and what it calls 'fixed installations' was one of the main issues during the creation of 2004/108/EC (the 2nd Edition of the EMC Directive). Its resulting requirements owe quite a lot to the EC's 1997 Guidelines.

2 2004/108/EC and Safety

First of all it is important to clear up the relationship between the EMC Directive and safety. Two kinds of safety need to be considered:

- Functional Safety (errors in operation, misoperation, malfunction or failure to function, that increases safety risks)
- Hazards to human health

2.1 EMC for Functional Safety

Neither 2004/108/EC [1] nor the UK's 2006 EMC Reg's [4] cover functional safety issues. Where errors or malfunctions in electrical, electromechanical, electronic or programmable electronic devices, equipment, systems or installations could increase human safety risks, the work required to control EMI to achieve acceptable levels of risk could be very much greater than is required simply for compliance with 2004/108/EC.

These 'EMC for Functional Safety' issues need to be fully addressed when complying with:

- The Product Liability Directive [11] (which is mandatory for all goods supplied in the EU)
- IEC/EN 61508 [12]
- IEC/EN 61551 [13]
- IEC/EN 62061 [14]
- The Machinery Directive [15]
- The Low Voltage Equipment Directive (LVD) [16]
- The Medical Device Directive: 93/42/EEC
- The Active Implantable Medical Devices Directive: 90/385/EEC
- The In-Vitro Diagnostics Directive: 98/79/EEC
- The General Product Safety Directive: 2001/95/EC
- Any other EU safety directives, such as: Personal Protective Equipment, Potentially Explosive Atmospheres, etc. where electrical, electromechanical, electronic or programmable electronic technologies are involved.

Unfortunately, as yet there are *no* published EMC or safety standards that effectively control functional safety risks caused by EMI, for any types of equipment or systems (including medical), published by any standards organisations worldwide. This includes all safety standards that include EMC requirements.

At the time of writing (March 2008) the only standardisation work that is at all effective in the area of EMC for Functional Safety is the draft 2nd Edition of IEC/TS 61000-1-2 [17]. This is unlikely to be adopted as a full IEC standard for at least 5 years (maybe 10) – but this does not stop it from being used. The author hopes to get its principles adopted in the 4th Edition of IEC 60601-1-2 (EMC for medical equipment) but it is too soon to say whether this will happen.

However, the Institution of Engineering Technology (IET) has a Professional Guide on EMC and Functional Safety [5], provides some other resources [6], and is working on another guide intended for publication in 2008, which will describe practical steps that should be taken.

However, at least we can say that fully applying good EMC engineering practices as required by 2004/108/EC for fixed installations and described in this Guide, should in general help to reduce the possibility that EMI will lead to safety incidents.

2.2 EMC and human health risks

Neither 2004/108/EC [1] nor the UK's 2006 EMC Reg's [4] cover health hazards caused by human exposure to electromagnetic fields (EMFs). In the EU this is controlled by EC Recommendation 1999/519/EC, which gets its legal force via the Low Voltage Directive [16] and via the Radio & Telecommunications Terminal Equipment Directive (1999/5/EC).

Unfortunately, we cannot say whether fully applying 2004/108/EC to fixed installations (and to custom equipment and systems intended for use in them) will help reduce the possibility that EMFs will cause hazards to human health.

3 Applying 2004/108/EC

3.1 Applying the Directive to fixed installations

2004/108/EC applies to equipment that is placed on the market or put (taken) into service. Its definition of 'equipment' includes both 'apparatus' and 'fixed installations', with special legal meanings for the common words: apparatus, and fixed installation. The terms 'placed on the market' and 'put into service' are not defined in 2004/108/EC, so the EC 'Blue Guide' [10] definitions apply.

2004/108/EC treats fixed installations very differently from apparatus, as shown by Figure 3. Apparatus is not within the scope of this Guide so its requirements are not described here. Fixed installations are discussed in 2.3.3 – 2.3.13, and "apparatus intended for use in a specified fixed installation and not otherwise commercially available to an end user as a single commercial item' is discussed in 2.5.

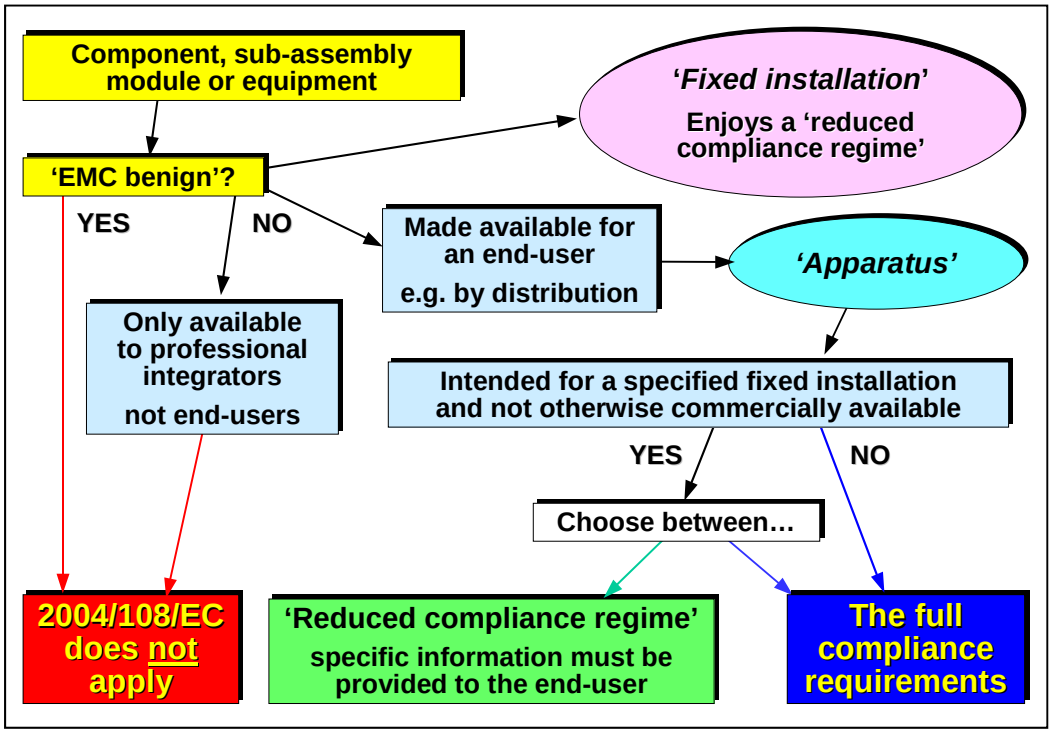

Figure 3 Applying 2004/108

All fixed installations in the EU must comply fully with 2004/108/EC from 20 July 2007.

