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International Remote Monitoring Project
Argentina Nuclear Power Station Spent Fuel Transfer
Remote Monitoring System

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ABSTRACT

The Autoridad Regulataria Nuclear (ARN) and the United States Department of Energy (DOE) are cooperating on the development of a Remote Monitoring System for nuclear nonproliferation efforts. A Remote Monitoring System for spent fuel transfer will be installed at the Argentina Nuclear Power Station in Embalse, Argentina. The system has been designed by Sandia National Laboratories (SNL), with Los Alamos National Laboratory (LANL) and Oak Ridge National Laboratory (ORNL) providing gamma and neutron sensors. This project will test and evaluate the fundamental design and implementation of the Remote Monitoring System in its application to regional and international safeguards efficiency. This paper provides a description of the monitoring system and its functions.

The Remote Monitoring System consists of gamma and neutron radiation sensors, RF systems, and video systems integrated into a coherent functioning whole. All sensor data communicate over an Echelon LonWorks Network to a single data logger. The Neumann DCM 14 video module is integrated into the Remote Monitoring System. All sensor and image data are stored on a Data Acquisition System (DAS) and archived and reviewed on a Data and Image Review Station (DIRS). Conventional phone lines are used as the telecommunications link to transmit on-site collected data and images to remote locations. The data and images are authenticated before transmission. Data review stations will be installed at ARN in Buenos Aires, Argentina, ABACC in Rio De Janeiro, IAEA Headquarters in Vienna, and Sandia National Laboratories in Albuquerque, New Mexico.

INTRODUCTION

As part of the International Remote Monitoring Project, an expanded Remote Monitoring System will be installed at the Argentina Nuclear Power Station in Embalse, Argentina, also referred to as the Central Nuclear Embalse (CNE). This installation will eventually replace the current Remote Monitoring Station (RMS) that was installed in March 1995 at the CANDU reactor spent fuel storage area. The new system monitors the entire spent fuel transfer process from the spent fuel pond, through the welding hot cell, to the silo storage area. The system is under test and evaluation at SNL. SNL and ARN are awaiting final approval to install this system. This field trial is a joint effort and collaboration by ARN, ABACC, DOE, SNL, LANL, ORNL, and the IAEA.

FACILITY/OPERATIONS

The cooled spent fuel at the Embalse CANDU reactor is moved into a basket that is welded shut prior to being transferred to a dry-storage silo. Sixty bundles are packaged in each of the dry-storage baskets, and nine baskets are sealed in an Embalse silo.

Fuel movements at the facility usually occur bi-annually. During a fuel movement campaign, facility operators, ABACC, ARN, and IAEA personnel must be present at all times to monitor spent fuel storage activities. The new RMS will be installed in the Spent Fuel Pond, the Welding Hot Cell, and at the silo field.

SAFEGUARDS

A Remote Monitoring System designed by SNL to monitor four spent fuel storage silos at CNE was installed in March 1995. This system uses RF transmission of data from the silos to a receiver on the reactor service building. Data from the current system is available on site as well as through remote communication links to ARN and SNL. The demonstration of this system exposed ARN and ABACC personnel to remote monitoring technologies for nuclear safeguard purposes.

The new RMS monitoring process allows for a continuity of knowledge throughout the transfer process by using spent fuel radiation signatures. The objective of this installation is to demonstrate the feasibility, effectiveness, and efficiency of using remote monitoring technologies to reduce the requirement for on-site inspections. Once accepted, this technology is expected to reduce the cost of safeguard activities both to the monitoring agencies and to the monitored facilities, while maintaining or increasing the effectiveness of the safeguard measures.

SENSOR TRACKING

Commercial as well as national laboratory sensors are used to monitor the spent fuel transfer process. These sensors are used to track the spent fuel process beginning with the Spent Fuel Cooling Pond, monitoring the material present in the Welding Hot Cell and the basket placement of the material in a Dry Storage Silo (See Figure 1).

