HAZARDS OF ELECTROMAGNETIC RADIATION TO ORDNANCE (HERO) CONCERNS DURING UXO LOCATION/REMEDIATION

Kurt E. Mikoleit
Naval Surface Warfare Center, Dahlgren Division
Dahlgren, Virginia

ABSTRACT: As part of most Department of Defense (DOD) environmental cleanup efforts, subsurface contaminants such as unexploded ordnance (UXO) and hazardous waste, together with geologic features such as ground water and soil layer boundaries must be located. Many currently available subsurface detection systems being proposed for this work are electromagnetic (EM) emitting devices such as ground penetrating radars, terrain conductivity meters, borehole loggers, and metal detectors. NAVSEAINST 8020.7B currently prohibits these systems from being used on any Navy facility where ordnance is/may be present prior to a hazards of electromagnetic radiation to ordnance (HERO) safety analysis being performed. Unfortunately, many of the Naval personnel in charge of administering EPA mandated environmental clean up efforts are not aware of the safety regulations governing the use of EM emitting devices at Naval installations and the potential threat to remediation personnel and equipment. This paper will discuss applicable safety instructions, their application and limitations, and will present limited HERO safety data for several remote sensing instruments that have been evaluated.

INTRODUCTION

Currently, geophysical surveys are being planned and conducted by military/defense and contractor personnel at various Department of Defense (DOD) facilities. The goal of these surveys is to locate subsurface contaminants such as unexploded ordnance (UXO) and hazardous waste, together with geologic features such as ground water and soil layer boundaries. Almost all of these surveys require the use of electromagnetic (EM) emitting detection/location systems such as ground penetrating radars, air-borne radars, terrain conductivity meters, borehole loggers, and metal detectors. Also new Congressionally mandated programs have been initiated to design detection systems that will see deeper into the earth with greater accuracy. All of these active systems have the potential to unintentionally detonate, both current DOD ordnance inventory items as well as interred UXO. Subsequent detonation could kill personnel, damage/destroy equipment, and further contaminate soils with energetic material residue.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **AUG 1994**	2. REPORT TYPE	3. DATES COVERED **00-00-1994 to 00-00-1994**

4. TITLE AND SUBTITLE **Hazards of Electromagnetic Radiation to Ordnance (HERO) Concerns During UXO Location/Remediation**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center,Dahlgren Division,Dahlgren,VA,22448**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM000767. Proceedings of the Twenty-Sixth DoD Explosives Safety Seminar Held in Miami, FL on 16-18 August 1994.

14. ABSTRACT
see report

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**5**	

BACKGROUND

The Navy's Hazards of Electromagnetic Radiation to Ordnance (HERO) program addresses the potential for electromagnetic (EM) radiation to unintentionally initiate electroexplosive devices (EEDs) contained within current Navy and Marine Corp ordnance items. OPNAVINST 8023.2C assigns the Naval Sea Systems Command (NAVSEA) responsibility for the implementation of the Navy HERO program. NAVSEAINST 8020.7B establishes the requirement for the Director, Safety Division to review all planned transmitting and antenna installations afloat and ashore, including mobile and portable, and installations involving ordnance to ensure that potential HERO problem areas are identified. NAVSEA OP 3565 defines the HERO safety criterion, and lists the HERO classification of current Navy and Marine Corp ordnance items. The Naval Surface Warfare Center, Dahlgren Division (NSWCDD), Code F52, Dahlgren Virginia is the center of excellence for HERO within the Navy and has been performing HERO tests and analyses to verify system safety since 1959. These tests and analyses are performed on ordnance items in the stockpile to launch configuration of their life-cycle to the requirements defined in MIL-STD-1385B.

In early 1992, as the geophysical survey requirements for the Installation Restoration Program (IRP) became apparent, NSWCDD, as part of its HERO responsibilities, initiated several efforts to address UXO susceptibility to EM radiation. The applicability of NAVSEA OP 3565 and MIL-STD-1385B in these instances is very limited. One effort involved developing a basic understanding of the potential HERO problems with interred UXO and the other was an investigation into the types of subsurface detection devices that could be used during geophysical site surveys. For EM emitting devices operational characteristics such as frequency, output power, antenna type, antenna gain, pulse width, and pulse repetition frequency of the various types of systems were identified. Many of these systems have very different operational characteristics than the EOD location devices currently and previously used for ordnance location. It soon became clear that the potential detection capabilities of ground penetrating radar (GPR) systems make this type of system a prime candidate for IRP geophysical surveys. Therefore some degree of emphasis was placed on investigating GPR systems. However, several other types of EM emitting survey systems such as metal detectors and ground conductivity sensors were also identified. An immediate observation was that many of these survey systems are battery powered and have low average radiated power, typically in the milliwatt, or less, range. However some systems, including GPRs, radiate short pulses at a high pulse repetition rates which produce higher average radiated power levels. *The initial technical gut feeling was that these systems would pose no HERO safety problem (especially the low output power devices), but after the test and evaluation of several of these systems, this initial conclusion was found to be erroneous*.

Using the operational characteristics of typical detection devices, NSWCDD performed a quick-look analysis to determine if any of these systems could potentially present a HERO safety problem. The quick-look analysis covered four commercially available GPR systems operating at different frequencies, in different modulation modes, and with different output power levels. The analysis utilized some simplifying but not unrealistic assumptions of the antenna gain, soil attenuation, EED parameters, etc.. Results indicated that two of the systems produced power densities, at one foot below the surface, which were well below the published HERO safety criteria. The third system produced power densities, at one foot, very close to the safety criteria. The fourth system, a high power version of the third system, produced power densities significantly above the safety criteria.

