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2004/108/EC: Systems, Installations and Good Engineering Practices

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1 Introduction

There has always been confusion about how the original Electromagnetic Compatibility (EMC) Directive 89/336/EEC [1] should be applied to systems and installations, and to equipment made specifically for them. Dispelling this confusion was a main aim of the European Commission’s (EC’s) 1997 Guide on the EMC Directive [2], but as this was not a legal document it did not change the EMC Directive, or the national implementing legislation in the European Union (EU) Member States.

2004/108/EC [3] is the 2nd Edition of the EMC Directive, and one of its major differences from 89/336 is that it includes specific requirements for installations, and for equipment that is sold directly for them (and not available to just anyone).

This article is concerned with the details of how 2004/108 will apply to systems and fixed installations, and to equipment intended for use in them. It discusses some ‘grey areas’, and the EMC competency that will be needed to achieve compliance.

It concludes that because of the need for a huge increase in EMC competency in the organisations involved with installations, and the equipment intended for them, it is likely that only a very few installations will be able to demonstrate compliance with 2004/108 for many years after 20th July 2007, when it first starts to apply.

2 Some background to 2004/108 and its Guides

All legal documents such as Directives are open to interpretation, and the EC intended to produce a guide to 2004/108 before most EU Member States had drafted their national laws implementing this new Directive, so that they could write their laws with a complete understanding of what 2004/108 was *supposed* to mean. What I understand is meant to be the 'final draft' of this EC Guide [4] was published on the 3rd August 2006, and it includes explanations of how the Directive is supposed to be applied to systems, installations, and equipment supplied only for them.

The draft UK Statutory Instrument implementing 2004/108 has also been published (Annex B of [5]) along with a draft Guide to this UK law (Annex C of [5]) that also includes explanations of how it applies to such equipment. All these documents are taken into account in this article, although it should be understood that they are only drafts at the time of writing and their final versions could be different.

"*Inherently benign equipment*" is excluded from the scope of 2004/108, whether it is an apparatus, system or fixed installation. The draft EC Guide [4] contains a list of what is currently considered to be inherently benign, including: cables, connectors, batteries (except 'smart' batteries), headphones, loudspeakers, circuit breakers, fuses, filament lamps, antennas, resistive loads, certain types of high-voltage equipment, etc., and systems/installations constructed entirely from such components.

Inherently benign equipment can never contain any semiconductors (rectifiers, transistors, ICs, MOVs, etc.).

The draft EC Guide [4] does not say so, but I would expect that inherently benign equipment also cannot contain any thermionic valves, klystrons, magnetrons, and the like. I am surprised that loudspeakers are included in the list of benign equipment, because it is known that they can suffer significant interference from magnetic fields at powerline and audio frequencies at levels sometimes as low as 1A/m [6].

The Technical Construction File (TCF) route in 89/336 does not exist in 2004/108, and EMC Competent Bodies will become obsolete on the 20th July 2007. EMC Notified Bodies, whose involvement in the compliance process is entirely optional, at the supplier's discretion, will replace them. It is important to note that as a result, under 2004/108 there will be no mandatory requirement to ever involve any third party, whether they are a test laboratory, Competent Body or Notified Body, with the EMC compliance of any equipment, whether it is an apparatus, system or installation.

2004/108 applies to "equipment" that is "*placed on the market*" for an end-user, or "*put into service*" by or for an end-user. Placed on the market is not defined in 2004/108, but it is defined in section 2.3 of the EC's 2000 Blue Guide [7] as: "…making something commercially available as a single functional unit intended for an end-user in the EU.". The action of putting into service (sometimes called taking into service) is not defined in 2004/108 either, but is defined in section 3.2 of the Blue Guide as taking place at the moment of first use within the EU by its end-user.

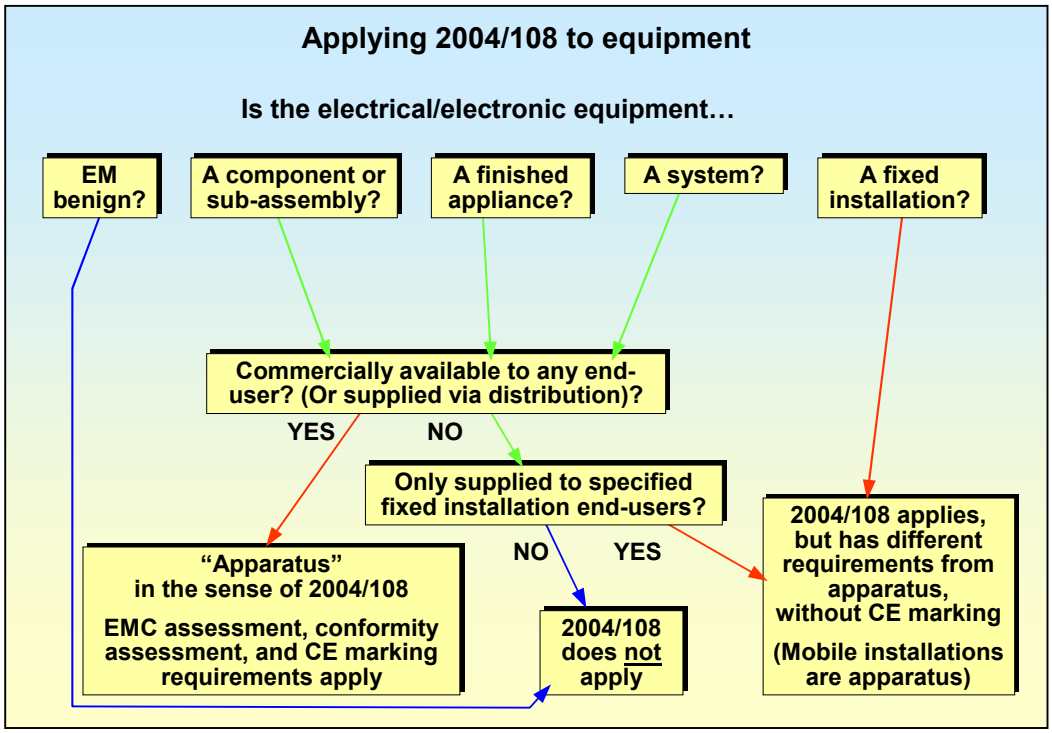
2004/108 splits *equipment* into two categories: "*apparatus*" and "*fixed installations*", and applies different compliance requirements to each. Like many other legal documents, it uses some common words in specific ways, including "*apparatus*", and "*fixed installation*". These compliance requirements, and the difficulties I see with them, are discussed below.

3 Apparatus

In 2004/108, "*apparatus*" means finished appliances that are made available to end-users. The draft EC Guide [4] says that an apparatus or finished appliance is any device or unit that delivers a function and has its own enclosure. We might also call these: finished products, finished goods, etc., and they are usually considered to be volume-manufactured electrical/electronic goods sold through retail shops, distributors, and in other ways that do not control who acquires them – so they can find themselves in the hands of end-users who have no EMC competency.

