REMOTE-READING SAFETY AND SAFEGUARDS SURVEILLANCE SYSTEM FOR 3013 CONTAINERS

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ABSTRACT

At Hanford’s Plutonium Finishing Plant (PFP), plutonium oxide is being loaded into stainless steel containers for long-term storage on the Hanford Site. These containers consist of two weld-sealed stainless steel cylinders nested one within the other. A third container holds the plutonium within the inner cylinder. This design meets the U.S. Department of Energy (DOE) storage standard, DOE-STD-3013-2000, which anticipates a 50-year storage lifetime. The 3013 standard also requires a container surveillance program to continuously monitor pressure and to assure safeguards are adequate. However, the configuration of the container system makes using conventional measurement and monitoring methods difficult.

To better meet the 3013 monitoring requirements, a team from Fluor Hanford (who manages the PFP), Pacific Northwest National Laboratory (PNNL), and Vista Engineering Technologies, LLC, developed a safer, cost-efficient, remote PFP 3013 container surveillance system. This new surveillance system is a combination of two successfully deployed technologies: 1) a magnetically coupled pressure gauge developed by Vista Engineering and 2) a radio frequency (RF) tagging device developed by PNNL. This system provides continuous, 100% monitoring of critical parameters with the containers in place, as well as inventory controls.

The 3013 container surveillance system consists of three main elements: 1) an internal magnetic pressure sensor package, 2) an instrument pod (external electronics package), and 3) a data acquisition storage and display computer. The magnetic pressure sensor is housed inside the innermost 3013 container and employs a magnet on a Bourdon tube as a pressure gauge. The external instrument pod resides on the end of the outermost cylinder. A wireless RF tag is installed within the instrument pod to collect and transmit data from a number of inputs. Pressure-induced changes in magnetic field are detected from the magnetic pressure sensor, and these data (and other information) are transmitted to the external data-monitoring computer. The stainless steel allows magnetic fields to pass through the nested cylinders. The system continuously monitors pressure changes inside the 3013 container over time so that the pressure build-up does not exceed the container’s design limits. Additional sensors (e.g., temperature sensors, motion sensors, and tamper indication) are incorporated in the instrument pod for safeguarding the plutonium.

The surveillance system described in this paper has many benefits for PFP and DOE in terms of cost savings and reduced personnel exposure. In addition, continuous safety monitoring (i.e., internal container pressure and temperature) of every container is responsible nuclear material stewardship and fully meets and exceeds DOE’s Integrated Surveillance Program requirements.

INTRODUCTION

The U.S. Department of Energy (DOE) standard, *Stabilization, Packaging, and Storage of Plutonium-Bearing Materials* (DOE-STD-3013-2000) provides criteria for stabilizing plutonium-bearing materials at DOE facilities to safe and stable forms that can be packaged and placed in storage with minimal surveillance for up to 50 years. The 3013 standard applies to plutonium-bearing metals and oxides containing at least 30 wt% plutonium plus uranium.

In accordance with DOE's Nuclear Materials and Facilities Stabilization Program, the Hanford Site's Plutonium Finishing Plant (PFP) is packaging plutonium oxides in sealed stainless steel containers. The containers comply with DOE-STD-3013-2000 for long-term storage that anticipates a 50-year storage lifetime. PFP 3013 containers consist of two small weld-sealed stainless steel cylinders nested one within another. A third, screw-lid container placed inside the inner sealed container holds the plutonium materials. Approximately 3000 of these 3013 containers will be loaded with plutonium oxide and stored horizontally on specially designed racks in a vault at the Hanford Site for an estimated 14 years. The DOE standard also requires a container surveillance program for continuous assurance of safety. Because of the nature of the materials stored within these containers there is a concern for the potential of producing high-pressure, possibly explosive, conditions during transport and storage.

Direct measurement of internal pressure and temperature is needed to identify potential problem containers well before they reach unsafe conditions. However, the design of the thick-walled outer 3013 container as a pressure vessel makes it impossible to determine indications of internal pressures by measuring deformation of the outer container. Radiography of inner container lid deflection has been demonstrated, but is operationally inefficient. Sampling the containers by digital radiography requires removing containers from storage and transferring them to an X-ray instrument in an adjoining building, performing the analyses, and then manually moving the containers back into storage. Personnel performing these manual operations are estimated to receive radiation doses that will challenge established limits. Consequently, a remote system that leaves the containers in place during monitoring is a safer and more efficient surveillance method.

This paper describes a study conducted by Fluor Hanford (who manages the PFP), Pacific Northwest National Laboratory (PNNL), and Vista Engineering Technologies, LLC, to create a remote-reading surveillance system to meet the PFP's requirements for monitoring the 3013 containers within the vault storage area. The new surveillance system merges two technologies already deployed for other applications: a magnetically coupled pressure gauge developed by Vista Engineering and a radio frequency (RF) tagging device developed by PNNL. In the remote-reading surveillance system, the containers will be equipped with a magnetically coupled pressure sensor (magnetic pressure sensor) inside the innermost sealed container. A wireless RF tag will collect and transmit data from a number of inputs from within an instrument pod mounted on the outside of the outermost container. The instrument pod will detect pressure-induced changes in the magnetic field from the magnetic pressure sensor and transmit these data and other container-related information to the external data acquisition control system. These data will be further transmitted to a DOE Integrated Surveillance Program database at Los Alamos National Laboratory (LANL).

