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A COMPARISON OF THE REVISED EMC DIRECTIVE WITH THE VIEWS OF THE INDEPENDENT STUDY

UNE COMPARAISON DE LA DIRECTIVE CEM RÉVISÉE AVEC LES POINTS DE VUE DE L'ETUDE INDÉPENDANTE

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***Abstract* — A "revised" EMC Directive will soon be published. This paper presents some of the views of the Independent study prepared in the context of this revision, concerning items subject to the directive, electromagnetic phenomena, electromagnetic environments and their classification, protection requirements, persons responsible for compliance, installations and EMC standards. These views are compared with the "current" and "revised" EMC Directives.**

***Résumé* — Une Directive CEM "révisée" sera bientôt publiée. Cet article présente quelques-uns des points de vue de l'Etude indépendante préparée dans le contexte de cette révision, concernant les entités soumises à la directive, les phénomènes électromagnétiques, les environnements électromagnétiques, les exigences de protection, les personnes responsables de la conformité, les installations, et les normes de CEM. Ces points de vue sont comparés avec la Directive "actuelle" et la Directive révisée.**

I. Introduction

The EMC Directive [1] of 3 May 1989 is applicable in the European Community (now the European Union) since 1 January 1992. Since 1 January 1996, *all apparatus liable to cause electromagnetic disturbance or the performance of which is liable to be affected by such disturbance* must comply with the requirements of the EMC Directive before being placed on the market or taken into service in the territory of the Member States. In this Directive, *apparatus* means *all electrical and electronic appliances together with equipment and installations containing electrical and/or electronic components*.

It was found early that the implementation of this legal document presented several areas where clarification was needed. In 1997, the Commission issued a Guide [2], which was a substantial contribution toward homogeneous application of the EMC Directive. Unfortunately it was only an informal document which did not provide the necessary legal certainty.

The Simpler Legislation for the Single Market (SLIM) initiative was launched by the Commission in May 1996 with strong encouragement and support from Internal Market Ministers. The first task was to identify ways in which the existing single market legislation could be simplified. The resulting EMC SLIM report [3] is the foundation of the revision of the EMC Directive which should be completed shortly.

Excem was awarded a study contract with the European Community to provide technical support to the activities carried out within the context of a possible revision of the EMC Directive. We worked on this project from February 200 to November 2000. At the date of this paper, our final report [4] can be downloaded from the web site of the Enterprise Directorate-General, by clicking on *Independent study*.

This paper discusses some of the recommendations of this Independent study, and compares them with the "current" EMC Directive [1], and the "revised" EMC Directive, at the stage defined in § II.

II. Current stage of the Revision

The Commission, helped by a working group including representatives of the member states and representatives of enterprises, reached the stage of a draft Directive called EMCD 2000.8 [5], during the first quarter of 2001. In December 2002, this document became a proposal for a new EMC Directive, presented in the document COM(2002)759 final [6]. It contained significant changes. For instance, according to its Article 7 and to the paragraph 1 of its Annex II, the manufacturers would become entitled to deviate from harmonized standards, provided they can demonstrate that they comply with the essential requirements of the Directive. Today, the "current" EMC directive requires that any such deviation be investigated by a "competent body" [6].

The paragraph 7 of the explanatory memorandum of this proposal for a Directive indicates that the technical findings of the Independent study have brought to "include ready-made connecting devices within the scope of the Directive and to regulate specifically fixed installations".

In 2004, the European Parliament introduced 39 amendments to the proposal, 33 of which were adopted after a vote. On June 18, 2004, the Commission introduced an amended proposal, presented in the document COM(2004)446 final [8]. In this document, the Commission finds that all of the adopted Parliament's amendments [7] are acceptable. When this paper was finalized (early November 2004), it was expected that the amended proposal would soon be adopted by the Council and become a new EMC Directive, applicable 30 months after the date of its publication (manufacturers having the possibility of only complying to the "current" EMC Directive for two years thereafter).

The major differences between this "revised" EMC Directive (referred to as REMCD hereafter) and the "current" EMC Directive of 1989 (referred to as CEMCD hereafter) are the following:

- the definition of apparatus is changed;
- two classes of items are subject to the directive, *apparatus* and *fixed installation*, different obligations and procedures being applicable to each class;
- a conformity assessment procedure is defined for apparatus, which prescribes the creation of a technical documentation providing evidence of the conformity;
- the competent bodies are replaced by *notified bodies*, but their intervention is not mandatory, even where the manufacturer has not applied harmonized standards, as explained above;
- when a manufacturer does not apply all the relevant harmonized standards, he must perform an electromagnetic compatibility assessment demonstrating that the apparatus meets the protection requirements;
- a specific regulatory regime is applicable to fixed installations.

