THE INTERNATIONAL REMOTE MONITORING PROJECT -

RESULTS OF THE SWEDISH NUCLEAR POWER FACILITY FIELD TRIAL

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Abstract
The Swedish Nuclear Power Inspectorate (SKI) and the US Department of Energy (DOE) sponsored work on a Remote Monitoring System (RMS) that was installed at a Swedish Nuclear Power Facility operated by Sydcraft. The RMS, designed by Sandia National Laboratories (SNL), was installed in August 1994 at the Barseback Works located north of Malmo, Sweden. The RMS was designed to test the front end detection concept that would be used for unattended remote monitoring activities. Front end detection reduces the number of video images recorded and provides additional sensor verification of facility operations. The function of any safeguards Containment and Surveillance (C/S) system is to collect information which primarily is images that verify the operations at a nuclear facility. The Barseback Nuclear Power facility is ideal to test the concept of front end detection since the majority of activities of safeguard's interest is the movement of spent fuel which occurs once a year.

The RMS at Barseback uses a network of nodes to collect data from microwave motion detectors placed to detect the entrance and exit of spent fuel casks through a hatch. A video system using digital compression collects digital images and stores them on a hard drive and a digital optical disk. Data and images from the storage area are remotely monitored via telephone from Stockholm, Sweden and Albuquerque, NM, USA. These remote monitoring stations, operated by SKI and SNL respectively, can retrieve data and images from the RMS computer at the Barseback Facility. The data and images are encrypted before transmission. This paper will present the details of the RMS and the test results of this approach to front end detection of safeguard activities.

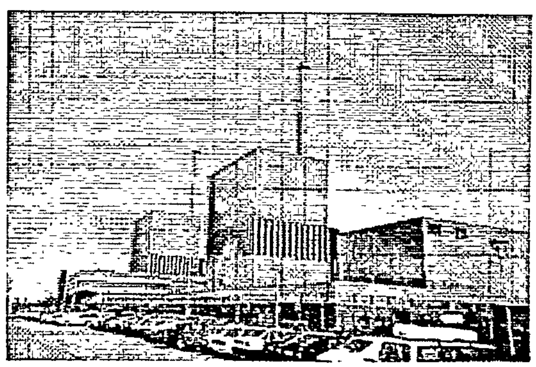

Figure 1. Barseback Nuclear Power Reactor

Introduction

The Swedish Nuclear Power Inspectorate (SKI) and the US Department of Energy (DOE) sponsored work on a Remote Monitoring System (RMS) installation at the Barseback Works

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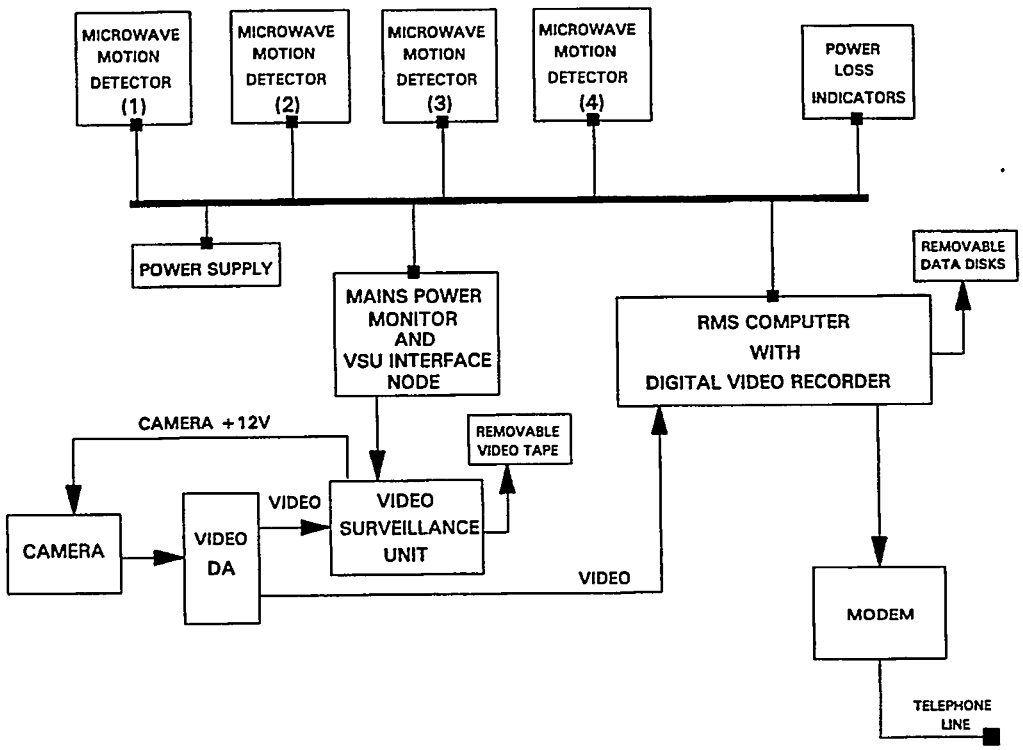

