ALTERNATIVE METHODOLOGIES FOR THE CONDUCTED EMISSION MEASUREMENT OF LARGE MACHINES

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Abstract
On the legal aspect, the new European Directive on ElectroMagnetic Compatibility 2004/108/EC concerns also large machines. On a technical point of view, the special situation to characterise the EMC behaviour of large machines imply that current procedures are complex and very expensive, and in some cases even not possible. Adapted measuring methodologies and procedures are needed.

1. Introduction
Regarding EMC, the machinery-industry drags along a set of problems that makes testing and characterising very complex and expensive. Therefore, adapted procedures are needed.
One of the important aspects is that they are basically system-integrators of electrical and electronic modules. Moreover, most of the machines have characteristics (size and dimensions, weight, supply voltage, power consumption, other auxiliary provisions as cooling water, pressured air …) that make the self-certification based on the complete machine testing on an EMC test-site very complex, expensive or impossible. Most of the times, it is not feasible to transport the machine and evaluation must be carried out “in-situ” at the manufacturer or user premises.

2. European EMC Directive and standards
First of all, the EMC legal aspect should be considered. The new European Directive on ElectroMagnetic Compatibility 2004/108/EC [1] concerns also large machines. Concerning standards, one might consider the product family standards for machine tools EN 50370-1 [3] and EN 50370-2 [4], respectively for emission and immunity. Of course, large machines are not only machine tools but these standards might be applied as a reference.
The test approach described in these standards is quite informative. Type testing of a finished product should be the normal method for conformity assessment. In the case of a complete machine, a complete testing is only technically and economically feasible for a limited number of machines. It should be well defined what a type-testable machine is considering weight, dimensions, operation, testing costs and testing delay conditions.
The decision for the test procedure is mainly based on the question if the machine contains or not electromagnetic relevant components and/or modules. In the second case, no tests are required. In the first case, three procedures are applicable:

- procedure A is a type-test on the complete machine,
- procedure B is a type-test on the entire electrical set of the machine, and a visual inspection regarding the correct installation of the components and cabling,
- procedure C is to divide the machine in EMC relevant modules and test them separately under lab conditions, followed by a visual inspection, and a test as final check at the manufacturer premises.

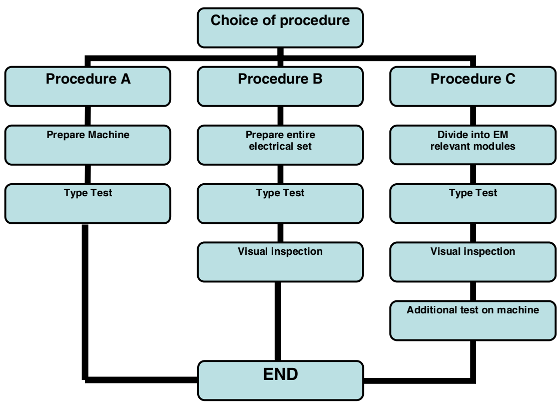

Table 1. Procedure for compliance as given in EN 50370

It is clear that procedure C sounds interesting to the machinery community, also because this allows a flexible way of handling, especially for these machines including a lot of customer based options. It allows an in-depth characterization and validation of all separate modules, and only an additional test is needed on the complete machine. These final testing may be performed using alternative methods, as developed in the research project TEMCA2. This project was conceived and proposed by a joint Working Group formed by CECIMO (European Committee for Co-operation of the Machine Tool Industries) and CENELEC. This group prepared also the EN 50370-1/2 standards, dealing with EMC and Machine Tools.

3. Conducted emission

The main problem for large machinery is related to two items:

- the current consumption, and the current handling capacity of a LISN
- the fact that it is nearly impossible to insert a measuring probe in the power mains cabling
- if possible, to develop measuring setups, with a non-contacting probe for the power mains

Therefore, a number of possible alternative methodologies have been analysed, and an example of measuring results is given in the next sections.

<u>3.1. LISN used as a voltage probe (or LISN in parallel)</u>

In this case, the LISN is only used as a voltage probe, so that the current density is not a restriction on its use. This method is specified in CISPR 16-2-1 [5], and requires the insertion of inductances between 30 and 50µH in the power mains cabling. The only advantage of this method with respect to the “classical” use of a LISN is that a low current handling LISN can be used.

