HEALTH HAZARD EVALUATION REPORT

HETA 92-0224-2379
NORFOLK POLICE DEPARTMENT
NORFOLK, VIRGINIA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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Norfolk Police Department
Norfolk, Virginia

NIOSH Investigators:
Robert Malkin, D.D.S., Dr.P.H.
C. Eugene Moss HP, CSS
Salaam Kadamani
Jeffrey Smith, M.D.

SUMMARY

On April 20, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation (HHE) from traffic police officers at the Norfolk Police Department concerning the risk of cancer from the use of traffic radar devices which emit microwave radiation. On July 13, 1992, NIOSH investigators conducted a site visit. During the course of the visit, employees were interviewed, medical and employment records were reviewed, measurements of microwave exposure were made and work practices associated with the use of the radar units were assessed. Two main types of radar units were identified, hand held devices (radar guns) and fixed units, mounted in automobiles.

The power density level of a fixed-mounted radar unit located inside a patrol car was 0.5 milliwatts per square centimeter (mW/cm^2), rapidly decreasing with increased distance from the unit. Output of hand-held radar guns ranged from 0.09 mW/cm^2 (at 12 inches from the unit) to 2.2 mW/cm^2 (when measured in contact with some older units). These levels were below the Institute of Electrical and Electronics Engineers (IEEE) C9S.1-1991 standard for occupational exposure to microwave radiation.

Two cases of cancer occurring in different organ systems, and possibly a third case, were identified at the Norfolk Police Department in police officers who had used radar at some time in their career. The third case was not definitively identified as cancer, but this officer only worked with radar at the Norfolk Police Department for two years before developing his illness. This amount of time is usually insufficient for the development of cancer, which usually has a latency period of between 10 and 15 years. In any case, a definitive epidemiologic investigation of cancer among police officers would require a larger group of officers that has used hand held radar guns than found in the Norfolk (and any other single) police force. Such a study is beyond the scope of the NIOSH HHE program.

The measured levels of microwave radiation produced by the traffic radar devices did not exceed applicable occupational exposure criteria. Improved training is needed to assure safer use of the devices. Recommendations to decrease microwave exposure from radar guns are included in this report.

KEYWORDS: SIC 9221 (police protection), traffic radar guns, electromagnetic fields (EMF), microwave radiation, cancer

INTRODUCTION

On April 20, 1992, the National Institute for Occupational Safety and Health (NIOSH) received a request for a Health Hazard Evaluation from traffic police officers at the Norfolk Police Department (NPD) concerning the use of police traffic radar devices. Traffic police officers were concerned that they were exposed to levels of microwave radiation from these devices that caused cancer. On July 13 and 14, 1992, NIOSH investigators visited the NPD. Preliminary findings were presented at a closing conference on July 14, 1992, attended by police officers, police management, and city officials. An interim report was sent to the requestor and the NPD on July 28, 1992.

BACKGROUND

A. Description and use of police radar-emitting devices

Over the last 25 years law enforcement agencies have used traffic radar systems to measure vehicular speed and enforce traffic laws. Traffic radar devices operate within one of three frequency bands: X-band (10.525 gigahertz (GHz)), K-band (24.15 GHz), and Ka Band (33.7 GHz). The transmitters used in these units produce total output powers ranging from 10 to 100 mW, with 15 mW being a typical average value. Radar devices operate by transmitting a microwave signal toward a moving automobile and then detecting the portion of that signal that is reflected by the moving automobile. The device detects the frequency difference between the received and transmitted signals, from which it computes and displays the speed of the automobile.

The early radar devices were mostly of the X-band type, but since the 1970s there has been a shift in preference toward K-band units. Most of the police radar units now being manufactured are K-band systems. It is estimated there are approximately 100,000 radar devices currently in use in the United States (Fisher 1993).

Radar has been used by the Norfolk Police Department since 1956. The first unit was known as the Teko and has long since been superseded by more modern units. At the time of the investigation, Norfolk used the Kustom® Systems HR-8 or HR-10, which are hand-held units, or the KR-12, which is a car mounted (fixed) unit. There are approximately 600 police officers on the Norfolk force, and approximately 20 are traffic officers. Norfolk has increased the use of radar to include the local precincts and, at the time of this investigation, there were an additional 50 officers with radar training.