Figure 2. Block Diagram of Barseback RMS

located north of Malmo, Sweden. Figure 1 shows the facility which houses two power reactors. The Barseback Nuclear Power Facility provides an excellent location to test the concept of front end detection since the major activity of safeguard's interest is the movement of spent fuel which occurs once a year. The work in this report has been sponsored by the Department of Energy in the United States and the Swedish Nuclear Power Inspectorate under a bi-lateral agreement. The work was performed by personnel from SNL, SKI, and the Sydkraft.

SNL personnel arrived at Barseback on Friday, August 12, 1994, to begin the installation of the sensors and video camera. The installation work was completed by the following Thursday. Testing and alignment of the sensors and detectors at Barseback began on Friday, August 19th. handling fixture was used to simulate a spent fuel cask for testing. One microwave sensor was set with higher sensitivity than was required and generated false alarms during the weekend test. Additional tests and adjustments were completed on the following Monday. No spurious sensor signals occurred during the test on Monday night indicating that a stable operating configuration had been obtained. Additional tests were made on Tuesday before closing up the system for operation. The Data and Image Review Station (DIRS) was installed at the SKI office on August 15th and 16th. The DIRS was used to conduct testing with the RMS equipment at SNL and at Barseback on August 16th.

Technical Description

The block diagram in Figure 2 shows the configuration of the remote monitoring system. A network of nodes collects data from four microwave motion sensors that are used to trigger video recordings. An AC mains power monitor sends signals over the network to a "loss of AC power" alarm box. The microwave motion detectors attached to the network are used to determine if any activity is occurring in selected areas. Detection of any activity will trigger video recordings to be made on the Video Surveillance Unit (VSU) and in the Remote Monitoring System (RMS) computer. The VSU recordings are made on 8 mm video recorders that produce the same type of recordings as the MIVS systems and can be reviewed in the same manner. The VSU is programmed to make recordings when a microwave motion sensor detects activity near the exit hatch or at periodic time intervals. In this RMS the VSU has been programmed to record at six minute intervals which is the same as the Modular Integrated Video System (MIVS) being used for surveillance by the International Atomic Energy Agency (IAEA). Figure 3 shows the installation of the RMS camera and the crane microwave detector near the MIVS camera.

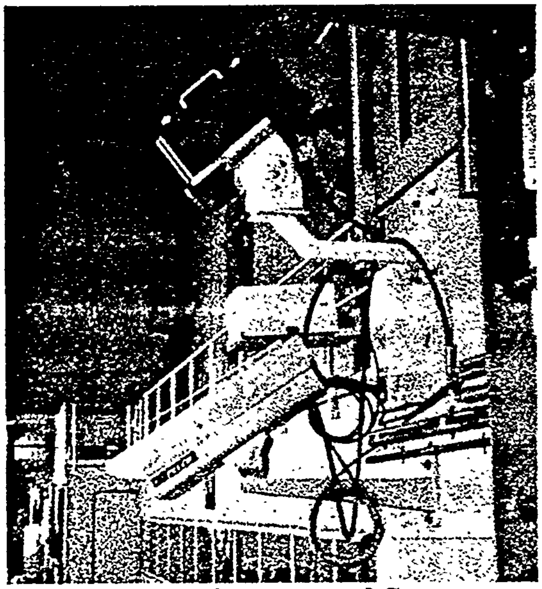

Figure 3. Camera and Sensor Installation

A second video system in the RMS computer uses digital compression technology which processes digital images that are stored on a hard drive and a removable optical data disk. The data can be accessed from either drive for remote transmission. The video compression card turns the computer into a "Digital Video Recorder" for storing images.

Network Sensors

Microwave motion detectors on the network are used to determine if any activity is occurring in the area. The microwave motion detectors send out RF pulses at approximately 10 GHz to detect motion in the area. Placement of the microwave sensors is shown in Figure 2. Two detectors (detectors 2 and 3) cover the exit hatch. By placing the beams in this configuration, a video recording is made when a large object is present in the hatch area.

Microwave detector number 1 uses a beam to detect when the crane is moved into a position that might allow spent fuel handling activities to occur. Microwave detector number 4 is used to make a recording when there is activity in the cask loading area. These detectors have a number of adjustments for sensitivity and motion thresholds. In addition, the logic in the nodes can be programmed to require motion activity in an area for a specified time period before sending trigger signals.