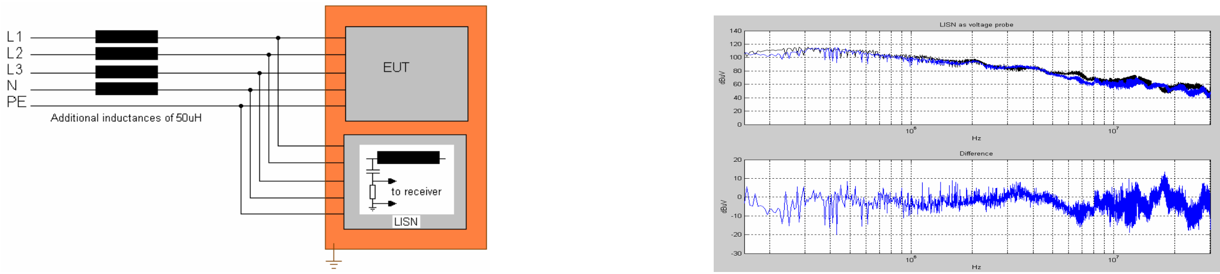

Figure 1. LISN used as voltage probe, and comparison of LISN (black) and LISN as voltage probe (blue)

<u>3.2. Voltage probe 50/1500 Ohm</u>

Referring to both CISPR 16-2-1 [5], a voltage probe can be used for measuring the conducted emission levels. This method is not suffering from any restriction about the current density. But it needs a direct contact to the life wires of the power mains, and it introduces an extra attenuation of the signals of about 30 dB, which may cause problems in a noisy environment.

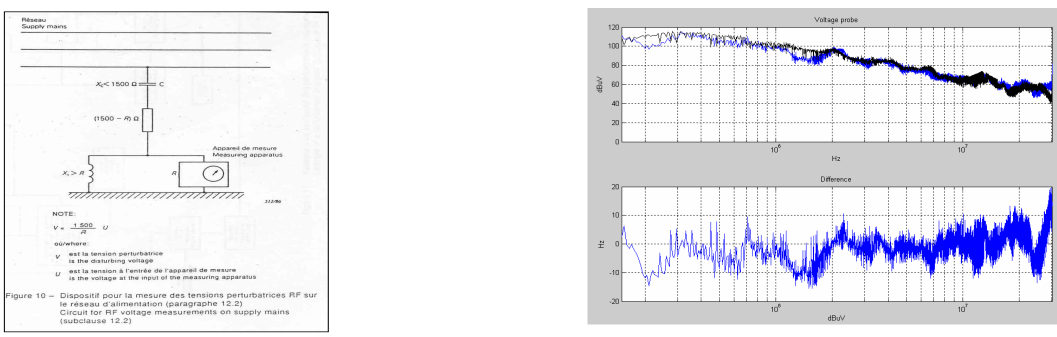

Figure 2. Voltage probe, and comparison of LISN (black) and voltage probe (blue)

<u>3.3. Capacitive Voltage Probe (CVP)</u>

A capacitive voltage probe has been developed, for measuring conducted interference from signal and data communication lines. Originally, it has been standardized in CISPR 22, but is now part of the CISPR 16 set.

Within TEMCA2, the probe has been evaluated for use of measuring the conducted interference at the power mains cabling. The main advantage of the CVP is the non-contacting measuring setup and the built-in pre-amplifier, giving an overall flat attenuation factor. The CVP is shown in the next figure 3, which clearly shows the construction and use of the probe, and an example of measured.

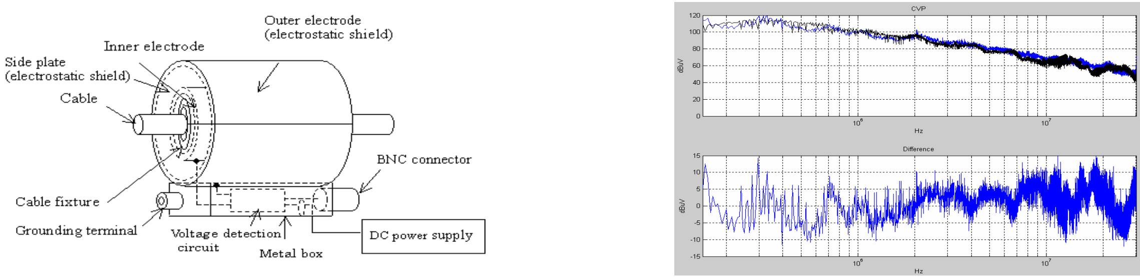

Figure 3. Capacitive Voltage Probe (CVP) and comparison of LISN (black) and CVP (blue)

3.4. EFT capacitive clamp for conducted emission

The EFT capacitive clamp as described in EN 61000-4-4, is normally used to test the immunity of an equipment against Electrical Fast Transients.

