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Improved NIKE-HERCULES - Personnel Safety - Microwave Radiation - Case 27675-2

April 27, 1960

MEMORANDUM FOR FILE

The Improved NIKE-HERCULES system generates microwave power levels that approach or exceed the recommended safety limits established by the American Telephone and Telegraph Company,[1] the Bell Telephone Laboratories,[2] and the U. S. Army[3] under certain conditions of frequency, pulse width, pulse repetition frequency and distance. The safety limits have been established on the basis of the most recent medical research and represent the concurrent opinion of many different agencies and industries.

The safety limits established for the Bell System are:

(1) Power levels of 10 mw/cm^2 are considered potentially hazardous and personnel should not be permitted to enter areas where they may be exposed to such levels.

(2) Power levels between 1 and 10 mw/cm^2 are safe for casual or incidental exposure.

(3) Power levels under 1 mw/cm^2 are safe for indefinite exposure.

The Army directive only includes item (1) above.

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[1]Letter, "Microwave Radiation - Possible Hazard to Personnel," by R. R. Hough, Assistant Chief Engineer, October 24, 1957.

[2]Letter, "Microwave Radiation - Possible Hazards to Personnel," by J. P. Molnar and W. C. Tinus, January 31, 1958.

[3]Department of the Army Directive, AR-20-583.

The above recommended safety levels are based on average power and are conservative to insure a reasonable degree of safety.

Many medical groups, universities, military establishments and private industry are active today in investigating the effects of microwave radiation on animals and human beings. The 'Tri-Service Conferences on Biological Hazards of Microwave Radiation' sponsored by the Air Research and Development Command Headquarters at Griffiss Air Force Base, New York has done much to bring all the various investigating groups together for common dissemination of information on the problem of microwave energy.

Medical research to date suggests that the only effect of microwave energy on living tissue is the heat generated by the average radiated power. Consequently, exposure to microwave energy should not represent a hazard unless overheating is possible. The first sensation of microwave energy is generally body heating. If a person reacts to such heating by removing himself from the source, no other harm should occur. Diathermy represents a controlled beneficial effect of microwave energy. Microwave radiation should not be confused with nuclear radiation.

The possible effects of peak power and possible non-thermal aspects of microwave radiation are also being actively investigated. The medical research to date is not conclusive in this area.

The heating effect of microwave radiation is a function of the average power of the microwave energy. This is usually expressed in milliwatts per square centimeter. It is also a function of time, since total heating is an integrated effect. The depth of the heating effect is a function of the frequency of the microwave energy. Frequencies in the region 200 to 900 mc penetrate deeply; whereas for frequencies above 1000 mc, heating is developed at or near the skin surface.

The heating effects are (1) a general rise in the body temperature, similar to a fever, or (2) something more localized, akin to cooking in a radar oven, depending on the frequency.

It has been estimated that the human body is capable of dissipating 1000 watts of surface absorbed power.

The circulation system of the human body is very effective in dissipating heat. Consequently, the microwave hazard may be somewhat greater on hot days when the human body's circulation system is working near its maximum capacity. Therefore, protective clothing to minimize sun heating is beneficial in an R.F. radiation environment. Certain areas such as the eyes, testes and hollow viscera are more critical because of their lower cooling ability. Again, the duration of exposure is an important consideration.

In regards to the Nike family of radars, a previous MMF[4] by the writer presents personnel safety distance curves, power levels and sample calculations for the Nike radars. A summary of that data is given in Table I.

The distances given in Table I for the different Nike radars are for a collimated beam in free space and do not include the effects of ground reflections or reflections from adjacent buildings. With this table as a starting point the potentially hazardous areas should best be checked with a field intensity meter.

The selection of a test instrument should be given careful consideration to insure accurate data. The instruments must be adequately shielded to prevent stray R.F. pick-up. There are many types of commercial instruments available. Three instruments on the market designed specifically for microwave power density measurement are[5]:

(1) "Broadband Power Density Meter," Model NF-157, Empire Devices, Amsterdam, N. Y. covering the frequency range from 200 mc to 10,000 mc with three different R.F. pick-up probes. The power density for mid-scale reading is one mw/cm^2 to 1 watt/cm^2. The claimed accuracy is 1 db at midscale. The weight is 11 to 13 pounds.

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[4] MM-60-6412-2, "Improved NIKE-HERCULES Microwave Radiation", by R. B. Bagby, February 29, 1960, Confidential.

[5] Unpublished Report - W. W. Mumford.