The hand-held radar guns are aimed, like a gun, at the target and emit a continuous wave signal, rather than a modulated or pulsed signal. This means that the signal of the radar gun does not vary either in strength or frequency. These guns are used by motorcycle police officers as well as officers in cars. The fixed-mounted units can be mounted inside the police vehicle, typically on top of the dashboard or rear deck, and outside the vehicle on the driver's side or on the roof.

B. Review of previous microwave radiation exposure data

Table 1 shows power density levels on K-band traffic radar devices that have been documented in the literature over the last 12 years. It must be noted that Table 1 reports data that were collected at several locations using different measurement approaches, instrumentation, and assumptions. While every attempt was made to present comparable data, this was not possible in every case. In the reviewed reports, which included 4243 different measurements of K-band radar units, power density ranged from less than 0.01 to 4.6 mW/cm^2.

C. Use of Police Radar Units

Photographs were taken of police officers using the hand-held radar guns that illustrate the various positions the units can be held during operation. Hand-held guns were predominantly used by motorcycle police officers, although the guns were also used by officers in patrol cars. Figures 2 and 3 reflect typical hand-held side positions used while Figures 4 and 5 depict different frontal positions. Figure 6 shows the gun being held in a resting position. Figures 7, 8, and 9 clearly demonstrate how motorcycle police officers position the gun either on or between their legs. Figure 10 shows a gun being carried in a case behind the police officer's leg. NIOSH investigators were informed that often the gun is "on" when placed in the case or when held as shown in Figures 7-10.

Fixed-mounted radar units in patrol cars are usually mounted on the rear deck inside the car (Figure 11) or outside of the driver's side window (Figure 12). On occasion, such as during inclement weather, an outside-mounted unit may be brought inside the car. When this is done, the unit is mounted behind the police officer's head (Figure 13). Figures 14-16 show radar guns being used inside a patrol car under different situations.

EVALUATION DESIGN AND METHODS

A. Microwave Radiation Analysis

Microwave power density measurements were carried out using a Narda model 8716 monitor with a model 8723 isotropic probe. The probe responds to frequencies between 0.3 and 40 GHz over a power density range from 0.02 to 100 mW/cm2. The lowest meter indicating level (LMIL) is 0.01 mW/cm^2. Measured values were corrected by a factor of 0.860 for the K-Band based on the manufacturer's calibration data for the probe. Measurements of the radar guns were performed both in the field and in a test room.

1. Field measurements.

Exposures under actual field working conditions were measured both in and around patrol cars and motorcycles. The same Narda meter was used for field measurements and indoor measurements. In patrol cars, fixed-mounted radar units are traditionally located in one of three locations, outside the driver's window, and on either the front dash or rear deck. In this evaluation, measurements were made on an NPD patrol car that used a fixed-mounted radar device outside the driver's side window and on the rear deck. NPD personnel also placed a radar unit inside the car on the rear driver's side window, as would be done in inclement weather, to simulate a possible worst-case exposure to the driver's head. In addition, measurements were made of radar reflections (from fixed-mounted units) within the car and at certain body locations that would likely be exposed during routine use of the radar gun.

2. Test room measurements.

The radar gun and probe were levelled and the probe was aligned in contact with the center of the unit's front. Measurements were performed in the horizontal plane as shown in Figure 1. On-axis measurements were taken at three locations: in contact with the front cover, and at distances of 6 and 12 inches from the center of the probe head to the front cover.

B. Other Radiation Sources

During this evaluation NIOSH investigators observed police officers to be exposed to a variety of other devices emitting electro-magnetic fields (EMF). These devices included personal communication devices, citizen's band (CB) radios, and cathode ray tubes from video display terminals mounted in patrol cars. Measurements were made on some of these devices as part of the evaluation.

