FINAL REPORT

REMOTE SURVEILLANCE OF FACILITIES AWAITING D&D

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LIST OF ACRONYMS

β	Beta particle
γ	Gamma ray
$\mu\text{Ci/cc}$	microCurie per cubic centimeter
AC	Alternating Current
cm^2	square centimeter
D&D	Deactivation and Decommissioning
DC	Direct Current
DOE	Department of Energy
dpm	decays per minute
FIU	Florida International University
ft	feet
ft^2	square feet
ft^3	cubic feet
FY98	Fiscal Year 1998
FY99	Fiscal Year 1999
FY00	Fiscal Year 2000
HCET	Hemispheric Center for Environmental Technology
INEEL	Idaho National Engineering and Environmental Laboratory
LOFT	Loss of Fluid Test Facility
mA	milliAmperes
MCU	Measurement Control Unit
mR/hr	millirad per hour
R/hr	Rad per hour
PBS	Project Baseline Summary
PLC	Programmable Logic Controller
RF	Radio Frequency
RH	Relative Humidity
RTU	Remote Terminal Unit
SCAD	Supervisory Control and Data Acquisition
SRS	Savannah River Site
STCG	Site Technology Coordination Group

TAN Test Area North

V Volts

VDC Volts Direct Current

EXECUTIVE SUMMARY

The Department of Energy has several thousand contaminated facilities awaiting deactivation or decommissioning that require long-term monitoring to ensure the safety of the public and environment. Inspectors are required to periodically enter the facility to obtain measurements and samples. An alternative method that would increase safety, increase monitoring frequency, and decrease surveillance cost is to set up a remote surveillance system inside the building that can monitor essential items inside the facilities without any inspectors entering.

FIU-HCET has designed, tested and delivered to INEEL a remote surveillance system at the TAN-616 facility at the Idaho National Engineering and Environmental Laboratory. The system uses a datalogger that operates the sensors and transmits data from the sensors to an off-site computer via a radio modem. The sensors include water level for tanks and sumps, moisture for sumps and floors, and a temperature sensor. Personnel are able to monitor the system and obtain data from a computer outside TAN-616 and thus can monitor the facility without having to enter. INEEL personnel will deploy the system once TAN-616 is fully accessible. FIU-HCET plans to continue to improve the remote surveillance system and implement this solution to meet DOE needs.

1.0 INTRODUCTION

Several thousand facilities at Department of Energy (DOE) sites are awaiting deactivation and decommissioning (D&D). Typically, these facilities contain hazardous and/or radioactive materials and contamination. Due to fiscal constraints, many of these facilities remain in a shutdown state for at least several years before D&D commences. During this waiting period, periodical monitoring is required for various parameters to ensure that the facility is not endangering the safety of the personnel, public, and environment.

The monitoring tasks require survey personnel to periodically enter the facility to inspect the building, collect samples, and perform measurements. These activities are labor-intensive, expensive, and expose survey personnel to radiation/hazardous materials and increased risk of accidents in deteriorating facilities. Consequently, survey personnel enter the facility infrequently, resulting in surveys that do not provide a timely status of the facility. The DOE needs monitoring systems that can provide real-time information about the facilities without having to send in personnel. This remote surveillance system would increase safety and decrease cost.

The principal objective of this project is adoption and integration of commercially available sensors and components into a remote monitoring and surveillance system that meets the needs of the DOE. The system should provide cost-effective surveillance and reduction in worker exposure to radiation and other hazards. Florida International University's Hemispheric Center for Environmental Technology (FIU-HCET) first investigated and documented the remote surveillance needs of various DOE sites and facilities. FIU-HCET then designed a general system, which consists of three major subsystems: a data collection and transmission system, a transceiver with computer and data analysis software, and application-specific sensors.

A specific system could not be designed until a deployment site and the monitoring activities were chosen and agreed upon. Discussions with several DOE sites concerning deployment resulted in the decision to deploy a remote surveillance system at the TAN-616 facility at the Idaho National Engineering and Environmental Laboratory (INEEL). The system deployed includes water level, water presence (moisture), and a temperature sensor. These sensors are connected to a datalogger that transmits data to a computer outside the building via a radio modem.