Companies and organisations that supply apparatus to end-users under their own name are required to perform an EMC assessment and a conformity assessment, then create a Technical File that shows how these assessments, and the installation and use instructions provided with their products, ensure that they comply with the essential legal Protection Requirements of 2004/108. All this must be done before creating and signing a Declaration of Conformity to 2004/108, affixing the CE marking to the product and making it available to end-users.

This article is not concerned with apparatus, and instead focuses on systems and installations – and also on equipment that is supplied for use only in fixed installations, that 2004/108 does not consider to be apparatus.



4 Fixed Installations

End-users create all sorts of installations for their own use, for example domestic multi-media installations in private houses. But if they are not doing it professionally, and if they only use apparatus that is compliant with the EMC Directive and use it as intended by its suppliers – then 2004/108 requires no further conformity assessment or other EMC actions. Non-professional end-users cannot be expected to be competent in EMC engineering, and this is exactly why the conformity requirements for apparatus (see above) are so thorough.

However, the EC expects professional installers to be competent in all areas that concern compliance with the applicable Directives. I believe that this is a problem, because in my experience most professional installers have little or no EMC knowledge or competency, and so far I have not seen any evidence that they are trying to acquire it so as to be ready for the 20th July 2007, when 2004/108 starts to apply to their work.

Fixed installations are defined in 2004/108 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 installations to national electrical and telephone networks, and includes all commercial and industrial installations.

The draft EC Guide [4] includes the following examples of fixed installations:

industrial and power plants;
power supply, telecommunication, cable TV and computer networks;
airport luggage handling installation;
airport runway lighting installation;
automatic warehouse;
skating hall ice rink machinery installation;
storm surge barriers (with control room etc.);

ship elevator;
wind turbine stations;
car assembly plant;
water pumping stations;
water treatment plants;
railway infrastructures.

A fixed installation is one that is: "…*intended to be used permanently at a predefined location…*" – but 'used permanently' does not mean that it is in continual operation (which never happens in real life anyway) – the draft EC Guide [4] and the draft UK Guide (Annex 3 of [5]) both say that this phrase means that it was constructed with the intention of being permanently located at a predefined location.

Note that the definition of a fixed installation does not mention anything about placing on the market, or taking into service, thereby avoiding some of the problems with 89/336.

Note also that there is no 'transition period' for fixed installations – they must comply with 2004/108 from the 20th July 2007. Since many larger fixed installations can take more than one year to design, construct and commission – there are many projects due for completion in 2007 and 2008 that should already be taking the requirements of 2004/108 fully into account to be able to demonstrate compliance to 2004/108 when they are completed. My impression is that most, if not all such projects are currently ignoring 2004/108 – or else have not properly understood what the requirements of 2004/108 are, especially the requirement to employ good EMC engineering practices (see below).

Fixed installations must comply with 2004/108's "Protection Requirements", which are:
"*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."

These are very similar to the Protection Requirements used by 89/336. The wording of the emissions and immunity requirements has been clarified, but does not change their intended meaning from that of 89/336. But the "…*having regard to the state of the art…"* requirement is new in 2004/108, and could have significant implications for the compliance of fixed installations.

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, or initiate an investigation. Where non-compliance is established, the authorities: "*…may impose measures to bring the fixed installation into compliance with the Protection Requirements*" – which I understand based on previous enforcement actions in the UK can include switching the entire installation off, until such time as it can be shown by on-site EMC tests to be compliant.

Unlike apparatus (see above), fixed installations are not required to have:

- An EMC assessment;
- A conformity assessment;
- An EC declaration of conformity;
- The CE marking affixed.

However, 2004/108 does require fixed installations to follow a regime that demonstrates compliance with its Protection Requirements, by:

a) Following the installation and use instructions required to be provided with apparatus (see above)

b) Following the installation and use instructions required to be provided with equipment that is not placed on the market and is supplied only to specified fixed installations (see later)

c) The application of good EMC engineering practices to the fixed installation, having regard to the state of the art

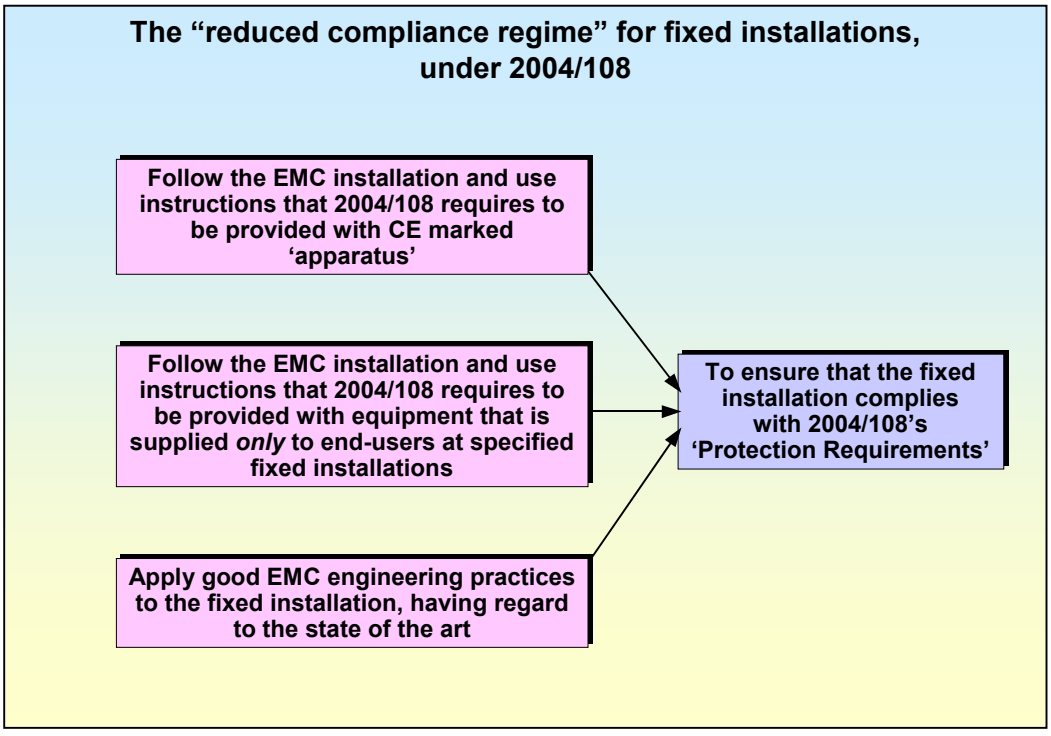
2004/108 requires apparatus to be provided with all of the EMC instructions or precautions necessary to ensure that, when put into service, the apparatus is in conformity with the Protection Requirements. But a fixed installation might include a number of similar or identical items of equipment, and because their

emissions can add up to increase the emissions from the installation at a given frequency, simply ensuring that each item of equipment complies on its own cannot ensure that the fixed installation will comply [8]. Competency in good EMC engineering practices is required to identify such situations, and to successfully deal with them.