The EFT capacitive clamp is rather a large and rigid construction, and cannot be used where no flexible access to the cabling is available. This is a drawback with respect to the CVP (and also the capacitive foil). However, shorter lengths for an EFT clamp could be envisaged for practical use, but making them less sensitive. The main advantage is the defined impedance level of 50 Ohm, ensuring a good match with a preamplifier and/or measuring receiver. Unfortunately, the attenuation of the EFT capacitive clamp is rather high, and will normally need a preamplifier which might cause problems in noisy environments.

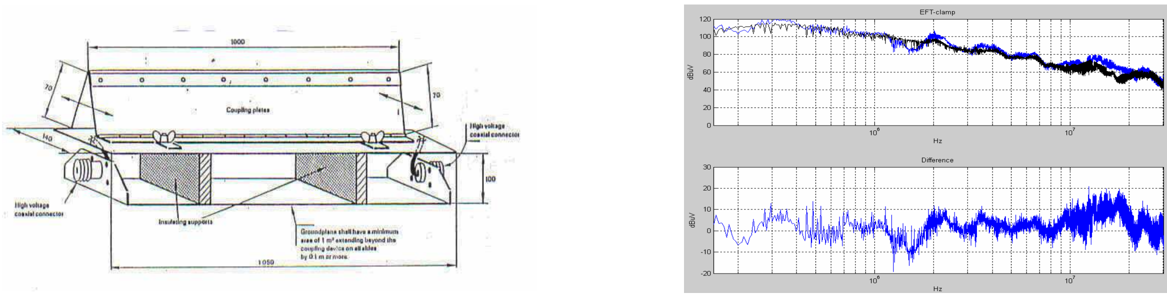

Figure 4. Comparison of LISN (black) and EFT clamp as voltage probe (blue)

3.5. Capacitive Foil Probe (CFP)

In order to combine all advantages of the discussed alternatives, a very flexible Capacitive Foil Probe (CFP) has been developed. It can be inserted in and around any power mains cabling. A capacitor is made by wrapping a foil (aluminium) around the cabling under test. The foil is connected to a measuring receiver or a preamplifier. A typical length of about 30 cm is used for this foil. A couple of practical examples is shown in the next figure.

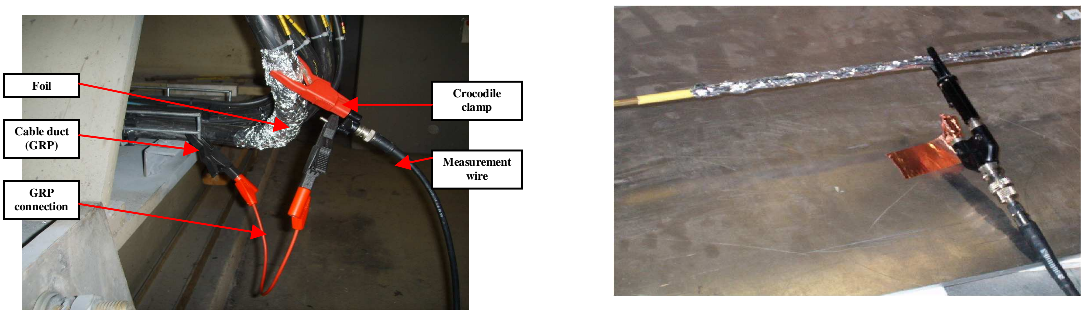

Figure 5. Examples of practical implementation of CFP

To validate this probe, calibration measurements in the laboratory have been performed, in order to identify and define the attenuation factor (or correction factor to be applied).
The laboratory setup and the resulting attenuation factor are given in figure 6. It follows that a short CFP of about 30 cm, rigidly wrapped around a cable, may be estimated to generate a capacitor of 50 up to 70 pF.