This report describes the project work and the remote surveillance system that will be deployed at TAN-616 at INEEL. Section 2.0 summarizes the history of this project, which began in Fiscal Year 1998 (FY98). Section 3.0 is a general description of the different components of a remote surveillance system. Sections 4.0 and 5.0 discuss the site-specific aspects of the deployed system: the TAN-616 facility in section 4.0 and the specific instruments and sensors used in section 5.0. Section 6.0 is a conclusion that includes the lessons learned.

Remote surveillance systems are a cost-effective alternative to the baseline method of inspectors entering the facility to obtain samples and perform measurements. INEEL has expressed interest in a second deployment, funded by INEEL, of a remote surveillance system at the LOFT facility. FIU-HCET will continue to improve and expand the remote surveillance system after the completion of this project and seek further opportunities to deploy this system.

2.0 HISTORY OF THE PROJECT

This project was based on Fernald's Technology Need OH-F012 and began in FY98. Discussions with DOE site representatives and operations contractor personnel and a review of Project Baseline Summaries (PBS) and Site Technology Coordination Group (STCG) reports showed that the Albuquerque Operations Office, Chicago Operations Office, Idaho Operations Office, Ohio Operations Office, Oak Ridge Operations Office, and Savannah Operations Office are in need of remote surveillance systems. The facilities include production areas, structures, equipment, utilities, drums, tanks, waste and effluent lines; they are periodically surveyed for various criteria: contamination level, structural deterioration (such as a leaky roof), water intrusion, water level, animal intrusion, integrity of storage containers, gamma radiation, air activity, temperature, humidity, and radioactive and hazardous waste release. A remote surveillance system is needed to provide continuous monitoring of the facility and reduce the need for labor-intensive, expensive, and hazardous surveys. Considering that many of the abandoned sites have no reliable source of power and a cost-effective method is necessary to the long-term success of the remote surveillance system, solar powering with storage batteries became an option.

After an outline of needs and requirements was completed, selection and initial evaluation of components began. Based on the STCG reports, PBS needs, and discussions with Bechtel and other site personnel, a survey was prepared and faxed to potential vendors with price quote requests. Price quotes from manufacturers/distributors of solar panels were also received. Information concerning the results can be found in the FY98 Year-End Report (Dua and Ebadian 1999).

Work was performed in FY99 toward completion of the remote power maintenance subsystem for powering the remote surveillance system. Battery and solar units were analyzed. A matrix of possible transducers, power sources, and supply conventions was also assessed. The compatibility between solar and battery systems emerged as an important consideration. The sensor array was tested with sensors residing at FIU-HCET.

In FY99, Bechtel Hanford expressed great interest in the project at the midyear review for the D&D Focus Area. Discussions were held with representatives of Bechtel Hanford and Pacific Northwest National Laboratory regarding deployment of custom remote surveillance systems at Hanford facilities. Incorporation with and improvement to the sampling systems already in place at the Redox and Purex facilities was specifically mentioned. By the end of FY99, most sites had not defined specific performance requirements; thus, discussions were held for deployment of a monitoring system capable of monitoring three or four parameters and yet expandable to six. However, no agreement with representatives at the Hanford site was obtained after extensive negotiations, so no deployment was possible in FY99.

Prior to FY00, the hardware selection was completed except for the final sensors relying on specifications from the DOE sites. Discussions were held in January of FY00 with representatives from the Savannah River Site (SRS) and INEEL. The SRS representative identified the P-reactor and Naval Fuel Facility as possible candidates for a remote surveillance system. However, after further investigation, the SRS representative decided that the facilities were not appropriate for a remote surveillance system since 1) items to be monitored are so subjective that sensors do not exist for them; 2) the system can remotely monitor some items, but

others require human intervention; and 3) some monitored items would need too many sensors. Therefore, no deployment was possible at SRS.