Unfortunately, 2004/108/EC does not say what this means for the very large numbers of fixed installations in the EU that were already in existence before the 20th July 2007. The EC's Guide [8] and UK's 2006 EMC Regulations [4] say that pre-existing fixed installations must only comply with 2004/108/EC if they are modified on/after 20th July 2007. The UK's Guide [9] goes even further and says that compliance is only required for the areas of the fixed installation where the EMC characteristics were affected by the modifications.

But it is important to note that the actual legal text of 2004/108/EC could possibly be interpreted as meaning that instead every fixed installation in the EU must fully comply from 20th July 2007 – which was of course impossible. Similarly, the actual legal text in the UK's 2006 EMC Regulations could possibly be interpreted as meaning an entire installation must be made to comply with 2004/108/EC if any part of it is modified – which, if not impossible, would often be totally impractical.

3.2 Inherently benign equipment

'Inherently benign equipment' is equipment that is incapable of emitting any significant EM disturbances, and also incapable of being interfered with by the normal EM disturbances in its environment. As such, it is excluded from the scope of 2004/108/EC, whether it is an apparatus or a fixed installation.

The draft Guide contains a list of what is currently *considered* to be inherently benign:

- Cables and cabling, cables accessories, considered separately;
- Equipment containing only resistive loads without any automatic switching device; e.g. simple domestic heaters with no controls, thermostat, or fan;
- Batteries and accumulators (without active electronic circuits)
- Headphones, loudspeakers without amplification
- Pocket lamps without active electronic circuits
- Protection equipment which only produces transitory disturbances of short duration during the clearing of a short-circuit fault or an abnormal situation in a circuit and which do not include active electronic components, such as fuses and circuit breakers without active electronic parts or active components
- High voltage types of equipment in which possible sources of disturbances are due only to localised insulation stresses which may be the result of the ageing process and are under the control of other technical measures included in non-EMC product standards, and which do not include active electronic components.
- Capacitors (e.g. power factor correction capacitors)
- Induction motors
- Quartz watches (without additional functions, e.g. radio receivers)
- Filament lamps (bulbs)
- Home and building switches which do not contain any active electronic components
- Passive antennas used for TV and radio broadcast reception
- Plugs, sockets, terminal blocks, etc.

Note that passive (e.g. moving-coil) loudspeakers and headphones can be interfered with by audio-frequency magnetic fields, although the levels required are not often met in normal applications. Quartz watches have been known to suffer from interference. Home and building switches always emit broadband EM noise and conducted transients when they break a current, which some switches might do quite often in some applications, and the levels can exceed 1kV. Approximately 1% of coiled-coil mains-powered filament lamps are significant VHF transmitters.

The EC's Guide does not say so, but it is reasonable to assume that any equipment that contains any semiconductors (rectifiers, transistors, ICs, MOVs, transorbs, etc.) or thermionic valves cannot be considered EMC benign.

3.3 Definition of a 'fixed installation'

Fixed installations are defined as:
"A particular combination of several types of apparatus and, where applicable, other devices, which are assembled, installed and intended to be used permanently at a predefined location."
This definition covers all installations from the smallest residential electrical installation, through to national electrical and telephone networks, including all commercial and industrial installations. The EC's Guide's examples of fixed installations include…

- Industrial, and power generating plants
- Electrical power distribution networks
- Telecommunication, and cable TV networks
- Computer networks
- Airport luggage handling, and runway lightning installations
- Automatic warehouses
- Skating hall ice rink machinery installations
- Storm surge barrier installations (with the control room etc)
- Wind turbine stations
- Car assembly plants
- Water pumping stations, and water treatment plants,
- Railway infrastructures

- Air conditioning installations

Notice that a fixed installation need not be a whole site; it could be a part of a site, such as the electrical wiring, computer network, HVAC installation, etc. So a given building or site could have several fixed installations within it, each with their own Responsible Person (see later).

A fixed installation is intended for permanent use at a predefined location, which means it was constructed with the intention of being permanently located at that particular location. According to the UK's guide, if its constituent parts are expected to be moved during their expected lifetime, and taken into service at another location, then it is not after all a fixed installation, and must be treated as an apparatus instead.

End-users create all sorts of fixed installations, for example domestic multi-media system/installations in their own homes. But if they are not doing it professionally, and if they only use apparatus that is compliant with the EMC Directive and intended by their manufacturers for the use they put it to – then no further EMC actions are required for compliance with the Directive.

Fixed installations are made of 'apparatus' or 'other devices'. There are three kinds of apparatus covered by the EMC Directive:

- Benign apparatus that inherently complies with the Essential Requirements.
- Apparatus placed on the market for an end user. These are items that anyone can buy, from a shop, distributor, catalogue or website. They are generally manufactured in quantities of more than one, and their requirements for EMC compliance and CE-marking under 2004/108/EC are not discussed in this Guide.
- Apparatus intended for incorporation into a specified fixed installation and not otherwise commercially available to an end-user as a single functional unit, see 2.5.

According to [8], the 'other devices' that can be used to create a fixed installation means items that are not covered by the EMC Directive.

The term '*Large Machine*' appears in [1]. If a large machine meets the definition given for a fixed installation, then it is treated as such. In all other cases, large machines are treated either as…

- Apparatus…
- Or 'apparatus intended for a specified fixed installation and not otherwise commercially available' (see 2.5)

'Mobile Installations' are defined as: "…a combination of apparatus and, where applicable, other devices, intended to be moved and operated in a range of locations.", and [8] uses the example of an outside broadcast vehicle. Mobile installations are treated as apparatus that is placed on the market for an end-user, because – just like products sold in shops – they can be used anywhere in the EU, and the manufacturer has no control over their EM environment.

The term '*Moveable Installation*' does not appear in [1], but is a term that has been proposed for something that is constructed anew on each site, such as a fairground, open-air touring pop concert, etc. [8] says:
"Installations which are regularly dismounted and rebuilt at different locations are not considered as mobile installations. They may thus be identified as apparatus or as fixed installations according to the particular cases."

The word '*System*' is commonly used to describe a variety of possible constructions, but does not appear anywhere in [1]. [8] discusses a limited range of systems, but is not comprehensive. Where a system is created and supplied to an end-user by a manufacturer – if it fits the definition of 'apparatus' it is treated the same way as an apparatus. But a custom-engineered (bespoke) system is considered to be: 'apparatus intended for a specified fixed installation and not otherwise commercially available' (see 2.5).

Where end-users create their own systems, they are either treated as fixed installations in their own right, or as component parts of fixed installations.