Also, apparatus that fully complies with all relevant EMC standards and has the CE marking legally affixed could have emissions that are too high for some fixed installations (e.g. recording studios, scientific laboratories, close proximity of GPS receivers, etc.) and/or will have immunity that is insufficient for many EM environments (e.g. close proximity of cellphones, walkie talkies or vehicle mobile radio; electric welding; metal smelting; steel rolling mills; chlor-alkali processes; dielectric heating, induction heating, etc.). Competency in good EMC engineering practices is required to identify such possibilities, and to successfully deal with them.

A common problem reported by the systems integrators and installers who do try to follow suppliers' EMC instructions, is that they sometimes conflict with each other. For example, it is common to find suppliers specifying that their products be interconnected using screened cables, with the cables' screens terminated at only one end (generally to a specified terminal on the product). Leaving aside the fact that such instructions generally indicate that bad EMC engineering practices have been used in the electronic and/or mechanical design of the products – the problem is that when interconnecting two such items of equipment, which ends of the cable screens should be terminated? Whichever end is terminated, the EMC instructions for one of the apparatus have not been followed and its EMC performance compromised.

For these reasons and others it is not sufficient to rely solely on following suppliers' EMC instructions, so there is obviously a need for the person responsible for the compliance of a fixed installation to be competent in applying good EMC engineering practices.



5 Good EMC Engineering Practices

2004/108 requires fixed installations to be constructed using good EMC engineering practices. In fact, it uses the phrase "…*good engineering practices…*", but of course only good EMC engineering practices are capable of controlling EMC. The draft EC Guide [4] makes it clear that what is needed is the application of good EMC engineering practices. It also borrows from ISO/IEC Guide 2 to help understand the requirements of the Directive: "*Good engineering practice represents the state of the art, the recognised definition of which is: developed stage of a technical capability at a given time as regards products, processes and services, based on the relevant consolidated findings of science, technology and experience. The basis of good engineering practice is mainly formed by legal requirements and recognised standards / codes of practice.*"

The draft EC Guide [4] goes on to say that: "*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.*"

However, apart from a few notable exceptions there appears to be a general lack of EMC knowledge in the area of systems and installations (especially in the medical, commercial and industrial areas). The result is that many organisations seem to think that complying with the applicable national electrical code (e.g. the IEE Wiring Regulations, BS7671, for the UK) will achieve compliance with the EMC Directive. Although such electrical codes are indeed good engineering practices, they do not control EMC so have nothing to do with achieving compliance with 2004/108.

Those that do claim to have some EMC engineering knowledge mostly seem to think that all that is required is to use single-point earthing/grounding systems; terminate cable screens at only one end; and connect filters and cable screens to earth/ground using any length of conductor as long as it has green/yellow insulation. Such methods have not been good EMC engineering practices for many decades, even in professional audio and/or video systems/installations, and in fact are a common cause of interference, malfunction, downtime, and actual equipment damage. Many EMC engineers around the world earn a significant proportion of their income from correcting systems built using such outdated EMC techniques, but they are usually only called in after the end-user has wasted very large amounts of money through downtime or rejected production, whilst fiddling about with outdated techniques for weeks or months, sometimes even years, and getting nowhere.

I believe that the requirement to employ good EMC engineering practices is likely to cause big problems for the majority of installation owners, system integrators, control panel builders, custom engineers, installers, contract electricians, etc., few of whom seem to have any EMC engineering knowledge at all.

There are a number of sources of information that can help people develop their knowledge of good EMC engineering practices in systems and installations. A great deal of practical information is readily available, in particular the IEC 61000-5 series of 'good-practice' guides [9] (especially IEC 61000-5-2 and –6), textbooks such as [10], and magazine articles such as [11]. [12] has useful information on performing on-site EMC tests for emissions and immunity, including how to adjust the test methods to cope with their uncontrolled electromagnetic (EM) environments. Military standards and guides from the UK [13] and USA [14] contain useful information that can be helpful in non-military applications. [15] provides useful guidance on assessing the EM environment – an essential part of the EMC characteristics of a fixed installation.

Unfortunately for the prospects of compliance of fixed installations with 2004/108 from the 20th July 2007, it does not seem likely that most of the necessary people will achieve sufficient competency in EMC engineering anytime soon.

6 The "Responsible Person" for a fixed installation

2004/108 requires that, from 20th July 2007, each fixed installation will have a "Responsible Person" appointed, to be responsible for the EMC compliance of its site. He or she will be responsible for ensuring that the fixed installation complies with the EMC Protection Requirements, and also for keeping the compliance documentation for the site ready for inspection by the national EMC enforcement authorities for as long as the site is in operation.

Each member state is to decide on the rules they will apply for identifying the responsible person, and both 2004/108 and the draft EC Guide [4] are silent on what those rules might be. The draft UK Statutory Instrument (Annex B of [5]) defines a fixed installation's Responsible Person as: "*…the person who, by virtue of their ownership or control of the relevant fixed installation is able to determine that the configuration of the installation is such that when used it complies with the protection requirements;…*".

7 What a Responsible Person needs to know about EMC

The draft EC Guide [4] says that where a fixed installation is comprised solely of apparatus that has been placed on the market in conformity with the EMC Directive and carries the CE marking, the Responsible Person should be able to satisfy the documentation requirements by retaining the suppliers' instructions for installation, use and maintenance. To this I would add the rather obvious comment that simply having a folder of supplier documents is not enough in itself – the Responsible Person should also be able to demonstrate that these instructions had been correctly followed.

Of course, this ideal scenario assumes that all of the equipment suppliers actually provided complete EMC instructions on assembly, installation and use with their products. The provision of such EMC instructions is required by 2004/108, but apparatus already on the EU market and declared compliant with 89/336 has a transition period until 20th July 2009 to be brought into compliance with 2004/108. Since 89/336 does not require the provision of EMC instructions, and 2004/108 applies to fixed installations from 20th July 2007, it is obvious that – until summer 2009 at least – many suppliers might quite legally not be providing the instructions that are needed to help achieve EMC compliance for a fixed installation. Even after the summer of 2009, there could still be some suppliers whose EMC instructions are not fully in accord with the requirements of 2004/108.

Another problem was mentioned earlier – a fixed installation might include a number of identical items of equipment, and because the emissions from an installation are the aggregate of the emissions from the individual items of equipment incorporated within it, simply ensuring that each apparatus complies cannot on its own ensure that the emissions from the fixed installation will comply [8]. Also as mentioned earlier, CE marked apparatus that fully complies with its relevant EMC standards can have excessive emissions or insufficient immunity for many installations, and problems can arise when the EMC installation instructions from different suppliers conflict with each other.

