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by

W. Nevyn Rankin and T. Richard Herold

E. I. du Pont de Nemours and Company
Savannah River Laboratory
Aiken, South Carolina 29808

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COMMUNICATION IN HAZARDOUS ENVIRONMENTS

W. Nevyn Rankin and T. Richard Herold
E. I. du Pont de Nemours and Company
Savannah River Laboratory
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ABSTRACT

Radios were investigated for use in hazardous environments where protective breathing equipment such as plastic suits and respirators interfere with communication. A radio system, manufactured by Communications-Applied Technology (C-AT), was identified that was designed specifically for hazardous environment communications. This equipment is used successfully by the U. S. Army and NASA.

C-AT equipment was evaluated in plantwide applications at the Savannah River Plant (SRP) using temporary frequencies obtained by the Department of Energy - Savannah River (DOE-SR). Radios performed well in all applications, which included a tritium facility, high-level caves, a nuclear reactor building, tank farm, and a canyon building interior.

Permanent frequencies were obtained by DOE-SR for two complete six-man C-AT systems at SRP. Because of the relatively short range of these systems, replicate systems will cover all applications of this type of equipment plantwide. Twelve radio systems are currently being used successfully in plantwide applications.

INTRODUCTION

The Savannah River Plant (SRP), operated for the U. S. Government by the Du Pont Company, has safely produced special nuclear materials for defense and peaceful applications since 1953. Fuel is manufactured at SRP, irradiated in SRP nuclear reactors, and processed in SRP canyon facilities to recover products. High-level radioactive wastes are temporarily stored in large, double-walled tanks until they can be solidified in glass for permanent disposal.

The Savannah River Laboratory (SRL) provides technical assistance to SRP. Technology is currently being investigated to reduce personnel exposure, minimize the potential for release and uptake of radioactive material, and increase safety during dismantling and removal (D&R) of decommissioned radioactive facilities. Normally, this work requires protective breathing equipment because of the potential of airborne radioactive contamination. Because this equipment interferes with voice communication, radios were investigated as a way of increasing safety and reducing radiation exposure by decreasing the time required for completing a task in a radiation field.

EXPERIENCE AT OTHER SITES

Radio systems used for communication at other sites doing D&R work were investigated. Bechtel, prime contractor for decontamination at Three Mile Island, uses radios manufactured by U-Ni-Com.* This equipment consists of a small transmitter, receiver, and battery pack attached to "ear muffs" which are worn on the head. A pair of these radios was purchased for evaluation at SRL, but were not satisfactory for our application. There was no room inside the SRP-designed plastic suit for the antenna attached to the equipment. The voice-actuated switch fragmented conversation. Transmission was intermittent and sometimes garbled. The units became very uncomfortable after about 30 minutes of use because of their weight and pressure on the ears.

Westinghouse at West Valley had the same problems with U-Ni-Com radios. They recommended Controlonics** equipment. We visited Controlonics for a demonstration. The equipment they demonstrated also was not satisfactory for our application. Transmission was similar to the U-Ni-Com radio. They thought they could modify their equipment so that it would operate better, and they also knew of another radio system manufactured by Communications-Applied Technology*** (C-AT) that possibly would work better in our application. We invited both companies to come to SRL and demonstrate their radios with workers dressed in plastic suits.

The C-AT radios performed well in the demonstration. The videotape of the demonstration was well-received by the SRP Policy Review Committee and they enthusiastically endorsed purchase of a C-AT radio system for evaluation. Radio frequencies necessary for the experimental C-AT radio system were procured by DOE-SR. DOE-SR requested that SRL evaluate the C-AT radio system in plantwide application.

DESCRIPTION OF C-AT RADIO SYSTEM

The radio system consists of a base station and up to six mobile units operating from the base station (repeater) as a full-duplex, wireless, intercom system.