This new remote-reading surveillance capability will continuously monitor container pressure and temperature, while optimally providing a radiation signature, unique container identification, and tamper indication to a remote data collection and processing station. It will also provides a continuous inventory of all containers and their locations. Safeguards inventories that would have been conducted every 6 months without a remote monitoring system can be reduced to every 2 years or longer using this system.

The development team has also designed new storage racks, with negligible impacts, to accommodate the new system. Furthermore, 25 first-generation magnetic pressure sensors and instrument pods have been fabricated. Incorporating miniature radiation sensors in future versions of the instrument pod is a viable upgrade for further safeguards.

INTEGRATING EXISTING TECHNOLOGIES INTO AN IMPROVED NEW PLUTONIUM STORAGE CONTAINER SURVEILLANCE SYSTEM

The 3013 mission was interpreted in terms of the redesign of the existing technologies and the functional and operational requirements for the magnetic pressure sensor, instrument pod, and data acquisition control computer. The demonstrated functionality of the system in the actual vault setting, as depicted in Figure 1, was completed as part of the design for fabrication effort to ensure timely and successful deployment of the integrated system at the PFP.

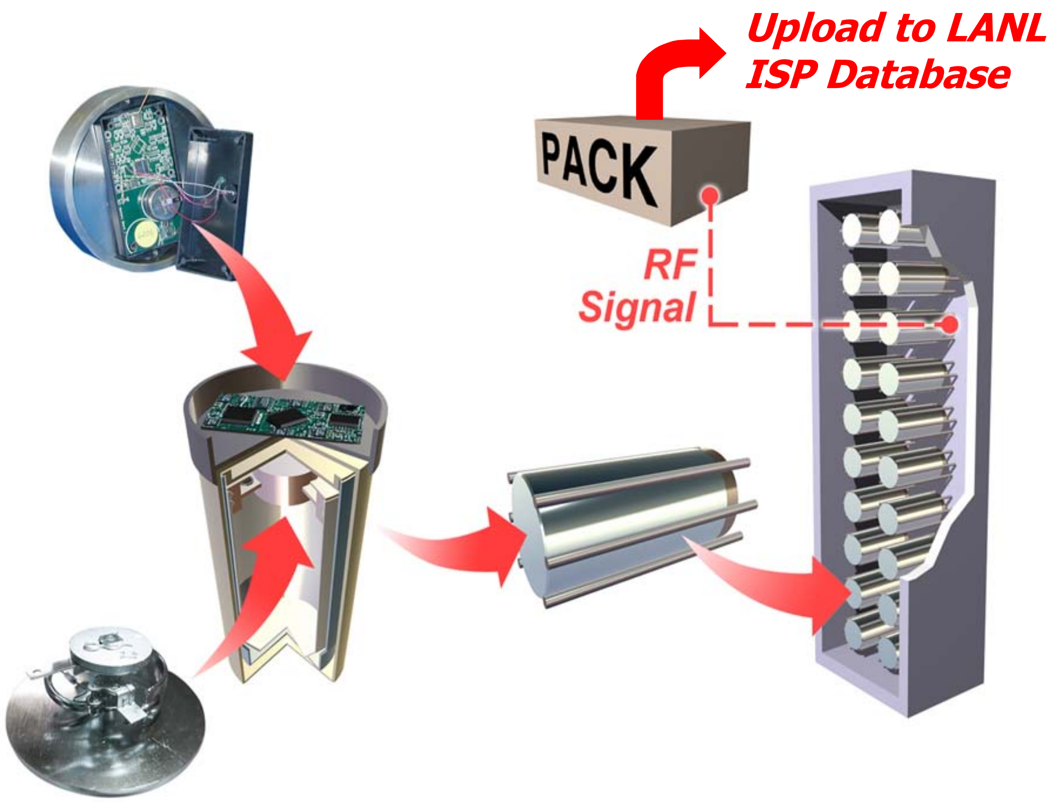

Fig. 1. 3013 containers with magnetically coupled pressure sensor and radio frequency instrument pod will be stored in the vault.

Magnetic Pressure Sensor

Vista Engineering's magnetically coupled pressure gauge (MCPG) technology was redesigned for use in the 3013 remote surveillance system to become the magnetic pressure sensor. The design includes the following features:

- be compatible with 3013 standard (i.e., no organics inside the container) and provide an alternative means to obtain the required "non-destructive indication of a buildup of internal pressure"
- measure pressure over 3013 container working pressure range (0 – 699 psi)

- be operable for up to 50 years
- communicate pressure data outside container to suitable receiver/signal relay unit (i.e., the instrument pod)
- minimize the displacement volume lost for plutonium packaging as a result of installation of the magnetic pressure sensor.

