Remote Monitoring of Alpha Gamma Hot Cell Facility by ARG-US RFID System - 15177

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Argonne National Laboratory (Argonne) has developed a monitoring and tracking system for nuclear materials based on radio frequency identification (RFID) technology. The system, called ARG-US ("Watchful Guardian"), has been in fielding testing and applications at selected U.S. Department of Energy (DOE) sites since 2010. ARG-US utilizes battery-powered tags to remotely and continuously monitor the environmental parameters, e.g., radiation levels, of the tagged items such as containers of radioactive materials. To demonstrate that the system can monitor nuclear and radiological facilities as well, a compact system was installed in the Alpha Gamma Hot Cell Facility (AGHCF) at Argonne in 2013. AGHCF is a Hazard Category 2 non-reactor nuclear facility that is being decommissioned. It is also being used to support de-inventory of other facilities on the Argonne site. As such, large quantities of radioactive materials and wastes are being discharged from the hot cell, loaded into transport containers, and shipped away. The deployed ARG-US system monitors worker areas, material transfer areas, cell exhaust HEPA filters, and—on a rover/robot—in-cell locations of AGHCF. Thus far, the system is performing as designed and yielding results that can be corroborated by existing surveillance means. The in-cell unit is particularly valuable, as it yields information that would otherwise be hard to obtain. In time, the benefits of automated monitoring 24/7 by ARG-US should become apparent and may lead to a fuller system with more distributed tags in the hot cell areas until the facility is fully decommissioned.

THE ELECTRONIC HARDWARE OF THE ARG-US RFID SYSTEM

The ARG-US system consists of battery-powered RFID tags, a reader network, an application software suite, secured database servers, and storage and transport web applications. Its functionality has been described in detail in previous articles [1–6]. The system has several main features. The current ARG-US RFID tag (Figure 1a) incorporates a full suite of sensors for temperature, humidity, shock, seal integrity, and radiation (gamma and neutron). The tactile seal sensor is not shown in Fig. 1a, however.

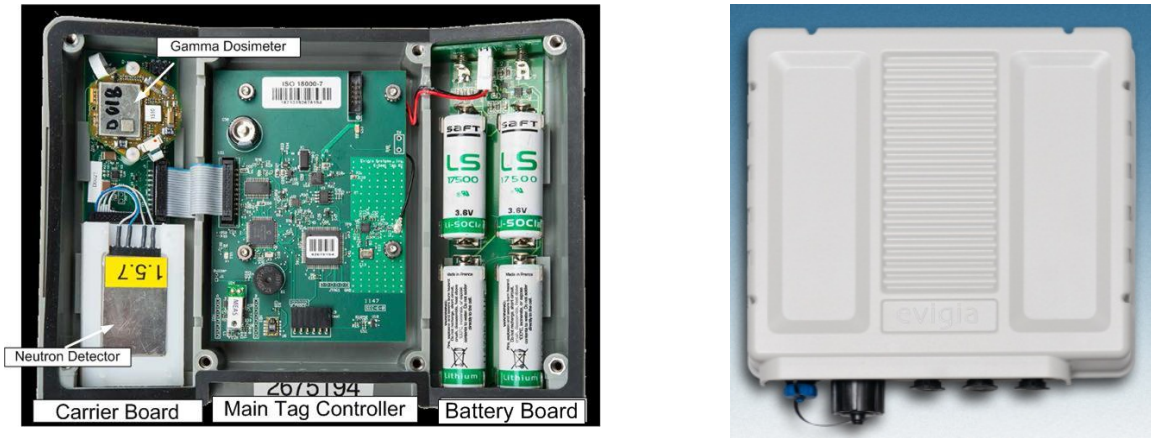


FIGURE 1. Electronic hardware of the ARG-US RFID system: (a) the RFID tag, shown with the metal back-plate removed, and (b) the reader. [The tactile seal sensor is not shown in (a).]

This versatile suite of sensors provide information on the exposure environment of the tagged items; all sensor data are regularly collected by reader(s) (shown in Fig. 1b) at pre-programmed intervals, whereas alarms are automatically sent whenever any of the sensor thresholds is violated. The low-power design of the electronic circuitry and long-life batteries (shown in Fig. 1a) are among the unique features of the ARG-US RFID system.

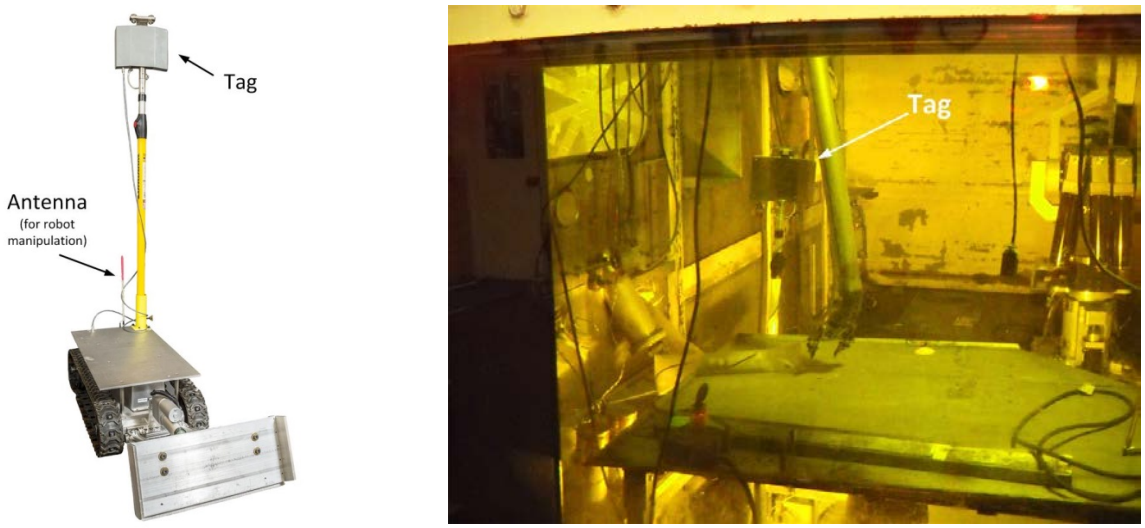
AUTOMATIC SPATIAL RADIATION SURVEY OF THE AGHCF