At INEEL, facilities were identified that would benefit from a remote surveillance system. The facilities initially identified included the Engineering Test Reactor, Loss of Fluid Test Facility (LOFT), TAN-660 Containment Service Building, and the Power Burst Facility Reactor Building. Later, the TAN-616 facility was identified and chosen for the deployment site of the remote surveillance system (see section 4.0 for further detail), with the possibility of deploying an additional system later for LOFT, covered by funds from INEEL. Monitoring of LOFT would tentatively include water level in sumps, water level in tanks, airborne radiation monitors, and the maximum/minimum temperature.

The TAN-616 facility required a characterization to be performed before allowing INEEL and FIU-HCET personnel to enter the facility and set up the system. Delays in this characterization and unforeseen problems with entering the evaporator pit have shifted the date of preparing the TAN-616 facility for deployment by months, resulting in FIU-HCET shifting the deployment date until November 15, 2000. At mid-November, only the control room and pump room were accessible, so the deployment was postponed.

FIU-HCET sent one staff member during November, 2000 that operated and trained INEEL personnel in the operation of the system. The remote surveillance system was set up with sensors and tested at Engineering Research Office Building, a DOE facility off-site of INEEL, on November 15. The transmitting and the receiving MCUs were connected by and communicated through a cable. The system was set-up and tested on November 16 in the North Holmes Laboratory in which the MCUs communicated via the radio modems. They installed the transmitter in the RF/anechoic room with the receiver outside the room. The remote surveillance system operated successfully after they established the correct amount of attenuation of the radio frequency through the room door. INEEL staff will deploy the system when TAN-616 becomes available. Due to INEEL delays in the characterization of the TAN-616 facility, the current estimated date of full deployment is January 2001.

During initial discussions, an airborne radioactive particulate monitor was selected as one of the monitoring requirements. However, after the monitor was purchased and tested, radiation control at INEEL decided that it could not be used for its original objective of personnel monitoring. The original intent was to monitor the facility for airborne radioactive particulates remotely before allowing anyone to enter. If the monitor could not be used for this purpose, then deploying the monitor as part of the remote surveillance system would incur extra cost with no additional benefit. Therefore, both INEEL and FIU-HCET decided to remove the airborne monitor from the system.

3.0 REMOTE SURVEILLANCE SYSTEM BASICS

A remote surveillance system consists of a data collection and transmission system, a transceiver with computer and data analysis software, and application-specific sensors.

3.1 DATA COLLECTION AND TRANSMISSION SYSTEM

The combination of data acquisition and telemetry is commonly known as Supervisory Control and Data Acquisition (SCADA). SCADA consists of acquiring data from sensors, transmitting data to a central site, displaying and communicating the data to the operator, and controlling the sensors, actuators, and other instruments. The data acquisition unit is called a datalogger; it contains microchips and can process data and generate commands. The datalogger in the field, to which the sensors are connected, is called a Remote Station. The Remote Station may either be a Remote Terminal Unit (RTU) or a Programmable Logic Controller (PLC). An RTU is a standalone unit that acts as the intermediary controller between the central computer and the sensors. It obtains data from the sensors and transmits it to the computer. The PLC is a unit that uses computer code to perform logic functions that control the remote system. It evaluates the data received from the sensors to determine what actions should be performed.

The data is transmitted from the remote station to a central computer via telemetry, which is the transfer and receiving of information over a medium. The information medium may be a telephone line, cable, radio, cellular, or a satellite. A radio, cellular, or a satellite modem is required for remote locations that have no telephone lines or cables and often is used as a backup means of communication even when telephone lines or cables are available.

3.2 TRANSCEIVER WITH COMPUTER AND DATA ANALYSIS SOFTWARE

A receiving modem and datalogger is connected to the computer to receive the transmitted signal and process it. The receiving datalogger is connected to the central computer. Specialized software displays the data to the user on the computer and allows the user to submit commands to the field datalogger. Any IBM-compatible PC may be used for storing and manipulating data. The software plays an important role in the remote surveillance operation, as it is the interface between the physical components and the operator.