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*Remic Corporation, P. O. Box 1446, Elkhart, Indiana 46515
**Controlonics Corporation, Six Liberty Way, Westford, MA 01886
***Communications-Allied Technology, 10413 Samaga Drive, Oakton, VA 22124

The base station is typically placed in a clean, accessible area from which work in plastic suits is directed and monitored. The base station can be used with a head set containing a boom microphone or with a telephone-type handset. An amplified speaker can be connected to the front panel so that interested observers can monitor all conversation from all units.

Each mobile unit contains a transmitter, a receiver, and a battery. These parts are contained in a molded vinyl housing which is attached to a webbed belt. The contact microphone is held against the side of the workers larynx by an elastic strap with a Velcro™ latch. The earphones are contained in light-weight plastic housings which fit over the ears. The wires from the microphone and the earphones plug into a junction box attached to the belt. Once the radio has been placed on the worker and activated, the worker will be heard on the radio whenever he speaks. The mobile unit can also be packaged in a vinyl shoulder-holster configuration, if desired. This arrangement is preferred by some workers who are not required to work in plastic suits or other protective clothing.

Figure 1 is a pictorial diagram showing how the base station interacts with mobile units worn by workers. For clarity, only two mobile units are shown. Each transmitter requires a unique transmitting frequency, but all units receive on the same frequency. Therefore, seven different transmitting frequencies are required for six mobile units operating from one base. In Figure 1, the base transmitter frequency is labeled T_1, while the workers transmitting frequencies are labeled T_2 and T_3, respectively. All units receive on a common frequency R_1. This is accomplished electronically by mixing the audio signals from the mobile units and applying them to the base transmitter mixer. The base transmitter also accepts audio from its local microphone. The composite audio signal from the transmitter mixer then modulates the transmitter carrier frequency for simultaneous transmission to all mobile units, which receive it as frequency R_1. The audio circuitry in the base unit also includes a "modulation limiter" to control the peak level of the mixed audio signals to the transmitter. This is important when more than one person speaks at the same time. When this happens, the limiter automatically lowers the mixer gain, thereby preventing distortion that would otherwise occur from excessive composite audio levels.

The radio system has considerable versatility. The antennae mounted on the base unit are useful for local communications up to a few hundred feet. External antennae may be used if additional range is required or operation in and around heavy reinforced concrete or metal vessels is necessary. Any good quality VHF antenna may be used provided it is tuned to the approximate frequency in use. Coaxial cable can be used to remote the external antenna up to 100 feet from the base unit. The base unit can also be connected to a hardwire intercom system so that radio users can communicate with intercom users via the base unit. The base unit will also interface with conventional telephone networks.

The RF power output of the base and mobile transmitters is design-limited to 50 milliwatts to control the range of operation. The crystal-controlled transmitters operate in the VHF high band (150 to 225 MHz) where there is virtually no possibility of interference with aircraft avionic systems, RF remote control-operated equipment such as cranes and pressure-relief valves, other site radio systems, or computer "clocks".

EXPERIENCE WITH C-AT RADIOS AT OTHER SITES

Tooele Army Depot, Utah, successfully uses C-AT radio systems. This facility decommissions artillery shells containing hazardous chemicals. Workers that enter operating areas to perform routine tasks such as maintenance must wear rubberized suits. Continuous voice communication among all workers in work areas with a standby and with supervision in a clean area is required for all entries into work areas. Workers have made up to 600 entrances into work areas each year for four years with no abortions due to lack of communication.

NASA's Ames Dryden Research Center, Edwards Air Force Base, California, is responsible for the installation, check out, operation, and maintenance of all instrumentation used to collect data for experimental programs involving aerodynamic behavior during flight. A C-AT radio system is used by this group when installing and checking out aircraft equipment. Their radio system is interfaced with the aircraft's intercom system so that workers inside the aircraft can have hands-free communications with workers outside the aircraft. They have had good operating and maintenance experience for over a year with C-AT equipment.

Another group at this facility uses a C-AT radio system in an aircraft thermal stress facility and in an engine run-in test facility. This group has used a C-AT radio system for two years. Good communications were possible even in high noise areas. Essentially no maintenance of the radio system was required.

