

Monitoring of Electromagnetic Field Strength and the Physical Agents Directive.

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Abstract

The present and potential status of the Physical Agents Directive is presented with an estimate of the time for implementation, if passed by the EC. The monitoring of electromagnetic fields and health surveillance will be major tasks for employers if the Directive is adopted. A brief description of the calibration methods used at NPL for field strength meters and probes is presented, together with typical defects and shortcomings of some of these meters and probes that are commonly used.

Introduction

Radio frequency (RF) and microwave fields are widely used in manufacturing industry for drying, cooking, heating, welding, blister packaging and also in medicine. Very high RF and microwave powers are transmitted for television and radio broadcasting, communications, radar and navigation purposes. Hand-held transmitters such as cellular telephones, mobile radio-communications sets and radar speed guns are becoming widely used. At very low frequencies there are high field strengths close to overhead power transmission lines.

In these and many other applications at work, at home and in the pursuit of leisure activities people are subjected to levels of electromagnetic radiation significantly higher than occurs in the natural environment. It is therefore important to monitor such fields and to ensure that people are not subjected to unacceptably high field strengths which could be distressing or even injurious to health.

Present Situation HSE/NRPB guidelines

Legislation introduced in January 1993 for the management of health and safety at work requires the employer to assess risks from all possible causes including physical agents. Steps should then be introduced to reduce these risks to an acceptable level. At the present time the HSE recommends that their inspectors use the NRPB guidelines on "Restrictions on human exposure to static and time varying electromagnetic fields and radiation", when investigating cases of potential excess exposure. Using these guidelines the "Investigation Level" is the only reference that is used for current, field, power flux density etc. Investigation levels are not limits on exposure, they are to be used as a guide to when checks should be made for compliance with the basic restrictions.

The Physical Agents Directive

What is it attempting to do?

This proposal aims to improve the protection of workers against the risk due to exposure to physical agents and to harmonise health and safety requirements in this area. It is an individual Directive under the Framework Directive 89/391/EEC. The proposal is intended to set out a framework of harmonised requirements for physical agents. Specific provisions for the protection of workers from noise, vibration, and optical and non-ionising electromagnetic radiation are set out in a series of annexes. It is concerned with both static and time varying electromagnetic fields.

Where it is now?

A new version of the Directive containing over 40 amendments was published in the Official Journal of the European Communities Volume 37, dated 19 August 1994.

In order to progress the Directive time needs to be allocated by the EC for this purpose and all member states must agree the wording of the document, which will then need to be adopted by the Council of Ministers. In each member state there will need to be a consultation period before the implementing legislation can be prepared and passed by the Governments. A conservative estimate by the Department of the Environment is that it will take two and one half years to implement the Directive once it has been passed. At the moment there seems to be no political will within the EC to progress this Directive with any degree of urgency.

Current Reaction?

The proposal fails to reflect the complex issues involved in trying to produce a new framework applicable to all physical agents, and it does not adequately deal with the rapidly developing state of scientific knowledge on some of the agents, in particular non-ionising electromagnetic radiation. The proposal does require the workers' exposure to risks to be assessed. However in the UK Government's view, it also requires employers to take prescriptive, burdensome protective measures even when the risk of harm is low. Therefore the proposal cannot be justified on scientific grounds. The UK believes the proposal is an unsatisfactory attempt to create a new sub-framework under the existing framework Directive, pulling together provisions on agents which do not have enough in common to make this a sensible approach.

There is concern that so many disparate things are being drawn together under one Directive and that other Physical Agents may be added later which will have to be taken into UK legislation, if the Directive is implemented.

Cost benefit analysis?

A cost benefit analysis was carried out by the Employment Department, HSE's Economic Advisers Unit in August 1994 on the original EC proposal published in 1993. A separate CBA was conducted for each type of physical agent. In the case of fields and waves the 10 year cost was estimated at £ 70 M for assessing exposure and conducting health surveillance. Because the

disease under surveillance is not known, health surveillance would consist of a general medical examination. Due to the large uncertainties in the analysis, the cost of reducing exposure was not estimated, but could be of the order of £ 20 M in the first year. It was impossible to estimate the savings from a reduction in death rate from an unspecified disease.

The overall conclusion for all the agents covered by the Directive was that the cost would outweigh the benefits by a factor of 5 to 1 over a period of ten years.

What it will mean to you if it is implemented?

The amended Directive uses three levels of exposure, Threshold Level, Action Level and Exposure Limit Value. Below the threshold level there are no adverse effects on health, at the Action level measures specified in the Directive must be taken. Above the Exposure limit value a person is exposed to unacceptable risks and it is prohibited to exceed this limit for an unprotected person.

