

# Report on Radio Frequency Identification 2010 Category I Vault Testing Program

Richard E. Koenig,<sup>1</sup> Terence Willoner,<sup>1</sup> Richard Turlington,<sup>1</sup>  
Hanchung Tsai,<sup>2</sup> Yung Liu,<sup>2</sup> and Daniel Leduc,<sup>3</sup>

<sup>1</sup>Savannah River Site, Aiken, SC 29808

<sup>2</sup>Argonne National Laboratory, Argonne, IL 60439

<sup>3</sup>Savannah River National Laboratory, Aiken, SC 29808

## ABSTRACT

The U.S. Department of Energy (DOE) (Environmental Management [EM], Office of Packaging and Transportation [EM-45]) Packaging and Certification Program (DOE PCP) has developed a Radio Frequency Identification (RFID) tracking and monitoring system, called ARG-US, for the management of nuclear materials packages during transportation and storage. The performance of the ARG-US RFID equipment and system has been fully tested in two demonstration projects in April 2008<sup>1</sup> and August 2009. Planning has also been underway for field testing and applications of the ARG-US RFID systems at selected DOE sites and national laboratories, including the Savannah River Site (SRS), the Nevada Test Site (NTS), Argonne, Los Alamos, Oak Ridge, and Sandia National Laboratories. With the strong support of DOE-SR and DOE PCP, a field testing program has been authorized to be performed in Savannah River Site's K-Area Material Storage (KAMS) Facility, an active Category I Plutonium Storage Facility, in 2010.

This paper will report field testing progress of the ARG-US RFID equipment in KAMS, the operability and reliability trend results associated with the applications of the system, and discuss the potential benefits in enhancing safety, security and materials accountability.



## Business Summary

The primary objective of the 2010 Category I Vault Testing Program is to demonstrate the operating capabilities and functionality of the ARG-US RFID equipment and system under a realistic environment in the KAMS facility. Deploying the ARG-US RFID system leads to a reduced need for manned surveillance and increased inventory periods by providing real-time access to status and event history traceability, including environmental condition monitoring. The successful completion of the testing program will provide field data to support a future Facility Operators' campaign to finance and deploy the ARG-US RFID equipment and system. This will increase Operation efficiency and cost effectiveness for vault operation.

## Facility Test Overview

### Scope

The Category I Vault testing is the first field testing attempt of ARG-US RFID system in a real storage environment. The test consists of two dependant plans, to be performed in series. The first plan, the *Off-line Compatibility Test*, must be performed in C-Area Electronics Lab to ensure compatibility with existing K Facility Radio Frequency Tamper Indicating Devices (RFTID). Following a successful compatibility test, the equipment would be relocated to K Facility where the *In Facility Test* will be performed.

For each test, an individual test plan was written and approved for use in the specific facility where the test would be carried out.

## Off-line Compatibility Test

### A. Off-line Compatibility Test Purpose

The primary offline compatibility test criteria were to verify the Argonne Radio Frequency Identification system did not operationally impact the existing Material Monitoring System (MMS) Radio Frequency Tamper Indicating Devices (RFTID), or the NTVision video surveillance system. These two systems, MMS and NTVision, together make up the Continuous Item Monitoring and Surveillance (CIMS) system utilized in the K Facility. A Go / No Go criteria was placed on this specific test. Meaning, any result from this test criteria indicating interference from the ARG-US system to the Facility Operating system would prohibit any further ARG-US testing.

### B. Off-Line Compatibility Test Plan

- Receipt of Argonne RFID tags with the batteries installed.
  - Prior to beginning the CIMS Operability test all batteries were removed.
- CIMS Operability Test
  - To ensure the components from the CIMS Systems dedicated for the test were operable
- Initial Power-up
  - One battery on one RFID tag was installed. The unit beeped which indicated the tag powered up properly; if it had a triple beep that means the battery is weak, but the tag is nonetheless powered up. If beeps are absent the tag is defective.