III. Items Subject to the Directive

An area where the CEMCD is not satisfactory, and where the clarifications of the Guide [2] have been most needed, covers:

- defining categories of items subject to the directive,
- expressing meaningful protection requirements,
- modulating the protection requirements according to the categories of items,
- designating which item should be CE marked.

This Guide presents a "decision flow chart" and states that "the manufacturer has to determine the classification of his electrical apparatus as component, finished product, system or installation". In the end, the Guide uses four classes to which different obligations apply: "component without direct function", "component with direct function and finished product", "system" and

"installation". The Guide says that components without direct function are not considered as apparatus within the meaning of the CEMCD, and explains that the applicability of the directive to installations is limited, contrary to the words of the CEMCD, but in line with the contents of recognized EMC standards and practices.

In order to avoid discussions concerning the class to which a given item belongs, the Independent study proposed a subjective classifications of items, according to which the supplier has to state to which of the four classes below the item he delivers belongs:

- EMC-component,
- EMC-self-contained apparatus,
- EMC-system,
- EMC-installation.

He would be entitled to pick the class he prefers and different obligations would be associated to each class. No obligation would be attached to EMC-components, but non-professional customers would have to be informed that the EMC-component can only be used as a part of an EMC-self-contained apparatus, or an EMC-system or an EMC-installation. The Independent study advocates that obligations should be applicable to EMC-installations, which will be explained in the § VIII below.

The approach of the REMCD as regards the different classes of items is a compromise between the approach of the Guide and the views of the Independent study: it contains an objective classification of items, and prescribes obligations applicable to installations. In order to achieve this, the definition of *apparatus* is changed in the REMCD. It means:

— *any finished appliance, or combination thereof made commercially available as a single functional unit intended for the end-user, and liable to generate electromagnetic disturbance, or the performance of which is liable to be affected by such disturbances*, or

— a component or a sub-assemblies *intended for incorporation into an apparatus by the end-user, which are liable to generate electromagnetic disturbances, or the performance of which is liable to be affected by such disturbances*, or

— a mobile installation *defined as a combination of apparatus and where applicable, other devices, intended to be moved and operated in a range of locations*.

Two other classes of items are defined in the REMCD:

- *fixed installation means 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*.
- *equipment means any apparatus or fixed installation*.

The REMCD *regulates the EMC of equipments*, apparatus and fixed installation being subject to the same protection requirements, but different procedures are applicable.

Apparatus are subject to a conformity assessment procedure and to CE marking prior to placing on the market and/or putting into service. The manufacturer of an apparatus must provide information on any specific precautions needed to obtain the conformity to the protection requirements, and, in cases where compliance with the protection requirements is not ensured in residential areas, a restriction of use must be indicated.

Fixed installation must be installed applying good engineering practices, but are not subject to CE marking. When there are indication of non-compliance of a fixed installation, the competent authorities may request evidence of compliance of the fixed installation, and initiate an assessment.

IV. Electromagnetic Phenomena and Electromagnetic environments

The independent study uses a broad definition of *electromagnetic phenomenon*. Electromagnetic phenomena encompass a wide variety of events like the generation of disturbances (either by man-made emitters or by natural phenomena), various kinds of couplings, and effects of disturbances. Therefore several electromagnetic phenomena are usually at work in a given EMC paradigm. An analysis will usually involve at least three electromagnetic phenomena:

— one or several electromagnetic phenomena related to the generation of potentially harmful electromagnetic power,

— one or several electromagnetic phenomena related to coupling between the emitter or the natural phenomenon, and the susceptible device,

— one or several electromagnetic phenomena related to the effect of the coupled electromagnetic power on the susceptible device.

For this reason, the independent study defines seven categories of electromagnetic phenomena:

— underlying electromagnetic phenomena (UEP),

— original individual electromagnetic phenomena (OIP), closely related to emission,

— coupling and propagation electromagnetic phenomena (CPP),

— combination of individual electromagnetic phenomena (CIP),

— local electromagnetic phenomena (LEP),

— environment to item coupling electromagnetic phenomena (EIC),

— effects of the electromagnetic environment on a given item (EEE), related to immunity.