3.3 SENSORS

The sensors are placed in the facility to measure desired properties such as radiation levels, temperature, pressure, humidity, water level, and moisture. The sensors are connected by cables to the datalogger and receive power from and send output to the datalogger. More information about different sensors is available in the FY98 and FY99 year-end reports (Dua and Ebadian 1999, Freeman et al. 2000). Output is either digital or analog: current (4-20 mA) or voltage (1-5 V). The sensors used in a system are specific to the site and are discussed further in section 5.0.

Sensors are not available for all items that require monitoring. The structural stability of a roof is one such item that can not be measured by remote sensors. However, it can be measured indirectly by measuring leaks through the roof by water presence or level sensors on the floor, in

sumps, or elsewhere. Other items that can not be directly monitored are those that are significant only when an inspector is inside the facility, such as the operability of the lights, elevator, or fire extinguishers. Such items would not need to be monitored if a remote surveillance system was installed.

If a facility has monitoring requirements that can not be performed by sensors, requiring inspectors to enter the facility for surveillance, a remote surveillance system can still be effective. Sensors can be used to monitor the items that

- require more frequent measurements, thereby reducing the number of times an inspector must enter the facility
- are located in the more dangerous sections, thus reducing the risk to inspectors
- are most urgent, increasing the real-time early warning capability
- require the most time, are subjective or difficult, thereby reducing the time required by an inspector to be in the facility and to increase accuracy.

3.4 POWER

The power system is a major concern for a remote surveillance system since many shutdown facilities on DOE sites will not have a regular power supply after closure. The majority of the data acquisition systems are powered by 12 volts direct current (VDC) sources, and power consumption by dataloggers, peripherals, and sensors is minimal. An optimal power supply is a sealed rechargeable battery that is recharged continuously by a renewable energy source, such as a solar or wind power generator. A regulator controls how the power generator charges the battery and is an integral part of the system.

The components of a solar power system are the solar panels (photovoltaic cells), charge controller, battery, and inverter. Solar photovoltaic cells use semiconductors made from silicon or other materials to convert sunlight to electricity. High-quality solar panels are designed for a lifetime of 30 years and often have a 20-year warranty. The charge controller (or regulator) regulates the electrical flow into the battery so that the battery is properly charged (prevent overcharging). If alternating current (AC) is required, the inverter is installed to change the current from direct current (DC) to AC.

The basic components of a wind power system are the blades (rotors), generator, tower, regulator, and batteries. The wind moves the blades, which turn a shaft, and the generator converts the shaft motion into electricity. The wind is stronger higher up from the ground, so the turbine (rotors and generator) is placed on a tower to maximize energy output. Buildings and hills can obstruct the path of the wind, so location is important. Optimal places for a wind generator are the plains (no natural barriers), mountain passes (act as funnels), and coastlines (have a steady breeze). Common applications for small wind power systems are for remote telecommunications, farm residences, and water pumping.

A deep-cycle battery must be used and should have a power capacity (amp hour) 20% larger than the power required to operate the system during the longest expected period in which no sun, such as extremely cloudy conditions, or wind is available. Lead-acid batteries are the most common batteries used due to lower initial cost and ready supply (they are available nearly everywhere in the world). High-quality lead batteries last a maximum of seven years. Absorption

Glass Mat and Gel-cell deep-cycle batteries are other commonly used batteries that have a longer life and do not contain lead.

4.0 DEPLOYMENT SITE

The TAN-616 facility (Figure 1) is located in the Test Area North (TAN) of INEEL and is also called the Liquid Waste Treatment Facility. It was built in 1954, has an area of 2,958 ft², and has the dimension 36 ft x 46 ft x 15 ft. The building is sectioned into an evaporator pit, valve-operating room, caustic pump room (in basement), control room, and a vestibule on the ground level. The basement has a pump, and on the roof are a cooling tower and a heating and ventilation room. It is one story with concrete walls and floor, a built-up roof, and masonry exterior walls.