- RF Communication Tests
  - With the fixed reader and the control computer powered on, and the ARG-US Onsite software loaded the RF test was initiated. All of the Argonne RFID tags were turned on and loaded into the system. All tags showed up in this collection with their tag ID numbers.
- Seal Alarm Test
  - All of the tags were shipped with a bolt and nut on the seal sensor to establish a “closed seal” condition. The alarm state is identified as a green indicator. The nut on the seal was loosened to generate an alarm while changing the indicator to red. The results were recorded on the data sheet.
- Seal Alarm Reset Test
  - One tag was mounted on a 9975 drum; the two seal-sensor bolts of the tags were tightened. This action compressed the seal sensor which removed it from the alarmed state.
- Systems Co-Operation Compatibility Test
  - On the CIMS system, all active RFTIDs were polled to verify that the components were operating normally. No ARG-US System components were affected.
  - On CIMS a seal open alarm was generated to verify an alarm was received. ARG-US System was not affected.

### **C. Off-Line Compatibility Test Results**

The CIMS system responded as normal and no signal interference nor incompatibilities between the operation of the two systems.

## **In Facility Test**

### **A. In Facility Test Purpose**

The purpose of the In Facility Test is to demonstrate the operating performance, reliability and functionality of the Argonne Radio Frequency Identification (RFID) Monitoring System within a K Facility Category I Vault. A system test plan was developed and approved to initiate the short term testing of the ARG-US RFID system.

### **B. In Facility Test Plan**

The plan is to conduct a short term test (March 2010-October 2010) of the Argonne Radio Frequency Identification system to be conducted in the K Area Material Storage (KAMS) Process Room.

Test Criteria related to performance and operability of the ARG-US System includes:

- Seal Tamper Indicating Reliability
- Seal Temperature Recording Accuracy
- Seal Humidity Recording Accuracy
- Seal Shock Sensitivity and Reliability
- Battery Level Indication

Prior to test data collection, various facility preparations had to be conducted. These preparations included:

### 1. SARP/COC Basis and Application – Package Safety

License changes to both the 9975 and the 9977 have been issued to include the RFID monitoring system. The RFID tags on the 9975 and 9977 are shown in Figure 1 below. Each tag is attached on the side of the drum just below the closure and uses existing closure hardware.

An evaluation of the possible affects of the RFID tag on the performance of the package has been performed for both packages. Structurally, the RFID adds insignificant weight (2 lbs) to either the 9975 or 9977/9978 drum packages. The backing plate of the RFID is just 0.058 gage stainless designed to deform easily without causing excessive loads on either RFID or drum closure.

The RFID contains four A-size Li-SOCL<sub>2</sub> non-rechargeable batteries each with a nominal energy capacity of 13 W-h. Given the robust nature of the host package, there are no hazards associated with these batteries that can affect package safety performance.<sup>2</sup>



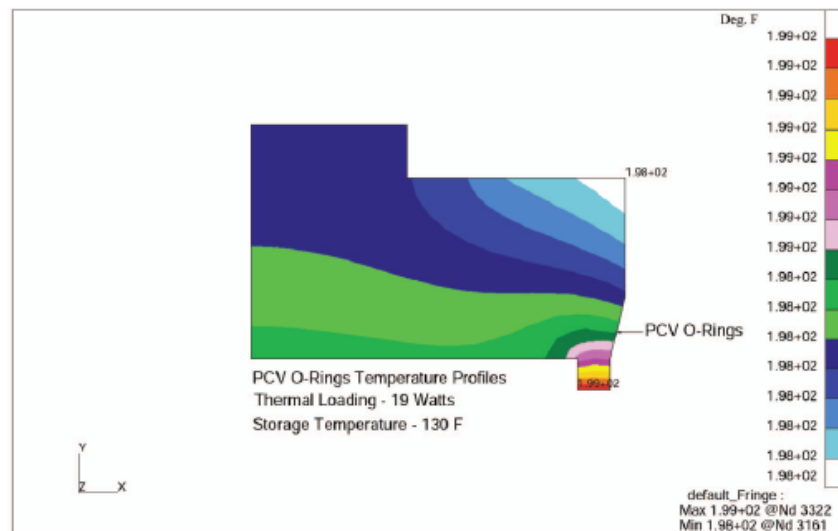
**Figure 1**  
**RFID Tag Detail**

### 2. SARP/COC Basis and Application – Extended Maintenance

Continuous temperature monitoring capability is the most important feature of the RFID system with respect packaging use. Radioactive Material Packages with containment closures including elastomer seals generally require leak testing every year including replacement of any O-ring seals that are part of any containment boundary or leaktest volume. The one year maintenance interval has become standard practice to limit deterioration of seal material from high temperatures during packaging use.