C. Medical Evaluation

The medical evaluation consisted of interviewing the three employee requestors, interviewing personnel at the police department occupational medicine clinic, reviewing individual employee medical records and reviewing police department medical and employment records.

EVALUATION CRITERIA

Many of the observed biological effects of exposure to MW radiation can be attributed to a rise in body temperature. The heating effect of MW depends on the amount of energy absorbed by the skin. The rate of absorption, denoted the specific absorption rate (SAR) is measured in watts per kilogram (W/kg) for the whole body or parts of the body. The SAR depends on many factors such as the frequency and intensity of the radiation, size and shape of the exposed worker, and the worker's orientation in the radiation field.

The most influential standard for occupational exposure to MW radiation is the Institute of Electrical and Electronics Engineers (IEEE) standard published by the American National Standards Institute (ANSI) and known as ANSI C9S-1991. The IEEE committee concluded that a SAR of 4 W/kg represents the threshold absorption level above which adverse health effects may arise as body temperature increases. A safety factor of 10 was then added to give a SAR of 0.4 W/kg as the maximum permissible exposure limit, averaged over the entire body. The standard uses dosimetry measurements of MW radiation to calculate the power density limit necessary to achieve a SAR of 0.4 W/kg. For the traffic radar frequency, this power density limit is 10 mW/cm^2. The Occupational Safety and Health Administration (OSHA) has a radiation protection guide (defined as the radiation level which should not be exceeded without careful considerations of the reasons for doing so) of 10 mW/cm^2 averaged over any possible 0.1 hour period (29 CFR 1910.97 [1991]). In addition, the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) is based on 10 mW/cm^2 in the same frequency range.

RESULTS

A. Medical Evaluation

Radar was used by the NPD predominantly in the traffic division. NIOSH investigators toured the division, reviewed departmental records and interviewed the three police officers requesting the HHE and other police department personnel in order to identify other cancer cases.

Eight cases of cancer were identified among police officers but only three among officers who had used radar in the past; one of those had worked at NPD for only two years before developing his disease and his diagnosis of cancer could not be confirmed. In any case, there is usually a latent period between exposure and onset of disease of 10-15 years so his disease is unlikely to be related to his working at the NPD. The two cases of cancer among radar using officers were penile cancer and brain cancer. Further case identification among radar using officers was limited since police department personnel records do not indicate whether a police officer used radar-emitting devices or not and, if so, the time spent working with radar. Originally, radar was used only in the traffic division but has since been extended to other precincts throughout the city. Records of who worked in the traffic division and for how long were not available nor was it possible to accurately determine which officers had used radar in other precincts.

Because of the relative infrequency of penile and brain cancer, an epidemiologic investigation of cancer among radar using police officers would require a larger group of exposed individuals than what was available the NPD, or any other single police force. (NIOSH investigators were told by the union and management that there were only 100 police officers who had ever worked in the traffic division.) Much greater numbers are required in order to develop the statistical power in order to see a difference in the cancer rate between an exposed group (radar using police officers) and a non-exposed group.

B. Microwave Radiation

1. Test Room Measurements.

Table 2 shows the results of all power density measurements made in the test rooms. Radar emission from the radar guns at contact ranged from 0.3 to 2.2 mW/cm^2 at contact and from 0.07 to 0.7 mW/cm^2 at 12 inches. All radar guns had peak levels at the front of the unit, which dropped off with increasing distance. No levels above the LMIL were detected at 12 inches from the back surface of any gun. Several test measurements confirmed the fact that microwave emissions were concentrated to a narrow cone of about half the on-axis intensity at an angle of approximately 16 degrees with the axis.

2. Field Measurements.

When the fixed-mounted radar unit was positioned outside the patrol car, as shown in Figure 12, the level measured on the unit used on the day of evaluation was 0.5 mw/cm^2 at contact and 0.03 mw/cm^2 at 3 feet from the unit. There was no leakage of microwave radiation into the patrol car greater than the LMIL with the unit mounted outside the car. Measurements were made at the rear of an officer's head for a unit placed inside the car, as shown in Figure 13. The maximum level measured under this situation was 0.05 mw/cm^2 for the particular unit used in that car. Placing the unit behind the officer's head occurs infrequently; the unit is brought inside the car only during inclement weather.

