Verification Experiment on the Downblending of High Enriched Uranium (HEU) at the Portsmouth Gaseous Diffusion Plant

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"Digital Video Surveillance of the HEU Feed Stations"

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As part of a Safeguards Agreement between the US and the International Atomic Energy Agency (IAEA), the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio, was added to the list of facilities eligible for the application of IAEA safeguards. Currently, the facility is in the process of downblending excess inventory of HEU to low enriched uranium (LEU) from US defense related programs for commercial use. An agreement was reached between the US and the IAEA that would allow the IAEA to conduct an independent verification experiment at the Portsmouth facility, resulting in the confirmation that the HEU was in fact downblended. The experiment provided an opportunity for the DOE laboratories to recommend solutions/measures for new IAEA safeguards applications. One of the measures recommended by Sandia National Laboratories (SNL), and selected by the IAEA, was a digital video surveillance system for monitoring activity at the HEU feed stations.

This paper will describe the SNL implementation of the digital video system and its integration with the Load Cell Based Weighing System (LCBWS) from Oak Ridge National Laboratory (ORNL). The implementation was based on commercially available technology that also satisfied IAEA criteria for tamper protection and data authentication. The core of the Portsmouth digital video surveillance system was based on two Digital Camera Modules (DCM-14) from Neumann Consultants, Germany.

Introduction

The purpose of the video surveillance was to provide the IAEA with visual confirmation of the facility operator's declared activities at the nine HEU feed stations, i.e.; visual data indicating the number of HEU cylinders that have been emptied. The Portsmouth experiment provided an excellent opportunity for the DOE laboratories to apply and the IAEA to evaluate new/recent technologies that are currently available for safeguards. Even though this installation/activity was classified as an experiment, the goal was to meet current IAEA requirements for data surety, thus, data authentication and tamper indicating enclosures were included in the system design.

DISCLAIMER

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One of the goals of the experiment was to implement a video surveillance solution as soon as possible, hence, neither time or funding existed for any new development efforts. SNL presented the IAEA with three video surveillance system options that were recently developed for safeguards, although not currently in routine use by the IAEA:

1) The Neumann Consultants DCM-14
2) The Aquila Technologies GEMINI digital video system
3) The SNL developed Integrated Camera and Authentication Module (ICAM)

Ultimately, the IAEA selected the Neumann DCM-14.

This paper will describe the video surveillance system that was implemented at the Portsmouth facility. The paper includes a detailed description of the individual system components - two Neumann DCM-14 camera modules, video data collection computer, data review computer, integration with the LCBWS, and tamper indicating and data authentication measures that were implemented. The paper will also present the results/conclusions of the seven month long experiment. An overall description of the entire experiment and the safeguard measures that were applied is presented in a separate paper.[1]

Overall System Description

The Portsmouth video system is comprised of four major components: 1) Two DCM-14 camera modules, 2) Data collection computer, 3) Data review computer, and 4) Integration with the LCBWS, which was based on the commercially available Echelon LONWorks (Local Operating Network) technology. The DCM-14 modules, the LON network, and the data collection computer, were connected to an uninterruptible power supply (UPS).

The DCM-14 camera modules captures and stores video images of activity at the HEU feed stations and transfers the images to the data collection computer on command. The images are stored on the hard drive of the computer. During the short notice random inspections (SNRI), the IAEA inspectors copied the video data onto a removable media (JAZ Disk). The disk was hand-carried by the inspectors to the IAEA Portsmouth office and copied the data onto the removable hard drive of the data review computer. The video data was reviewed/analyzed onsite using the data review computer.

Due to Portsmouth computer security regulations, it was not permitted to connect the data collection computer to a modem and/or an internal local area network (LAN), which would have allowed for remote transmission of the video images to the review computer, hence, the use of removable media.

Video images were captured and stored by DCM-14 modules whenever any of the following conditions were met: 1) scene change detection, 2) external trigger from the LCBWS over the LON network, and 3) preset interval (1 hour) recording.

Neumann Digital Collection Module (DCM-14)

Two commercially available DCM-14 camera modules were utilized during the experiment. Dr. Neumann Consultants, of Germany, developed the DCM-14 module. The unit has the following capabilities/features, which satisfy IAEA safeguards requirements for data surety, redundancy, and internal battery backup during mains power loss.

1) Authentication of every image using a complex authentication algorithm based on the triple Data Encryption Standard (DES) algorithm.
2) Local storage of video images on an internal 40 MB PC flash card – images are stored on the PC card until they transmitted to data collection computer over RS485 bus.
3) Built-in battery backup (three hours if scene change detection is turned on and up to ten days using a ten minute interval only).
4) Multiple trigger sources - scene change detection, LON trigger, external trigger (not used in this application), and interval.
5) Encryption of images for transmission to data collection computer (not used in this application).

