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DOES THE BASIS FOR A STANDARD EXIST?

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ABSTRACT

In considering the need for a standard or guideline for limiting exposure to static or slowly varying magnetic fields, one must seriously question whether sufficient knowledge exists to make any proposal at all. Indeed, it is worthwhile to review the purpose and impact of such standards. Even a "guide-line" suggests some knowledge of potential injury thresholds. The promulgation of a standard exposure limit suggests still more, and often limits support of further biological studies to determine thresholds of injury and interaction mechanisms. Past history shows that premature standards can stifle technological advance--or at the least, foster a slow-down effect. Proposals in the past have often resulted from an attempt by those working with high field strengths to quiet concerns about potential hazards, and working levels were set which could readily be accepted without interfering with current operations. Rapidly varying magnetic fields are another matter, and valid concerns should lead to the establishment of interim limits based upon current knowledge.

BACKGROUND

Occupational exposure limits (EL's) are developed to protect workers from potentially hazardous exposure to known physical or chemical agents in the work environment. A number of governmental and non-governmental professional organizations at both the national and international levels have been involved in setting such EL's. A recent four-day international symposium devoted to the philosophy of setting occupational EL's was held in Copenhagen, Denmark during 23-26 April 1985. To review the philosophies set forth in that symposium in this brief lecture is quite impossible. Although most of the presentations at that symposium related to setting limits for airborne chemical contaminants, the proceedings of that symposium are worthwhile to review for obtaining a broad perspective on this issue (ACGIH, 1985).

During the past 15-20 years as part of my assignment at the US Army Environmental Hygiene Agency and as a member of the Committee on Threshold Limit Values (TLV's) for Physical Agents of the American Conference of Governmental Industrial Hygienists (ACGIH), I have periodically reviewed the state of knowledge regarding the biological effects of static, slowly varing, and pulsed magnetic fields with an eye toward potential hazards and control measures. We have even published bibliographies on the subject (Sliney, 1984). However, we have always come to the conclusion that there was an absense of scientific information pointing to pathologic or any other adverse effects at available magnetic field strengths. With the advent of clinical Magnetic Resonance Imaging (MRI), this perspective could of course change, but it is worthwhile to note that the magnetic flux densities in occupational settings seldom approaches those experienced by the MRI patient. We have never measured more than a few hundred gauss (< 0.1 T) in industrial settings, and high-energy physics research facilities have a very small number of workers exposed to higher levels. To say that setting occupational limits for static magnetic fields has not had a high priority is an understatement. In 1980, ACGIH published a statement that insufficient knowledge existed to set guidelines for magnetic field exposures (ACGIH, 1980). I think that this statement is worthy of reference in any objective review of occupational "standards" for magnetic field exposure.

M. Repacholi has reviewed the current occupational guidelines of several US and CERN high-energy physics laboratories (Repacholi, 1985). It is worthwhile to note that all of these were guidelines for those highly specialized laboratories. From my informal discussions with health and safety personnel in two of these laboratories, it appears that there was little basis for the earlier guidelines other than to have something on paper that would trigger attention if occupational exposures significantly exceeded those experienced by accellerator magnet assembly staff during the late 1960's, and presumed to be "safe." Such guidelines were internal documents and not intended for widespread dissemination.

THE RATIONALE FOR AN EL

For any chemical or physical agent, there exists a range of biological effects. If I may be permitted to generalize, Figure 1 illustrates the typical range of effects as a function of exposure dose. At very high concentrations of a chemical agent or very high doses of a physical agent, a clearly adverse physiological effect occurs, and a threshold can generally be defined for producing that effect. A consensus of scientific opinion also frequently exists which enables us to define a range of exposures where no adverse effects appears possible, and even beneficial effects occur. Controversy sometimes occurs with regard to the grey area in between these two dose ranges. With regard to magnetic fields, we find it difficult to define the upper range of adverse effects. We cannot even plot a dose response curve with respect to other physical variables such as those shown at the bottom of Figure 1. Any theoretical concerns for adverse effects provide calculated field strengths above the range of current occupational exposure. I cannot see how one can realistically propose an occupational EL in this vacuum.

CONTROL MEASURES

If there appears to be little or no reason for concern regarding conventional occupational exposure to magnetic fields, is there any justification for protective measures. In the absence of knowledge, one can always encourage an avoidance of needless exposure--particularly for rapidly switched magnetic fields, where some theoretical concerns could be voiced.

Protective measures for industrial and scientific applications of intense magnetic fields can be categorized as engineering design measures, the use of separation distance, and administrative controls to limit needless exposure time. Another general category of hazard control measures--namely personal