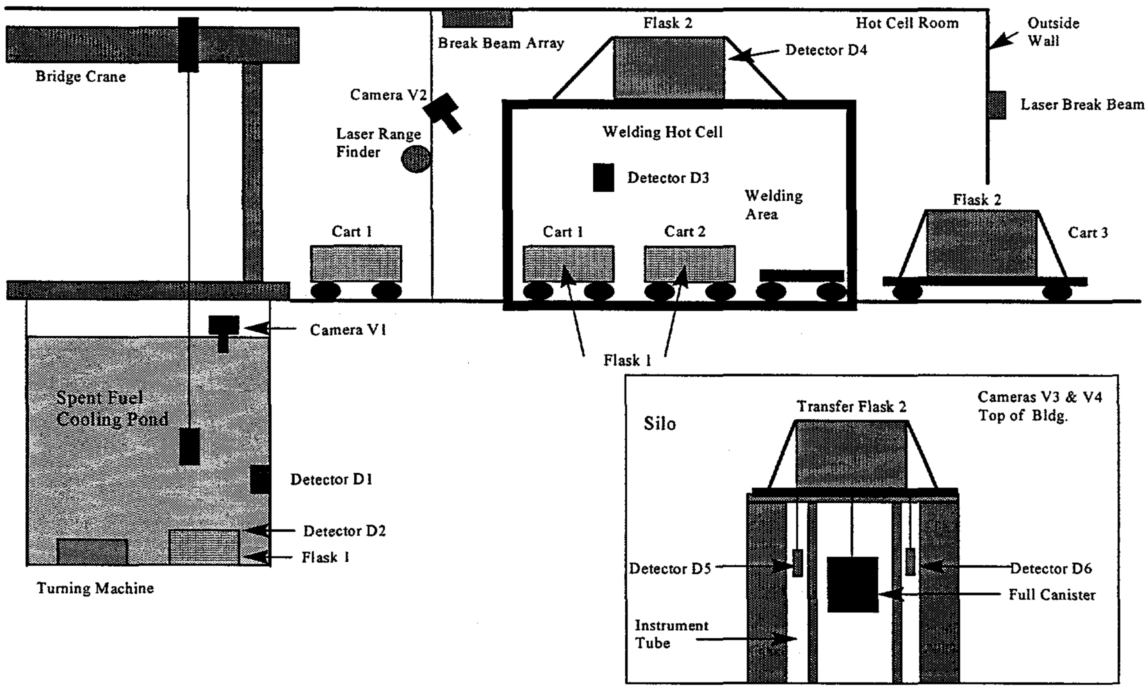

Figure 1: Embalse Nuclear Power Station with RMS Sensors

The steps in the spent fuel transfer process and the assorted monitoring devices are described in the next three sections.

Spent Fuel Pond

- To begin the transfer, a tray is moved from the cooling area to the turning machine.
- Flask 1, with the lower half of the basket, is already in the pool. The operator attaches a tool to the bridge crane and moves the bundles, one by one, to the basket.
- A Los Alamos gamma/neutron radiation sensor (D1) located in the pool sends out a count reading over the LON network to the data logger and an underwater camera (V1). When the pre-programmed count is exceeded, a trigger message is sent to V1 and an image is captured each time a fuel bundle passes through D1 prior to being loaded in Flask 1.
- After Flask 1 is filled with 60 fuel bundles, the lid is placed on top of the flask.
- Flask 1 is then raised, drained, dried with compressed air, and placed on Cart 1 which moves on rails between the pool side and the welding hot cell.
- Data from the Ludlum gamma detector (D2), which is mounted on the lid of Flask 1, is transmitted over an RF system to a receiver that is connected to the Echelon network.

Welding Hot Cell

- As Cart 1 approaches the entrance to the hot cell, a break beam array is triggered and a message is sent to the data logger and camera V2.
- The signal from D2 and the break beam array trigger camera V2 to take an image.
- The basket of spent fuel rods is removed from Flask 1 inside the welding hot cell. The lid is positioned on the basket and prepared for welding.
- During the course of this process, a second Los Alamos gamma/neutron radiation sensor (D3) located inside this welding hot cell, transfers radiation count data over the Echelon network to the data logger. The basket is then lifted into Flask 2.
- A Ludlum gamma detector (D4) connected to an RF transmitter, is mounted on the lid of Flask 2. When the threshold is exceeded, a message is sent to the data logger and camera (V3).
- At the time Flask 2 leaves the hot cell, a break beam mounted 3 meters above the ground is tripped and a message is sent to the data logger and camera V3.
- Camera V3 captures images of Flask 2 being transported to the silo field.

Silo Dry Storage

- Flask 2 is moved to the selected silo and is lifted by a crane to the silo top.
- Operators then ascend the silo to lower the basket into the silo.
- Two ORNL gamma detectors (D5-D6) monitor the dose rate as each basket passes the sensor. These gamma sensors are located inside two instrumentation tubes that are on opposite sides of the storage tube and transmit an RF signal to the Echelon network.
- When Flask 2 is removed and light is present, the RF transmitter sends out state of health data every 4-6 hours. The purpose of this design is to save on battery life for each transmitter.
- When D5 or D6 radiation threshold is exceeded, camera V4 is triggered to capture images of the silo activity.