The essential components for the magnetic pressure sensor are listed below:

- stainless steel Bourdon tube pressure gauge
- magnet
- stainless steel aneroid reference chamber
- sintered metal frit filter
- instrument pod readable zero-index magnet
- integral magnet rotational stop pin and container rotational index readable by X-ray.

Instrument Pod

The PNNL RF tagging device technology was redesigned for use in the 3013 remote surveillance system to become the instrument pod. The design includes the following features:

- be fabricated no more than 5.25 inches diameter by 1-inch thick, and be attachable to the bottom of a 3013 outer container (compatible with vault modifications)
- provide unique identification of instrument pod
- convert magnetic rotational angle data from the magnetic pressure sensor to signal proportional to pressure
- measure container surface temperature
- be equipped with tamper indication if separated from the container or rack
- transmit all data to the remote data processing computer
- have wireless transmission technology with up to 8 years of battery life
- provide adequate space within the instrument pod for additional sensors in the future.

The essential components for the instrument pod (RF sensor tag) are listed below:

- RF transceiver
- microcontroller
- sensor suite
- nonvolatile memory
- battery
- rugged package
- instrument Pod Sensors
- pressure – electronic interface to Vista Engineering magnetic pressure sensor
- temperature – Silicon IC chip; Range: -55 °C to +130 °C; Accuracy: ±1.5 °C
- tamper detection – Mechanical and/or solid-state tilt switches; future sensor attributes of radiation, pressure, and temperature
  - Radiation detectors being considered.

Data Acquisition Computer

The RF tagging device reader technology was adapted for use in the 3013 remote surveillance system to become the data multiplexing and acquisition control system (computer). The design includes the following features:

- receive data from the instrument pod
- maintain historical record of all data (e.g., pressure versus time record)
- provide alarm capability for safety and safeguards purposes.

The essential components for the data multiplexing and acquisition control (RF tag reader) are listed below:

- computer
  - Standard PC or PDA (PalmPilot, Pocket PC, Handspring)
- RF interface
  - RF transceiver
  - microcontroller.

DESCRIPTION OF INTEGRATED SYSTEM COMPONENTS AND FEATURES

The two existing technologies were tailored and combined to provide the optimal system for the surveillance application.

Magnetically Coupled Pressure Gauge

Vista Engineering developed and is manufacturing the MCPG for the Hanford Spent Nuclear Fuel (SNF) Project's multi-container overpacks (MCOs). The MCPG measures the pressure within the MCO's stainless steel pressure boundary and transmits the pressure value through an 8-inch-thick stainless steel shield plug in the MCO as the angular position of an internal magnet that rotates as the pressure changes. The MCPG is a purely mechanical device, uses no electrical power, and requires no maintenance or other support. It was designed to operate in a high-radiation environment, at high temperatures, for a period of 40 years.

The method of sensing and indicating pressure is similar to that used in most mechanical pressure gauges. The sender unit senses the pressure with a Bourdon tube installed in an aneroid reference cell, then transmits the sensed pressure by rotating a magnet in place of the pointer on the shaft of the mechanical gauge.

For the 3013 application, the MCPG reduction of magnet size, selection of strength, and axial placement of the magnet inside the 3013 container optimize the PFP pressure-sender unit. The pressure-sender unit design and construction provides a durable mechanical, shock resistant (e.g., can withstand 25 Gs of shock) device that is compatible with handling, storage, and transportation protocols. A Honeywell™ HMC-1512 magnetic angular displacement sensor device was selected for the readout and is mounted in an instrument pod external to the container. Sensing the magnetic rotation angle (relative to an index location at zero gauge pressure), the Honeywell device converts the magnet's rotational angle to an electronic signal.

The magnetic pressure sensor, optimized to minimize the volume displacement within the 3013 container, has been integrated into the screw top lid of the material container that is within the inner-sealed cylinder.

Although not expected, should handling cause inner container rotation with respect to the instrument pod fixed on the outer container, the rotation would appear as a change of pressure. Methods to return to the zero index point are included. The magnetic pressure sensor design also includes a zero-index magnet that will be used to align the instrument pod to the container during installation. The magnetic pressure sensor design also includes an internal mechanical stop and finger to prevent magnet over-rotation that also is an absolute rotational index detectable by radiography, if ever needed.

Figure 2 shows a photograph of the interior of an early version of the magnetic pressure sensor. In this photograph, the Bourdon tube and gearing, magnet, and finger are clearly seen. The PFP magnetic pressure sensor is composed of this mechanism installed in a sealed aneroid reference.