3.4 CE + CE does not equal CE

The 'CE + CE = CE approach' is the name given to the assumption that if someone buys CE-marked items of equipment 'in good faith' and assembles them following their suppliers' instructions, then there is no more EMC work required to make the resulting equipment (apparatus, system or fixed installation) comply with the EMC (or any other CE-marking) Directive.

This approach is acceptable for end-users who are not doing it professionally, but not otherwise.

There has never been any legal or technical justification for the use of this approach (see [18]), even under the original EMC Directive 89/336/EEC – but unfortunately this has not stopped it from being widely used at all levels of all industries.

[8] includes the following statement:
"It should be noted that combining two or more CE-marked finished appliances does not automatically produce a "compliant" system e.g.: a combination of CE-marked Programmable Logic Controllers and motor drives may fail to meet the protection requirements."
This should make it much harder for anyone using the CE +CE = CE approach to successfully argue that their product, system or fixed installation complies with the EMC Directive.

3.5 Requirements for fixed installations

Unlike apparatus placed on the market for an end-user, fixed installations are not required to have…

- An electromagnetic compatibility assessment
- A Conformity Assessment
- An EC Declaration of Conformity (DoC)
- The CE-marking affixed

But, as shown in Figure 3, 2004/108/EC does apply a "reduced compliance regime" to fixed installations – they must comply with the Directive's 'Essential Requirements', which has two parts:

1) The Protection Requirements
2) The Specific Requirements for Fixed Installations

The **Protection Requirements** state:
"Equipment shall be so designed and manufactured, having regard to the state of the art, as to ensure that:

a) the electromagnetic disturbance generated does not exceed the level above which radio and telecommunication equipment or other equipment cannot operate as intended;

b) it has a level of immunity to the electromagnetic disturbance to be expected in its intended use which allows it to operate without unacceptable degradation of its intended use."

The Protection Requirements are just a statement of what EMC is all about, and it is hard to imagine that any manufacturer or installation owner would be happy if these requirements were not met in practice.

It is important to understand that a Fixed Installation is something that *the end-user creates for his own use*. A manufacturer cannot supply a Fixed Installation to an end-user [19]. Anything that a manufacturer supplies to an end-user must conform with the EMC Directive either by being a CE-marked apparatus, or by being 'apparatus intended for a specified fixed installation and not otherwise commercially available' (e.g. custom-designed equipment).

The EMC conformity and CE-marking of apparatus is not covered in this Guide, but the conformity of: apparatus intended for a specified fixed installation and not otherwise commercially available is covered in 2.5. A contractor who is providing assembly/installation services to an end-user according to the end-user's design, is not a manufacturer, and so the EMC Directive does not apply, see 2.4.

The Specific Requirements for Fixed Installations have three parts:

A) The application of "good engineering practices"

B) Installation "respecting the information on the intended use of its components, with a view to meeting the essential requirements"

C) Documentation of the good engineering practices that have been employed, kept ready for inspection, by a named "Responsible Person", for as long as that installation is in operation.

These three issues are discussed in following subsections.

3.6 The application of Good Engineering Practices

The phrase 'good engineering practices' actually means 'good EMC engineering practices having regard to the state of the art'. For example, although BS7671 (the IEE Wiring Regulations) are good engineering practices and reflect the state of the art in electrical wiring for inherent safety purposes, they do not (at the time of writing) cover EMC practices and so they are not appropriate for complying with the EMC Directive.

The EC's Guide has the following to say about good EMC engineering practices:

"Good engineering practice comprises of suitable technical behaviour taking into account recognised standards and codes of practice applicable to the particular fixed installation. The "good engineering practices" referred to in Annex I, 2 mean practices which are good for EMC purposes, at the specific site in question. General information on good engineering practice within the context of installations is available in several EMC handbooks, courses and technical reports. For example some technical reports published by standardisation bodies deal with installation and mitigation guidelines for EMC. Good engineering practices, particularly in the field of EMC, are in constant evolution. Whilst there is a need to have regard for the 'state of the art' practices it does not necessarily follow that they are relevant for all installations. Standards for installations cannot cover all specific local conditions: therefore it is necessary to be aware of some guiding principles when aiming to demonstrate installation according to good engineering practices:

- — Emissions: take appropriate actions to mitigate the source of disturbances by EMC design, e.g. by the addition of filters or of absorption devices etc.
- — Coupling and radiation: take appropriate actions in respect of distances, equipotential earthing, selection of cables, shielding etc.
- — Immunity: take appropriate actions to ensure that sensitive equipment is protected against the various types of disturbances that might be expected.

When applying the protection requirements to a defined fixed installation, it is essential to define the borderlines/geographical limits of this fixed installation in order to distinguish it clearly from the external environment.

It is fundamental to identify:

- — The ports/interfaces where conducted (high or low frequency) disturbances may cross the borderline from or towards the fixed installation (power supply port, control and telecommunication ports etc.)
- — The coupling mechanism with the external environment
- — The radiation towards or from the external environment

It should be noted that it is not the purpose of the EMC Directive to ensure electromagnetic compatibility between specific equipment inside the borders of the defined fixed installation."

The final sentence in the quotation above means that the EMC Directive is only concerned with 'inter-system' interference (between a fixed installation and other equipment) – and is not concerned with items of equipment within an installation interfering with each other, known as 'intra-system' interference. Intra-system interference is not uncommon, can cause significant lost production, and may be more important financially to the owner of the installation than inter-system interference (see 3.1).

So this Guide covers good EMC practices for both inter- and intra-system interference, to help everyone maximise cost-effectiveness whilst reducing financial risks and complying with legal requirements.

This requirement to employ 'good EMC engineering practices having regard to the state of the art', is a big problem for end-users, architects, electrical consultants, system integrators, panel builders, custom engineers, M&E (mechanical and electrical) contractors, and electrical engineers, etc., since most of them seem to believe that all that is required for good EMC engineering is to use single-point earthing (grounding), terminate cable shields at one end only, and that any length of wire may be used to terminate a cable shield or 'ground' a filter – as long as it has green/yellow insulation.

These might possibly have been acceptable EMC practices in the 1950s, when FM Radio and Television at VHF were new and considered to be the pinnacle of high technology, and digital circuits and software were not even on the horizon. But they are generally bad EMC engineering practices these days, so they fail the 'having regard to the state of the art' requirement in the new EMC Directive.

But the date, 20th July 2007, on which good EMC engineering practice was made mandatory for all fixed installations in the EU has passed, and very few (if any) of the people involved with designing, creating and maintaining fixed installations seem to have any clue about how to do it properly.

We just have to hope that the enforcement activities are as insignificant as they were under the old EMC Directive. In fact there is every likelihood that they *will* be stepped up during the next few years, due to a proposed EU Directive that would force Member States to do more enforcement [20].