If the Directive is approved and eventually is incorporated into UK legislation employers will be required to:

- Assess and measure the exposure level
- Endeavour to reduce exposure level to below the threshold level
- Provide personal protection as necessary
- Restrict access to risk areas
- Provide training and information for workers
- Consult and discuss with workers the content of the Directive
- Provide health surveillance of workers supervised by a doctor
- Ensure that the work place and equipment used shall be designed to reduce exposure below the threshold level if possible.
- Assess extension of exposure caused by prolonged working

Derogations may be granted in special circumstances but a list of these must be reported to the Commission once every two years.

Monitoring of Electromagnetic fields

Types of monitor available

There are monitors that keep continuous watch over prescribed areas and alarm when field strength rises above a pre-set threshold level. Recently introduced are the personal monitors with a pre-set alarm threshold, which can be worn by field engineers when working on antenna towers or in other potentially hazardous environments. The number of these in use is likely to grow very rapidly because they are small, can readily be "worn" by the user and are relatively inexpensive. The largest type of monitor in use is the hand-held variety and there are at least 30 different types of these, supplied by eight manufacturers, in use for EMC and safety monitoring purposes as indicated from the probes calibrated at NPL.

At lower frequencies it is more reliable to measure the limb or whole body current produced by

induction or contact. There are several meters available to make such measurements although the calibration of these is not so well established as for field-probes. There is also a range of ELF monitors designed for the measurement of low frequency magnetic fields, particularly at power line frequencies.

Calibration of monitors

Probes used to measure field strength or power flux density are calibrated in a linearly polarised field of known strength using a structure or local environment appropriate to the frequency of calibration and the probe geometry. Below 300 MHz TEM cells covering a range of sizes are used. A known power at the required frequency is input to the cell and the field calculated from the cell dimensions. In the range from 300 MHz to 6 GHz a tapered cell is used; this is effectively the first tapered section of a TEM cell, properly terminated at the end of the taper. Here again the known field is calculated from the input power and the cell dimensions. From 1 GHz to 60 GHz it is more convenient and accurate to make the measurements in an anechoic chamber using a calibrated antenna and power meter to establish the known field at the point of measurement in the chamber. The calibration facilities at NPL are being extended upwards to 60 GHz and to 100 GHz as demand necessitates.

In the coaxial-line type of structure the uncertainty achieved in the probe calibration is ± 1 dB and in the free space environment ± 0.5 dB for suitable probes. These uncertainties are quoted for a 95 % confidence limit. Power flux densities of 10 mW/cm^2 can be established at all frequencies quoted in the range above, 20 mW/cm^2 at most frequencies and 60 mW/cm^2 for 100 MHz and lower frequencies.

Low frequency magnetic field probes can be calibrated in a pair of Helmholtz coils where the field is deduced from the current in the coil and the coil dimensions. The uncertainty obtained at power frequencies is of the order of $\pm 1\%$ and at frequencies up to 120 kHz is of the order of $\pm 3\%$.

Problems with monitors

Even a calibrated probe can be misused and the wrong measurement made. Some probes are calibrated by the manufacturers in one configuration and can be used in a different one thereby producing a measurement in error by a significant amount. Some typical problems that arise in the use of field probes are identified below.

Linearity

All probes are non linear with frequency to varying degrees. Others are non-linear from range to range where the correction factor might change by 25% between adjacent ranges. It is therefore important that probes are calibrated at a range of frequencies and field strengths appropriate to the requirements of the customer.

Isotropy

Many "isotropic" probes are anything but isotropic and exhibit significant variations in output when rotated about three orthogonal axes in a plane polarised field. Variations of as much as ± 0.5 dB to ± 1.0 dB are not uncommon and will make a significant contribution to the uncertainty given at the time of calibration. However if a user is working with a field of known polarisation the probe can be correctly oriented and a more precise measurement can be made.

Variability and Stability

Nominally identical probes produced by one manufacturer can vary by as much as 30% in their response when subjected to a reference electric field, although the frequency response of each is very similar. The degree of non-isotropic performance also varies from probe to probe for nominally identical probes. The performance of most probes changes quite significantly with time and it is therefore advisable to have them re-calibrated at least once per year.

"Misuse"

Some manufacturers calibrate their probes in particular configurations with respect to the polarisation of the calibrating field. If these probes are then used in a different configuration very large errors can be introduced. One type of probe when used with its handle parallel to the polarisation direction of the E Field can give a reading which is 6 dB in error. However if this probe is calibrated in this orientation, and used in the same way, a measurement within the more usual uncertainty limit of ± 0.5 dB to 1 dB is obtained.

Conclusions

If the Physical Agents Directive is passed by the EC and implemented in UK legislation, employers will be burdened with a need to carry out extensive surveys of fields and currents to meet the requirements of the Directive. They will also be required to carry out health surveillance.

From the information available at present it appears that the cost of implementation greatly outweighs the benefits arising from this Directive.

References

- 1) "Board Statement on Restrictions on Human Exposure to Static and Time Varying Electromagnetic Fields and Radiation", Documents of the NRPB, Vol 4, 1993.
- 2) "Explanatory memorandum on European Community legislation" submitted by the Employment Department, 31 August 1994, 8392/94, COM(94)284.