To be at IEEE Meeting, Toronto, Sept 77 Glaser

EMISSION

EMISSION AND EXPOSURE STANDARDS FOR MICROWAVE RADIATION

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Summary

The difficulties encountered in drafting maximum permissible levels (MPL) of microwave exposure from the presently available bioeffects data are discussed, with particular reference to the widely varying MPL's in the U.S. and the U.S.S.R. Health and Welfare Canada is proposing an MPL for continuous exposure of 1 mW cm^{-2} for occupationally exposed workers and 0.1 mW cm^{-2} for the general public. The basis for this proposal is discussed along with the allowable microwave leakage levels in the Canadian Microwave Oven Regulations.

Setting Protection Standards

Few will argue that, with the tremendous increase in the number of commercial, domestic and industrial devices utilizing microwave radiation, and their virtually uncontrolled use, radiation protection standards are necessary to set limits on the amount of microwave exposure that occupational workers and the general public can accept safely. The fact that maximum permissible exposure levels are recommended indicates that confirmed biological effects have been found, and that definite health hazards exist. However, as Michaelson[1] points out "If there were a clear-cut relationship between exposure level and pathophysiologic effect, the problem of setting standards would be greatly simplified. Not only are there numerous variables to be considered, but it is often difficult or impossible to obtain the necessary data to draw valid conclusions concerning effects of exposure to various radiant energies."

In reviewing the literature one must be sure to distinguish between two types of biological effects - those that are reported as a phenomenon and those that may constitute a potential health hazard. A further complicating factor in standard setting is the apparent frequency dependence of observed biological effects. To add further to this problem, it appears[2] that there are different influences of the electric and magnetic components of the electromagnetic field with varying frequency. At the higher frequencies (GHz) the electric component dominates, while at lower frequencies (MHz-kHz) the magnetic component seems to exert an increased effect.

International Standards

Significant[3] differences exist in the maximum permissible levels (MPL) of microwave exposure, between Western and Eastern Bloc countries. In the U.S. where the microwave frequency is defined as between 10 MHz and 100 GHz, the MPL for continuous exposure to radiation workers and the general public is 10 mW cm^{-2}, and was based primarily on the maximum thermal load that a person could dissipate. However there is increasing dissatisfaction in the U.S. with the 10mW cm^{-2} figure since it does not contain sufficient safety factors to allow for the increased effects observed with pulsed beams or for such situations as workers involved in physical labour under conditions of elevated temperature and humidity.

The USSR and in fact most of Europe define the microwave range to be between 300 MHz and 300 GHz. Values of MPL in the USSR for occupationally exposed workers varies with time as shown in the table.

USSR Values of MPL for Occupational Exposure

Exp. time per day	24h	2h	20 min.
Exp. level ($mWcm^{-2}$)	0.01	0.1	1.0

The MPL values in the USSR are microwave intensity levels that can be received in any one day for the exposure times indicated. If a worker receives say 1 mW cm^{-2} for a period of 20 min. the intensity of irradiation must not exceed 0.01 mW cm^{-2} for the rest of the working day.

For microwave exposure of areas occupied by the general public, the MPL in the USSR is 1 μW cm^{-2}. 0.01 mW/cm²

The Soviet values of MPL appear to be based solely on non-thermal bioeffects data and take into account functional changes and behavioural effects reported from extended low level exposure to microwaves.

Canadian Proposals

In Canada, the Canadian Standards Association[4] recommended MPL is largely a reproduction of the American National Standards Institute value of 10 mW cm^{-2}. This standard applies to electromagnetic radiation in the frequency range 10 MHz-100 GHz. However the Federal Department of Health and Welfare's Radiation Protection Bureau is presently considering the following: for any exposure to microwave radiation workers microwave radiation, either continuous wave or pulsed, the average energy flux shall not exceed 1 mW hr. cm^{-2} for a whole body exposure in any one period nor shall the average power density exceed 25 mW cm^{-2}. Thus for a given power density P(mW cm^{-2}) the maximum exposure time t (minutes) for any one hour period is given by t= 60/P. Exposure

levels in areas occupied by the general public or personnel other than microwave radiation workers shall be restricted to one-tenth of the maximum permissible level for microwave radiation workers. The Radiation Protection Bureau defines the electromagnetic radiation frequency range to which the recommended MPL's apply, as 10 MHz to 300 GHz.

These MPL's have been set between the US and USSR values since it is believed that the US value does not take into account the large body of evidence on non thermal effects presented by Eastern Bloc countries. On the other hand, although most of these non-thermal effects have not yet been confirmed in the West, this does not mean the effects do not exist. The Eastern Bloc data have been criticized for inadequate controls and poorly designed and reported experiments.

In setting standards of microwave exposure, at this point in time one has to be reasonably conservative. It also appears that the USSR occupational and public health standards have been adopted on the basis of complete prevention of health risks and safety factors of at least 10 or even 100 have been introduced. The Canadian proposed MPLs are up to 100 times higher than the USSR values and between 10 - 100 times lower than the US value. The philosophy for using a factor of 10 lower MPL for the general public is the same as that used by the International Commission on Radiation Protection in setting MPL's for ionizing radiations. The general public represents a much larger population than the radiation workers and so one cannot accept as high a risk probability.

The Canadian Microwave oven regulations drafted under the Radiation Emitting Devices Act require that the microwave leakage radiation does not exceed 1 $mW\ cm^{-2}$ at 5 cm from an external surface, with the minimum operating load in the oven cavity. Since the domestic use of microwave ovens allows the potential for virtually uncontrolled exposure to the general public, including pregnant women and children, the allowable microwave leakage exposure has to be very low. The exposure received from a typical operation of domestic microwave oven conforming to these regulations has been estimated[3] at 5 - 20 $\mu W\ cm^{-2}$.

In developing the recommended MPLs for Canada, no consideration was given to varying these levels for different frequency ranges. It is felt that reliable data concerning the threshold levels for injury to critical organs of the human body is lacking. Also insufficient information on the frequency dependence of biological effects is available to make any meaningful recommendations. This proposal is put up for discussion and is still subject to further review within the Department of Health and Welfare.

References

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4. Canadian Standards Association, CSA Standard Z65-1966 "Radiation Hazards from Electronic Equipment", September 1966.