Fig. 2. Interior and exterior of a prototype of the PFP magnetic pressure sensor

Wireless Radio Frequency Tagging Device

PNNL has been developing the RF tag technology for over 10 years, and it has been used in applications such as medical ID tags, F-16 aircraft brake temperature monitoring tags, clothing tags, rail car inventory tags, and pallet inventory tags. The RF "tagging" device can be incorporated into many items to provide specific information about each one; for example, the serial number identification of each tagged item. Each tag can be "polled" by a remote interrogation device, or all of the tags can report their status asynchronously. The basic tag is battery-operated with a nominal service lifetime of up to 8 years between battery changes. When required, batteries are easily replaced by removing the slip-fit pod from the 3013 container, and unscrewing the face-plate cover. With the onboard microprocessor, PNNL's tagging device has been configured to accept inputs from various sensors, including pressure, temperature, and motion.

Further safeguards features, such as radiation sensors and additional tamper indicators, are currently being designed for the second-generation units.

The circular instrument pod is controlled by a high-performance microcontroller. The microcontroller digitally acquires the 1) pressure data, 2) external container skin temperature, 3) onboard electronic component temperature, 4) mechanical shock, 5) motion detection, and 6) tamper indication. This information set is conveyed by a wireless RF link to a RF tag reader placed in a rack in the vault. A single RF tag reader is designed to monitor all the individual RF links (up to 28) in a single cubicle. The RF tag readers are hardwired on a twisted-pair cable employing an RS-485 network-type interface. Each reader cable run also has integral DC power. The instrument pods operate with batteries that allow them to accompany the containers during removal and transfer. To facilitate the requirements for Safeguards & Security, the instrument pods have both tamper-detect switches and motion detectors. The motion detectors serve a dual purpose because they are capable of measuring shock events due to mishandling. The sensor tag/reader scenario is shown in Figure 3.

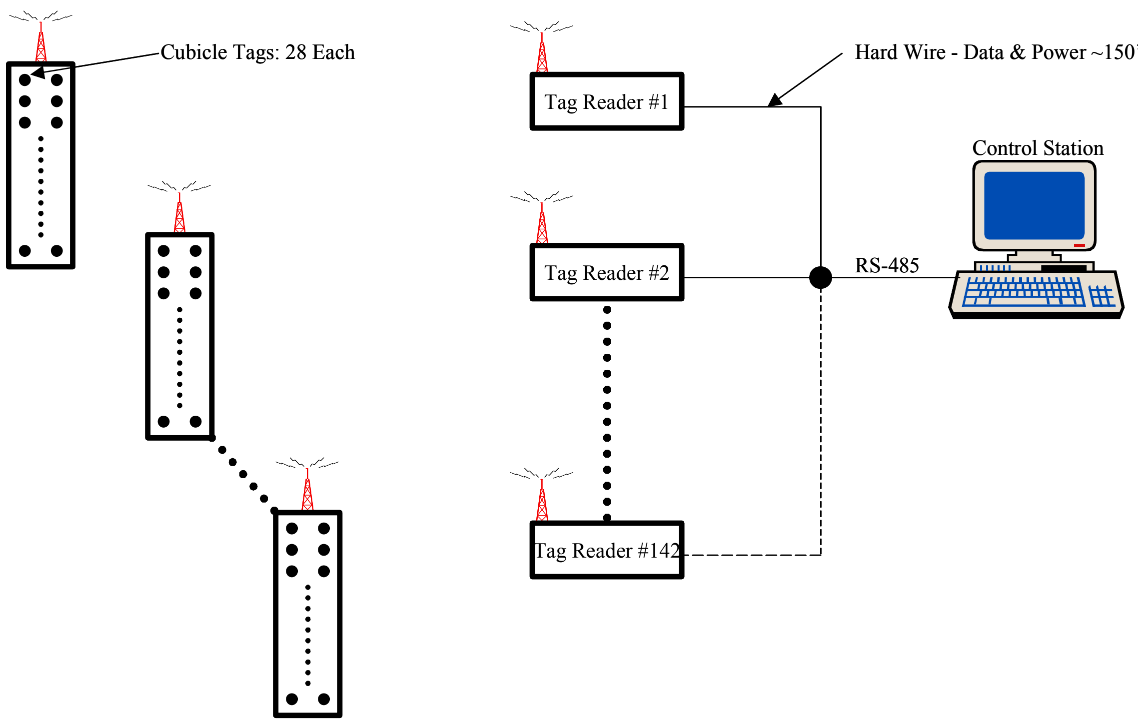

Fig. 3. Sensor tag/reader scenario

All the RF tag readers are interfaced to a data multiplexing and acquisition system computer. The RS-485 serial interface allows for networking and can sustain distances of several hundred feet. The data acquisition computer is PC-based and employs a graphical user interface for status display. The interface from the computer to the RF tag readers is bi-directional. In the normal mode, the computer will multiplex through the tag readers, asking them to request data from their corresponding instrument pod. Additionally, each instrument pod can autonomously signal a tamper alarm to the data acquisition computer. Custom algorithms are used to translate pressure measurements into engineering units.

3013 Container Wireless Smart Sensor System – Instrument Pod

Figure 4 shows a block diagram of the instrument pod sensors and photos of the prototype. Individual features are described below.