The Independent study discusses in detail the undefined concept of "environment" in EMC, and its usage in existing relevant documents. Several conflicting meanings have in fact been implied, especially in EMC standards, which of course led to a lot of misunderstanding. One should therefore be careful to only use the well-established concept of *electromagnetic environment*, noting that the electromagnetic environment at a given location is the set of local electromagnetic phenomena (LEP) at this location. The § 8.6 of the Independent study therefore recommends that a definition of electromagnetic environment be included in the revised directive.

The amendment 13 of the Parliament [7], accepted by

the Commission [8], introduces the definition of *electromagnetic environment* into the "revised" EMC Directive:

"*Electromagnetic environment means the whole of all electromagnetic phenomena observable in a given location*."

The Parliament explains that the reason for this introduction is that it is important to distinguish the concept of "electromagnetic environment" from the concept of "place, location".

The 7 categories of electromagnetic phenomena listed above are *a priori* relevant to the subject matter of the directive. This of course does not mean that these seven categories of electromagnetic phenomena should be covered by standards, or that they should be mentioned in an EMC directive. However, having the protection requirements of the "revised" EMC Directive defined in the Annex I of [6] as

"*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 telecommunications 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."

might be a problem because it focuses the attention on original individual electromagnetic phenomena (OIP) and effect of the electromagnetic environment on a given item (EEE) only, whereas it is often more effective to apply prescriptions to other electromagnetic phenomena when one wishes to avoid an electromagnetic interference (EMI).

Considering the different categories of electromagnetic phenomena has the first advantage of showing not only which electromagnetic phenomena are included in the electromagnetic environment, but also all relevant electromagnetic phenomena that are not included. This helps to prevent improper uses of this concept.

A second advantage of using several categories of electromagnetic phenomena, is the following: if an EMI occurs on a first item, which is related to disturbances produced by a second item, it is useful to identify what is the category of electromagnetic phenomena which plays an excessive role, so that suitable technical (or legal) action can be taken. If this category is OIP, corresponding to an excessive emission, the technical responsibility falls on the second item. If this category is EEE, corresponding to a lack of sufficient immunity, then the technical responsibility falls on the first item. However, the category playing an excessive role can be one of the other categories as well, for instance the coupling and propagation electromagnetic phenomena (CPP) or the environment to item coupling electromagnetic phenomena (EIC), which are strongly related to installation practices and protection distances.

V. Protection Requirements

The Independent study suggests that the protection requirements of a new EMC directive should go a step further than referring to "adequate" immunity and emission levels. It should implement an appropriate parameter for evaluating adequacy. The only practical way of achieving EMC is to appropriately co-ordinate emission levels of emitters, couplings, the number of emitters and immunity levels, with due consideration to the possible effects and their criticality. This co-ordination can be achieved with the use of electromagnetic compatibility levels. This question is covered in detail in IEC 61000-1-1 [9]. However, this document fails to address the fact that there are two different kinds of co-ordination needs at radio frequencies:

- there is a need for coordinating the highest disturbance levels, for instance those produced by radio-transmitters, with the immunity level of equipment which do not use the frequency band of the disturbance for receiving radio communications;
- there is a need for coordinating the much lower levels of unintentional emitters with the immunity level of radio receiver with respect to in-band disturbances.

The first need can be covered by the specification of electromagnetic compatibility levels. In order to address the second need, the Independent study defines a "radio-noise compatibility level". In the case of an electromagnetic interference, such levels could be used as a parameter to decide what is inappropriate.

The Independent study also says that the essential requirements of a future directive could simply refer to the existence, in standards, of the definition, for different classes of locations, of suitable "electromagnetic compatibility levels" and "radio-noise compatibility levels". They could also include requirements which would apply to categories of electromagnetic phenomena other than those corresponding to emission and immunity, for a better legal coverage of all electromagnetic phenomena at work in EMC matters.

The REMCD neither refers to "electromagnetic compatibility levels" nor to "radio-noise compatibility levels". However, it contains specific requirements for fixed installations (application of good engineering practices) and the delivery of information on the installation of apparatus by their manufacturer. This should help controlling unwanted couplings and combinations of phenomena.