The pump room in the basement (Figure 2) is 13 ft x 25 ft x 11 ft, is cast-in-place concrete with 1 foot thick walls, and contains no drains. The collection sump, which is required to be monitored, is 2 ft x 2 ft x 1.5 ft. Liquids in the sump were transferred to Tank V-9 during operations. Due to leaks in the pump seals and the piping/valving system, this room is contaminated. General body fields are 100 to 150 mR/hr beta/gamma (β/γ) with hotspots up to 600 mR/hr β/γ at contact. The highest loose contamination was 101,000 dpm/100 cm² β .

The evaporator pit is 11 ft x 25 ft x 15 ft and is cast-in-place concrete with walls ranging from 2 to 3 feet thick. The floor of this pit is 4 feet below the first floor. The evaporator pit can not be accessed from inside the building. Personnel enter by climbing down a ladder through the access hatch cover on the roof. A new roof was installed over the old roof, reducing the space for personnel above the access hatch cover. About 25 irregularly shaped lead sheets are placed on the floor to shield personnel from contamination. The general radiation field is 100 to 150 mR/hr β/γ , and the highest measured loose contamination was 62,000 dpm/100 cm² β/γ on the floor between the receiver and evaporator tank and 150 dpm/100 cm² alpha on the floor near the evaporator. The radiation level is up to 18 R/hr under the lead sheets.

The evaporator pit contains no drains. The collection sump, which is required to be monitored, is 2 ft x 2 ft x 1.5 ft. Liquid in the sump was transferred to Tank V-9 during operations. Tanks to be monitored for water in the evaporator pit include Tank V-5, V-7, and V-8. The head tank (V-5) is a 1,000 gallon flanged stainless steel tank located directly above the receiver tank (V-8). It is configured as a vertical cylinder with an outside diameter of 6 feet and a height of 5 feet. It contains approximately 5 to 27 ft³ of sediment in the bottom. The outside bottom of this tank has a radiation field of 2.5 R/hr β/γ at contact.

The evaporator tank (V-7) is a 1,000 gallon flanged stainless steel kettle with a steel steam jacket. It is configured as a vertical cylinder with an outside diameter of 6 ft and a height of 6.5 ft. Sediment are known to be in the bottom, but no other information concerning them is known. The receiver tank (V-8) is a 1,000 gallon flanged stainless steel vessel configured as a horizontal cylinder with an inside diameter of 4.5 feet and a length of 8 ft. No samples were obtained, so it is not known if sediment are inside the tank.

The facility has power in the vestibule, which is close to the control room. The liquid levels in the tanks and sumps require monitoring to ensure that no water is leaking into the facility through the walls, roof, or other pathway. Water leakage is not expected, so the normal state will be a dry facility. Water presence (moisture) will be monitored with a moisture detector. Airborne monitoring of radioactive particles throughout the facility is also required. Temperature will be measured as a general indicator of conditions such as freezing.

1983-TAN-616 Exterior; looking east

Figure 1. Picture of the TAN-616 facility.

1983-Pump Room; Sump in south corner;
V-9 tie-in to V-1, V-2, V-3 manifold; looking southeast

Figure 2. Picture of the sump in the pump room.

Figure 3. Picture of the access ladder into the evaporator pit, before the new roof was installed.

Figure 4. Picture of the tanks in the evaporator pit.

5.0 FIU-HCET'S REMOTE SURVEILLANCE SYSTEM

The system employed includes

- water level sensor per tank for three tanks in the evaporator pit
- water level and moisture sensor per sump for a sump in the evaporator pit and a sump in the pump room
- temperature sensor in the control room
- datalogger in the control room that operates the sensors
- radio modem on the roof, connected to the datalogger by a cable
- transceiver radio modem and datalogger in a trailer outside the TAN-616 facility
- computer in the trailer to operate the system.