The DCM-14 modules were configured with a low power video camera (Sony) and a LON video node mounted inside an IAEA approved tamper indicating camera enclosure (see figure 1). The modules were programmed to operate with scene change detection turned on using a five minute lockout, i.e.; image captured every five minutes during continuous motion. Image captured when triggered by the LCBWS via the LON video node. Image captured every hour using the interval-recording feature (state of health image). Each of the image capture mechanisms operated independent of each other.

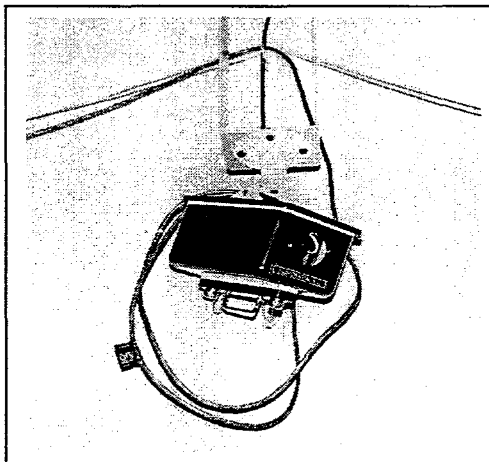

Figure 1 - DCM-14 camera module

The camera lenses that were selected and the final mounting position of the cameras provided a field of view of all nine HEU refeed stations by each of the cameras. The full coverage of the area of interest by each of the cameras satisfied an IAEA requirement for redundancy.

Video Data Collection Computer (DCC)

The DCC was located in a room next to the feed cylinders inside of a tamper indicating 19" rack (see figure 2). The DCC was an industrial rack computer with an internal hard drive, JAZ disk drive, and a CD ROM, for loading programs, and operated under the NT 4.0 operating system. The rack also contained the LCBWS computer, which operated under WIN 95 operating system. The two computers shared the monitor and keyboard, which were controlled via a switch box. Both computers were connected to the UPS. The DCC was labeled as classified by Portsmouth computer security; thus, any type of connection to the outside was prohibited.

The main purpose of the DCC was to retrieve and store the video images from the two cameras. The DCC was configured to automatically start retrieving video data from the DCM-14s after power up and/or reset, hence, human interface was not required to put the system into operation. This feature is extremely important in unattended systems. The images were retrieved by the "polling" software application that was developed by Neumann Consultants. The images files from the two cameras were automatically sorted (alarm and state of health) and stored into their own subdirectories. The "archive" software application developed by Aquila Technologies performed this function. The application also renamed the video files to correspond with the date/time when the image was captured.

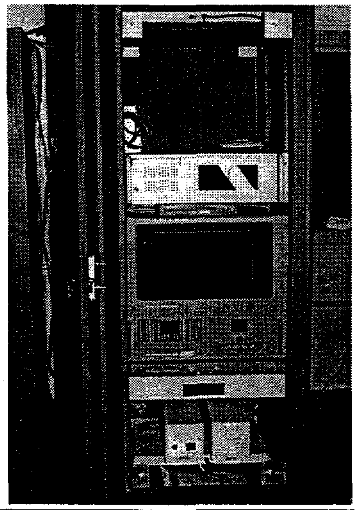

Figure 2 - Data Collection Computer Rack

The images were stored on the DCC's internal hard disk drive. During an SNRI, the inspector could verify the operation of the system with the "viewer" software, developed by Neumann Consultants. The "viewer" software allows the inspector to view/playback the video images that were collected by the DCC. Satisfied with the operation of the system, the inspector would copy the video images onto a removable JAZ disk. The inspector would hand-carry the JAZ disk to the review computer to allow for a detailed review of the data. These were the only tasks required by an inspector in order to retrieve the video data.

Data Review Computer (DRC)

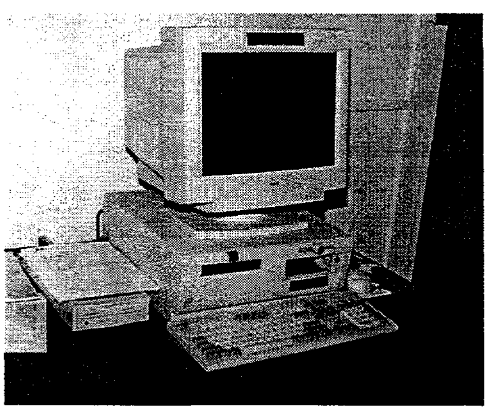

Figure 3 - Data Review Computer

The DRC was located in an office that was set aside for the IAEA inspectors (see figure 3). The DRC was a normal desktop computer that contained a removable hard drive, a JAZ disk drive, and an external CD ROM , for loading programs, and operated under the NT 4.0 operating system. The DRC was also labeled as classified, thus, the requirement for a removable hard drive that was locked up in a safe when not in use by the inspectors.

During the SNRI, the inspector would copy the video from the JAZ disk onto the removable hard drive. The data would then be reviewed/analyzed with the Generic Advanced Review Software (GARS), developed by Aquila Technologies. The GARS validates the authentication signature on all the video images and also has the capability for back end motion detection, i.e.; can filter out images that contain motion in area of interest defined by the user. The GARS can also differentiate between the captured images – scene change, LCBWS trigger, or interval.