So, although the draft EC Guide [4] tries to make the duties of Responsible People appear easy – they still need to have sufficient competency in good EMC engineering practices (or access to it) to determine whether a supplier has provided sufficient EMC information. They also need sufficient competency (or access to it) to successfully deal with situations where the supplied information is lacking or contradictory, the EM environment at the site goes beyond what suppliers have tested their products to, and the 'adding up' of emissions from multiple products.

Resolving such problems requires competency in good modern EMC engineering practices, so notwithstanding the draft EC Guide [4] – Responsible Persons should not assume that all they need to do is simply follow suppliers' EMC instructions. There is no escaping the need for them to have adequate levels of EMC knowledge and competency.

A number of sources of information that can help Responsible People develop their knowledge in EMC at the level of systems and installations were already mentioned above: [9] (especially IEC 61000-5-2 and –6) [10] [11] [12] [13] [14] and [15].

However, I expect that the majority of Responsible Persons will not learn any more about EMC or compliance with 2004/108 than they feel they can get away with – instead, they will expect the system integrators and electrical installers they employ to take care of it all for them, and provide them with the necessary EMC compliance documentation at the end of the project, as discussed in 12 and 14 below.

8 Modifications to fixed installations

2004/108 says nothing specific about modifications to a fixed installation, and neither does draft EC Guide [4]. But modifications or additions to a fixed installation can completely alter its EM characteristics, with some modifications or additions possibly being larger and costing more than the original installation.

2004/108 only permits a fixed installation to be "…*put into service only if it complies with the requirements of this Directive when properly installed, maintained and used for its intended purpose*" (from Article 3). Is this supposed to mean that a fixed installation only needs to comply on the day that it is first used by its end-user? Most fixed installations are subject to a continual process of repairs, refurbishments, upgrades, modifications and additions, which would mean that the period during which it actually complied with the EMC Directive could be quite short, maybe a few days, possibly just a few hours. Such an interpretation would make the application of 2004/108 to fixed installations pointless.

So it seems certain that 2004/108 will require fixed installations put into service after 20th July 2007 to be compliant, and remain compliant during their entire period of operation. This conclusion is supported by the inclusion of 'maintenance' in the above quotation, and in general by the text of the draft UK Statutory Instrument (Annex B of [5]) and in particular by the draft UK Guide (Annex C of [5]).

Assuming the above interpretation to be the case, what does it mean for a fixed installation that is already being used before the 20th July 2007, and does not (yet) comply with 2004/108? Does 2004/108:

- Allow the fixed installation to continue not to comply after 20th July 2007, regardless of any modifications and additions after that date?
- Require compliance only for that part of the installation, where the EMC is affected by the modifications or additions after 20th July 2007?
- Require the whole fixed installation to comply as soon as any part of it is subject to a modification or addition that has an EMC effect?

The draft UK Statutory Instrument (Annex B of [5]) has something to say on these questions. In Part II, Clause 6(2), its existing text says: "*(2) In the case of a fixed installation put into service before 20th July 2007, these Regulations shall apply if it is modified after that date in a way that may affect its electromagnetic compatibility.*" However, this still doesn't make it clear whether the whole installation must be made to comply with 2004/108, or just the modified part. I understand from discussions at public meetings and from the draft UK Guide (Annex C of [5]) that it was supposed to mean that just the part that's EMC was affected by the modification or addition had to comply (the middle bullet in the above list).

9 Large machines

2004/108 mentions large machines in its 18th "*Whereas*", and this has given rise to some confusion – with some machinery manufacturers claiming that it means they can use the fixed installation compliance regime for their larger finished products.

This is discussed in the draft EC Guide [4], which makes it clear that all machines are actually apparatus, and should be treated as such, unless they meet the definition of a fixed installation. The example given of a large machine that could perhaps be treated as a fixed installation under 2004/108, is a factory production line.

10 Mobile and moveable installations

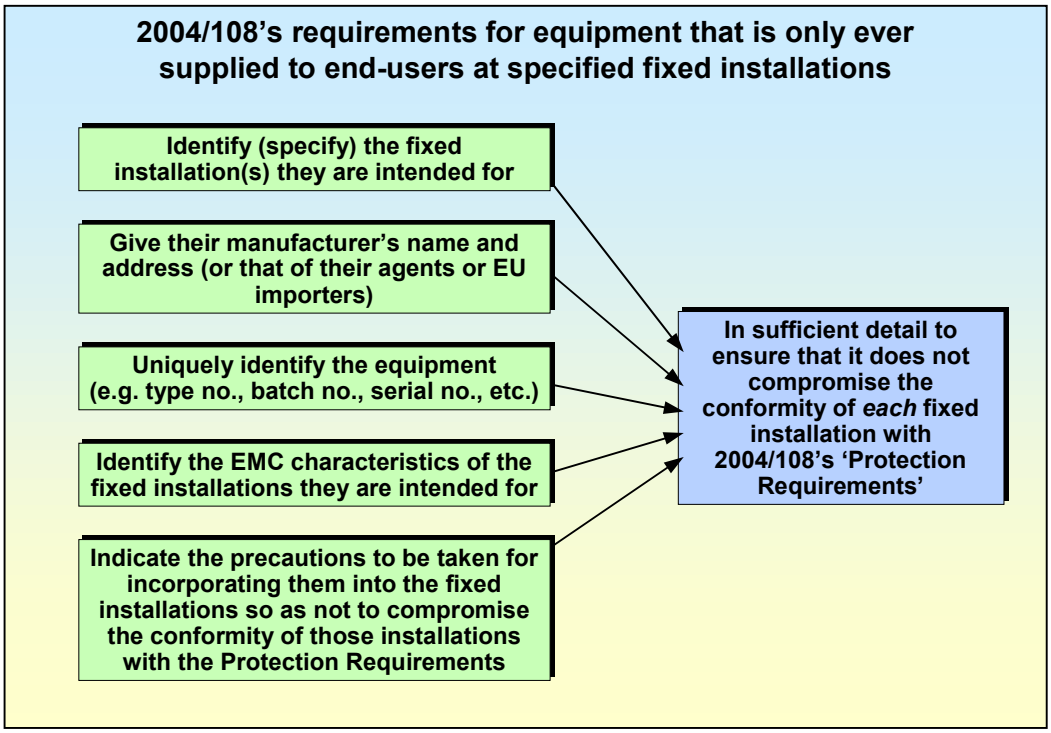
Mobile installations are defined in 2004/108 as: "*…a combination of apparatus and, where applicable, other devices, intended to be moved and operated in a range of locations.*" and are treated in exactly the same way as apparatus. The draft EC Guide [4] gives an example of such a mobile installation as a "*portable broadcast studio container*".