Levels recorded with police officers riding motorbikes who held the radar gun in their laps were as high as 0.4 mw/cm^2 with older units and 0.06 mw/cm^2 with newer radar guns. Police officers might use different units on different days and each officer may have a distinct way of resting the radar gun. However, the maximum occupational exposure level that could be received was 2.2 mw/cm^2, which was the highest output from radar guns measured at contact.

Forward and scattered radiation measurements were made with a fixed-mounted radar unit installed on the rear deck. The output from the unit at contact was 0.5 mW/cm^2. Levels transmitted through the rear window at contact were measured and ranged from 0.2-0.4 mW/cm^2 depending on the degree of window tint and the presence of de-icer strips. The levels of radiation scattered backwards into the car was below LMIL at 18 inches from the window. Older fixed-mounted radar units, with higher power output levels, might produce greater amounts of scattered and transmitted microwave radiation.

Results of field strength measurements made inside patrol cars, with only the roof-mounted CB radios (27.065 megahertz [MHz]) operating, indicated that no radiation levels greater than the LMIL were found at locations where police officers sat while operating the radio. Field strength measurements in the vicinity of the head and stomach were also made on several police officers who wore a 840 MHz dispatch radio operating at 30 watts. The results of these measurements indicated exposure levels were well below both the ANSI Maximal Permissible Exposure (MPEs) and OSHA radiation protection guide of 2.8 and 10 mw/cm^2, respectively. No measurements were made on the car-mounted video display terminal (VDT), which was located near the driver's leg, due to the non-availability of appropriate instrumentation.

DISCUSSION

Many of the biological effects seen from exposure to microwave radiation are a response to a rise in body or partial-body temperature (Suess, 1985). Although it is known that very high levels of microwave radiation can be harmful, there is no firm evidence at present that the lower levels of microwave radiation emitted by traffic radar units can be hazardous.

Absorption of large amounts of microwave (MW) energy, however, can adversely affect a worker's health. Human and animal studies indicate that this type of radiation can cause harmful biological effects due to excessive heating of body tissues. MW radiation can penetrate the body and cause heating of internal tissues. The body's heat sensors are located in the skin and do not readily sense heating deep within the body. Therefore, workers may absorb large amounts of radiation without being immediately aware of the presence of such energy. There have been reports that personnel exposed to MW fields from radar equipment, MW heaters and sealers, and radio/TV towers have experienced a warming sensation some time after being exposed.

Exposure of pregnant animals to high thermal levels of MW energy can cause birth defects and kill the fetus (EPA 1984). MW radiation exposures have also been associated with human miscarriages, irregular menstrual cycles, and decreased lactation in nursing mothers (EPA 1984). Testicular damage and sterility in male animals have been produced at high levels of MW radiation (EPA 1984). Sterility, decreased sperm production, decreased sperm motility and decreased libido have been reported in workers exposed to MW (EPA 1984). Exposures to high levels of microwave (radar) radiation (>100 mW/cm^2) generate heat with tissue damage possible in less vascular areas (Michaelson 1971) and can damage the brain, spinal cord, muscles, blood, liver, kidneys and skin. At present, there is little supportable evidence that MW radiation can cause cancer, however some evidence suggests that it may act as a cancer promoter in animals (EPA 1984).

Studies of human health effects caused by low-level microwave radiation exposure have been inconclusive. Lilienfeld et al. (1978) examined cancer in employees stationed in the United States Embassy in Moscow. These employees were exposed to microwave radiation in the range of 0.005 to 0.018 mW/cm^2. No increased overall or specific mortality was evident when compared to State Department workers at other embassies. In another study (Robinette et al. 1980), United States Navy radar personnel were divided into high and low radar exposure groups. Cancer rates were elevated in the high exposure group for cancers of the respiratory tract, digestive system and leukemias. These differences, however, were not statistically significant. When the high exposure group was further divided to distinguish between those most highly exposed, a statistically significant excess of lung cancers was evident. Smoking history was not available so it was possible that the excess lung cancers were due to increased smoking in the most highly exposed group.