3.7 Following suppliers' EMC instructions

2004/108/EC describes this requirement as the practice of constructing a fixed installation:
"..respecting the information on the intended use of its components, with a view to meeting the Essential Requirements".
This means that EMC installation and use instructions should be obtained from each equipment supplier, and then applied as appropriate.

The word 'respecting' implies that it is not mandatory to mindlessly follow a supplier's EMC instructions – which is a good thing because sometimes they can be unsuitable for a particular application that the supplier had not envisaged. However, the supplier's instructions must be 'respected', so if they are not followed exactly their EMC effect should be achieved by whatever means are most appropriate to the installation, using good EMC engineering practices 'having regard to the state of the art'.

3.8 The Responsible Person

A Responsible Person must be identified by name for each fixed installation. He or she is responsible for ensuring that the fixed installation complies with the EMC Directive (which means complying with the Protection Requirements plus the three special requirements for fixed installations) – and also must keep documentation showing how good EMC engineering practices have been employed since the 20th July 2007 (see 2.3.10). This compliance documentation must be kept ready for inspection by the national EMC enforcing authorities for as long as the fixed installation is in operation.

The Directive allows each EU member state to decide on its own rules for identifying Responsible Persons. For the UK, SI 2006 No.3418 [4] defines a Responsible Person (for a fixed installation) as…
"…the person who, by virtue of their control of the fixed installation is able to determine that the configuration of the installation is such that when used it complies with the essential requirements."

And the UK's Guide [9] says:
"It will be necessary for operators of fixed installations to identify the responsible person before the installation is taken into service"

Notice especially that a Responsible Person must have authority (control) over the design and construction of the fixed installation they are responsible for. The UK's Guide also says that a Responsible Person does not have to be an EMC expert, and can seek appropriate advice in fulfilling their obligations. *But they cannot delegate their responsibility.*

As 2.3.3 shows, there could be several fixed installations on a given site (e.g. computer network, HVAC system, etc.), each with their own Responsible Person. In such situations it seems reasonable to expect the Responsible Persons to coordinate their activities so that the entire site complies with the EMC Directive's Protection Requirements by not causing unacceptable interference to other equipment. It also seems reasonable for them to work together to ensure that the different fixed installations on the site do not cause unacceptable interference with each other.

It seems likely that many responsible persons will try to treat 2004/108/EC in the same way they deal with other technical issues (such as the IEE Wiring Regulations, BS7671) by not bothering to learn much about it – simply expecting their suppliers, architects, electrical consultants and M&E Contractors to do it all for them, and provide them, at the end of the project, with all of the compliance documentation that they are supposed to keep ready for inspection by the authorities.

But few suppliers, and even fewer architects, electrical consultants or M&E contractors have adequate EMC skills (yet), and ensuring EMC compliance for a fixed installation can be a complex issue, requiring a level of overall knowledge and control of the installation that most contractors do not have – or are not permitted to have (especially a problem when a contractor is required just to work on a modification).

3.9 EMC skill requirements

Unfortunately for the level of EMC skills required to be applied by (or on behalf of) Responsible Persons, the compliance of a fixed installation can easily become complex, for example…

- Suppliers' instructions can be contradictory, often requiring significant EMC expertise to resolve the conflict using good EMC engineering practices
- The emissions from large numbers of individually EMC compliant items of equipment can build up to cause serious interference problems, especially: variable-speed motor drives; variable-power heaters; electronically-controlled luminaires; low-energy lightning; data communication systems, wireless communication systems; etc.

For example, Figure 4 shows an example of the control cubicle for a modern sausage-manufacturing machine. Machines incorporating variable-speed AC or DC motor drives almost always require very careful design, construction, installation and maintenance in order to be EMC compliant.

Figure 4 Example of a Fixed Installation that has very complex EMC issues

Example of (part of) a complex fixed installation…

The control cubicle for the sausage machine installed at Stork Townsend B.V., The Netherlands, in 2006

**10 metres long;
60 variable speed drives;
18 multi-axis servo drives**

The large cabinet housing the control system takes care of the 60 variable speed motors and 18 servo drives. In the nearest cabinet are two rows of Kinetix servo drives; the red units below them are safety relays.

Figure 4 Example of a Fixed Installation that has very complex EMC issues

3.9.1 Issues with CE-marked apparatus

The second bullet in the list above is of particular concern. Aggregation of emissions *always* happens, in any real system or installation, but the emissions limits for a site are no different from the emissions limits for an item of equipment.

Where there are many identical items of equipment, their emissions will all fall into the same frequency bands, so since their manufacturers will generally have cut costs by just 'scraping-in' under the emissions limits, so it is likely that just two or more will have emissions that are above the limits.

However, where there are two or more *different* items of equipment, in the past it has been generally the case that their highest emissions occurred at different discrete (narrow) frequencies, so the effect was to make the spectrum of emissions from the site 'busier', rather than higher in level.

However, the modern trend is to use spread-spectrum techniques that 'smear' an equipment's emissions over a wider band, in some cases (e.g. broadband over powerline, BPL, also known as power-line communications, PLC, or power-line technology, PLT) over tens of MHz all at the same time. No discrete (narrow) frequencies can be discerned in their emissions spectrum. These techniques are used in digital processors, switch-mode power converters, and data communications (both wired and wireless), to enhance performance whilst complying with EMC standards at the lowest cost.

So what will happen is that modern equipment using spread-spectrum techniques will have their aggregate emissions add-up and increase the level, as if they were identical items of equipment. Their emissions spectrum will already be very 'busy', so increasing their number will make little difference to spectrum crowding, but the overall emissions level will increase.

Unfortunately, existing emissions standards assume a certain 'diversity' of emissions, such as was common in the past but is becoming rarer and may disappear completely. The standards process cannot keep pace with technology, and all electronic manufacturers are strongly driven to reduce their costs.

So it is reasonably foreseeable, even likely, that modern and future systems and installations will cause much more interference than was normal in the past, even though the equipment they are constructed from individually complies with their emissions standards.