Integration with Load Cell Based Weight System – Echelon LONWorks

The LCBWS was developed by ORNL and was integrated with the video system in order to provide another trigger mechanism for the cameras (see figure 4). The integration was accomplished with LONWorks, a commercial technology developed by Echelon Corporation, hence, all nine scales and the two DCM-14 camera modules contained a LON node. In the past, LON technology has been is used for all the remote monitoring systems that have been developed and deployed by SNL as the backbone for integrating sensors, radiation detectors, devices, and cameras onto a single network.[2]

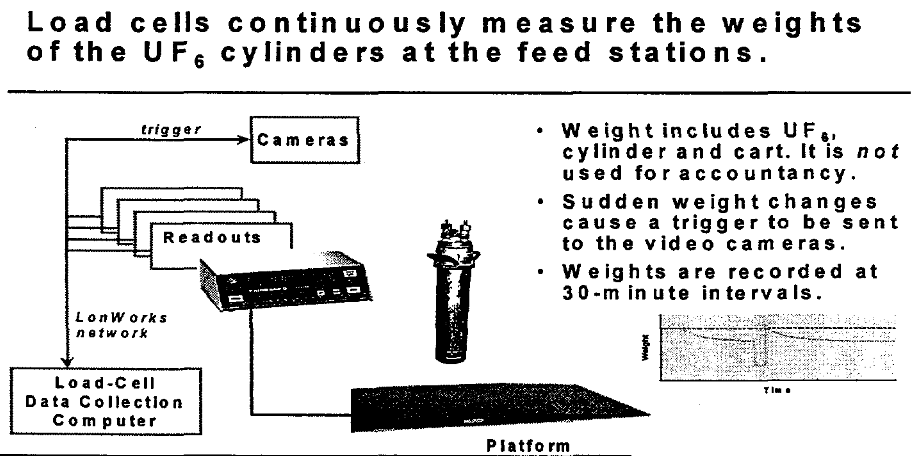

Figure 4 – Integration of Video System with LCBWS

The LCBWS is comprised of nine weight scales that report the weight of the HEU cylinders to a data collection computer. Under normal operating conditions, the weight of the HEU cylinders gradually decreases as the material is emptied out from the cylinders. Any sudden weight fluctuation, up or down, of greater than 2kg will cause the scale to send a trigger message to the cameras. All nine scales are logically bound to both cameras, i.e.; an abnormal weight fluctuation on any scale will send image capture command to both cameras simultaneously. A complete description of the LCBWS is presented in a separate paper.[3]

Tamper Indicating and Data Authentication Features

All video data and commands that were transmitted over exposed cables were authenticated. The DCM-14 uses a complex implementation of the DES private key algorithm to attach an authentication signature to every video image before transmitting the data to the DCC computer, via a RS485 bus. Communication between the HEU weight scales and the video nodes was accomplished with the built-in authentication algorithm that is part of the LON protocol. The authenticated video images were validated at the DRC computer.

The IAEA currently uses the Modular Integrated Video System (MIVS) for a majority of their surveillance applications. The same camera housing that is used in MIVS was implemented for the DCM-14 modules, thus providing the same level of tamper indicating security that is currently acceptable to the IAEA. Both the video and weight scales data collection computers were housed in a standard 6 foot, 19" rack which was modified by SNL to meet IAEA requirements for tamper indication. Both the 19" equipment rack and camera enclosures allowed for attaching IAEA Type-E metal seals.

Summary/Results

The complete video system functioned successfully for the entire duration of the experiment, eight months. There was no loss of video data, thus satisfying an IAEA requirement for continuity of knowledge. The IAEA was completely satisfied with the ease of use of the entire system. The system also satisfied IAEA requirements for data surety (authentication) and tamper protection.

Detailed review of the video images by the IAEA revealed two minor anomalies with the system. It was discovered that camera 1 was not capturing images whenever it received a trigger from the LCBWS system. But since the LCBWS system sends the trigger to both cameras simultaneously, camera 2 captured an image for every LCBWS trigger. A complete analysis of the system to pin-point the problem was not accomplished. A second anomaly occurred at the data collection computer. After copying the video files to the removable JAZ disk, the computer was supposed to automatically delete the files from the internal hard disk this did not occur. Thus, duplicate copies of the video files were transferred to the review computer during the inspections. This caused the hard disk on the review computer to fill up. This was remedied by manually deleting duplicate files on both computers.

Acknowledgments

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[1] D.M. Gordon, Brookhaven National Laboratory, "IAEA Verification Experiment at the Portsmouth Gaseous Diffusion Plant,", INMM 39th Annual Meeting, July 1998.
[2] R.L. Martinez, Sandia National Laboratories, "Implementation of LON Based Applications for Safeguards", INMM, July 1996
[3] R. Lenarduzzi, Oak Ridge National Laboratory, "Load Cell Based Weight System for the Portsmouth Gaseous Diffusion Plant", INMM 39th Annual Meeting, July 1998.

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