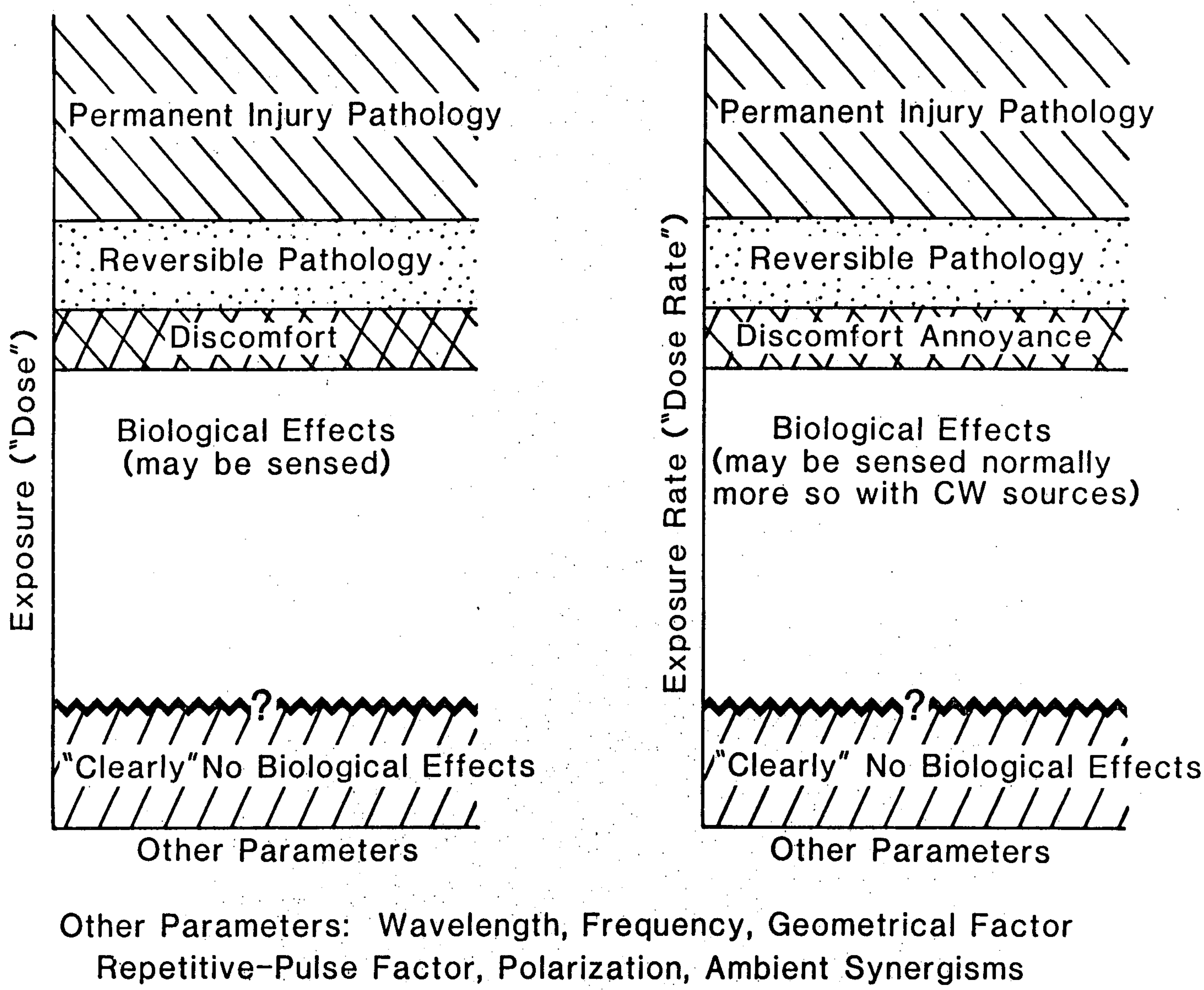

Figure 1. Range of Biological Effects of Interest When Considering Potential Health Hazards from Physical Agents. For any physical factor, such as noise, heat, light, vibration, radio-frequency radiation or magnetic fields there exists a range of biological effects. To propose occupational exposure limits for any agent, the range of biological effects should be plotted against other parameters such as wavelengths, frequency, geometrical factors, etc.

protective equipment (e.g., special garmets or face masks)--do not really exist. However, protective measures against ancillary hazards created by magnetic forces imparted to ferromagnetic surgical and dental implants or induced in electronic implants are also important to consider when assessing the need for "control measures." Three general types of controls have been employed to reduce needless exposure:

(1) Distance. Limit human acess and/or occupancy duration in locations where field strengths are excessive. Since the external magnetic flux density generally decreases as the inverse cube of the separation distance from the magnetic device, distance is the fundamental (and often least expensive) control measure. Small ferromagnetic objects are kept at a distance, and non-ferromagnetic tools are employed at close proximity to large magnets.

(2) Magnetic Shielding. The use of ferromagnetic core materials restricts the spatial extent of external flux lines of an electromgnet device. External enclosures of ferromagnetic materials can also "capture" flux lines and reduce external flux densities. However, shielding is nomally an expensive control measure limited in use to scientific instruments and has not generallly been shown to be cost-effective for large installations if compared to the application of separation distances (Hassenzahl, et al., 1978).

(3) Administrative Controls. The use of warning signs, and special accesss areas to limit exposure of personnel near large magnetic facillities has been of greatest use to control exposure of personnel with medical implants. Generally, areas below approximately 5 G (0.5 mT) have not been shown to be a potential source of interference for cardiac pacemakers, etc.

CONCLUSION

A comprehensive statement at this time is not possible regarding the health effects associated with exposure conditions (including field strength, duration, switching time exposure geometry, etc.) to define levels at which adverse effects cannot occur. Furthermore, it is not possible in many instances to state conclusively that safety has been established. Nevertheless, for particular applications and exposure situations (such as clinical applications of NMR), guidelines can be drafted based upon the available biomedical knowledge and benefit-vs-risk estimates.

For time varing fields predictions can be made of induced current densities within the body which may lead to acute -- even life threatening -- conditions and these levels have been discussed by Bernhardt and others in this symposium (Bernhardt, 1985).

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