Elastomer seal which are not subjected to temperature extremes can perform their sealing function for many years without replacement. The RFID provides a means of verifying seals on a particular package have not been subjected to temperature extremes that could degrade O-rings. This allows for extension of the periodic maintenance leaktest and seal replacement from one year to two, five or even more years.<sup>3</sup>

The K Area Complex is conducting an on-going surveillance program to verify that fluoro-elastomer O-rings used in the 9975 shipping packages, perform after being subjected to elevated temperatures for extended periods of time. This testing has shown that O-ring seals, kept at a temperature below 200 °F, perform their normal sealing function for at least a decade. This is important because thousands of packages currently use the specific fluoro-elastomer compounds tested in this surveillance program.



**Figure 2**

**Temperature Profile of Seal Region Assuming 19 Watts and 130 °F**

Figure 2 shows the resulting temperature profile of the inner containment boundary seal region for a 19 Watt heat load and an RFID indicated storage temperature of 130 °F.

### 3. Establishing Test baseline and Parameters

The test plan required four Radio Frequency Identification (RFID) tags to be installed on individual 9975s and up to an additional sixteen Argonne RFID tags will be randomly placed throughout the KAMS Process Room Area to satisfy testing in field conditions. Facility procedures and schedules had to be revised to accommodate the operations to be conducted during normal operating hours. The four installed units were applied during the Non-Destructive Examination (NDE) repackaging operation in the K Area Interim Surveillance (KIS) facility. The additional sixteen RFID tags were mounted on stanchions during the testing cycle.

A system cart, which provides a portable work test station, is utilized to facilitate the testing criteria. The cart has an integrated reader, laptop and work station to allow all system polling, data collection and system operation to take place during testing periods.

During non-testing operation, the cart is removed from the CAT. I vault and stored in a storage location which was previously reviewed and approved by Facility Management and Security.

### C. In Facility Test Results

RFID tags have been positioned in specified areas throughout Process Area. The test plan is specific in altering the general tag positioning each month to accumulate data for comparison related to environmental and physical conditions at time of data polling. Maps and locations are recorded in the test log for use in final result analysis following the end of the testing period.

Observations and Results to date:

- Current field conditions have ranged from 17 deg C to 30 deg C.
- Humidity has been ~40% to 80%.

- Discovered during early test runs that the shock value was set to a value which did not trigger events during normal handling. Set value for more sensitive level to gain better understanding of system sensitivity ( set from 15 to 1)
- The system has been relatively stable. RFID tags usually report with 2 poll attempts (line of sight ~ 50feet).
- The last polling attempt required five polls to obtain all 20 RFIDs, field temperature was 30 deg C and Humidity was at 60%.
- One assigned RFID tag (5714244) will not maintain stacked position with two other RFIDs. Appears to be software error. Plan to delete tag and position and re-enter unit into storage reader grid.
- Continuing to verify tamper and seal open alarms periodically.
- Initial problem with Seal open alarms. Replaced these sensors. Units appear to be operating normally.
- Physically relocating RFID tags in field based on accessibility and noting any changes.
- Test conditions: No unusual alarms have been noted; system is reporting normally.

Throughout the testing period (up to the time of paper development), we have noticed various trends and data which support an operable, reliable seal. Table 1 represents actual test data as generated during a weekly test run.

