EUROPEAN STANDARDIZATION

It would have been very difficult to prepare a useful survey of the standardization related to EMC in a short report. Fortunately, just a few days before beginning with this article, the author received from Mr. Nissen of the Danish Research Center for Applied Electronics ECR Electroniccentralen, Ventighedvej 4, DK-2970 Hørsholm, the publications ECR 79 and ECR 80 "Survey of international and national standards and regulations on electrical interference and susceptibility". Part I of this survey concerns the non military standards and Part II, the military and special industrial standards. Those publications contain an especially well documented and easy to consult reference manual. The first two chapters give information about vocabulary, abbreviations and organizations related to EMC. The next two chapters concern the organization and work of the IEC, the CISPR and the CENELEC. Chapter 5 condenses the CISPR publication Nr 9 on national standards and regulations, giving the titles of the standards and regulations, the date of their publication, the related measuring techniques, the limits and the status of the limits, voluntary or legal. The last chapter of Part I contains information on the following other standards and reports of EMC problems:

d) Electromagnetic susceptibility

e) Transients

f) Low frequency EMC problems

In Part II (Publ. ECR 80) there is a chapter on the format of EMC test plans followed by a chapter with a list of military and special industrial standards. In chapter 9 the international NATO standards are listed. The rest of the publication condenses the standards of the Federal Republic of Germany, Sweden, United Kingdom and USA.

As Mr. Nissen pointed out in his introduction "it is extremely difficult to obtain complete information on existing standards and authority requirements on EMC because new standards and newer editions of papers appear all the time. Many standards have become obsolete... consequently the ECR publications 79 and 80 cannot claim to be complete and up to date in every aspect."

The name CISPR is the abbreviation of "Comité International Spécial des Perturbations Radio Électriques". It is a joint committee (constituted in 1934) of the IEC (International Electrotechnical Commission) and the International Broadcasting Union (UIR) with representation of a number of other international organizations. Historically, the CISPR was the first coordinating organization on an international level which produced standards for one of the most important EMC problems, namely the protection of the reception of radio-transmission.

Details concerning the terms of reference, the membership and the structure of the CISPR may be found in Publ. CISPR N. 10 or in Publ. ECR 79, p. 44 to 51.

The results of the work of the CISPR during the past 44 years are contained in publications issued by the Central office of the IEC in Geneva (Distributed by the secretariats of the national committee of the IEC). The publications 1 to 5 concerning the general methods of measurement are now superseded by the publication 16 which combines in a single document, the texts of the former publications and their amendments. The most important standards in this publication are the specifications of selective voltmeters for the ranges 10 to 150 kHz, 150 kHz to 30 and 25 to 1000 MHz, as well as the specifications of coupling devices, artificial mains networks, absorbing clamp, current probe, high impedance voltage probe and antennas. For the time being, there are specifications of current measurements only for the range 10 to 150 kHz.

The use of those instruments and the limits for the interferring capability of equipments and systems are described with full details in the publications 11 to 15 of the CISPR.

Publ. 9 contains in a first part the lists of the limits recommended by the CISPR followed by the limits used in a number of countries. Its second part gives tables of the permissible leakage currents, of the highest capacitance and of the highest energy stored in capacitors allowed by national safety regulations.

A publication on high-voltage equipment, energy transportation and a draft for EMC standards for digital processing equipments and office machines should be at least in part, approved at the next CISPR meeting.

As already said, Part I of the Nissen report contains a good summary CISPR publication 9.

What is the status of CISPR ? As publication 9 shows, many countries have adopted in their regulations, the methods of measurement and the limits recommended by the CISPR. The CENELEC (European Committee for Electrotechnical Standardization) harmonization documents and the Directives of the council of the European Communities follow the CISPR recommendations with the exception of relatively minor points.

Most important for Europe are the "Harmonization documents" issued by the CENELEC (Comité Européen de Normalisation Electrotechnique) and the Directives of the Council of the European Communities.