To complicate matters still further, the harmonised EMC standards that are used to CE mark apparatus make certain assumptions that are often not true in real-life installations, for example they assume that:

- Personal hand-held cellphones and walkie-talkies are not used nearby (but they always are, in real life)
- Group 2 ISM equipment is not used nearby (but it can be, in real life)
- Powerful vehicle-mobile transmitters (e.g. police, ambulance, fire, taxi, etc.) are not used nearby (but they can cause problems, in real life, if a vehicle can get within 10 metres, and typical walls present little barrier to their signals).
- All vehicle-mobile radio transmitters operate within legal power ratings. However, it is known that some long-distance commercial vehicles (trucks, juggernaughts, etc.) are fitted with illegal CB radio transmitters rated at 1kW or more, allowing them to communicate with their bases across whole continents. The very high levels of emissions from these have been implicated in bus crashes in Japan (see No. 331 in [21]), and several other incidents, and they could be a concern if an installation is situated close to a route of depot used by long-distance hauliers.
- Overvoltage surges on the mains supply are no higher than ±2kV (but ±6kV or more is widely known to occur on single-phase installations in real life, see [22], and ±12kV or more can occur on three-phase systems that have no single phase mains sockets or equipment connected.)
- Electrostatic discharge (ESD) occurs up to 8kV (but >15kV can occur during periods of low humidity (see IEC 61000-4-2) and 25kV or more has been reported in a number of facilities including hospitals (see No. 418 in [21]).)
- That only one EM phenomenon occurs at a time (not true in real life). [23] shows that apparatus that passes each of its 'CE' immunity tests individually, can fail very easily when two EM disturbances at the same or lower levels occur at the same time.
- Some EM phenomena can be ignored (e.g. continuous EM disturbances between 50Hz and 150kHz, and above 1GHz) – which might not be the case for certain installations
- EMC performance does not vary with ambient temperature (but it does, see [24])
- EMC performance does not vary with ageing and wear-and-tear caused by the physical environment (but it always degrades over time, see [25])
- There is no electric arc welding taking place nearby (but it can be, during modification or maintenance works)

Other concerns about the suitability of the 'CE-marking' EMC test standards for real-life applications exist, and some of them are expressed in [26].

For example, and considering Figure 4, the EMC standard for motor drives, IEC/EN 61800-3, that is listed as providing a 'presumption of conformity' under the EMC Directive, can be less than helpful to end-users trying to make their Fixed Installations EMC Compliant. Soon after its initial publication, the European Association of Competent Bodies (renamed the European Association of Notified Bodies under 2004/108/EC) requested that the European Commission (EC) withdraw this standard from being listed under the EMC Directive.

This (and similar) requests were not successful, but eventually the EC did appoint an EMC expert whose job, amongst others, was to approve or reject IEC and EN standards for listing under the EMC Directive. Different experts have different views, for example one EC EMC Consultant thought that the EN 550121 series of EMC standards for railway equipment and installations did not provide sufficient protection for listing under the EMC Directive (a view shared by many other experts, including this author), but when he was replaced by a different expert the 550121 series was suddenly approved and listed under the EMC Directive without any modifications.

Equipment that fully meets harmonised EMC standards can still cause or suffer significant EM interference. Excessive levels of EM emissions are especially likely from electric traction (trams, trains, cars), and Group 2 ISM equipment under EN 55011 (CISPR 11) [27], e.g. diathermic heating devices, plastic bag sealers, glue dryers, microwave heaters/cookers/dryers, induction heaters, electromagnetic stirrers, electric welders, etc.

Group 2 [27] allows very high levels of emissions at the 'ISM' frequencies – a number of narrow frequency bands that are not used for broadcasting or licensed radiocommunications, set aside by international agreement for use by industry, science and medicine (hence: 'ISM') so that they can use high-power radio-frequency (RF) equipment without interfering with radio and TV reception over large areas. But the emissions from [27] Group 2 that is legitimately 'CE-marked' under the EMC Directive could be so high in its vicinity as to cause hazards to human health (see 2.2.2) and to interfere with almost any electronic equipment.

It is also notable that some of the ISM bands are now being used for unlicensed communications, in particular the 2.4GHz band is being extensively used by Wi-Fi, Bluetooth, ZigBee, and a number of other low-cost wireless data and voice communication systems. At the time of writing, many industries and healthcare are enthusiastically embracing these wireless systems, using them in place of wired datacommunications because they cost less.

Many people have experienced problems with their domestic Wi-Fi when their microwave cooker (a Group 2 ISM apparatus) operates. But more powerful Group 2 ISM equipment is capable of wiping out these new ISM-band wireless systems over large areas – and the fact that this is perfectly legal is no comfort to those whose wireless LANS and Bluetooth or ZigBee systems no longer function.

3.9.2 Issues with bespoke or custom-manufactured apparatus

Note that it makes no difference to a supplier of the bespoke or custom-manufactured apparatus, whether its end-user will treat it as a fixed installation in its own right, or as a part of a fixed installation.

This 'reduced compliance regime' works best when the Responsible Person engages with the supplier of the bespoke or custom-manufactured equipment, to define its overall EMC Product Specification so that it will not cause his/her fixed installation to fail to comply with its legal obligations under the EMC Directive.

For example, imagine a large site on which several different projects are on-going at the same time, all provided by different suppliers (or different project teams working for the same supplier).

They may each measure the EM environment of the site, and specify their final product to 'use up' whatever margin there is between the existing emissions of the site, and the limits beyond which significant interference will occur, with the potential to trigger complaints and even cause enforcement action against the site (e.g. partial or total shut-down, in the extreme).

Because the different projects are run by different people or organisations, they will probably not coordinate their EMC specifications, so it is foreseeable that when all of the projects are commissioned, the total site emissions could exceed the limits and causes significant interference.

It should be understood that emissions from a site can have serious safety consequences, for example when they interfere with safety radio services. It should also be understood that the normal methods of measuring site emissions (e.g. CISPR 11) are very poor indeed at determining what emissions are radiated vertically, and so might interfere with aircraft flying above the site. So ensuring that emissions are low enough can have significant ethical, liability and financial implications.

For this reason, it is strongly recommended that whenever a supplier to a fixed installation employs the 'reduced compliance regime' available to him under 2004/108/EC for bespoke and custom-manufactured apparatus, they do it with the full cooperation of the Responsible Person, who agrees and signs the overall EMC Product Specification for that apparatus, before design commences.

All of the above (and more) are issues that EMC consultants worldwide are often employed in solving – actual problems in real-life systems and installations. They exemplify some of the reasons why simply relying on suppliers providing products that comply with the EMC Directive, and following their EMC instructions, is not necessarily sufficient to ensure compliance for a fixed installation. The situation will only get worse as increasing amounts of more sophisticated electronics and power-control are used in installations, and as the EM environment continues to worsen and power quality continues to degrade.

3.10 Documenting EMC compliance

There are no EMC standards for fixed installations listed under 2004/108/EC, for emissions or immunity. However, the [27] test method is specified for 'in-situ' measurements of the emissions from items of large industrial 'ISM' equipment (see 2.3.9) after installation, and is sometimes used for assessing the emissions

from an entire installation at the boundary of its site. DD CLC/TS 50217 [28] is a draft CENELEC Technical Specification that can also be helpful for measurements of an installation's emissions. It is *possible* (though not considered to be very likely) that some appropriate standards for measuring the emissions and immunity of a fixed installation could be created in the future and listed under 2004/108/EC.

