MR 1147

AUTHORS: Neidlinger RW:

DATE: 1971

TITLE: Microwave cataract.

SOURCE: IEEE Trans Micwv Theory and Techniques 19 :250-51, 1971

MAIN SUBJECT HEADING:

AN	HU	AT	IH	M
ANALYTICS	HUMAN EFFECTS	ANIMAL TOXICITY	WORKPLACE PRACTICES-ENGINEERING CONTROLS	MISCELLANEOUS

SECONDARY SUBJECT HEADINGS: AN HU AT IH M

Physical/Chemical Properties

Review

Animal Toxicology

Non-occupational Human Exposure

Occupational Exposure

Epidemiology

Standards

Manufacturing

Uses

Reactions

Sampling/Analytical Methods

Reported Ambient Levels

Measured Methods

Work Practices

Engineering Controls

Biological Monitoring

Methods of Analysis

Treatment

Transportation/Handling/Storage/Labelling

is constant and equal to the intrinsic far-field free-space impedance. This, of course, may not be true near the surface of an oven [3]. The energy in the electric and magnetic fields are equal in the free-space condition. The power density $P_d = (\epsilon E^2)c$, where c is the velocity of propagation of the fields. The energy in the electric field is

$$U_e = 1/2(\epsilon E^2).$$

$$U_e = 1/2(P_d)\frac{1}{c}.$$

This leads to a convenient factor to convert power-density (P_d) indicated meter readings on the radiation meter in milliwatts per square centimeter, to energy-density readings in microergs per cubic meter. U_e in microergs per cubic centimeter is equal to 0.167 P_d.

EDWARD E. ASLAN
Narda Microwave Corp.
Plainview, L. I., N. Y.

REFERENCES

[1] "Standards report on measuring field strength in radio wave propagation," IEEE Std. 291, May 1969.
[2] P. W. Crapuchettes, "Microwave leakage—its nature and means for its measurements," *J. Microwave Power*, vol. 4, Oct. 1969.
[3] E. Aslan, "An electromagnetic radiation survey meter," presented at the Nat. Bur. Stand. Conf. Precision Electromagnetic Measurements, Boulder, Colo., June 3, 1970.
[4] P. F. Wacker, "Quantifying hazardous microwave fields: Analysis," Nat. Bur. Stand. Tech. Note 391, Apr. 1970.
[5] R. Bowman, "Quantifying hazardous electromagnetic fields: Practical considerations," Nat. Bur. Stand. Tech. Note 389, Apr. 1970.

Microwave Cataract

Abstract—**The production of cataract by exposure to microwave radiation can occur, although just how it occurs is not well established. Clarification as to the occurrence of cataract in microwave worker population can only be achieved by careful cumulative records of the visual and ophthalmological status of microwave worker populations.**

That cataracts can be produced by exposure to microwave radiation is well established [1]. The mechanism and conditions of exposure required for this effect remain matters of speculation, however, since microwave radiation appears both to be quite insidious in its effect and to be difficult to assess dosimetrically. Both of these features contribute to the mysterious aspects of the health hazard from microwaves. A clear and correct expression of the microwave cataract issue is of great importance to all who have industrial or military health and safety responsibilities.

The lens contains cells derived from a single-cell type with a regular arrangement. Disorders of the function, structure, or arrangement of these elements produce opacity, which may be small and insignificant or large enough to interfere with vision.

The following are at least four main mechanisms by which such opacifications may appear.

1) An alteration in the nutrition of the lens, as may occur from disease of eye elements around it, may be followed by cataracts that often is limited to the posterior capsule of the lens. This is called *cataracta complicata*, and the similarity in appearance of this cataract and some cataracts produced by or allegedly produced by microwave exposures has been mentioned repeatedly.

2) The lens is living tissue that must remain living if it is to remain transparent. Its cells have a growth pattern that is slow but life long. If anything interferes with the growth pattern of the lens, a corresponding opaque defect results. This sort of result has been demonstrated to follow exposure to ionizing radiation. Such injury has not been demonstrated consistently to be a predominant feature of microwave injury.

Manuscript received May 8, 1970; revised June 29, 1970. The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

3) Changes in the regular shape and smooth surface of the lens impair its transparency. Subtle changes in the posterior lens capsule have been described as microwave effects and may very well be the predominant effect of microwave exposure. It is possible that such changes in the capsule may increase the water content of the lens or otherwise alter metabolism to produce cataract.

4) A final possible route of microwave injury involves modified cells called lens fibers. These are really stretched out cells that are metabolically quiescent and therefore individually contribute little to any lens change. Nevertheless, since these elements constitute the main bulk of the lens, it is reasonable to expect a small effect upon this bulk of tissue to have a considerable collective effect on lens transparency.

The four possible major routes of cataract formation just mentioned are not necessarily independent. All four routes, or still others, may combine in various proportions to produce cataracts. The operating combination may vary according to physical factors, such as absorption characteristics, field strengths, direction of presentation, frequency, or according to individual factors such as age and state of health or nutrition, size, etc.