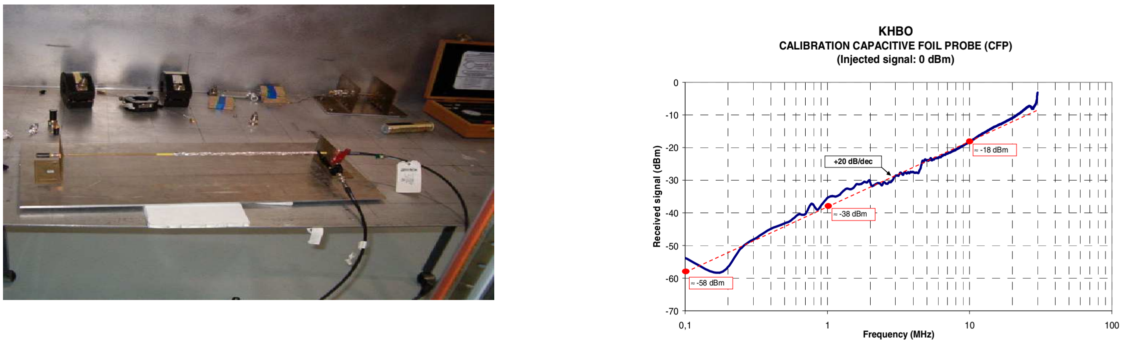

Figure 6. Calibration of the CFP

4. Example of testing a large machine in practice

In this section, an example is given how to apply the methods discussed to perform the tests under practical conditions. The machine tested is and Electrical Discharge Machine (EDM) tool from the company ONA ™. The machine uses a wire for spark erosion machining and has been used as a reference machine in the TEMCA2 project.

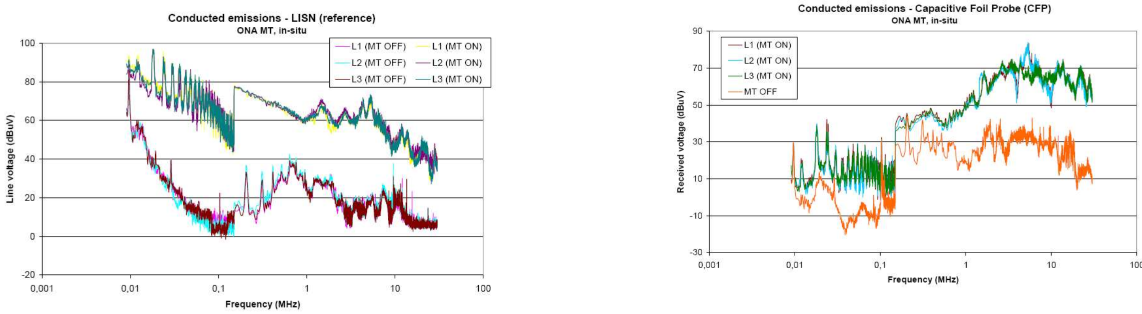

Figure 11. Conducted emission using LISN (left) and CFP probe (right)

5. Conclusions

In this paper, an "easy to apply" CFP (Capacitive Foil Probe) has been identified, characterized and evaluated.
Anyway, it is referred to the standards EN 50370-1/2 [3,4] for EMC testing of large machinery, and especially to the "path C" to show evidence of compliance, by characterising relevant subparts and modules, and by checking the final implementation in the machine by combined visual inspection and simple testing.

Acknowledgement

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References

[1] Directive 2004/108/EC of the European Parliament and of the Council of the 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC.

[2] TEMCA2, "Alternative EMC testing methods for large machines", No. G6RD-CT-2002-00865 for the 5th European Framework Program, GROWTH, Objective 6.2.1. (Methodologies to support standardisation)

[3] CENELEC, EN 50370-1, EMC – Product family standard for machine tools. Part 1: Emissions, 2005

[4] CENELEC, EN 50370-2, EMC – Product family standard for machine tools. Part 2: Immunity, 2003

[5] CISPR 16-2-1, Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods – Part 2-1: Methods of Measurement of Disturbances and Immunity – Conducted Disturbance Measurements, IEC, Rev. 1.1, 2005