The original plan for deployment included an airborne radioactive particulate monitor in the control room with a manifold that allowed sampling of air from up to five different locations. Hoses from the manifold would extend to different parts of the facility to draw air from these locations to be analyzed by the airborne radioactive particulate monitor. The monitor would measure airborne radioactivity before anyone entered the facility. After the monitor was purchased and tested, radiation control at INEEL decided that this monitor could not be used for personal monitoring. This decision resulted in the monitor adding cost but no benefit to the remote surveillance system; therefore, both INEEL and FIU-HCET decided not to deploy the airborne radioactive particulate monitor as part of the the system.

The general schematic of the remote surveillance system is shown in Figure 5. One design problem with installing the system is stringing the cables in such a way that personnel in the facility do not trip over the cables, especially in those areas with limited space and where a respirator is required, which reduces one's vision. Stringing cable out of the way results in longer cable lengths that are hard to predict beforehand.

Figure 5. Schematic of the remote surveillance system.

5.1 SCADA SYSTEM

Model 2380/20 Measurement Control Unit (MCU) from Geomation was chosen for the datalogger. The 2380 MCU is designed to interface with virtually all industry-standard, analog-type transducers and sensors. Each unit is equipped with multiple communication capabilities and with industrial and military grade electronics to insure compatibility with temperature and environmental extremes. The MCU will be housed in an enclosure with the dimensions 23.6 inches by 23.6 inches by 8.6 inches.

Geomation's SCADA system was chosen because it was considered the only commercial data acquisition system that would meet the unique requirements of this project. The system must be reliable (since once installed, the unit will not be accessible by site personnel except at high cost), remotely programmable, and be easy to program initially. Other commercial systems required extensive programming and debugging of the software and extensive integration and testing of the components, which would decrease the reliability. Geomation's SCADA system has a well-developed, validated, plug-and-play software. The radio frequency (RF) wireless communications module, datalogger, Pentium PC compatibility, and open SQL database are all integrated and proven. Personnel without specialized skills can perform installation and maintenance. Cost savings are realized by having a lower installation, integration, and support effort.

The 2380 MCU is different from an RTU in that the MCU can function autonomously for local data acquisition, control, and communications. An RTU performs tasks under the timing and direction of the central computer. Furthermore, 2380 MCUs can share information with each other in peer-to-peer communications. The units are equipped with an absolute, as well as a relative, time that allows peer-to-peer communications even over different time zones.

The software for the 2380 MCU, GEONET Suite, uses an SQL database and uses an open-architecture client/server operation to manage and analyze data online. The software can operate with any other software that supports the Open Data Base Connectivity industry standard running on Windows 95, 98, and NT. GEONET includes built-in software functions that minimize the complexity of configuring the system components in the field. The GEONET Engine program initiates communication between the computer, the MCU connected to the computer, and the remote MCU. The GEONET Monitor program allows the user to view the data being transmitted by the remote MCU.

The radio interface subsystem used is Geomation's VHF radio transceivers, which has a frequency of 457.525 MHz and a 2 Watt transmission power level. The transmission range is 15 miles over open terrain. A low-loss external antenna cable is used that is 14.5 mm (0.57") in diameter from the MCU to the radio modem and antenna on the roof.

The system is designed and configured to be completely "Plug and Play". All sensors contain quick disconnects to the SCADA unit for quick and easy replacement. The entire system is self-contained with most components enclosed in one enclosure (see Figure 6).

Figure 6. Picture of the SCADA unit inside the enclosure, showing the MCU on the upper right side, battery on the left, components of the moisture sensors on the bottom, and the quick disconnects for the sensors exited the box through the lower right corner.

At the trailer, an uninterruptable power supply will be utilized to meet the requirement of backup power (2 to 5 hours of power to the personal computer) in the event of a power outage. The entire system has a capital cost of \$8,700.