It would be boring to describe how a recommendation of the CISPR is made and how it becomes an EEC directive after a long and difficult digestion in working groups, committee, technical experts translators and lawyers. As an American author said, "there are two things that the people should never see being made, sausages and laws."

Several committees of the IEC have independently produced standards concerning EMC measurements and limits pertaining more or less to the domain of CISPR. The Committee of Action of the IEC set up an ad-hoc group of experts for advising it how to remedy this lack of coordination. This group, called "the five-man group", included the chairmen and the secretaries of the CISPR and of the technical committee 77 (Electromagnetic compatibility between electrical equipments including networks) under the chairmanship of Mr. van Rooij, chief of the standardization department of the Philips Company in Eindhoven. As enlarged, the 5 man group with Prof. R. Showers of the University of Pennsylvania and Mr. G. Jackson, Director of the Electrical Research Association of Leatherhead as invited experts, this group produced 13 recommendations which were approved at the meeting for the Committee of Action of the IEC in June 1978 in Florence.

An important document of this group reports on the results of an inquiry sent to 105 secretariats and technical committees of the IEC concerning their work which could be involved with EMC problems. Thirty of them stated that they were directly interested in EMC matter while 19 replied positively to a question concerning regulation of dangerous radiation.

From the recommendations of the "5-man group" the following are of major interest:

RECOMMENDATION 7:

The enlarged 5-man group proposes that the Committee of Action requests formally TC (Technical Committee) 40 (capacitors and resistors for electronic equipment) (IEC) to start this work in the most appropriate manner and to adapt its scope to cover filters, including suppression inductors for radio interference suppression. TC 40 should deal with sizes, characteristics and types of filters (in close cooperation with CISPR Sub-Committee A) whereas CISPR Sub-Committee A should deal with measuring methods (in close cooperation with TC 40). This will avoid TC 40 having to bring in new experts and will put the CISPR statistical information on network impedances to good use.

RECOMMENDATION 8:

Test methods for emission *and immunity* above 10 kHz should be dealt with by CISPR and below 10 kHz by TC 77. For limits for immunity, however, it is not clear where this should be handled, although CISPR and TC 77 (Electromagnetic compatibility between electrical equipments including networks) (IEC) could perform a coordinating function to advise other interested Technical Committees. The Technical Committees should be instructed to contact CISPR and/or TC 77 (according to the frequency involved) in case immunity problems arise.

Note— It will be necessary for immunity to transient disturbances to be defined and in this case, there will be no simple line of demarcation between TC 77 (< 10 kHz) and CISPR (>10 kHz). Finally, Recommendation 11 calls for more permanent coordination in the IEC by "the creation of an advisory committee working for the Committee of Action along similar lines to ACET or ACOS."

The great effort of the IEC Central Office to sustain the work of the 5-man group must be thankfully recognized. One of its last moves was to send to the national committees of the IEC, an administrative circular inquiring information about the situation concerning the advances in the sector of electromagnetic immunity. Nine answers were received, namely from Australia, Belgium, Netherlands, Norway, South Africa, Switzerland, United Kingdom, USA and from the European Computer Manufacturer Association (ECMA) pertaining to:

a) Man-made EM fields (Industrial, Scientific and Medical equipment, Radar, transmitters, corona etc.)
b) Mains supply harmonics
c) Transients

The information is rather poor. There exists a great need of standards for the measurement and limits concerning transients and the immunity of apparatus.

On domestic power lines, the number of short spikes (0,1 . . . . 1 µs) per day may approximatively be

$$N = \left[\frac{165}{V}\right]^5$$

That is an average of one spike of 165 V each day. According to other authors, the frequency of occurence may be 20 to 50 times higher.

On overhead lines, the rate of spikes is about 1000 times higher for the same peak voltage for the spikes lower than 500 V.

The following considers some aspects of standards (especially CISPR standards) not immediately evident but important.