Tag ID	Tag Model	Drum ID	Drum Model	Originator	Seal	Temperature (°C)	Humidity (%)	Shock	Rad. (mSv/h)	RSSI	Battery
5714134	Mk-series	5714134	9975	SRS	OK	25	59	OK	0	140	OK
5714164	Mk-series	5714164	9975	SRS	OK	27	60	OK	0	106	OK
5714239	Mk-series	5714239	9975	SRS	OK	25	57	OK	0	127	OK
5714169	Mk-series	5714169	9975	SRS	OK	27	60	OK	0	134	OK
5714224	Mk-series	5714224	9975	SRS	OK	26	56	OK	0	150	OK
5714269	Mk-series	5714269	9975	SRS	OK	26	60	OK	0	115	OK
5714144	Mk-series	5714144	9975	SRS	OK	26	57	OK	0	132	OK
5714244	Mk-series	5714244	9975	SRS	OK	27	62	OK	0	103	OK
5714159	Mk-series	5714159	9975	SRS	OK	27	60	OK	0	108	OK
5714274	Mk-series	5714274	9975	SRS	OK	27	57	OK	0	113	OK
5714149	Mk-series	5714149	9975	SRS	OK	27	63	OK	0	115	OK
5714249	Mk-series	5714249	9975	SRS	OK	26	64	OK	0	105	OK
5714254	Mk-series	5714254	9975	SRS	OK	27	60	OK	0	104	OK
5714264	Mk-series	5714264	9975	SRS	OK	26	57	OK	0	113	OK
5714229	Mk-series	5714229	9975	SRS	OK	26	57	OK	0	123	OK
5714219	Mk-series	5714219	9977	SRS	OK	27	57	OK	0	114	OK
5714199	Mk-series	5714199	9975	SRS	OK	28	57	OK	0	109	OK
5714234	Mk-series	5714234	9975	SRS	OK	26	63	OK	0	110	OK
5714259	Mk-series	5714259	9975	SRS	OK	26	56	OK	0	103	OK
5714204	Mk-series	5714204	9975	Argonne	OK	27	60	OK	0	138	OK

**Table. 1**  
**Standard Test Data Log Sheet**

### Remaining Test Scope

To reiterate, we are currently in the final month of a six-month testing program. We will continue to follow our test plan for the remainder of the test period and continue collecting data on sensor performance and system

reliability. We have held a mid-term review of the testing results and made slight adjustments to the system test parameters as established in the facility. Corresponding test plan maps and locations were updated, and relevant data continues to be recorded in the test log. At the completion of the test we will perform trending and prepare final analysis of the results.

## **System Outlook**

The Category I Vault testing is the first field testing attempt of ARG-US RFID system in a real storage environment at KAMS. The data collected during the six-month, in-facility testing and the trending analysis performed, therefore, should provide the basis that aids the decision for deploying ARG-US RFID system in a larger scale application at KAMS. Data collection and field testing beyond six month would also extend our knowledge on sensors and system long-term reliability, which is valuable information that cannot be obtained otherwise.

Extending the leak rate testing interval of the 9975 package from annual to a maximum of five years by continuous environmental temperature monitoring can result in significant operating cost reduction, i.e., approximately \$10,000 per package over 5 years. Studies have shown that the elastomer O-ring seals used in the 9975 package can perform their sealing function for many years without degradation, if the temperature of the O-ring can be kept below 93 deg C (200 deg F). The ARG-US RFID system provides a means of verifying seals on a particular package have not been subjected to temperature extremes that could degrade the O-rings.<sup>3</sup>

The ARG-US RFID monitoring has already been approved for allowing extended maintenance for the 9977 package from one to two years. Approval for five year extended maintenance has been requested for the 9975 package based on the referenced analysis.

Safeguards and Materials Control and Accountability is another potential area of application for the ARG-US RFID system in KAMS, if the seal integrity sensor in the RFID tag can be credited for its tamper indication function and increase the interval of periodic validation.

## References

1. *Report on a 2009 Mini-Demonstration of the ARG-US Radio frequency Identification (RFID) System in Transportation, ANL/DIS-09-06, Tsai et.al., Argonne National Laboratory*
2. *Justification of Extended Maintenance with Use of the Radio Frequency Identification System, S-SARA-G-00008, Revision 1.*
3. *Thermal Evaluation of 9975 Package O-Rings under Varying Thermal Loading and Storage Ambient Temperature Conditions for RFID Implementations, M-CLC-A-00380, Revision 0.*