EVALUATION AT SRP

The C-AT radio system, with experimental frequencies procured by DOE-SR, was evaluated in actual radioactive jobs, and in long-term tests.

Actual Radioactive Jobs

The C-AT radio system was used in the SRP Tritium Facility. Communication was possible between operators in plastic suits and supervision on the same level of the building, and between Health Protection personnel on one level and control room personnel on another level.

The C-AT radio system was evaluated in a high-level caves facility. The base station located in front of the cells was able to communicate with a worker wearing a mobile radio under his second pair of coveralls, an assault mask, and a hood. The base-station operator directed the operator to move to several locations in a highly contaminated area behind the cells. The operator directly transmitted to the base station radiation readings being measured in the area.

Tests

The C-AT radio system was evaluated in a decommissioned SRP reactor building. Building-wide communication was possible using an external antenna system.

The C-AT radio system was evaluated in an SRP Tank Farm application. The operator in the cab of a crane with the engine running was able to communicate with an operator on the ground (handling a tether attached to the load) who was wearing an assault mask, and with supervision in a more distant clean area.

The C-AT radio system was evaluated in a canyon building. Workers in plastic suits were able to communicate with each other and with supervision in an uncontaminated area.

Long-Term Tests

Upon completion of the SRP evaluations, the radios were returned to the SRP Tritium Facility for long-term tests. The radio system was used in several applications with good results and with only minor maintenance problems.

All participants in the evaluation of these radios at SRP were impressed by the increased communications they provided.

RECOMMENDATION

Based on the favorable results from the evaluation of the C-AT radio system in plantwide applications, and on the years of favorable experience with similar systems at Tooele Depot and at NASA, immediate procurement of 14 frequencies needed for the operation of two separate base stations with six mobile units operating from each base station was recommended for SRP. Because of the relatively short range of these systems, replicates of these systems will cover all applications of this type of equipment plantwide.

FREQUENCY PROCUREMENT

All frequency allocations for government entities such as DOE, FBI, USAF, Army, Navy, etc. are handled through the Interdepartmental Radio Advisory Committee (IRAC) in Washington, D. C. The IRAC requirements for SRP exceed the usual FCC requirements, in that any device transmitting at any power level must be licensed.

In addition, only discrete frequencies not currently used on plant could be used with the radio system, and these frequencies must not interfere with any of the frequencies in use, or be interfered with by these frequencies or other frequencies in the area such as radio, TV, ham band, police, fire, etc. This is the rule regardless of the power levels involved. A computer program is available within IRAC in which all known local frequencies are entered to determine what frequencies can be safely used without interference from primary, harmonic, or sub-harmonic frequencies.

Because some frequency space was available in the Government band, the initial effort was directed toward operating the radio equipment in this band, which would have made it easier to secure the desired frequencies. DOE-SR was unable to secure permanent frequencies in an appropriate band within the tuning range of the vendor's equipment. They then directed their efforts toward security frequencies in an acceptable, available band where noninterference could be guaranteed.

The 14 frequencies selected for the Savannah River radio systems ensure that two complete base stations, with six mobile units operating from each base station, can operate within any given area at Savannah River without interfering with each other. Our comprehensive study of all SRP and SRL work areas had indicated that this number of units would satisfy any known or projected work requirement.

Figure 1 shows how the 12 mobile frequencies were "interleaved" to obtain the maximum number of frequencies in the smallest allocated frequency space. Lower frequencies must be used for the base stations because the equipment design dictated at least 10 MHz spearation between the mobile frequencies and the base repeater frequency. All 14 frequencies are within the vendor's equipment tuning range, meet the vendor's criteria for channel separation, and are in accordance with the National Table of Frequency Allocations. The "A" frequencies denote the six mobile frequencies operating from base station "A", while the "B" frequencies operate from base station "B" with no interference to "A" frequencies, so that all 14 frequencies can be used side-by-side in the same work area if desired.

OPERATING EXPERIENCE

Permanent frequencies for operation of this equipment were obtained by DOE-SR. Twelve C-AT systems have been procured. Operating experience with these systems has been good, confirming the experience of the U. S. Army at Tooele Depot, and NASA at Edwards Air Force Base.