1. A relatively short survey shows that the bulk of standards covers a surprisingly small content. Many standards are the repetition or the distortion of others: they have the same experimental background although they seem different. For example, the limits of the radiation from motor vehicles required by the SAE (Society of Automotive Engineers) seems to be more severe by 22dB than the CISPR limits. As a matter of fact, the SAE limits require exactly the same amount of suppression to be satisfied as the CSIPR limits, but they are referred to peak voltages and 1 kHz bandwidth, whereas the CISPR limits are given in quasi-peak values measured with a receiver having a bandwidth of 120 kHz. (The effective agreement between SAE and CISPR Standards is the result of the good work of a common member of both organizations).
2. *The signification of limits* is very important for the mutual recognition of type approvals of mass produced appliances.
   2.1 *The CISPR recommendation that the acceptance tests should ensure with 80% probability that at least 80% of the items of the batch comply with the limit* is much more severe than it seems at first look. Knowing from previous measurements, the standard deviation of the interference levels in a batch and assuming a Gaussian Distribution, a test for approval can be made on a single item provided that a suitable margin of security be used. It can easily be shown that the tested item must comply with a limit 1.7 times the standard deviation below the nominal CISPR limit. For example, if the nominal limit is 60 dB (µV) and the standard deviation is of the order of 4 dB, the batch can only be accepted if the tested items comply with a limit of 60-(1,7 x 4) = 53 dB (µV).

   Figure 1 shows the distribution of the levels in a batch containing exactly 80% of items complying with the CISPR limit. To ensure that such a batch will be accepted only one time with five tests made on one item, we must accept only the items having the lowest levels

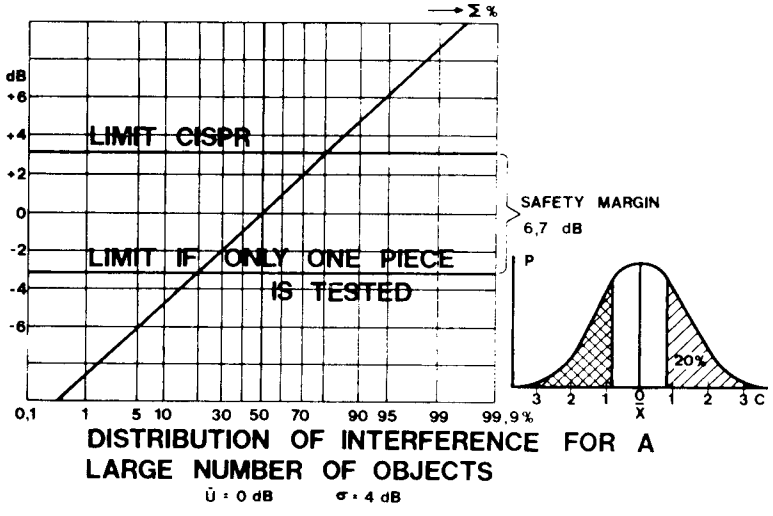

Figure 1.

up to 20% of the distribution. If we would measure all items of the batch, we would obtain 100% confidence that 80% of the items comply with the limit.

CISPR recommends use of sampling tests based on the so called non-central distribution or on the binominal distribution of the interference level of a small number of items. In the first test, the acceptance depends on the average level of the levels, on their standard deviation, and on the number of items. In the second test, it is not necessary to measure the value of the disturbing level but only to state if the level of the tested items is higher or lower than the limit. A batch is accepted if in a given number of items the number of bad units does not exceed a given value. The second test needs more items to be tested. *The operating characteristics* of both tests are given in Publ. 16 of the CISPR. They show the *acceptance probability* of batches containing a given percentage of defective units.

For example, if a production batch shall be accepted at the testing station with 90% probability, the test being made on a sample of 6 items, the batch should not contain more than 2% of defective units. If the test is made according to the binominal distribution on a sample of 7 items, the batch should not contain more than 1.6% of defective units for the same acceptance probability. This shows how hard is the "80% / 80% " rule of the CISPR. The common practice for type approval to measure only one item and accept it if its interference level is 2dB below the limit only proves that the manufacturer is capable of making products adequately suppressed. The products offered for sale should then periodically be tested.