But the draft Guide also says that if a mobile installation is intended to substitute for, or extend a fixed installation (e.g. for electricity generation or transmission in the high-voltage network) then they may be able to be treated as a fixed installation – but it points out that the temporary connections to the networks of such installations should be carefully planned, and installed by experts

The EMC Working Party in their meeting of the 8th March 2006 decided that something that is constructed anew on each site (e.g. a fairground, open-air touring pop concert, etc.) was a 'moveable installation'. They decided that a moveable installation is not a mobile installation (i.e. an apparatus) – it is a fixed installation, and that words to this effect would be put into the Guide.

But the 3rd August draft EC Guide [4] contains nothing about 'moveable installations', it just 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.*" So it seems we are not going to get any very useful guidance on this grey area after all.

11 Equipment supplied only to specified fixed installations



Apparatus that is 'placed on the market' – finished products that are commercially available to general end-users – must comply with all of 2004/108's provisions for apparatus, have an EC declaration of conformity and carry the CE marking, even when purchased for use in a fixed installation. Examples of such equipment include: Personal Computers (PCs); Ethernet devices; DC power supplies; motor drives; instrumentation and control modules; generators; etc.

But 2004/108 allows a different approach for what it calls: "*…apparatus which is intended for incorporation into a given fixed installation and is otherwise not commercially available.*". Such equipment could be machines, systems or networks of any size, or any other equipment, sub-systems or devices, but they must never be 'placed on the market' – that is, never made available to the general public or sold via distribution. The draft EC Guide [4] adds the comment that the supply of such equipment to the fixed installation must involve a provider-customer relationship. Because 2004/108 only applies right at the end of a supply chain, at the point where the legal ownership of the equipment concerned passes to its end-user (see the section on 'Supply Chain Issues' below), this provider-customer relationship must be between a supplier of equipment and the owner of the fixed installation concerned.

Note that, just as for 89/336, any equipment that is not being supplied to its end-user does not come within the scope of the EMC Directive. So in supply chains (see later) it is important that equipment EMC is controlled by technical specifications in the purchasing contracts at every stage – because neither 89/336 nor 2004/108 controls it.

Equipment that is only ever supplied to directly to end-users at specified fixed installations could be standard finished products made in volume – such as industrial PCs or industrial instrumentation and control devices – as long as they were not available to the general public or sold through distribution, so were not 'placed on the market'. They could also be standard equipment that is modified to suit a specified fixed installation, or equipment that is entirely custom-designed equipment for a specified fixed installation.

2004/108 still applies to such equipment, but does not require:

- Compliance with the Protection Requirements
- A conformity assessment
- The CE marking to be affixed (but note that it may be needed by other applicable Directives)

However, 2004/108 does require all such equipment to be provided to their end-users with documents that:

- Identify the fixed installations they are intended for
- Give their manufacturers' names and addresses (or that of their agents or EU importers)
- Uniquely identify them (e.g. type no., batch no., serial no.)
- Identify the EMC characteristics of the fixed installations they are intended for
- Indicate the precautions to be taken for incorporating them into the fixed installations so as not to compromise the conformity of those installations with the Protection Requirements

The last two bullets in the above list need some explanation. Identifying the EMC characteristics of the fixed installations could mean anything from a general overview (e.g. 'as described in the generic standards for the commercial environment') to a complete in-depth qualitative and quantitative assessment of every one of the 30+ EM phenomena that could possibly exist.

Neither 2004/108 nor the draft EC Guide [4] provides any enlightenment on this issue, but the draft UK Guide (Annex C of [5]) goes into more detail. It makes clear that even where the same model of equipment is supplied to a number of fixed installations, its manufacturer must understand the EMC characteristics of each of the fixed installations in sufficient detail to design or adapt each item of equipment, and/or identify any EM mitigation measures that should be employed during installation, to avoid compromising the conformity of each fixed installation.

It goes on to say that in "*…straightforward situations…*" it could be sufficient to employ the descriptions of the EM environment that are assumed by the relevant generic emissions and immunity standards. On the surface, this seems to imply that equipment destined for the majority of fixed installations can be dealt with very simply – but it does not mention the fact that significant EMC knowledge is required to be able to determine whether a situation is indeed straightforward enough, in EMC terms, to use this approach.

It is possible to use a questionnaire that can easily be completed by an end-user with no EMC skills, to help with this decision. An example of such a questionnaire is included in [15], and in the case where it does not indicate a straightforward EM environment; it indicates the directions to be taken by a subsequent in-depth EM investigation.

Note that where EM interference could possibly cause safety risks (e.g. by interfering with safety-related electromechanics, electronics and/or software) a much more rigorous and thorough investigation of the EM environment is required to achieve EMC for safety purposes. Such an investigation should assess the reasonably foreseeable worst-case EM phenomena that could occur over the anticipated lifecycle of the installation concerned, as discussed in [16] and [17].

The final bullet in the list above is concerned with manufacturers informing their customers of the EM precautions to be taken when incorporating their equipment into specific fixed installations, so as not to compromise the EMC conformity of the individual installations. The precautions to be taken will of course depend upon the EMC characteristics of each end-user's fixed installation, as discussed above. 2004/108 does not provide any detail on this topic, and neither does the draft UK Guide (Annex C of [5]), but the draft EC Guide [4] suggests: "*…precautions and requirements for cabling, for the choice of cables, for distances to be respected, for earthing, for screening, for equipotential bonding, for environmental restrictions etc.*".

In this context, 'environmental restrictions' means preventing interference by controlling the EM environment, for example by restricting the use of radio transmitters or electrically noisy equipment (e.g. electric welders, dielectric heaters, unsuppressed motor drives, etc.) within a certain distance of the equipment concerned. The draft EC Guide [4] does not mention the use of several other common EM mitigation techniques: filtering, shielding, over-voltage suppression, galvanic isolation, etc.

A great deal of practical information is available on the EMC precautions and mitigation measures that can be taken at the level of a system or installation, in particular the IEC 61000-5 series of 'good-practice' guides [9] (especially IEC 61000-5-2 and –6); textbooks such as [10], and magazine articles such as [11]. Military standards and guides from the UK [13] and USA [14] also contain useful information on EMC precautions at system and installation level, which can be useful in non-military applications.

12 Systems and system integrators

The word 'system' is widely used with various meanings. 2004/108 does not use the word 'system' at all, but the draft EC Guide [4] introduces this word as meaning a combination of finished appliances. It then says that: "*…a combination of several finished appliances which is made commercially available as a single functional unit intended for the end-user is considered to be an apparatus*."

Many companies and other organisations purchase electrical and/or electronic products and combine them together to create a new finished product. If the resulting finished product is made generally available for end-users, provides a function and has its own enclosure – then it is an apparatus according to the meaning of 2004/108 and must be treated as such (see above).