One incident of operating problems was experienced where the radio system was abused. In this case, the radios were broken and contaminated. The working parts of the radio were removed from the belts, determined to be uncontaminated, and were returned to the vendor for repair. Based on this experience, the SRP Radio Repair Shop, an uncontaminated facility, was trained to maintain the C-AT radio system plantwide.

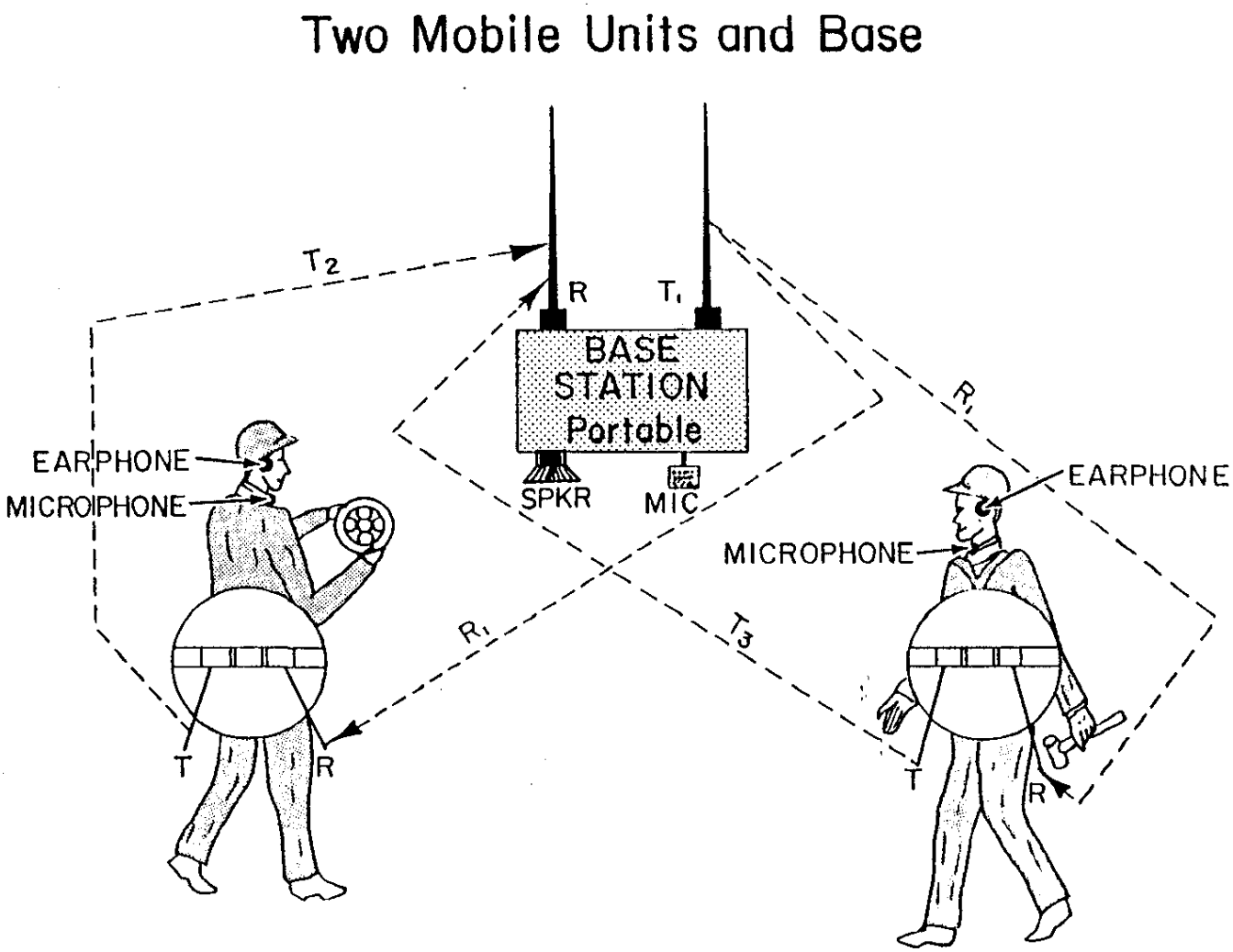

Figure 1. Two Mobile Units and Base.