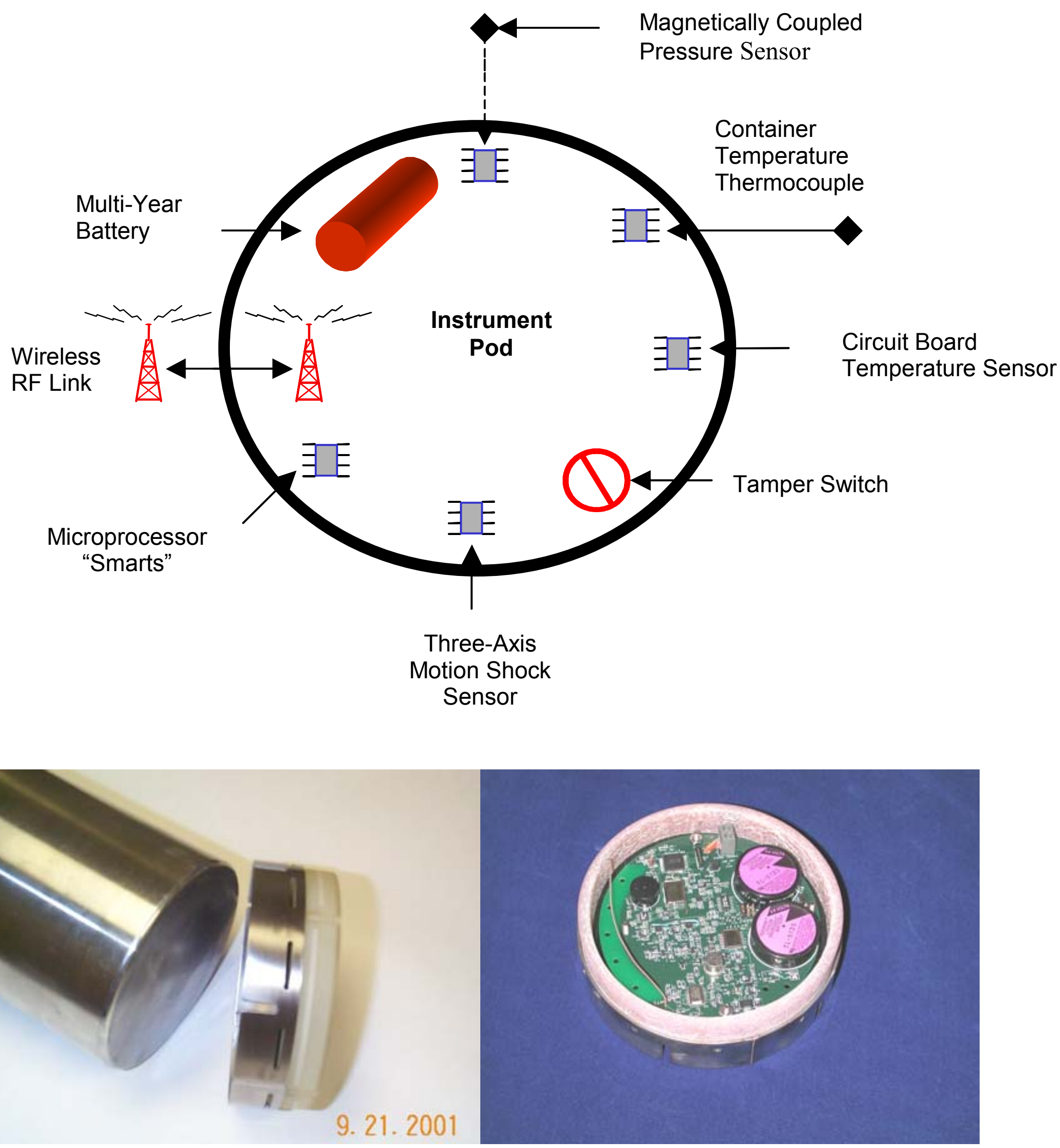

Fig. 4. Diagram of sensor tag and reader system, and instrument pod features

Magnetically Coupled Pressure Sensor. The sensor used is a magnetic sensor chip integrated circuit from Honeywell Corporation. It employs a thin strip of ferrous material to reflect a change in resistance in the presence of a rotating magnetic field. The sensor package incorporates a Wheatstone bridge to aid the measurement process. The device has two outputs — each 45 degrees from the other. This relationship allows for determining the angle position of the induced magnetic field. The device has an angular range of 180 degrees.

Container Temperature Thermocouple. The skin temperature of the 3013 canister is measured with a 30 AWG Type K thermocouple that is incorporated into an off-the-shelf spring plunger. The back set screw and plunger parts of the spring plunger are drilled out to allow the thermocouple wire to be passed through. The thermocouple junction is secured in the plunger with epoxy and the lead wires fed through the spring and set screw, which results in a spring-loaded thermocouple arrangement.