TABLE I

R.F. RADIATION RANGE SUMMARY - NIKE RADARS

NIKE Radars	Max. W (mw/cm^2)	Wo (mw/cm^2)*	R.F. RADIATION DISTANCES Range to (Ft.) 10 mw/cm^2* level	1 mw/cm^2* level
Improved NIKE-HERCULES				
HIPAR (Not. Scanning)	59.2	27.7	430	2400
HIPAR (Scanning)	-	27.7	33	160
LOPAR (Not Scanning)	19.38	9.68	125	740
LOPAR (Scanning)	-	9.68	-	38
TTR (Wide Pulse)	28.88	6.5	355	1120
TTR (Short Pulse)	2.88	0.65	-	325
TRR (Wide Pulse)	7.23	1.63	-	1000
TRR (Short Pulse)	1.45	0.29	-	410
MTR (HERCULES Mode)	6.94	1.74	-	560
MTR (AJAX Mode)	16.64	3.48	255	810
NIKE-HERCULES				
ACQ (Not Scanning)	19.38	9.68	125	740
ACQ (Scanning)	-	9.68	-	38
TTR	2.88	0.72	-	365
MTR (HERCULES Mode)	6.94	1.74	-	560
MTR (AJAX Mode)	16.64	3.48	255	810
NIKE-AJAX				
ACQ (Not Scanning)	39.78	19.39	240	1050
ACQ (Scanning)	-	19.39	-	70
TTR	9.82	2.46	-	380
MTR	28.28	5.89	195	610

*At Mid Frequency and mid-PRF

(2) "Electromagnetic Radiation Detector", Microline Model 646, Sperry Microwave Electronics Company, Clearwater, Florida. Three units are available to cover three bands (2700 to 3300 mc; 5400 to 5900 mc and 8200 to 12,000 mc), with three different antennas. The range of power density is 1 mw/cm^2 to 20 mw/cm^2 with 10 mw/cm^2 at midscale. The weight is about 8 pounds.

(3) "Densiometer", Model 1200, Radar Measurements Corporation, 190 Duffy Ave., Hicksville, N.Y. It covers five bands with 4 different antennas: VHF (200 mc - 225 mc); UHF (400 mc - 450 mc); S band (2600 mc - 3300 mc); C band (5000 mc - 3900 mc) and X-band (8500 mc - 10,000 mc). The power density, for midscale reading is 10 mw/cm^2. The weight is about two pounds. It comes with a handy "exposure meter" type of carrying case.

These devices which rely upon antenna pick-up probes all have three limitations in common: They are frequency sensitive, they are directive and they respond to only one sense of polarization. The field measurement must take these limitations into account.

It is interesting to consider the worst possible condition for the Improved NIKE-HERCULES System, with all radars focused on a common point such that the maximum possible microwave power density is obtained. Under these conditions, the Improved NIKE-HERCULES system could generate a total of 131.33 mw/cm^2 which is slightly less than the heat produced by the noon day sun at the equator. Actually this condition is not possible because of system interlocks and siting requirements.

Because no two sites are ever physically the same it is not possible to have an all inclusive safety directive. Each individual site must be examined by itself to set the system safety requirements for it.

The following operating and procedure safety rules can be established for any NIKE site:

(1) All personnel should be made familiar with the recommended safety limits and distances. Strict observance of these safety rules should be enforced just as in the case of the ever present high voltages.

(2) Operation of any radar at full power should be limited to the necessary tactical operation and maintenance and adjustment periods.

(3) Certain adjustment and alignment procedures require the transmitters to be active. Most of these procedures present no radiation problem because the antennas are either rotating or can be elevated. These include power measurements, track AFC adjustments, crystal checkout, etc. Two areas present a somewhat greater problem; use of the RF Test Set during boresighting and receiver checks, and command calibration of the missiles, particularly when the boresight mast and launching area locations are at a lower elevation than the Battery Control Area. In these instances all personnel must be alerted to the operation taking place and access to the area immediately in front of the antennas should be restricted, in accordance with the attached Table I.

At the present time no simple device that can be worn by a person is available to indicate microwave radiation levels. Since microwave energy is polarized the orientation of a warning device to the microwave energy is very important since the wrong orientation could give a false indication of safety. Devices such as neon bulbs which respond to peak power may not be operated in the environment of pulsed radars. The common X-Ray and nuclear radiation badges are not sensitive to microwave radiation. In any event, no warning device will substitute for education and personnel alertness.

While a possible microwave radiation hazard exists for the Nike radars, common sense and safe working habits will permit the system to be operated and maintained in a safe manner.

R. B. Bagby
R. B. BAGBY

WH-6412-RBB-MLW

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