Where a simple fixed installation consists solely of apparatus (placed on the EU market for an end-user, conforming to the EMC Directive, carrying the CE-marking), the Responsible Person *might* be able to satisfy the documentation requirements simply by retaining the EMC instructions for installation, use and maintenance, provided by the suppliers, and keeping records that show these instructions were followed using good EMC engineering practices.

But the provision of such user EMC instructions is a new requirement for apparatus in 2004/108/EC, and until 20th July 2009 types of equipment that were already on sale in the EU can continue to be legally sold as compliant with the 1st Edition EMC Directive (89/336/EEC as modified) *without* such instructions. So this Guide recommends that potential suppliers are asked about the availability of comprehensive EMC installation and use instructions as part of the process of deciding which apparatus to purchase.

As discussed in 2.3.9, EMC issues can become very complicated. The good practices described in this Guide can deal with all of those issues, and the compliance documentation should show how the issues were identified during the design process and realised in practice.

There are no mandatory requirements for the types of documentation that the Responsible Person must keep but (except for the simplest systems) it should show how sufficient confidence in complying with the Protection Requirements, was achieved, for example by…

- Knowledge of the EM environment (assessments, calculations, site measurements, etc.)
- Knowledge of the EM characteristics of the equipment incorporated into the installation
- Use of EM mitigation measures (shielding, filtering, etc.)
- Calculations, site measurements, etc.,

and the use of good EMC engineering practices must be documented, for example by…

- Retaining all of the EMC assembly/installation/operation instructions received from suppliers
- Reference to other specifications describing appropriate good EMC engineering practices
- Records of inspections, photographs, etc., showing that the specified practices were followed

The form in which compliance documentation should be kept is not specified, but this Guide assumes that graphics and text files on a computer system would be appropriate, as long as they can quickly be displayed or printed out for the benefit of an enforcement officer, and presumably reliably backed-up off-site.

Since the compliance documentation has to be kept available for the operational life of the installation, which could be decades, the ability to read the computer records many years after their creation is important. So either old systems that can read them should be maintained, or the data converted (without errors) to new versions or formats of computer software as necessary to keep them readable on current systems.

3.11 Enforcement possibilities

If the EMC of the fixed installation is suspect, or if complaints of interference are received, the national EMC authorities may request evidence of compliance (probably assessing the Responsible Person's documentation), or initiate an investigation (probably actual measurements of the site's emissions or immunity).

Where non-compliance is established, the authorities may impose measures to bring the fixed installation into compliance with the essential requirements. This could simply mean switching the offending installation off, until such time as it has been modified and can be shown to be compliant – an enforcement action that has already been taken a number of times in the past, in the UK at least, when installations caused troublesome interference problems outside their site boundaries.

3.12 The continuing compliance of fixed installations

Some installations are located remotely, which helps them avoid suffering/causing interference. But what if – in the future – radio, telecomm or other equipment is used nearby? For example, if a housing estate, commercial park, entertainment venue, sporting arena, industrial development or public road is built nearby?

Modifying a fixed installation to reduce its emissions can be very costly indeed, with a long downtime and huge loss of production. So should installations comply with all such possible future requirements when they are first constructed, so as not to have to be modified later on in case of such developments? Or is it acceptable to rely on remote locations to prevent interference from 'noisy' installations, even if they do not own sufficient area of land all around them to ensure that this happy situation is maintained for the operational life?

The EM environment will inevitably change over time. It changed dramatically during the 1990's with the rollout of GSM cellphone systems, and in the UK it changed during 2005-7 due to the rollout of the TETRA communications system. Both of these roll-outs caused significant interference problems to a variety of existing electronic equipment, now mostly solved (but paid for by the people who suffered the interference). In the near future we will see the large-scale rollout of Wi-Fi at 2.4 and 5-6GHz, with some cities going for metropolitan coverage instead of a few 'hot spots' in cafés and the like.

Other roll-outs in the pipeline include WiMAX, 4G cellphone systems, and the large-scale use of switch-mode power conversion in industry and in all motorised household appliances to save energy (and hopefully the planet) – which will considerably increase the levels of electromagnetic disturbances at RF on the public 230/400V mains supplies.

Further into the future, changes to the way that the radio spectrum is licensed are looking likely, allowing the use of software-defined and cognitive radio systems, so that radio 'channels' will no longer use fixed frequencies. This will allow a much greater volume of radio and TV transmissions to be fitted into the RF spectrum – with all sorts of hard-to-predict implications for interference.

As equipment wears and ages its EM performance (e.g. shielding, filtering, surge suppression) generally degrades, but fixed installations must continue to comply with 2004/108/EC throughout their life.

3.13 Purchasing a building, plant or site containing Fixed Installation(s)

When a site, plant or building is sold to a different end-user, the new owner's Responsible Persons become responsible for all of the good EMC engineering practices of their fixed installations and all of their EMC compliance documentation since the 20th July 2007 [19].

For any given Fixed Installation there is a good chance that the EMC compliance documentation will not be complete, or that it will not have been done with the attention to detail required by its new Responsible Person.

So, to help avoid taking on unknown financial risks when purchasing a building, plant or site, it is strongly recommended that the EMC compliance documentation is checked thoroughly *prior to purchase*. Where the documentation is poor, the prospective purchaser might want to offer a lower price, to allow for the financial risk.

4 Architects, consultants and M&E Contractors

This Guide recommends that architects, electrical consultants and M&E contractors discuss the following, with the Responsible Person for the fixed installation they are working on, *before quoting for the work*:

- What EMC activities they are required to perform
- What EMC information on the existing installation they will be provided with, what must they find out for themselves, and what they are not permitted to know
- What EMC documents they are required to provide at the end of the contract
- How much they will be paid for the extra EMC work covered by the above three bullets

There is a lot of competition in consultancy and contracting, which tends to drive down prices; so many consultants and contractors might be unwilling to follow the above recommendation for fear of being undercut by someone who ignores EMC issues.

So this Guide recommends that quotes contain two prices: one being the price following the usual pricing rules already established that ignore good EMC engineering practices and compliance with 2004/108/EC, and the other with the good practices and their documentation included. Then the customer can see that the quote is competitive in the 'usual' way, and also see what he has to pay if he wants the added EMC services.

The problem is that some Responsible Persons will assume that 2004/108/EC applies to their consultants and/or M&E contractors (it doesn't) and so will assume that any quoted price includes all the necessary good EMC Engineering practices and provision of EMC documentation. This will mean that these service providers could face great difficulties in getting paid; when it turns out they have no EMC documentation to provide at the end.