VI. Classification of Electromagnetic Environments

Following the approach of the IEC 61000-2-5 technical report [10] on the classification of electromagnetic environments, the Independent study defines a classification of electromagnetic environments as a combination of:

- the preliminary "classification of electromagnetic phenomena" including the definition of suitable

"electromagnetic phenomenon degree" for quantifying each electromagnetic phenomenon,
- and a subsequent "classification of locations" into "EMC location classes", including applicable "electromagnetic compatibility levels" and "radio-noise compatibility levels", specified as electromagnetic phenomenon degree, for the different electromagnetic phenomena.

The need for a classification of electromagnetic environments defined in this manner is both technical and economical. While considering only a limited number of EMC location classes, it allows to create optimal compromise between performance and cost. This optimization is desirable because:
- meeting EMC requirements has a cost which increases with higher EMC specifications (an increase in immunity levels or a decrease of the emission levels),
- engineering being a matter of compromise, higher EMC specifications often have negative impacts on some other technical characteristics,
- the most stringent requirements are only useful for specific electromagnetic environments which will be only observed at special locations.

It is also clear that it is not appropriate to let several classifications coexist. A versatile classification of electromagnetic environment could cover all needs of EMC engineering only if it:
- takes into account the relevant electromagnetic phenomena of the 7 above-mentioned categories, in order to give an acceptable picture of local electromagnetic phenomena (LEP) to be expected at a given location, once the EMC location class to which this location belongs has been determined,
- can be used as a basis for the prescription of immunity test levels and emission test levels or any other relevant test for EMC,
- addresses the need of taking into account mobile items which may be operated while they are moving.

In order to deal with the clause regarding mobile items without introducing a special case, it is possible to consider that the concept of "location" can be applied to any frame of reference. As a consequence, a location can be mobile. For instance, "inside a car" can be regarded as a location. We can for instance create a non-limiting list of useful EMC location classes:
— an EMC location class typical of residential rural locations,
— an EMC location class typical of residential urban locations,
— an EMC location class typical of commercial locations,
— an EMC location class typical of light industrial locations,
— an EMC location class typical of heavy industrial locations, generating plants and switch-yards,
— an EMC location class typical of telecommunication centers,
— an EMC location class typical of hospitals,
— an EMC location class typical of fixed outdoor installations,
— an EMC location class typical of hand-held equipments,
— an EMC location class typical of equipments installed in civilian surface vehicles.

The REMCD does not use the concept of EMC location class, but it defines an electromagnetic compatibility assessment procedure taking into account *all normal intended operating conditions* and *based on relevant phenomena*. In the case where all relevant harmonized standards have not been applied, carrying out this assessment will be very difficult if a suitable and up-to-date classification of electromagnetic environment is not available.

VII. Persons Responsible for Compliance

Even though the EMC Directive is concerned with various items and their technical characteristics, we note that obligations are born by persons. Another important consequence of having identified more than two categories of electromagnetic phenomena playing a role in an electromagnetic interference, is that it stresses that more than two persons are likely to be technically responsible for it. We therefore identify who these persons might be. The list is the following:
- electricity suppliers,
- telephone network operators, cable TV operators and other operators of widespread networks of electricity-carrying conductors,
- the constructor of a single-unit apparatus or of a multi-unit apparatus,
- the constructor of an installation,
- the user of an item capable of producing electromagnetic disturbances,
- the user of an item capable of behaving as a susceptible device,
- the standardization bodies,
- competent national administration.

It seems that an effective regulation of EMC would balance the obligations and responsibilities of these persons. A possible scheme is proposed in the Independent study.

It should be noted that the REMCD says that "*Member States shall set out the necessary provisions for the identification of the person or persons responsible for the establishment of the compliance of a fixed installation*".

VIII. Installations

In the Independent study "installing" means placing items in position, and establishing the necessary electrical connection and other technical provisions for use. An installation is defined as the new item resulting from installing one or several items. In this manner, an installation does not necessarily include any cabling. Even a hand-held, battery operated item, cordless item is installed prior to be used. At the other extreme, an installation may only include cabling. For instance, the cables and connectors laid and fixed in a building for

later (eventual) use as a medium for a local area network are installed.

Point 24 of the SLIM report [3] starts with "In practice installation rarely cause EMC problems to neighboring installations". The point of view of the Independent study is exactly the opposite: only installations have EMC problems. In fact, using the above definitions of *installing* and *installation*, this statement is almost a tautology because, by definition, it is not possible to use an item that has not been installed. A second aspect is that the larger the installation, the more important the coupling and propagation electromagnetic phenomena (CPP) are likely to be. This point is well known from EMC specialists who work on systems and installations.