SYSTEM HARDWARE

The system contains four different types of sensors: gamma, neutron, laser break beam, and a laser range finder. There are nine sensors altogether, and each sensor communicates to a node either by hardwire or RF. All the nodes are interconnected and form a Local Operating Network (LON). This LON technology is commercially available from the Echelon Corporation. The LON has been designed so that all nodes can communicate with each other, exchanging both sensor and state of health information over a double two-twisted pair, 18-gauge, copper wire cable. Each node is capable of processing sensor data and providing authenticated data transfers over the LON to the

DAS computer. The Argentina Remote Monitoring System is connected in a free topology configuration, which allows a more flexible solution for connection of nodes onto the network. (See Figure 2).

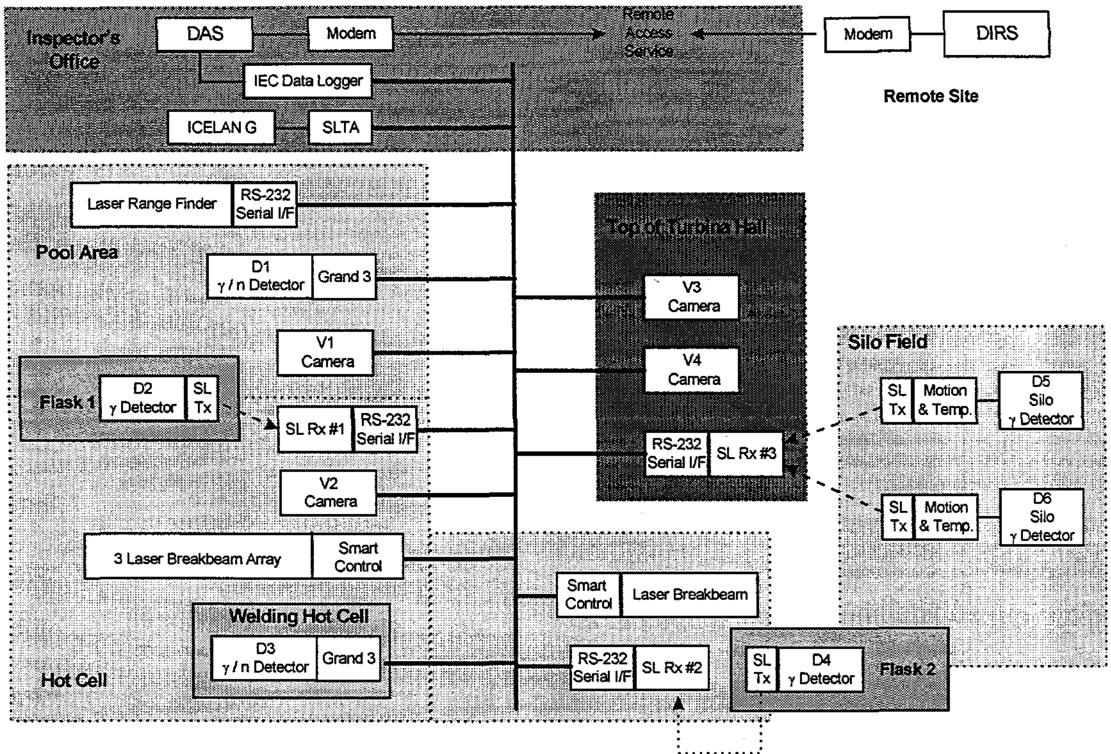

Figure 2: Argentina System Network

A video camera network made up of four camera systems (V1-V4) is also interconnected on the Echelon LON Network. The video system is responsible for capturing images when a certain set of conditions are met. Each camera system contains a Neumann DCM-14 module and is capable of digitizing video frames; compressing the digital image; authenticating the compressed digital file; and storing the image file until it can be transmitted to the DAS computer via RS-485 serial communications. All images received by the DCM-14 are triggered by sensors that have been "bound" onto the LON network.

The four gamma sensors (D2, D4, D5, and D6) are individually connected to RF transmitters. The signal received from each transmitter is a gamma reading represented in an analog voltage. The analog voltage is transmitted to a receiver at 915 MHz. The output of the receiver is attached to the LON via a serial LON interface.

The network nodes and sensors are powered by two AC/DC power supplies with a minimum of 3 hours UPS battery backup capability.

The Data Acquisition System (DAS), is a Pentium based, PC compatible computer running Windows NT V4.0 operating system, which interfaces to the LON via the data logger. The DAS communicates with the data logger via a serial communications port. The DAS collects pertinent sensor and video data for data storage. A modem is connected to the computer to provide telephone communications to the Data and Image Review station (DIRS) at remote locations. The DIRS computers, which have access to the DAS, are 486 or Pentium based computers running the Windows 95 operating system.