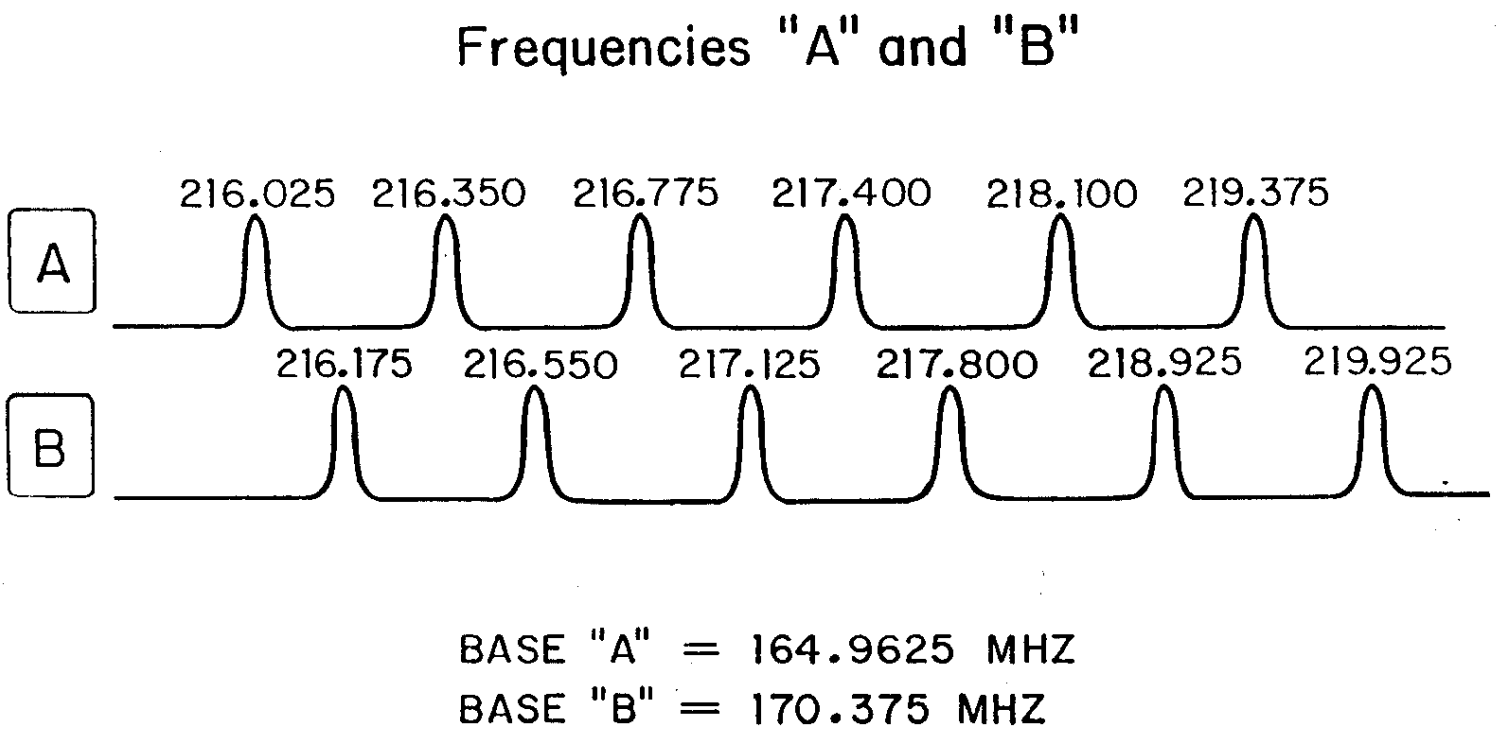

Figure 2. Frequencies "A" and "B".