Thomas et al. (1987) looked at mortality rates from brain cancer among workers exposed to microwave and radiofrequency radiation. They found an excess risk among men who had been employed in the design, manufacture, installation and maintenance of electronic or electrical equipment (relative risk=2.3) but did not find an excess risk in men expose to MW/RF radiation in other jobs. They concluded that these data suggested that simple exposure to MW/RF radiation may not be responsible for the excess cancers in the studied groups. In addition, the amount of MW/RF radiation could not be quantified by the researchers, therefore actual MW/RF exposure, if any, is not known. It appears that the exposure of many of the occupations included in the study was to ELF (Extremely Low Frequency) 60 Hz fields and not to microwave radiation.

Recent concerns among police officers have centered around cancer development, particularly testicular, skin, brain, eye and lymphatic cancers. Interest in health effects from police operated radar equipment has increased due to reports (usually in the popular and trade press) of cancer, most notably testicular and brain cancer occurring in police officers who had previously used the units (Table 3) (Poynter 1992). A cluster of testicular cancer has been reported among radar-using police officers in one police department (Davis and Mostofi 1993). No other studies have been published in the scientific literature that specifically address the effects of radar exposure on the development of cancer in police officers. However, the available data are insufficient to determine if there is a link between exposure to microwaves at the low levels emitted from radar guns and the development of cancer.

Although the occupational standard is based mainly on observed thermal effects, the standard acknowledges the possibility of non-thermal effects of exposure to microwave radiation. The IEEE chose not to incorporate this data in its determination of an MPE in the standard and offered the reason that "the biological significance of non-thermal interactions has not yet resulted in any meaningful basis for alteration of the standard." Future research may produce the need to consider non-thermal effects at the next revision of the standard.

CONCLUSIONS

Measurements of microwave radiation from radar guns currently in use revealed exposure levels below applicable occupational exposure standards. Newer radar guns were found to emit substantially less microwave radiation than older guns. Radar guns were found to emit most of their microwave radiation through the front of the device, with radar emissions through the side and back being orders of magnitude less. NIOSH investigators observed officers to be potentially exposed to a variety of other devices emitting electromagnetic radiation (EMF). These included personal communication devices (2-way radios that emit radio frequencies in the MHz range), CB radios, and cathode ray tubes from computer terminals mounted in patrol cars. The antenna for the communication device was in close proximity to either the police officers' head, waist, or chest, depending on the type of antenna used. Limited measurements of EMF from these devices were made, however, since the main concern of the HHE requestors was microwave radiation and equipment needed to evaluate other EMF emissions was unavailable.

The results of the test room measurements show that the radar guns used by the NPD emitted microwave radiation with power density levels, at contact, between 0.3 and 2.2 mW/cm^2. The power density levels diminishes rapidly with distance so that the levels measured 12 inches in front of the guns were below 1 mW/cm^2 for every gun tested.

Because of the small number of radar using police officers in the NPD and the lack of records as to the use of radar by individual officers, NIOSH investigators were unable to conduct a definitive epidemiologic study regarding the development of cancer among radar using officers at the NPD. Such a project would involve analysis of many police departments and is beyond the scope of the NIOSH HHE program.

Other branches within NIOSH, however, are studying the feasibility of conducting a large and reliable epidemiologic study of police who have used radar and have been surveying state and municipal police departments around the United States in an attempt to assemble a suitably large study population from available records. If such a study population is identified, it will probably be made up of a combination of several police departments where records exist suitable to support epidemiologic study. These studies usually take several years to complete.

However, in the interim, prudence would dictate lowering exposure to microwave emissions and recommendations are offered to that end.

RECOMMENDATIONS

Police officers were concerned that existing standards were inadequate to protect them from potential health hazards of radar exposure. Although rigorous scientific evidence of health effects from the low levels of microwave radiation emitted from the radar devices used by the Norfolk Police Department does not exist, it would be judicious to keep exposure levels as low as reasonably possible until the safety of microwave exposures can be determined. Recommendations for lowering exposure include:

1. Police officers should not rest the radar gun between their legs while the unit is on. If necessary, the police department should develop a holster-type device for holding the unit that could be mounted on the motorcycle. Since emissions are from the front of the unit only, this should substantially lower exposure of motorcycle police officers.