The draft EC Guide [4] includes the following note:

"*Manufacturers of systems described above should be aware that combining two or more CE marked finished appliances does not automatically produce a system which meets the protection requirements. E.g. a combination of CE marked Programmable Logic Controllers and motor drives put together to be placed on the market as a system may fail to meet the protection requirements.*" This is a reference to what is often mistakenly called the "CE + CE = CE approach to compliance", where companies only purchase products that are CE marked and combine them together to create new products. I have called this approach a mistaken one because it has no legal or technical basis – see [18] for more on why it doesn't work and what to do instead.

There are many things that are commonly called systems, but that do not fit the description used in the draft EC Guide [4]. Many products that are commonly called systems are in fact custom-designed for individually-named fixed installations, to meet a customer specification for that site. Since they are not "*…made commercially available as a single functional unit intended for the end-user…*" – in other words they are not a volume-manufactured product that could be supplied to anyone – they are not 'apparatus' in the meaning of 2004/108. They are just items of custom-designed equipment and can be treated in the same way as was described in 11 above.

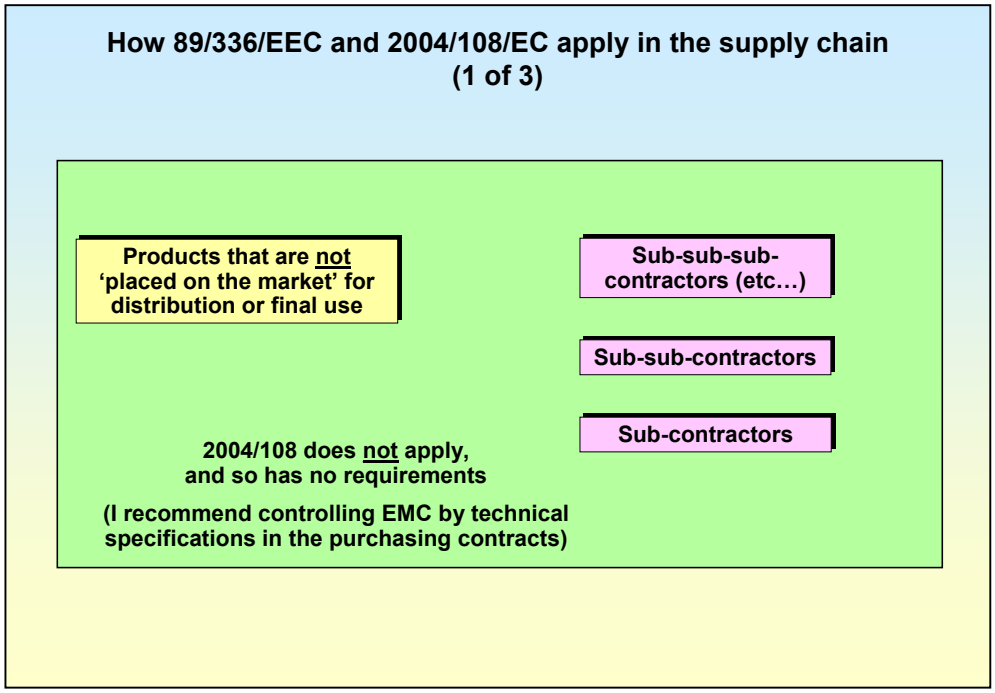
Many manufacturers of custom equipment seem to believe that they can use the CE + CE = CE approach. They also seem to believe that because they bought the constituent products 'in good faith', if a compliance problem arises due to one of them being non-compliant, the enforcement authorities would only target the supplier of that component. Unfortunately for them, as mentioned above and discussed in [18], this is an erroneous approach and cannot demonstrate compliance for the final equipment. Also, if a product constructed in this way was found not to comply, its manufacturer could be held responsible, as well as the supplier of the non-compliant part.

End-users create all sorts of systems for their own use, for example domestic lighting systems in private houses. But if they are not doing it professionally, and if they only use apparatus that is compliant with the EMC Directive, and if follow its suppliers' instructions – then no further conformity assessment or other EMC actions are required by 2004/108. As was mentioned earlier: non-professional end-users cannot be expected to be competent in EMC engineering, and this is exactly why the conformity requirements for apparatus are so thorough.

However, the EC expects professional system integrators to be competent in all areas that concern compliance with the relevant Directives. Just as was mentioned earlier in the section on fixed installations, in my experience most professional system integrators have very little or no EMC competency, and so far I have not seen any evidence that they are trying to acquire it so as to be ready for the 20th July 2007, when 2004/108 will apply to all new and modified fixed installations.

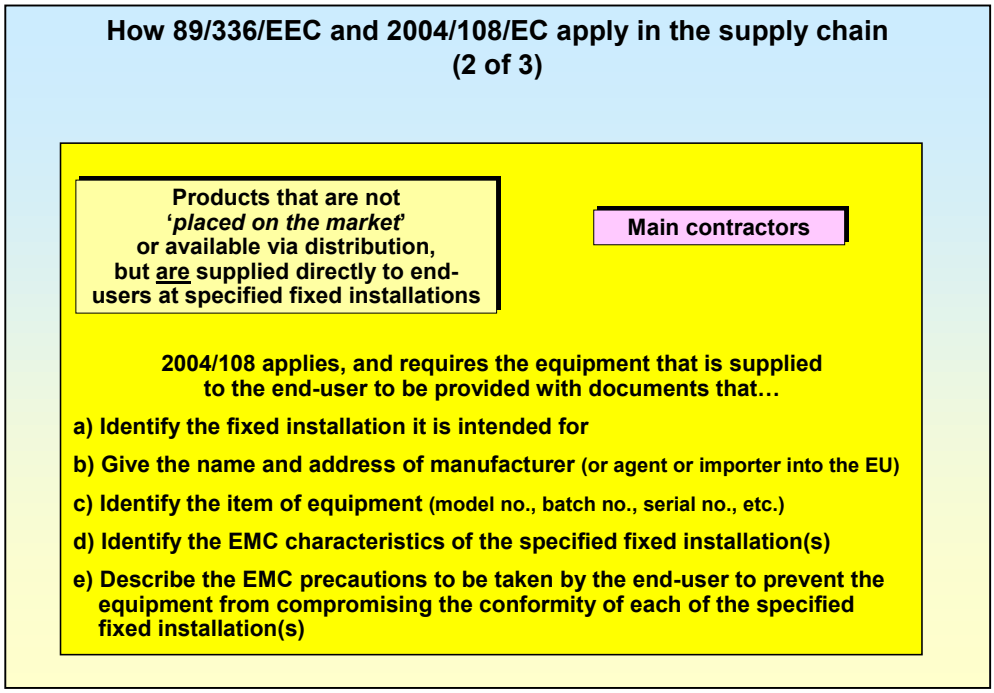
13 Supply chain issues

Unlike the Low Voltage Directive (the LVD: 73/23/EEC amended by 93/68/EEC), but just like 89/336, 2004/108 does not apply throughout the supply chain – it only applies at the point where the ownership of equipment changes to the end-user. So equipment that is only supplied to original equipment manufacturers (OEMs) or professional system integrators (such as industrial control system manufacturers) is outside the scope of the EMC Directive.