The output of the thermocouple is amplified by a low-power high-gain instrumentation amp (gain = 438), which produces a 10 mV/°F output temperature signal. This temperature is the difference between the 3013 skin and the junction on the printed circuit board. Therefore, the thermocouple temperature is added to the local circuit board temperature to calculate the 3013 skin temperature.

Circuit Board Temperature Sensor. The solid-state temperature sensor is a miniature, inexpensive, integrated circuit commonly used for monitoring electronic components or electronic packages. It has two functions for the instrument pod system; it serves as a reference measurement for the thermocouple interface in addition to measuring internal ambient temperature of the instrument pod. Because the 3013 containers are a heat source, there is a need to assure the instrument pod does not exceed temperatures that are detrimental to electronic components (approximately 85°C). The temperature sensors have an analog output that is digitized by the instrument pod microcontroller (see microprocessor description below). To conserve battery life, the temperature chip is powered off until a periodic measurement request is made.

Tamper Switch. The tamper switch is a simple mechanical leaf switch that protrudes through the instrument pod package, allowing it to make contact with the back wall of the cubicle rack. After insertion into the cubicle rack, the switch is in the depressed (closed) state. Removing the container opens the switch, sending an interrupt signal to the instrument pod microcontroller. The microcontroller immediately conveys this information to its RF tag reader, which signals the data computer that a tamper alarm has occurred.

Three-Axis Motion/Shock Sensor. A low-power, three-axis accelerometer integrated circuit is used for this sensor. Amplification is added to each channel, allowing it to be sensitive enough to detect physical motion. To assure shock events and motion are always detected, the accelerometer circuitry is always active by being powered on. Shock event data are recorded as a maximum (±g) along with a time-stamp (clock time and calendar date).

Microprocessor. The instrument pod controller is a single-chip, extremely low-power device from Texas Instruments. It is a high-performance, 16-bit RISC-based device that has reprogrammable internal flash memory. Onboard programming is done via a JTAG port allowing firmware code upgrades to be easily performed in the field. The microcontroller resides in the "sleep" mode the majority of the time, until it detects tamper/motion or RF requests.

Wireless RF Link. The RF link consists of a single-chip device that employs a simple amplitude modulation (OOK) scheme. This transceiver, contains both the transmitter and receiver are in the same package and share a common antenna. It is a low-power device that operates at 916 MHz, which is a license-free ISM (industrial scientific measurement) band. Transmit power is quite low (<1 milliwatt), limiting its read/write range with all data sends/requests in short bursts (<100 millisecs). The RF antenna is embedded into the instrument pod.

Each instrument pod has its own unique identification code (ID), allowing each individual pod to be addressed. A preset protocol includes the ID code, command code, setup values, and a packet validity checksum.

Multi-year Battery. The onboard batteries comprise two lithium devices connected in parallel. Each cell has a 3.6 volt output and a 2.4 amp-hour power density. The two cells are expected to power the instrument pod up to 8 years. Batteries are easily replaced by removing the slip-fit pod from the 3013 container and unscrewing the face-plate cover.

Data Multiplexing and Acquisition, Data Storage, User Interface Computer

The computer hardware (Figure 5) consists of the cubicle RF tag readers; the data multiplexing and acquisition unit; a data server; and a user interface/display. The computer reads, stores, and displays the sensor data collected from instrument pods. Each instrument pod is polled for data at a programmed time interval. In addition, any instrument pod may send an alert to the computer when it detects motion or a tamper switch change of state. The collected data are stored in a database, retaining the sensor data history of each container (temperature, pressure, shock, etc.).

The data multiplexing and acquisition software allows an operator to check containers into and out of the surveillance system by identifying the container's unique ID, vault number, cubicle, and rack position. Queries may be performed at any time on an individual instrument pod (using its unique ID or vault, cubicle, rack position) to review its recorded sensor data history. In addition, the software will alert the operator of conditions requiring attention such as tamper switch activation or abnormal pressure/ temperature trends.

The data multiplexing and acquisition unit is a compact PCI computer running Microsoft Windows 2000. It is configured with a multi-port RS-485 interface card to communicate with the RF tag readers and an Ethernet card to communicate with the computer's data server. The application software running on this computer provides the direct communications to and from the RF tag readers; collects the sensor data; and transmits it to the computer's data server.

The computer user client interface may be a desktop or notebook computer running any of the Microsoft Windows operating systems, including Windows 98, NT, ME, or XP. It runs the 3013 surveillance system's user client interface application software. Functions of this software include

- entry and removal of containers from the surveillance system
- queries for and display of archived data for an individual container
- operator alerts of detected abnormal data trends or tampering of a container.