2.2 Another peculiarity about the limits recommended by the CISPR concerns *impulsive interference* (clicks) caused mainly by switching operations. Their level is not constant but varies at random. Thus it was necessary to define statistically *a typical value* (as typical value the CISPR uses the so called upper quartile value which is the level exceeded by 25% of the number of counted spikes at the limit CN (continuous noise) allowed for continuous noise.) (See Figure 2) *of the impulsive interferences* caused by an appliance *being compared with the allowed limit.* The fundamental limits of the CISPR are specified for continuous noise and a relaxation is recommended for short impulsive interference according the following expression:

$$L_{clicks} = L_{cont.\ noise} + 20 \log 30/N$$

in which N is the average number of pulses per minute above the limit for continuous noise.

2.3 In AM, a whistle is much more annoying than a noise produced, for example, by a commutator motor. For an equal impairment of the reception of musical programs near the threshold of perceptibility, it is statistically recognized that the limits for "narrow-band" interferences (Whistle) should be in the average 12dB lower than the limits for "broad-band" interferences (Commutator motor, switches, and the like) if the interference is measured with a CISPR receiver.

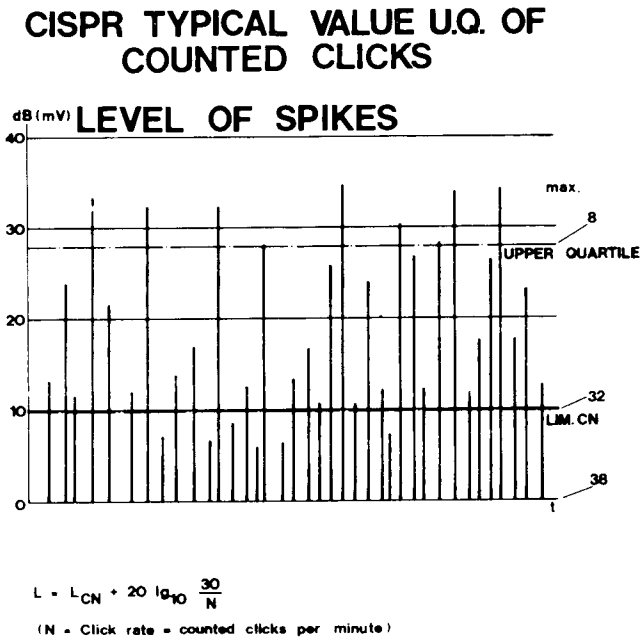

Figure 2.

Narrow-band interference can be measured with any receiver. The measurement of broad-band interference should be made with a quasi-peak detector and a specified bandwidth according to the CISPR publication 16, or with a peak RF voltmeter. In this case, it is usual to compare the level of the disturbance with the level produced by a generator of short pulses of a known amplitude referred to one kHz or one MHz bandwidth. Only for the interference caused by automobiles is there a standard CISPR conversion factor from quasi-peak to peak voltage referred to the same bandwidth of 120 kHz. CISPR limits for broad-band interference are always quasi-peak limits. The limits recommended by the CISPR for broad-band and for narrow-band are only partly consistent with the above explanations.

Those few examples show that standardization is not easy. In order to be practically implemented, the standardization requires agreements on controversial definitions and therefore may be questionable. Nevertheless, it is an absolute necessity for the progress of trade and industry. It is advantageous for industry not to wait for the proposals of official bodies like universities, PTT administrations etc., but to work with them at the earliest stage of the elaboration of standards. This may avoid delays of years for the publication and will result in a sound compromise between an academic perfectionism and the actual possibilities of the industry in view of the best service to the users of the products.

This article was prepared by J. Meyer de Stdelhofen Bern, President CISPR 1973-1978. At present consultant on EMC to SCHAFFNER AG, CH-4708 Luterbach. Reprinted by permission.