Based on these conclusions, NSWCDD advised the Naval Facilities Engineering Command (NAVFAC, Code 18) and NAVSEA (Code 665) that a HERO safety review of all proposed survey systems which emit EM energy, for IRP and other environmental/geophysical investigations, should be conducted prior to use at sites which may contain UXO. NAVFAC requested that NAVSEA provide a technical point of contact for guidance in this area. NAVSEA directed NAVFAC to terminate the usage of EM emitting devices for IRP surveys until the effects of EM emitting devices on buried UXO is determined. NSWCDD, Code F52, has been designated by NAVSEA as the technical agent to assist in remedying this problem. To date, dissemination of this NAVSEASYSCOM safety directive has been very limited and no work has been initiated to resolve this potential safety issue.

DISCUSSION

The IRP and other environmental clean-up efforts may involve sites which contain interred UXO. NAVSEAINST 8020.7B currently prohibits EM emitting detection systems from being used on any Navy facility where ordnance is/may be present prior to a HERO safety analysis being performed. HERO safety criteria exist for current Navy/Marine Corp ordnance inventory items, but no such criteria exist for interred UXO. In many cases where geophysical surveys are required, the types of UXO present are unknown and the UXO may be structurally damaged. Additionally, conductive mixes may be decomposed, the EED circuit safety features may be degraded, and in most cases the UXO will be armed; all of which can potentially increase their susceptibility to EM radiation. Furthermore, the ordnance, is immersed in a soil medium whose conductivity and dielectric effects on the system susceptibility are unknown.

NSWCDD proposed a program which, in part, would investigate the EM susceptibility levels of armed, damaged, and aged UXO with the objective of defining an appropriate safety criteria. To date the program has not been funded. To allow these systems to be used during environmental clean up efforts, an appropriate safety criteria and certification process must be defined. This safety criteria and certification process will eliminate most HERO safety concerns and expedite the HERO approval process for uncertified systems. The NAVSEA OP 3565 HERO UNSAFE ORDNANCE criteria is currently being utilized to evaluate specific EM emitting devices. However, the risk exists that this criteria may not provide an adequate safety margin for buried UXO. Passive, non-EM emitting systems, such as the MK 12 and MK 26 systems, and acoustic systems currently in use for ordnance location do not present a HERO safety problem and therefore are exempt from the review requirement.

CURRENT ACTIVITY

To provide an interim capability to evaluate the HERO safety of site survey systems, NSWCDD is using existing safety criteria. NSWCDD recognizes the risk that, because of the lack of data on the EM susceptibility of damaged and/or aged and armed UXO, these criteria may not be adequate. Therefore until further data is available, they should be treated as the minimum acceptable criteria.

> For frequencies above 100 kHz, electric field environments such as those generated by GPR systems, the HERO UNSAFE levels of NAVSEA OP 3565 are used. The HERO UNSAFE category covers damaged ordnance and ordnance which has exposed wiring. In the absence of more appropriate criteria, buried UXO in an unknown, but probably altered and/or damaged state, must be considered as HERO UNSAFE.
>
> For frequencies below 100 kHz, systems such as metal detectors and ground conductivity meters which magnetically induce eddy currents in conductive material, the general 16.5 dB safety margin of NAVSEA OP 3565 is used for the criterion on induced currents (maximum no-fire current reduced by 16.5 dB).

The NSWCDD evaluation process for a proposed EM emitting survey system is a combination of measurement data and analysis results. All relevant information describing the emitted EM signal is obtained from published manufacturers literature and, in all cases to date, directly from technical discussions with the system design engineers. NSWCDD has found that the published literature generally does not contain sufficient information to perform an adequate HERO safety analysis.

An analytic model of the nature of the EM emissions is developed and exercised to predict the appropriate EM effects as a function of victim (EED circuit) configuration and/or location. The analytical results are compared to experimental data obtained from direct measurements of the EM fields generated by the proposed survey system. These data consist of a set of measurements at different locations and orientations which can be compared to the analytical predictions. If there are discrepancies between the analytical results and the measured data, the model is reworked and measurements are retaken. When the analytical and experimental data are in general agreement, the magnitude of the analytic data is normalized to the measured data.

To date three systems, none of which were GPR systems, have been evaluated for use during DOD IRP and other clean-up activities where the presence of UXO was suspected. A Fisher Model 1266-XB metal detector (similar to currently used EOD survey instruments) was certified for use with no restrictions. A Geonics Limited Model EM31-D non-contacting ground conductivity meter was certified for use in its normal operating mode (carried at hip height) but was specifically restricted from one potential operating mode (on the ground for maximum accuracy). Lastly, a Geonics Limited Model EM34-3 ground conductivity meter was restricted for use in its normal operating mode (on the ground) unless a different system (e.g. the certified Fisher Model 1266-

XBmetal detector) was used first to assure that there was no buried UXO within 1 meter of the surface of the earth.

CONCLUSIONS

Insufficient data exist on the EM susceptibility levels of damaged, aged, and armed UXO to define a high confidence HERO safety criteria.

Analytical data exist, some of which has been validated with experimental measurements using the proposed survey systems, which show that existing HERO safety criteria could be violated when some systems are used in the vicinity of shallow buried UXO.

Under these conditions, it would be an abrogation of NSWCDD's HERO safety responsibility and imprudent for the DOD not to require a HERO safety review of all uncertified active EM survey systems proposed for use at any sites where UXO may be present.

RESOLUTION

Immediately notify all DOD activities and environmental contractors of the potential HERO safety problems associated with using any EM emitting devices in close proximity to UXO (Naval Ordnance Center letter in process).

Evaluate all uncertified EM emitting subsurface detection devices prior to use at sites which may contain UXO.

Initiate a program to define an appropriate HERO safety criteria for UXO and all EM emitting devices.

Review the HERO certification process for approved EOD EM emitting detection devices to ensure that all HERO safety requirements have been met.