2. Radar-emitting devices that are normally mounted outside the car or on the rear deck should never be positioned inside the car at locations where the radar beam would intercept any part of the officer's body.

3. To ensure proper operation of the radar emitting devices, police departments using them should purchase an appropriate meter to measure their power output as part of a regular maintenance program.

4. When replacement of radar units is required, units emitting higher levels of microwave radiation should be replaced with units that emit less microwave radiation and that require the activation of a trigger-type device before microwave radiation is transmitted.

6. Whenever possible, the hand-held radar unit should be turned off when not in use.

7. Training programs at the NPD should be updated to include current information about microwave emission levels, proper positioning of the radar guns and fixed-mounted units to minimize occupational exposure, and exposure to other electro-magnetic field generating equipment such as police communication equipment and video display terminals.

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AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared by:	Robert Malkin, D.D.S., Dr.P.H. Supervisory Epidemiologist Medical Section
	C. Eugene Moss Health Physicist Industrial Hygiene Section Hazard Evaluation and Technical Assistance Branch
Field Assistance	Salaam Kadamani, Ph.D. Health and Energy-Related Branch
	Jeffrey Smith, M.D. Guest Researcher Medical Section
Originating Office:	Hazard Evaluations and Technical Assistance Branch Division of Surveillance, Hazard Evaluations and Field Studies
Report Typed by:	Kathy Mitchell Secretary Medical Section Hazard Evaluations and Technical Assistance Branch

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3. OSHA Region III

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TABLE 1

K-band (24.15 GHz)Traffic Radar Power Density Measurements
Cited in the Scientific Literature

Norfolk Police Department
Norfolk, Virginia
HETA 92-0224-2379

Researcher	Number of units measured	Reported Range mW/cm^2
NBS (1981)	7	0.25-2.78
IPTM (1991)	302	0.01-0.55
Fischer (1993)	3925	0.2-4.6
Retlif (1991)	2	<0.01
Ontario Ministry of Labour (1993)	6	0.64-3.34
Balsano (1993)	1	<0.05
All groups	4243	<0.01-4.6

TABLE 2

RADAR GUN POWER OUTPUT

Norfolk Police Department
Norfolk, Virginia
HETA 92-0224-2379
July 13-14, 1992

UNIT	S/N	TAG NUMBER	MAXIMUM POWER DENSITY (mW/cm2)		
			CONTACT	6 inches	12 inches
FALCON	N7316	049369	0.6	0.28	0.12
HR-12	N3376	047698[8]	2.2	0.86	0.43
FALCON	FF5041	049137[10]	0.3	0.13	0.07
HR-8	N2853	047719	2.2	1.2	0.6
HR-8	N2764	047718[17]	1.7	1.4	0.6
HR-8	N2856	047710[16]	2.2	1.4	0.6
HR-8	N2837	047713[18]	2.0	1.0	0.6
HR-8	N2891	047275[19]	1.9	1.0	0.52
HR-8	N2772	047721[20]	2.2	1.2	0.7
FALCON	FF6042	049139[9]	0.3	0.13	0.09
Range of power density values			0.3-2.2	0.13-1.4	0.07-0.7

TABLE 3

Reported Cancer Occurrences in Police Officers
Using Different Types of Radar*

Norfolk Police Department
Norfolk, Virginia
HETA 92-0224-2379

Cancer type	Hand held	Fixed mounting	Both types	Unknown	Total
Testicular	30	7	2	1	40
Eye	1	8	1	0	10
Brain	0	15	2	1	18
Lymphoma	7	7	3	0	17
Leukemia	2	7	1	0	10
Skin	6	13	5	1	25
Other	18	14	2	1	35
Total	64	71	16	4	155

*Data in this table was compiled by Patrolman Poynter