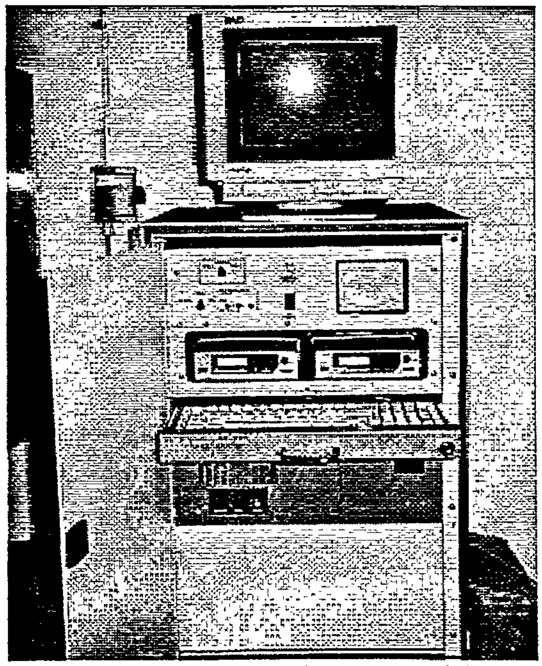

Figure 4. RMS Equipment Cabinet

Remote Monitoring

Data and images from the area under surveillance are remotely monitored via telephone lines from Stockholm, Sweden and Albuquerque, NM, USA. Remote monitoring stations at these two locations can call and retrieve data and images from the RMS computer in the facility. The data and images are encrypted before transmission. Access to the RMS computer cannot be obtained without the correct encryption keys and passwords. (A part of the installation activities was to install a DIRS at the SKI office.) The DIRS is assembled from commercially available hardware and is based on a standard PC computer configuration such as a 386/486 computer, 25-33 megahertz with 4

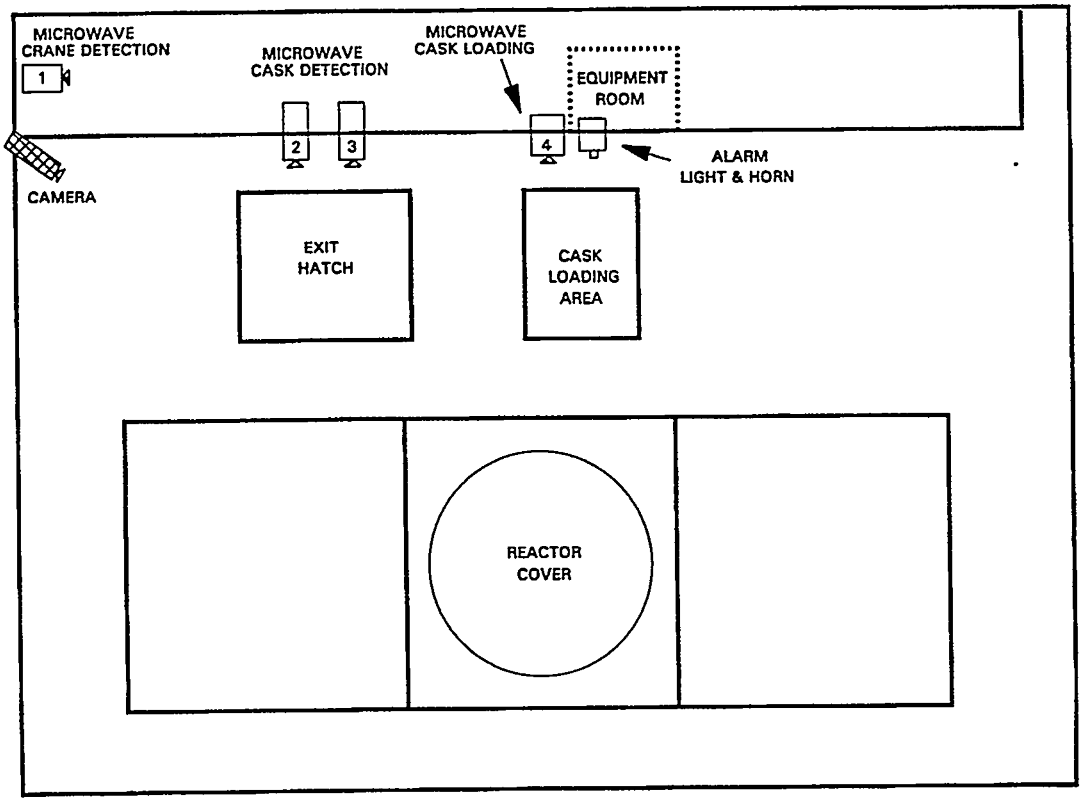

Figure 5. Sensor Layout

megabytes of RAM. It should also have a 3.5 inch 1.44 megabyte floppy drive and at least a 200 megabytes hard drive. SNL installs a special video compression board in the PC computer and remote monitoring software.