Such equipment is always covered by the LVD (if it is within the LVD's scope), and the resulting CE marking is often mistakenly assumed to mean compliance with the EMC Directive as well. This is one of the many reasons why the 'CE + CE = CE approach' doesn't work [18].

In large construction projects, the customer often employs a main contractor who parcels the work out to various sub-contractors, who in turn might parcel their work out to various sub-sub contractors. It seems to be quite common in such cases for each level of contractor to simply require the lower levels of contractor to



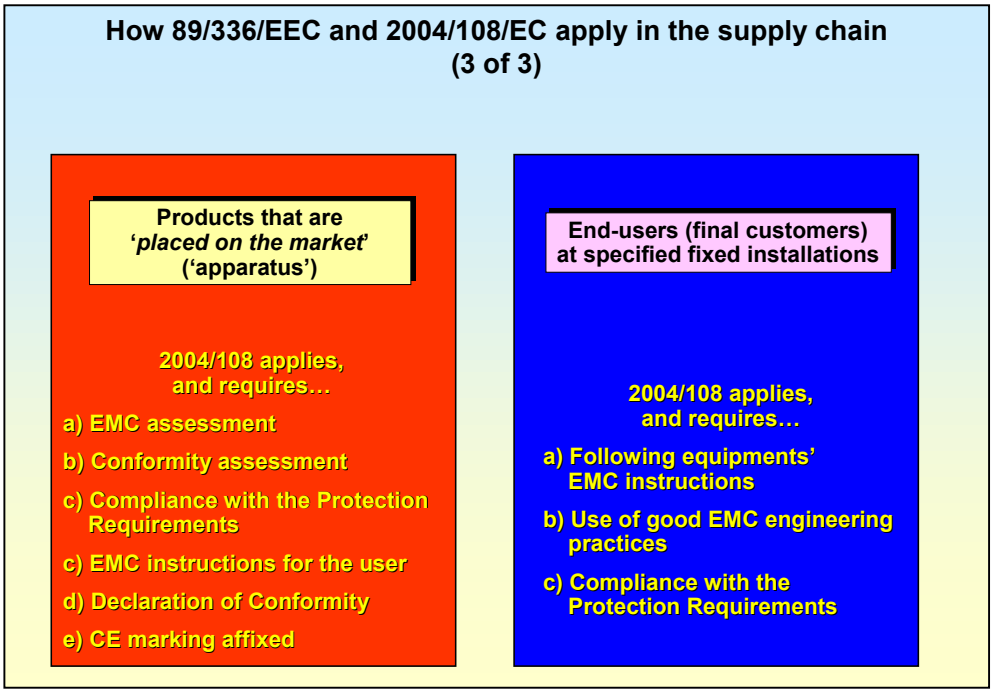
declare what they supply to be compliant with the EMC directive and affix the CE marking to it – but this is not what the Directive requires – and neither is it good EMC engineering practice.

Quite how 2004/108 will apply in such cases depends upon how the project is managed, and whether the final deliverable to the customer reasonably fits the description of an apparatus, fixed installation, or custom equipment intended for a specified fixed installation. But in any case the EMC assessment of the customer's site should result in an EMC specification for the main contractor's final deliverable item. Such a specification will generally include planning, design, verification (testing) and quality control (QC) requirements, and should be used as the basis for the various EMC specifications that form parts of the contracts with the various sub-contractors, for their deliverables.

In turn, the sub-contractors should use the EMC specification they agree with the main contractor as the basis for the EMC specifications that they make part of the contract with the sub-sub-contractors, and so on down the supply chain.

Simply writing a line such as: "Shall comply with the EMC Directive" into a sub-contractor's contract would be inadequate, and poor EMC engineering practice, even if the EMC Directive did apply.

Since the EMC Directive (whether 89/336 or 2004/108) cannot possibly apply to any work done by a sub-contractor, or lower down the supply chain, it cannot be made to apply by a contract term.



14 Electrical contractors and installers

Most fixed installations are actually constructed and modified by electrical contractors or installers employed on a contract basis by the owner of the installation. Their customers choose the equipment they are to install, and their job is to wire it up on site and make it work. In large and/or complex installations this can be a lengthy and/or complex project.

Where a fixed installation's Responsible Person is knowledgeable about EMC, and the custom equipment to be installed is supplied complete with all of the information required by 2004/108 (see 11), the installer should have nothing to do on EMC other than follow their instructions.

But what will probably happen in most fixed installations is that the contractors or installers will be expected to take care of almost everything to do with EMC, including applying good EMC engineering practices, and at the end of the project provide the necessary EMC documentation – exactly the sort of approach that is usually taken to comply with electrical safety regulations at the moment.

Consequently, although 2004/108 has requirements for the owners of the fixed installations, and has no requirements at all for electrical contractors or installers – it seems likely that it will not have all that great an

effect on the owners/users of the fixed installations – but will become very significant indeed for electrical contractors and installers.

At the end of a project, an electrical installer will probably be expected to provide the fixed installations' Responsible Persons with documentation 'certifying' the EMC compliance of the site (i.e. compliance with the EMC Protection Requirements), and showing that good EMC engineering practices have been followed. I would not be surprised to find that most Responsible Persons do little more than keep the documentation they have received from equipment suppliers and electrical contractors or installers ready for inspection by the national EMC enforcement authorities.

Since most Responsible Persons and their main contractors are unlikely to be expert, or even very competent in EMC, and since they will most probably expect the electrical contractors or installers to deal with it for them, (as they do for electrical safety at the moment) – there is the likelihood that their choice and specification of equipment to be installed could be deficient in EMC terms. This will lead to their electrical contractors or installers being faced with a list of equipment, comprising both volume-manufactured 'apparatus' and equipment custom-engineered for the fixed installation – some/all of it lacking the EM performance and/or installation information necessary to achieve or maintain the EMC compliance of the installation. But the electrical installer will nevertheless be expected to provide the necessary EMC compliance documentation 'proof' at the end of the project.

Thus it will be important for electrical contractors and installers to understand enough about EMC to tender appropriately, and maybe even to refuse contracts where they might not be paid enough for the work that would be required for the installation to be legally EMC compliant. For example, it is generally possible to adapt any item of equipment to its real-life EM environment by using shielding, filtering, surge protection, and other well-understood EM mitigation techniques. However, these will add cost and time to a project, so it will be important for the profitability of electrical contractors and installers to identify where such mitigation techniques will be needed, and include their time and cost in their tender submission.

Of course, for the reasons stated above, Responsible Persons and their main contractors might find it easy to be persuaded by the lowest-cost quotation from electrical contractors or installers who also know very little about EMC, maybe the ones who think that the CE + CE = CE approach is appropriate (see 12, 13 and [18]).