In the case of ionizing radiation, it is not at all surprising to see mitotic-linked injury predominating. The lack of a predominant mitotic-linked injury from microwave leads to the expectation of another role or combination of factors participating in cataract formation. In an age when so many chemical and physical agents are being accused of having a mitotic-linked threat, it is surprising that any other more subtle kind of injury can find expression.

Mitotic-linkage provides a very sensitive indicator of cellular injury, provided damaged cells live long enough to reproduce, for this then amplifies the effect so that the accumulated alteration can be observed. Thus, mitotic injury of cells has been shown to occur at levels of 25 rad or less, whereas cells that are incapable of mitotic activity do not show damage at exposures less than 1000 rad. This indicates that to have a cataract without mitotic-linked injury an especially sensitive target element of the lens must be affected, or a mechanism must exist that acts to concentrate the effect at some target element. Field hot spots have been postulated. Concentration of effect at the interface formed by the posterior surface of the lens and the vitreous is a possibility. This theoretically may cause a commensurately concentrated absorption of energy and a corresponding temperature elevation that alters the lens capsule, leading to cataracts. If this is the case, it seems reasonable to expect this to be frequency dependent because depth of absorption may be frequency dependent.

Experiments conducted with power levels in the watt range and using a "closed system" configuration have not supported this position. Experimental far-field observations have been inconsistent in producing cataracts but have suggested that the site of initial lenticular alteration may not be related to the microwave frequency. These findings suggest that the site of lenticular change is power related [1, pp. 14–16].

It appears to be extremely difficult to design an experiment that produces unequivocal results in a setting that has manifest fidelity to the occupational situation.

There are residual questions related to frequency of radiation and depth of effect, to the production of mitotic-linked damage, to a thermal component in the injury, and above all to the relation of each of these factors to the aging of a worker population and to other elements of the occupational environment.

Since the Army operates microwave equipment, the Surgeon General must be concerned about the safety of the operation personnel. Knowledge of all mechanisms is required to provide a complete capacity for predicting and avoiding microwave injury. Information of this type is essential to the development of precise criteria from which safety guidelines can be formulated. To be useful such guidelines must be formulated with fidelity to the subject, and they must also be useful to those who have responsibility for the health and safety of personnel. There is no reason to believe that current guidelines are inadequate for the protection of personnel from cataract formation. This is not to say that it is easy to differentiate

p. 251

microwave cataracts from all other cataracts, that all microwave cataracts that have been produced in personnel have been detected, or that all inaccurate allegations of microwave cataracts have been disproved. The military services, however, have supported efforts to monitor or detect microwave-induced cataracts in military and industrial personnel [2]. In the climate of such uncertain circumstances, adequate clarification of the subject is difficult to achieve and maintain. Clarification comes in part from experimental studies using animals and in part from the examination of workers who have been exposed accidentally or whose occupational exposure has been for some reason unavoidable. Such a clouded area is subject to unfortunate confusion. Confusion has been created by reports which have alleged microwave injury without substantial proof [3], [4]. Great care should be taken to minimize confusion by avoiding exaggeration. At the same time it is essential not to overlook any possibilities.

Experience gained by painstaking examination of selected populations with proper controls is essential to the elucidation of microwave cataract production in workers beyond the incidence that is normally expected with the passage of time. The determination of a small and subtle effect can only be achieved by the elimination of confusion by the establishment of precise records repeated at appropriate intervals during the lifetime of the worker population. This requires complete examination of the lens and a determination of fully corrected visual acuity. The status of other elements of the eye must be determined to eliminate confusion as to the cause of any present or future alteration in the lens and its relation to any impairment of visual function.

Summary

The production of cataracts by exposure to microwave radiation can occur, although just how it occurs is not well established. Clarification as to the occurrence of cataracts in microwave worker population can only be achieved by careful cumulative records of the visual and ophthalmological status of microwave worker populations.

Robert W. Neidlinger
U. S. Army Medical Res. and Develop. Command
Washington, D. C.

References

[1] R. L. Carpenter and C. A. Van Ummersen, "The action of microwave radiation on the eye," *J. Microwave Power*, vol. 3, no. 1, 1968, pp. 3–19, 14–16.
[2] L. P. LaRoche, M. M. Zaret, and A. F. Braun, "An operational safety program for opthalmic hazards of microwaves," *Arch. Environ. Health*, vol. 20, Mar. 1970, pp. 350–355.
[3] G. H. Kurz and R. B. Einaugler, "Cataract secondary to microwave radiation," *Amer. J. Ophthalm.*, Nov. 1968, pp. 866–869.
[4] A. T. Sigler, A. M. Lilienfeld, B. H. Cohen, and J. E. Westlake, "Radiation exposure in parents of children with Mongolism (Down's syndrome)," *Bull Hopkins Hosp.*, vol. 117, Dec. 1965, pp. 374–399.