Algorithm Development

The sensor used for measuring pressure within the 3013 containers consists of several components. The pressure device itself is of the common Bourdon tube construction. At the axis of the tube is a permanent magnet that rotates in response to the pressure applied to the Bourdon tube. The angular rotation of the magnet indicates the pressure. By design, the angular rotation is proportional to pressure and this behavior has been verified in experimental tests. Because the magnet is internal to the container, there can be no direct visual confirmation of the angular rotation. The rotation angle is sensed with a rotary displacement sensor manufactured by Honeywell (HMC 1512). This sensor contains a pair of bridge-type circuits with magnetoresistive elements; the second bridge is rotated 45 degrees from the first bridge. The Honeywell sensor is located co-axially with the permanent magnet and displaced from it approximately 1¾ inch. The quadrature voltage output from each bridge is a sinusoidal function of the magnet rotation angle.

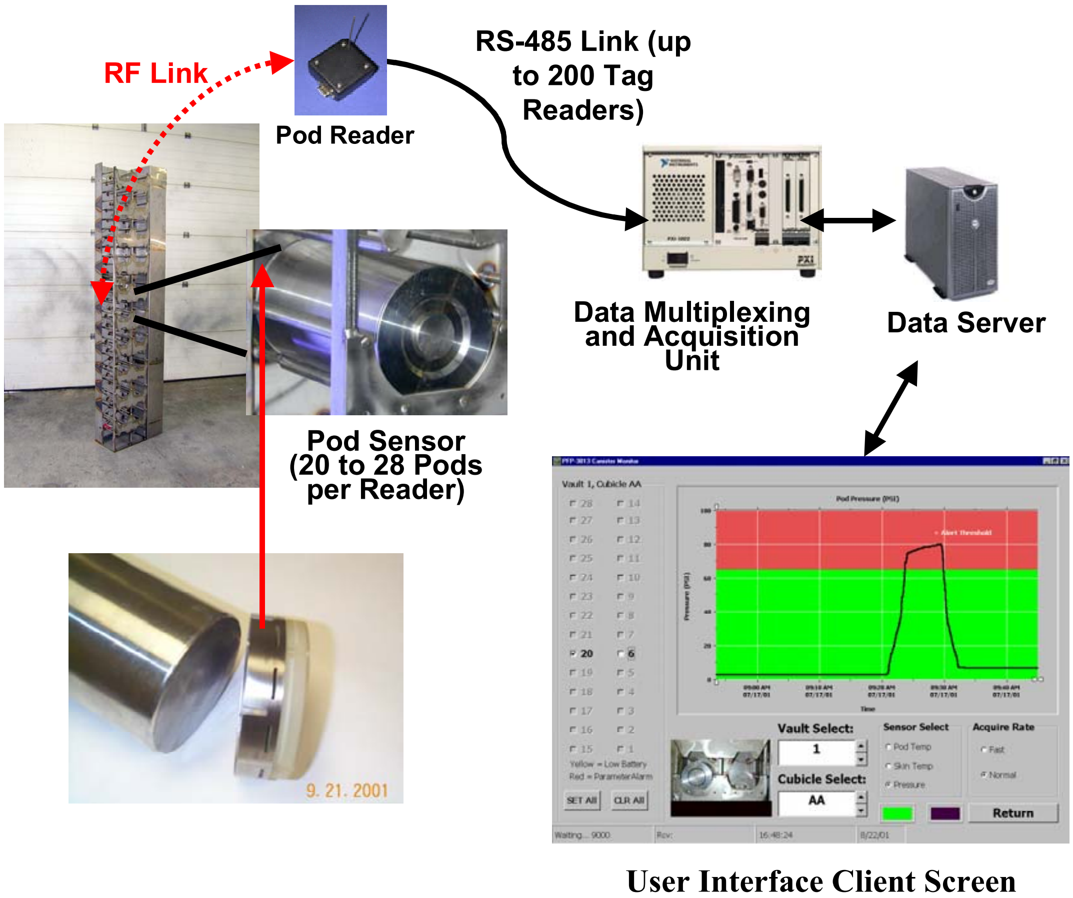

Fig. 5. 3013 computer hardware and system configuration

The HMC sensor is designed for use in saturation. However, because of the limited strength of the permanent magnet attached to the Bourdon tube and the displaced liftoff distance between this magnet and the Honeywell sensor, the condition of saturation is not achieved. The net result is that the voltage amplitudes are less than those obtained under saturation conditions, and the voltage variations with angle are only approximately sinusoidal. Nevertheless, it has been possible to obtain sufficiently accurate measurements of the pressure by using ratios of the outputs of the two bridges and observing the sign of the ratios. Over the full range of pressures, accuracies of about 5% of full-scale pressure have been demonstrated with liftoff distances ranging from 1.5 inches to 2.25 inches. The sinusoidal variation of output voltages with magnet rotation angle has been used without modification in algorithms developed to determine pressure from the Honeywell sensor voltage readings.

The simple ratio method described above successfully accounts for voltage variations resulting from differing liftoff distances. Prototype testing has indicated the overall measurement accuracy is within the design envelope without modification of the original algorithm. Refinements of the present algorithm are possible, which will enhance the overall accuracy.