The Independent study notes that a classification of electromagnetic environment such as the one described in § VI above would necessarily take coupling and propagation electromagnetic phenomena (CPP) into account in the definition of EMC location classes. As a consequence, installation practices providing given EMC performances would be implied in the definition of the EMC location classes for which an item is intended. The suitability of an installation could therefore be assessed with an inspection and/or with measurements.

The Independent study then suggests a possible analysis of the technical responsibility of persons involved in an installation, taking into account that installations are very often created or modified by non-professional, for instance consumers. This analysis, based on the assumption that every item should be regarded as being installed prior to being used, treats an installed item either as an EMC-self-contained-apparatus, or as a part of an EMC-system, or as a part of an EMC-installation. Different routes for the demonstration of compliance would apply to each case. This scheme is intended to be flexible, and to provide a fair balance of responsibility in this difficult area. According to this scheme, the following prescriptions play an important role:

- legal restrictions for use expressed by law or regulations, for a given category of item and/or a given category of EMC location class,
- restrictions for use prominently displayed at a private location,
- prescriptions prominently displayed in the instruction for use of an EMC-self-contained-apparatus of the installation.

The REMCD uses a somewhat different approach, based on the definitions shown in § III above. However, three aspects of the REMCD are close to the one just mentioned:

- separate provisions are applicable to fixed installations;
- an item which would normally be regarded as an apparatus, may eventually be exempt from conformity assessment procedure and CE marking if it is *intended for incorporation into a given fixed installation and is not otherwise commercially available*;
- when this option is not used, the manufacturer of an apparatus must *provide information on any specific precaution that have to be taken when the apparatus is assembled, installed, maintained or used, in order to ensure that the protection requirements are met*.

Note that networks of electricity-carrying conductors (power networks, telephone networks, etc) are fixed installations.

IX. Interface with Standards

The Independent study contains many suggestions for improving harmonized standards. For instance:

- the use of the words "environment" is confusing in EMC standards and should be forbidden, except when it immediately follows the word "electromagnetic";
- European standardization bodies should develop and implement a single classification of locations into EMC location classes, and a classification of electromagnetic environments,
- the purpose of a generic standard should be the prescription of EMC requirements for a given EMC location class defined in this classification, and take into account the different categories of phenomena,
- downloading standards should be free, since their authors receive no royalties (this is already the case for ETSI standards),
- the proliferation of EMC standards should be stopped,
- many unnecessary product and product family EMC standards should be withdrawn, in such a way that most items be subject to generic standards.

The REMCD says that the compliance with harmonized standards is not compulsory. The simplest way of carrying out the conformity assessment procedure should nevertheless remain the use of harmonized standards. However, the REMCD says that *the correct application of **all** relevant harmonized standards* can replace the electromagnetic compatibility assessment.

At the present time, it could be difficult to establish the list of all harmonized standards among the 111 listed in [11], which could be relevant to an innovative product combining several functions. One hardly needs to mention the fact that one needs to purchase standards to read their scope, and that the cost of these standards exceeds 4000 euros (for the French version). This situation could be improved.

X. Conclusion

The "revised" EMC Directive (REMCD) offers many improvements over the existing legislation.

One of the salient characteristics of the engineering field concerned with EMC, is that EMC specialists have to acknowledge that they often cannot avoid to deal with large uncertainties in EMC predictions. This is different from other fields of electrical engineering. It of course has an impact on the practicable ways of defining obligations, and on the best approach for an EMC directive: the perfect legislation is more difficult to achieve than in other fields.

A concluding remark concerns the fact that more equipment implement radio communications. Such equipment will not directly be covered by the REMCD, but will remain covered by the R&TTE Directive [12].

Excem is currently providing a technical assistance to the Enterprise directorate-general of the European Commission, relating to the application of the EMC Directive and R&TTE Directive. Because of this particular situation, it is necessary to stress that this paper only reflects an approach followed by the Authors, independently of any work performed by them for the Commission.

ACKNOWLEDGMENTS AND COPYRIGHT NOTICE

The authors wish to thank the Commission for having authorized Excem to use in this paper excerpts of the report [4] of the independent study, subject to the terms of the Licence Agreement LP-147-EN. The report [4] was prepared for the European Commission's Enterprise Directorate-General.

Responsibility for the information and the views set out in the report [4] lies entirely with he authors. Original Study: © European Communities, 2000.

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