5.2 WATER LEVEL SENSORS

The water level in the tanks and sumps will be measured by Global Water's WL300, a stainless steel submersible cylinder with a diameter of 3/4 inches and a length of 8 inches. The price per sensor was \$495, not including extra cable cost. A pressure transducer at the tip produces an electrical signal (4-20 mA for full scale) that is proportional to the pressure of the water above the sensor. The company calibrates each sensor, and the calibration equation is printed on the cable. Marine grade epoxy is used to ensure that water can not leak through the O-ring seals. The vent tube is bundled with the wires in a single cable and equilibrates the gage pressure of the sensor with the atmospheric pressure. A silicon diaphragm is used instead of a metal foil diaphragm, which tends to crinkle and stretch. A stainless steel micro screen cap with hundred of small openings protects the pressure sensor and prevents it from being fouled by silt, mud, or sludge. The sensor has a full range of 0 to 3 feet (other ranges are available), has an accuracy of

$\pm 0.2\%$ at 35 to 70 °F, and a linearity and hysteresis of $\pm 0.1\%$ full scale. Input voltage is from 10 to 36 VDC, and the response time is 10 ms. Before installation, the water level sensors will be tested at TAN-616 by placing them into a Nalgene bottle filled with water and reading the output with an ammeter. Three of the water level sensors to be deployed have a cable 50 ft long and the other two sensors have a cable 100 ft long.

5.3 MOISTURE (WATER PRESENCE) DETECTOR

Moisture will be detected by the Watchdog Water Alarm. Cost for the sensors were less than \$10. A water level of 1/32 of an inch can be detected, which causes a short-circuit and sounds an alarm. FIU-HCET modified the sensor so that the MCU can operate it by removing the buzzer and soldering a wire to one of the leads of the transistor that activates the buzzer. The output of this wire produces 11 VDC when no water is present and goes down to ground or 0 VDC when water is present. The moisture sensor normally operates at 9 VDC, but to simplify the integration with the MCU, it will be driven at 12 VDC. The sensors were tested for an extended period of time to ensure that using a higher voltage produces no excessive heat.

5.4 AIR TEMPERATURE SENSOR

The Thermometrics model MA100GG103B thermistor was used to measure the temperature. Temperature is measured by measuring the electrical resistance of the thermistor, which is a function of temperature.

5.5 AIRBORNE RADIOACTIVE PARTICULATE MONITOR

An airborne radioactive particulate monitor was part of the initial deployment plan but was later removed due to a decision by radiation control at INEEL not to allow its use for personnel monitoring. The beta/gamma airborne radioactive particulate monitor from Technical Associates, Model FM-7-ABGN, was to be used. A scintillation detector (Model PGS-31) constantly measures a standard free-flowing high-retention filter paper. The filter is easily changed with a unique quick-change no-leak holder. The measuring range is from 10^{-13} to 10^{-7} $\mu\text{Ci/cc}$, and the detection limit for Cs-137 at 70 liters per minute air flow is 4×10^{-13} $\mu\text{Ci/cc}$ integrated over an 8-hour period. The response time for an integrated dose can be set from 1 second to 40 hours.

Air is drawn into the monitor by a 115 V 60 Hz 2 Amp regulated pump. The monitor would have been located in the control room and connected via an air hose to a manifold with five ports, which would have an air hose per port to allow the monitor to draw air from up to five different locations. Each port is remotely controlled by a solenoid that will be opened and closed by a voltage change, provided by the MCU. Only one port would be opened at any one time, thus allowing the monitor to sample air sequentially from five different locations.

5.6 COST ANALYSIS

The regulatory requirement, according to 40 CFR 264.195 for tank inspections, is for daily inspections. However, if the remote surveillance system was not installed, less frequent (weekly, monthly, or quarterly) inspections would have been negotiated with the state. Each inspection

requires three people to enter the facility and would require a full 10-hour day at a fully loaded salary of \$50 to \$60 per hour. Therefore, each inspection costs from \$1500 to \$1800.

The capital cost of the remote surveillance system is \$11,600. One to two days is required to install and test the system, which would require 4 persons. Installation costs may add up to \$2,000 to \$2,400 for one day and \$4,000 to \$4,800 for two days. Therefore, the total cost of the system is from \$13,600 to \$16,400.