An encryption modem was installed between the computer and the telephone line for system operation for the first few months of operation. The transatlantic transfer of data could only be accomplished at 2400 baud with the encryption modem.

In March, 1995 a new software version was installed in the RMS and DIRS in Sweden. Software encryption was a new option for the remote monitoring equipment. Unencrypted modems were installed in the RMS and DIRS equipment in Sweden and the encryption function for protecting the data was shifted to the software. These changes allowed the exchange of data to be increased to 9600 baud for calls from Albuquerque. The new software also permitted the DIRS to display higher resolution images on the computer monitor.

Test Results

SKI personnel have accessed the RMS at Barseback from a Data and Image Review Station (DIRS) in Stockholm. SNL personnel have accessed the system from Albuquerque. The sensor network has performed without any problems. Excellent pictures have been obtained from the system. The sensor network has effectively screened out thousands of images that a time lapse system would have recorded. Reducing the number of images taken has reduced the amount of time that is required to transmit and review the data and images.

An example of the data reduction that has occurred can be illustrated by the fact that only 47 images have been captured by the RMS during the first month of operation at Barseback. In the same time period a MIVS or VSU would have recorded approximately 14,400 images on two recorders. The number of images to be reviewed have been reduced by a ratio of over 150 to 1 (or 300 to 1 if both tapes have to be reviewed).

Another example was the month of May, 1995, when there was a total of 21 motion triggers and a total of 13 images collected. 18 of the triggers and 11 of the images were taken during one 24 minute time period on 29 May. The image reduction ratio was more than 550 to 1 for the May time period. During these two periods of time, no significant activities occurred.

Spent fuel was moved out of the reactor during the last part of October and the first part of November, 1994. The movement of one spent fuel cask into and out of the reactor hall took approximately 49 hours. During that time period the MIVS observing the area should have taken about 1000 pictures on two recorders. The RMS recorded 272 triggers from the four microwave sensors and took 141 pictures. There were 141 "Cask loading/crane movement" triggers and 86 images associated with those triggers. This left only 55 images to be reviewed in order to determine the times of cask entry and exit from the reactor hall. There were no triggers during the two nights, and no images were recorded.

The VSU was programmed to operate as a time lapse recorder and took pictures at six minute intervals. It would also record pictures whenever any of the microwave sensors were triggered. The purpose of the VSU was to collect data for a comparison with the digital images being collected by the RMS. The tapes from the VSU were reviewed to confirm that there were no activities during the time periods when the sensors showed no activity. Comparison of the data verified the following conclusions.

1. The sensor system operated very reliably to detect movement in or near the exit hatch. All the movements of the fuel shipment casks were detected and recorded. Other large objects, such as handling fixtures, were detected when they were moved in or out of the pool area. There were no false triggers. Every time the sensors triggered, there was something in the picture that should have triggered the collection of an image.

2. The data collected with the RMS in Sweden demonstrated that this type of system with a sensor network can be used to significantly reduce the number of pictures to be reviewed by an inspector, both during periods of low activity and during times of high activity, when work such as spent fuel movements is occurring. For example, during spent fuel loading operations the sensors did not show any activity during the evening and weekend hours. A review of the VSU tape for the same period verified that there was no activity. The data also demonstrated that sensors can be selected and placed so that the normal day-to-day activity in a facility will not cause images to be recorded. A review of the VSU tape showed that personnel could enter and move about the pool area without causing any triggers. None of the activities detected on the VSU tape would have caused triggering and were not of safeguards significance.

3. The images collected by the RMS showed all the significant data required to determine the shipment activities. More images could have been collected by decreasing the system lock out time or fewer images could have been collected by increasing the lock out time.

4. The images were reliably retrieved by both SNL in Albuquerque, and SKI in Sweden. The resolution of the compressed and transmitted images were excellent.

Conclusions

The RMS at Barseback has performed extremely well and is providing valuable information for future safeguards applications. The Remote Monitoring System has demonstrated that a sensor network can provide sensor data to supplement image information and to selectively trigger the collection of images. The technology to do remote monitoring exists today and since it is based on standard computer components, it will improve as computer technology improves. The tests at Barseback are proving just how effectively a Remote Monitoring System can operate in a nuclear power reactor.

References

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