So it is best to get all this sort of nonsense out of the way before accepting a contract. If the customer says he wants things doing the 'usual' way – ignoring good EMC engineering practices – then the 'usual' pricing rules apply. But if the customer wants good EMC engineering applying and additional documentation providing, he must be prepared to pay for the extra work. The good news (such as it is) is that the Responsible Person is the only one held responsible under the law for ensuring that good EMC engineering practices 'having regard to the state of the art' are employed on their fixed installation.

So, if a consultant or contractor does *not* employ good EMC engineering practices in his work, whatever his contract with his customer he *cannot* be held liable under 2004/108/EC or the UK's 2006 EMC Reg's. However, the customer always has the option of suing the contractor, if he feels the work was not performed to the agreed specification.

Offering the Responsible Person EMC compliance services under 2004/108/EC provides an opportunity for the many professional M&E Contractors to distinguish themselves from their less-professional competitors, sometimes known as 'cowboys'.

The problem with the less professional contractors is that because they are not so highly trained, competent, well-equipped, or knowledgeable about standards and regulations that apply, they can quote much lower prices – and some customers are bound to employ them (although they may regret it later on). The presence of such people in the market depresses prices generally, making it hard for the proper professional contractors to get a reasonable rate for the services they provide, in turn making it harder for them to maintain their professionalism at the level that customers actually need.

At the time of writing, the vast majority of the owners of fixed installations are unaware even of the existence of 2004/108/EC, much less their legal duties under it. If contractors discuss their new EMC responsibilities with them, some will decide to purchase the additional good EMC engineering practice services offered by the more professional contractors despite the increased costs, and this might also reduce the cowboys' incomes and hopefully reduce their numbers.

Increasingly, contractors are undertaking facilities management, so it seems possible that they might be appointed as the Responsible Person for the fixed installations they manage.

5 Apparatus intended for incorporation into a fixed installation

The apparatus used in a fixed installation could be apparatus as defined in 2004/108/EC that is placed on the EU market with a DoC and CE-marking.

But it could be apparatus specially made for that installation (typically: custom-engineered, bespoke, etc.) and 'not otherwise commercially available to an end-user as a single functional unit' (meaning that it cannot be purchased from a shop, warehouse, or a catalogue – it has to be made to special order for each installation).

5.1 CE-marked apparatus

A potential problem is that this apparatus may not have been intended for use in the EM environment that obtains in the fixed installation, for example, a desktop or laptop PC used to control a heavy-industrial process will probably not be immune enough (even if the PC is put in a steel box for mechanical protection).

Another problem is that individually compliant apparatus might still cause interference problems within or outside a fixed installation, for example, if:

- The apparatus is very noisy Group 2 ISM equipment under EN 55011 [27]
- Two or more items of apparatus are used and their emissions aggregate
- The apparatus is used in a way that is not specifically addressed by its manufacturer's EMC installation and use instructions

The Responsible Person should make sure that the EMC compliance of the fixed installation is not compromised by purchased items of apparatus. He or she should be aware of the EM environment of their fixed installation and take necessary steps, not simply assume that because it is CE-marked it can be used without any additional EMC assessment or work.

5.2 Equipment custom-manufactured for a fixed installation

2004/108/EC [1] and its Guide [8] calls this type of equipment: "Apparatus intended for incorporation into a specified fixed installation and not otherwise commercially available to an end-user as a single functional unit." – but this was too long for a title. [4] and [9] call it 'certain equipment'.

According to the EC's Guide, for such 'bespoke' or 'custom-manufactured' apparatus there will always be a direct relationship between its provider and its final customer. For such apparatus, the manufacturer can choose to apply a 'reduced compliance regime' (see Figure 3) that does not require:

- Compliance with any essential requirements
- Any conformity assessment procedure
- A DoC to be created or the CE-marking to be affixed
  (but these may be needed by other Directives, e.g. the LVD [16])

But all such equipment must be provided to their end user with documents that:

- Identify the fixed installation it is intended for (e.g. by its street address)
- Identify the EMC characteristics of the fixed installation it is intended for
- Indicate the precautions to be taken when incorporating it into the fixed installation so that it does not compromise the installation's compliance
- Uniquely identify the item (e.g. its serial number)
- Give its manufacturer's name and address (or that of its agent or EU importer)

How much detail should the supplier's documentation go into? The EC's Guide gives these examples of information that should be provided:

- The required use of additional auxiliary devices (e.g. protection devices, filters etc.)
- The specifications and length of the cables required for external connections (and their connectors)
- The conditions for use (e.g. limits for proximity of walkie-talkies, cellphones, ISM equipment, etc.)
- Any special precautions for EMC (e.g. meshed bonding, etc.)

The UK's Guide adds that the supplier must understand the nature of the fixed installation in sufficient detail to specify the precautions for incorporation to avoid compromising its EMC compliance.

However, it is important to understand that there is no obligation on the part of the owner or operator of the fixed installation, or of its Responsible Person, to provide any EMC information at all to anyone who is not from the EMC enforcement authorities. So they might deny the supplier the information he needs to use this reduced compliance regime.

Where it is impossible or impractical to determine the EM characteristics of the fixed installation in sufficient detail, the supplier of the custom equipment should apply the usual compliance regime to his apparatus, as if it was going to be sold through a high-street shop (Conformity Assessment, DoC, CE-marking, etc.).

The author has heard of some companies who manufacture custom-engineered equipment or systems, who intend to supply them to their end-users by treating them as fixed installations. But [19] made it quite plain that this is not a legal option.

Anything that is supplied to an end-user must either follow the compliance route that is specified in [1] and [4] for apparatus (not discussed here, but see [29]) or else the compliance route for 'apparatus intended for incorporation into a specified fixed installation and not otherwise commercially available to an end-user as a single functional unit' – what [4] calls 'certain apparatus'. There are *no* alternatives.

5.3 Apparatus constructed professionally for 'own use'

According to the EC's Guide: if a company makes an item of equipment for its own use, then they are both manufacturer *and* end-user, so it is classified as either an 'other device, or as an apparatus – in which case all of the requirements of 2004/108/EC apply depending on whether it is classified as an 'apparatus', or as an 'apparatus intended for a fixed installation and not otherwise commercially available'.

6 References

[1] European Union Directive 2004/108/EC (as amended) on Electromagnetic Compatibility (2nd Edition) in English:
http://eur-lex.europa.eu/LexUriServ/site/en/oj/2004/l_390/l_39020041231en00240037.pdf
in any EU language: http://ec.europa.eu/enterprise/electr_equipment/emc/directiv/dir2004_108.htm

The Directive's official EU homepage includes a downloadable version of the current EMC Directive and its successor; a table of all the EN standards listed under the Directive; a guidance document on how to apply the Directive; lists of appointed EMC Competent Bodies; etc., all at:
http://europa.eu.int/comm/enterprise/electr_equipment/emc/index.htm.