An average cost will be used in the analysis: \$15,000 for the remote surveillance system and \$1,650 per inspection. The remote surveillance system is more cost-effective after 9 days for daily inspections, after 9 weeks (about 2 months) for weekly inspections, after 9 months for monthly inspections, and at 2.5 years for quarterly inspections.

6.0 CONCLUSION

A remote surveillance system was designed, tested and will be deployed at INEEL that will monitor the TAN-616 facility for water in sumps, tanks, and on the floor. The presence of water is an indication that the facility is not contained and that the risk of contamination escaping is increased. This system replaces the need to send inspectors into the facility with radiation control personnel to check for water. Some of the areas that would be checked by the inspectors have a high radiation field and little space for maneuvering. Therefore, this system also decreases the radiation exposure and increases the safety of these personnel.

A remote surveillance system has a higher initial capital cost for the equipment than the baseline method, which is to send inspectors into the building to obtain samples and perform measurements. However, the cost of operating and maintaining the system is negligible compared to the continuing cost of sending inspectors and radiation control technicians into the facility. The remote surveillance system has a lower cost in the long term when compared to the baseline method.

6.1 LESSONS LEARNED

Lessons learned from designing and deploying the remote surveillance system are described below.

- Many facilities have needs that are conditional on inspectors entering the facility. If a remote surveillance system is deployed, these needs should no longer be required. However, these monitoring needs can not be removed because regulators and site management have already decided that they are required, based on the baseline method of inspectors entering the facility. This acceptance obstacle for remote surveillance systems replacing the baseline method could be removed by building up monitoring data and experience by deploying in facilities that do not have these requirement problems.
- Deploying a remote surveillance system in a facility that is in the process of being shut down is subject to delays. For the TAN-616 facility, the deployment data was continually postponed due to delays at the site in preparing the facility. Further problems occurred due to changes in the monitoring requirements, as is evident in the airborne radioactive particulate monitor. One solution is to have the deployment date contingent on the date that the facility is ready and not on some calendar date. Furthermore, an extensive amount of time needs to be allowed for full communications with the different management and technical levels at the facility and site.

6.2 ABILITY OF A REMOTE SURVEILLANCE SYSTEM TO MEET NEEDS

DOE has several thousand contaminated shutdown facilities that require periodic inspection. Except for surveillance, personnel would not enter these facilities. A remote surveillance system can meet the monitoring needs of many of these facilities, as was shown by the deployment at TAN-616. Some facilities are larger than TAN-616 and will require an increased number of sensors. The costs of these extra sensors and dataloggers required would need to be considered when compared to the cost and frequency of inspectors entering the facility. However, a remote

surveillance system would still provide more frequent data at a lower exposure and risk to site personnel.

Some facilities have monitoring needs that can not be measured by sensors because these sensors are not available. Some of these monitoring needs are only required when inspectors enter the facility, such as verifying elevators and lights are operational, and therefore should not be a monitoring need if a remote surveillance system is installed. Other items may be monitored indirectly, such as measuring water at low points of the floor or in sumps as an indication of roof and building integrity.

A remote surveillance system could be effective even if inspectors still need to enter the facility if the sensors

- measure items that require more frequent measurements, thereby reducing the number of times an inspector must enter the facility
- are located in the more dangerous sections, thus reducing the risk to inspectors
- monitor the most urgent items, increasing the real-time, early warning capability
- measure the items that require the most time, are subjective or difficult, thereby reducing the time required by an inspector to be in the facility and to increase accuracy.

FIU-HCET plans to further develop and implement remote surveillance systems as a solution to DOE monitoring needs. Discussions are ongoing about expanding deployment at INEEL to a second facility (LOFT). Each remote surveillance system must be specific to the facility and each facility, has unique challenges for implementing a cost- and performance-effective solution. Remote surveillance is possible using available technology and can reduce surveillance costs, reduce exposure, and increase site safety.

7.0 REFERENCES

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