The AGHCF is a Hazard Category 2 nuclear facility at Argonne, which has been utilized for many years for the destructive and non-destructive examination of nuclear fuel and irradiated hardware. Figure 2 shows the work stations just outside the hot cell. Because of high radiation levels inside the hot cell, repair or replacement of instruments was generally difficult. Cost considerations also limit the number of fixed monitors inside the hot cell. Robotic surveying of radiation levels at different locations inside the hot cell has the advantage of being mobile, as well as performing other functions as described below.

FIGURE 2. AGHCF work stations with ZnBr-filled windows for viewing and remote operations in the hot cell.

The AGHCF “battlebot” (Figure 3a) is a small treaded remote-controlled robot that was constructed by personnel in Argonne’s High Energy Physics Division and then customized for the hot cell environment by AGHCF technicians. Built from off-the-shelf commercial components, the battlebot was designed to be able to maneuver under the tables inside the hot cell in order to clean the extensive amount of debris from the floor. With a base measuring 28 in. (71.12 cm) long, 16 in. (40.64 cm) wide, and 8 in. (20.32 cm) high, the battlebot is diminutive when compared to the six-foot robots utilized for in-cell operations. The battlebot is equipped with a 16-in.(40.64 cm)-wide plow that extends the total length of the device to 46 in. (116.84 cm). The front-mounted plow may be raised and lowered remotely and allows the battlebot to push objects weighing over 150 lb. (68.18 kg) across the floor of the hot cell. Mounted to the back of the plow is a bristled vacuum floor tool that can be used as a broom or connected to a HEPA-filter-equipped vacuum cleaner for gross decontamination of the hot cell floors.

Power connections on the battlebot allow for powering electronic devices from the two onboard deep cycle lead-acid batteries and are currently being used for a wireless security camera and an ARG-US RFID tag. The wireless security camera provides “eyes on” capability for viewing remote areas of the



(a) (b)

Figure 3. (a) Robot used for automatic survey. The ARG-US RFID tag is mounted at the top of a mounting pole. (b) The robot is seen through a ZnBr window of the hot cell.

floor that are difficult to see from the hot cell windows; the camera is connected to a video distribution system that will be used in the future to allow facility management and line workers to view the battlebot camera feed from their desktop computers. The camera also allows hot cell technicians to look through floor debris for samples or other items of interest.

The ARG-US RFID tag is being used to collect preliminary data about the radiological conditions that exist in the hot cell. In Figure 3(b), the robot is seen inside the hot cell through a ZnBr window. By gathering information on the dose rates that are present in the hot cell, workers can verify progress on the removal of highly radioactive waste from the hot cell, and the first cell entries to occur in over a decade can be planned without placing personnel into the hot cell environment to gather radiological data. The ability to identify areas in the hot cell with dose rates of concern is critical to the laboratory's goal of maintaining workers' whole-body doses as low as reasonably achievable (ALARA) during the cell entry process. Figure 4 shows the result of an automatic spatial radiation survey obtained by the battlebot.

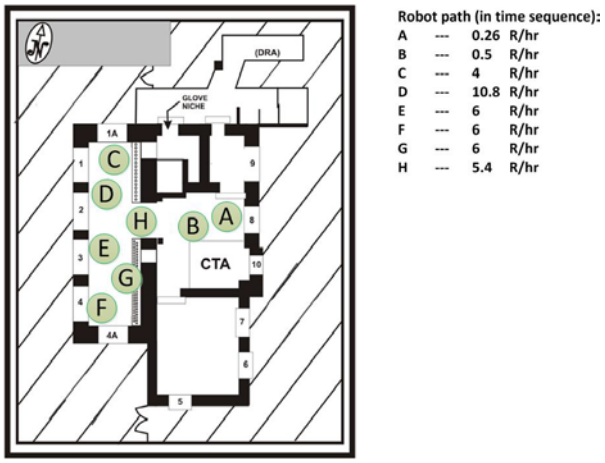


Figure 4. The radiation levels measured in different part of the AGHCF.

Different locations on the path of the robot during the survey are marked in the figure. At location D, the radiation level measured by the robot was ~11R/hr. The value is consistent with the expected relatively radiation level in that area, which had not been quantified until the robot measurement.

SUMMARY

In this article, the ability of the ARG-US RFID system to perform radiation measurements inside the hot cell has been described. The tags that have been deployed in the AGHCF were equipped with a suite of sensors for temperature, humidity, gamma radiation, neutron radiation, seal, shock, and battery strength. The collected data faithfully reflected the environmental conditions inside the facility. The data from the automatic spatial radiation survey matched the expected values. The measurement has shown that the AGHCF is a good place to test the facility monitoring capability of the RFID system. By the same token, the facility was very effectively monitored by the system.

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