At the moment, very few (if any) electrical contractors or installers seem to be at all knowledgeable about good EMC engineering practices, or 2004/108. There are only a few suppliers of training courses suitable for such companies, e.g. [19], and (as yet) no accreditation schemes that will enable them to demonstrate their competence in EMC matters to potential customers. I sincerely hope that this situation will improve considerably over the next few years, but I don't know whether we can expect it to.

15 Conclusions

2004/108 applies strict requirements for EMC conformity to all new and modified 'fixed installations' from 20th July 2007, which the Responsible Person appointed for each fixed installation must document and keep ready for inspection by the appropriate authorities. Achieving compliance requires the use of good EMC engineering practices, having regard to the state of the art – which means that Responsible Persons must either be competent in EMC engineering at system and installation level, or have access to such skills.

Equipment that is only supplied to fixed installations, and is not available to ordinary consumers, does not have to be CE marked or comply with the EMC protection requirements – but it must be provided in each case with instructions describing how to assemble/install it so that it does not cause that installation to fail to comply, taking into account its unique EM environment. This requires the use of good EMC engineering practices, having regard to the state of the art – which means that the supplier must either be competent in EMC engineering at system and installation level, or have access to such skills.

It is the author's experience that very few fixed installations, system integrators or other equipment suppliers have anything like the required EMC competency, and that there is not yet any significant demand for acquiring it. This is despite the fact that many fixed installations that will first be brought into service after 20th July 2007 are already being designed or constructed, and so will almost certainly not comply with 2004/108.

Many fixed installations, system integrators and other equipment suppliers still seem to think they can rely upon the 'CE + CE = CE approach', which despite being widely used under the old EMC Directive 89/336, has never had a legal or a technical basis, and which will be even more inadequate when attempting to demonstrate compliance with 2004/108.

Electrical contractors and installers have no obligations under 2004/108, and most of them seem unaware that many of their customers will soon start asking them to provide EMC compliance documentation at the end of a project, whilst in many cases being fairly ignorant themselves of what that might entail.

I expect that it will probably be at least 10 years before fixed installations, system integrators, electrical contractors and installers and other suppliers have acquired sufficient EMC competency for the majority of fixed installations to start to achieve legal compliance with the national laws implementing 2004/108. In the meantime, any EMC enforcement officer who decides to assess the compliance of fixed installations after 20th July 2007, should find it very easy to find almost as many non-compliant sites as are assessed.

16 References

[1] The 1st Edition of the EMC Directive: "*Council Directive 89/336/EEC of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive)*", available via the EMC Directive's official EC homepage: http://ec.europa.eu/enterprise/electr_equipment/emc/index.htm

[2] The EC's "*Guide to the Application of Directive 89/336/EEC*", 1997, ISBN: 92-828-0762-2 can be downloaded from the official EU EMC standards website… http://ec.europa.eu/enterprise/newapproach/standardization/harmstds/reflist/emc.html

[3] The 2nd Edition of the EMC Directive: "*Directive 2004/108/EC of the European Parliament and of the Council, of 15 December 2004, on the approximation of the Laws of Member States relating to electromagnetic compatibility*", available via the EMC Directive's official EC homepage: http://ec.europa.eu/enterprise/electr_equipment/emc/index.htm

[4] The EC's "*Draft Guide for the EMC Directive 2004/108/EC*", dated 3rd August 2006, download from the 'Documents' page of the EMC Test Labs Association website: www.emctla.co.uk

[5] "*Implementing the new Electromagnetic Compatibility (EMC) Directive 2004/108/EC in the United Kingdom. A Consultation Document. May 2006 URN 06/1141*", The UK Department of Trade and Industry, available from http://www.dti.gov.uk/consultations/page28218.html

[6] Banana Skin No. 12, UK EMC Journal, April 1998, page 6, included in the '*Compendium of Banana Skins*' downloadable from the 'Publications & Downloads' page at www.cherryclough.com

[7] The EC's 'Blue Guide', "*Guide to the Implementation of Directives Based on the New Approach and the Global Approach*", 2000, ISBN: 92-828-7500-8, can be downloaded in all 11 official EU languages from: http://ec.europa.eu/enterprise/newapproach/legislation/guide/index.htm

[8] "*Achieve EMC Directive Compliance With the Aid of a Spreadsheet*", Keith Armstrong, Conformity, February 2006, available via the 'Publications & Downloads' page at www.cherryclough.com

[9] IEC standards including the 61000-5 series can be searched and purchased using the Webstore facilities at www.iec.ch

[10] "*EMC for Systems and Installations*", Tim Williams and Keith Armstrong, Newnes 2000, ISBN 0-7506-4167-3, RS Components Part No. 377-6463

[11] "*EMC for Systems and Installations*" (in six parts), Keith Armstrong, EMC & Compliance Journal, 2000, available via from the 'Publications & Downloads' page at www.cherryclough.com

[12] "*On-site EMC Test Methods*", Keith Armstrong, published by the EMC Test Labs Association (www.emctla.co.uk) as Technical Guidance Note No. 49, download from the 'Publications & Downloads' page at www.cherryclough.com

[13] UK Defence Standards in the Def-Stan-59-41 series are freely available via http://www.dstan.mod.uk/, and include good practice EMC guides for vehicles (Def-Stan-59-41 Part 6) and ships (Def-Stan 59-41 Part 7).

[14] Most US military EMC standards are supposed to be freely available from official suppliers, but I have had more success identifying them and obtaining them using links discovered by Google. MIL-STD-464A is an important guide, others include MIL-STD-1310g, MIL-HDBK-419A, MIL-HDBK-1857.

[15] "*Assessing an EM Environment"*, Keith Armstrong, published by the EMC Test Labs Association (www.emctla.co.uk) as Technical Guidance Note No. 47, download from the 'Publications & Downloads' page at www.cherryclough.com

[16] "*Specifying Lifecycle Electromagnetic and Physical Environments – to Help Design and Test for EMC for Functional Safety*", Keith Armstrong, IEEE 2005 International Symposium on EMC, Chicago, Aug 8-12 2005, ISBN: 0-7803-9380-5, pp 495-499

[17] "*Design and Mitigation Techniques for EMC for Functional Safety*", Keith Armstrong, IEEE 2006 International Symposium on EMC, Portland, Oregon, Aug 14-18 2006, ISBN: 1-4244-0294-8

[18] "*CE + CE does not equal CE – What to Do Instead*", Keith Armstrong, Compliance Engineering's 1999 Annual Reference Guide, also Part 6 of the series "EMC for Systems and Installations", download from the 'Publications & Downloads' page at www.cherryclough.com

[19] Cherry Clough Consultants has for many years offered a range of very practical EMC training courses for custom-engineers, systems integrators, electrical contractors and installers, and Responsible Persons – visit the 'Training' pages at www.cherryclough.com for an overview.