The data logger is a commercial product available from Intelligent Energy Corporation (iEC). It is used to collect sensor data from the Echelon network. The data from the network is time-stamped and stored on a hard disk in the device.

The *iCELAN-G* software from iEC provides network management of the LonWorks network. It is a Windows based graphical design environment used to configure and control the LonWorks network. The *iCELAN-G* application is installed on a separate PC which is referred to as the Network Management System (NMS). The NMS requires the appropriate hardware for a connection to the LonWorks network Serial to LonTalk Adapter (SLTA). When the configuration of the network is complete the NMS can be disconnected from the network. Network configuration information is transferred from the NMS to the DAS and then distributed to the DIRS during data transfer.

SYSTEM SOFTWARE

The software running on the DAS and DIRS is a suite of commercial and custom programs designed at SNL called the MIMS (Modular Integrated Monitoring System). A key component of the MIMS software is the database, which resides on both the DAS and the DIRS. Changes to the configuration of the system are reflected by changes to data in the database. The software components of MIMS are primarily driven by data in the database. Changes to the configuration of the system do not require code changes.

The DAS software collects sensor and configuration data for a site and maintains it in the database. Data being collected can be viewed at the DAS using the software. The DAS software manages connections and data transfer to DIRS.

Data communication between the DAS and the DIRS is achieved by modem connection. The data transfer applications on the DAS and DIRS use the Remote Access Service (RAS), which is a standard communication service that is provided with Windows NT and Windows 95. During data transfer an authentication signature is generated for the database. The authentication algorithm uses the NIST Digital Signature Standard, a public-key authentication algorithm. After all files have been transferred, the authentication signature will be verified by the DIRS. The Echelon authentication is used between the nodes on the LON network.

The user can establish a connection and retrieve data, or review data which has already been transferred to the DIRS. For each site, a set of overview pictures can be provided which help the user better understand the facility.

The DIRS Review Mode allows the user to view sensor event information in the database. In Review Mode the window displays a Location picture. The Location picture originated in *iCELAN-G,* and was transferred from the NMS to the DAS and then to the DIRS. The Location picture graphically shows the layout of the sensor network. Icons appear on the picture for each sensor in the network. The user can click on an icon to obtain additional information about the sensor. Any of the locations defined through *iCELAN-G* may be viewed. The database keeps track of changes to the configuration of the sensor network. The user can choose from a selection of configuration versions deployed during the life of the system.

The Review Mode has several ways to examine the event data. The data can be filtered by Time and Date as well as by individual Sensor and by message types. An indication of data transfer authentication is provided. One option shows the number of events per day. Further analysis can be performed by using the Data Analysis component which is initiated from the Review Mode.

The Download Mode allows the user to retrieve data from a selected DAS. In this mode, options are provided for the types of data to transfer, data authentication, and time and date range of data to be downloaded. The DIRS application uses the DIRS Data Transfer application to perform the actual download. Once the transfer has been started, the DIRS Data Transfer application runs as a separate process. The user may perform other functions in the DIRS application while a transfer is in progress. When the transfer is complete the user is notified. If the DIRS application is halted before the data transfer has been completed, the transferred data will be added to the database the next time the DIRS application is run.

SYSTEM IMPLEMENTATION

The remote sites that will be able to call up the DAS and acquire information are ARN, ABACC, SNL, and possibly the IAEA Only one DIRS can be connected at any single time to the DAS. Information accessible by a remote DIRS includes state of health reading on all nodes and sensors; records of previous events; trigger histories of video data; video images acquired; and the current status of the system. Other interested remote sites may have access to this data.

STATUS

Upon completion of the system installation, a field trial evaluation will take place. The main objective of the field trial evaluation is to demonstrate the technical feasibility of the Remote Monitoring System for the spent fuel transfer. This includes the overall system reliability; data authentication on-site and across the link to the remote site; and data confidentiality during remote transmission. Technical parameters and protocols will be examined to define not only a better upgraded system, but a system that could be accepted for international safeguards.

SUMMARY

With proper authorization, the Argentina Remote Monitoring System may be accessed by local, state, and IAEA inspectors for nuclear material accountability. With this remote monitoring process a continuity of knowledge is maintained throughout the transfer process by using the spent fuel radiation signature (D1-D6). With the Remote Monitoring System an IAEA inspector can "dial-in" and download the data to his/her remote station without making costly site visits.

REFERENCES

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