[2] IEC 60364-4-44:2006 "*Electrical installations of buildings – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*", Clause 444: "*Measures against electromagnetic influences*"

[3] BS EN 62305:2006, "*Protection Against Lightning*", in four parts. It is identical to EN 62305:2006 and also to Parts 1, 2 and 4 of IEC 62305:2006. BS EN 62305-3 is essentially the same as IEC 62305-3, except for some common modifications.

[4] The EMC Regulations 2006, United Kingdom Statutory Instrument 2006 No. 3418:
http://www.opsi.gov.uk/si/si2006/uksi_20063418_en.pdf

[5] The IET's guide on EMC and Functional Safety, from:
http://www.theiet.org/publicaffairs/sectorpanels/emc/index.cfm

[6] "*List of Resources on EMC and Functional Safety*", The IET,
http://www.iee.org/OnComms/PN/emc/EMCandFunctionalSafety.cfm

[7] "*Reducing Risks, Protecting People*", the Health & Safety Executive (HSE) 2001, HSE Books, ISBN 0 7176 2151 0, available from www.hseboooks.co.uk. The 'HSE InfoLine' is another source of information, via www.hse.gov.uk.

[8] The EC's official Guide to 2004/108/EC can be downloaded from:
http://ec.europa.eu/enterprise/sectors/electrical/files/emc_guide__updated_20100208_v3_en.pdf

or http://ec.europa.eu/enterprise/electr_equipment/emc/directiv/dir2004_108.htm#guide

[9] The UK's official guide to the 2006 EMC Regulations is posted under 'Related Documents' at:
http://www.berr.gov.uk/whatwedo/sectors/sustainability/regulations/ecdirect/page12469.html

[10] The EC's 'Blue Guide', "Guide to the Implementation of Directives Based on the New Approach and the Global Approach", 2000:
http://ec.europa.eu/enterprise/newapproach/legislation/guide/index.htm, also (English only) from:
http://ec.europa.eu/enterprise/newapproach/legislation/guide/document/1999_1282_en.pdf

[11] The Product Liability Directive, 85/374/EEC amended by 99/34/EC, implemented in the UK as the Consumer Protection Act 1987, http://europa.eu/scadplus/leg/en/lvb/l32012.htm, http://www.dti.gov.uk/files/file22866.pdf

[12] IEC 61508: "*Functional Safety of Electrical, Electronic and Programmable Electronic Systems*" (seven parts)

[13] IEC 61511: "*Functional safety: Safety instrumented systems for the process industry sector*"

[14] IEC 62061: "*Safety of Machinery – Functional safety of electrical, electronic and programmable control systems for machinery*"

[15] The 'Machinery Safety Directive': "*Directive 98/37/EC of the European Parliament and of the Council of 22 June 1998 on the approximation of the laws of the Member States relating to machinery*"

The new Machinery Safety Directive: "Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)"

[16] The consolidated version of the Low Voltage Directive, 2006/95/EC, replaces 73/23/EEC and its amendment by 93/68/EEC, http://europa.eu.int/comm/enterprise/electr_equipment/lv/index.htm

[17] IEC TS 61000-1-2, basic safety publication, draft second edition, January 2008, "*Electromagnetic Compatibility (EMC) – Part 1-2: General – Methodology for the achievement of the functional safety of electrical and electronic equipment with regard to electromagnetic phenomena*."

[18] "*CE + CE does not equal CE – what to do instead*" available from the 'Publications and Downloads' pages at www.cherryclough.com

[19] From the BERR/EMCTLA/EMCIA meeting held at the Newbury Hilton, 29th Nov 07, at which BERR's EMC consultants responded to a series of questions about how to interpret the UK's 2006 EMC Regulations.

[20] "*The Future of Market Surveillance for Technical Products in Europe*", Ivan Hendrikx, Conformity, Apr 1, 2007, www.conformity.com.

[21] "The First 500 Banana Skins", Nutwood UK, 2007. This amazing little book summarises 500 published reports and anecdotes on interference events, and costs about £10. Read it at www.theemcjournal.com, or buy from www.emcacademy.org/books.asp (approximately £10).

More 'Banana Skins' are published 6 times a year in 'The EMC Journal', available free at www.theemcjournal.com or www.compliance-club.com

[22] BS EN 50160:2000, "*Voltage characteristics of electricity supplied by public distribution systems*"

[23] "*Combined Effects of Several, Simultaneous, EMI Couplings*", Michel Mardiguian, 2000 IEEE International Symposium on EMC, Washington D.C., August 21-25 2000, ISBN 0-7803-5680-2, pp. 181-184

[24] "*EMC Performance of Drive Application Under Real Load Condition*", F Beck and J Sroka, Schaffner EMV AG application note, 11th March 1999

[25] "*The Case for Combining EMC and Environmental Testing*", W H Parker, W Tustin and T Masone, ITEM 2002, pp 54-60, http://www.interferencetechnology.com

[26] "*Breaking All the Rules: Challenging the Engineering and Regulatory Precepts of Electromagnetic Compatibility*", D A Townsend et al, 1995 IEEE International Symposium on Electromagnetic Compatibility, Atlanta, 1995, pp 194 – 199.

[27] BS EN 55011:2007 (CISPR11 Am2 Ed. 4.0:2006) "*Industrial, scientific and medical (ISM) radio-frequency equipment - Electromagnetic disturbance characteristics - Limits and methods of measurement*". The scope of this standard includes: Interference relating to industrial, scientific and medical radio-frequency apparatus, other (high power) industrial equipment, overhead power lines, high voltage equipment and electric traction. At the time of writing (August 2007) the 5th Edition of CISPR11 has been finalised and will be published very soon.

[28] DD CLC/TS 50217:2005, "*Guide for in situ measurements – In situ measurements of disturbance emission*", Cenelec Technical Specification CLC/TS 50217:2005, published by British Standards Institution as a draft for development (DD). A Technical Specification (TS) is not a standard, but it is considered to be a proposal for a standard that needs further experience with its use before a final version could be agreed. However, in the absence of a relevant standard, a TS can be used as an expression of the present state-of-the-art for the issues within its scope.

[29] "*Complying with the EMC Directive (2004/108/EC) Second Edition*", Keith Armstrong, Conformity, March 2008, pp 12-23, www.conformity.com.

EN and IEC standards may be purchased from British Standards Institution (BSI) at: orders@bsi-global.com. To enquire about a product or service call BSI Customer Services on +44 (0)20 8996 9001 or e-mail them at cservices@bsi-global.com. IEC standards can also be purchased with a credit card, in English and many other languages, from http://webstore@iec.ch.