EXPECTED PERFORMANCE OF THE SYSTEM

The first-generation remote-reading surveillance system will monitor and record the pressure inside the 3013 container at least daily. While all components of the system have demonstrated "high" accuracy in an isolated environment, an overall system performance requirement of ±15 percent for the pressure measurement has been the design objective.

Design, Fabrication, and Testing

The Vista and PNNL technologies were combined and redesigned to remotely monitor the 3013 container according to the PFP's requirements. Working prototypes have been fabricated to enable actual vault demonstration to be conducted. The work emphasized the safety-related functions of the magnetic pressure sensor/instrument pod/data acquisition computer concept (internal container pressure, container temperature, and unique identification of each can). Subsequent work will add safeguard features to the instrument pod technology, as depicted in Table I.

Table I. Functions of the Instrument Pod

Instrument Pod Capability	Provides Safety Function	Provides Safeguards Function
Pressure	Yes	No
Temperature	Yes	Yes
Unique ID	Yes	Yes
Radiation Signature	Yes	Yes
Additional Radiation Signature	No	Yes
Integral Diversion Monitoring	No	Yes
Tamper Indicator(s)	No	Yes
Multiple Channels	No	Yes

Bench Test and Field Evaluation of Magnetic Pressure Sensors, Instrument Pods, and Computer

Essential components of magnetic pressure sensors and instrument pods have been bench tested separately to calibrate, verify, and document the operation of the individual units. Each of the assembled pressure sensors were helium leak checked to maintain the integrity of the aneroid reference chamber over the 50-year life span of the pressure sensors. Applied pressure versus magnetic field rotation was measured for the 25 initial magnetic pressure sensors to establish the algorithm to be incorporated in the instrument pods. Thermal measurements were taken and the RF transmission was field tested within the storage vault using available RF tags before the tags with pressure sensing capabilities were incorporated into instrument pods. This test ensured that the design addressed heat shielding of electronic components and antenna encapsulation in the instrument pod. Assembled pressure sensors, instrument pods, and data acquisition control computer were bench tested alone and together to validate system performance. Additional integrated tests are planned, culminating in a total system demonstration in an actual vault.

Design and Fabrication of Production Units

Based upon the current design of the magnetic pressure sensor, instrument pod, and computer system, together with the results of the bench test, vault test, and evaluation, a final design for fabrication has been completed for a ready-for-deployment fully integrated system. Production of the Vista magnetic pressure sensor is well underway, with the first production units scheduled for delivery to the PFP during the third quarter of fiscal year 2002. These units can now be purchased directly from Vista. The PNNL instrument pod prototype device is been commercialized and will be manufactured for PFP. The first commercial production units will be delivered during the third quarter of fiscal year 2002 commensurate with the magnetic pressure sensors.

COST AND BENEFITS

The continuous inventory capability of the remote-reading surveillance system provides optimal material safeguarding and allows the maximum period between physical inventories, thereby minimizing cost and personnel exposures. The 3013 containers will be continuously monitored for pressure, further ensuring worker safety and acceptability of containers for shipment.

A combined cost savings and avoidance of $18 million is expected over the 14-year storage period of materials in 3013 containers at PFP. Avoidance of high radiation doses to personnel associated with periodic (e.g., semi-annual) physical inventories of vaults and container handling for pressure surveillance is consistent with ALARA requirements.

Cost reduction is achieved by avoiding the thousands of periodic manual transfers of containers for digital radiography; by cutting required safeguards accountability inventories by at least a factor of 4, and by taking credit for dose avoidance to personnel for the examinations and inventory activities:

Average Annual Savings	$ 1.7 million
Life Cycle Cost Savings	$17.8 million
Return-On-Investment (ROI)	300%

This new surveillance system is expected to benefit other DOE sites as well. The remote-reading surveillance system would help ensure the safety of containers prior to shipping to other storage sites, as well as providing representative pressure sampling for many materials throughout the DOE complex. In situ pressure monitoring of containers provides the means to validate current plutonium storage container performance modeling efforts.

CONCLUSIONS

The new, remote-reading surveillance system has many benefits for PFP and DOE in terms of cost savings and reduced personnel exposure. In addition, continuous safety monitoring (i.e., internal container pressure and temperature) of every container is responsible nuclear material stewardship and fully meets and exceeds DOE-Headquarters Integrated Surveillance Program requirements.

The pre-existing container and storage vault designs presented many significant technical and administrative constraints to the development team. However, innovative solutions were evaluated and the existing technologies were extended or improved as a result. The most notable example is the use of the magnetic angular displacement sensor selected for the readout device that is integral to the instrument pod. The melding of two technologies and simultaneous integration with ongoing modifications of plutonium packaging and storage systems throughout the development process was essential to enable rapid transition from a technology application concept to a deployable system in less than a year. Rigorous integrated system testing in the storage vault environment will ensure successful deployment of this container surveillance system in the near future.

ACKNOWLEDGMENTS

Hanford's Plutonium Finishing Plant graciously acknowledges the financial contributions from the DOE Office of Science and Technology (OST) and the Nuclear Materials Focus Area (NMFA).