RH-TRU WASTE PACKAGING VISUAL CONFIRMATION USING A DUAL-CAMERA VIDEO SECURITY AND DOCUMENTATION SYSTEM

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ABSTRACT

During decontamination and decommissioning of a hot cell research laboratory located near West Jefferson, Ohio, Battelle Memorial Institute (BMI) is generating remote-handled transuranic waste (RH-TRU) to be certified for permanent disposal at the Waste Isolation Pilot Plant (WIPP). The U.S. Department of Energy (DOE) and New Mexico Environment Department (NMED) require sites generating TRU waste to document the verification of the physical contents of each waste container prior to shipment to the WIPP facility. BMI has developed and implemented innovative video/audio technology to document compliance with these requirements. The two-camera system records item-by-item packaging activities and maintains continual area monitoring to document container integrity at all times. The video and audio record produced through the use of this system supplements the paper record generated for waste items during packaging of each container. In addition to real-time video recording of packaging operations, advanced video editing, time-lapse recording, and motion-sensing/alarm capabilities enhance the use of the video record.

By implementing this system, Battelle Columbus Laboratories has addressed and successfully integrated the following goals of the TRU Waste Certification Program:

- Create a video record of each item placed into every container
- Document the absence of items prohibited from disposal at WIPP
- Document proper waste packaging
- Create a record that is easy to review and creates regulator confidence
- Assure container integrity by recording peripheral and off-hour activities
- Limit future costs and personnel exposure by reducing the likelihood that additional container inspection or radiography will be required.

BACKGROUND

On April 16, 1943, Battelle Memorial Institute (BMI) entered into a contract with the Manhattan Engineering District to support atomic energy research and development programs. BMI was selected as one of the original participants in this program because of its metallurgical expertise.

Nuclear reactor development activities, especially materials development, were performed for the U.S. Department of Energy (DOE) and its predecessors and constituted the major portion of BMI's participation in the atomic energy program. During World War II, BMI played an important role in development of reactors used for plutonium production. Studies involving the extrusion and degassing of uranium were among the company's most significant contributions.

The first large-scale application of nuclear power was nuclear submarine propulsion reactors. Ongoing research was performed by BMI for the U.S. Navy during the development of these reactor systems. When the program began, no material with a low-absorption cross section was available that provided adequate corrosion resistance to hot water. BMI invented and developed Zircaloy, a zirconium corrosion-resistant alloy used in fuel elements and assemblies. Other major accomplishments included the design and fabrication of the original reference fuel for the Nautilus program and the development of the Hot Isostatic Pressure and Picture Frame bonding technologies used to fabricate nuclear submarine cores.

The Battelle Columbus Laboratories Decommissioning Project (BCLDP) was initiated by BMI and the DOE Columbus Environmental Management Project (CEMP) to decontaminate and decommission 15 buildings and associated grounds at BMI's Columbus King Avenue and West Jefferson North facilities. These buildings became radioactively contaminated as a result of the atomic energy research performed by BMI for the DOE, the Navy, and other U.S. government clients.

The West Jefferson North facility, located near West Jefferson, Ohio, was constructed in 1954 and 1955. The oldest and most contaminated building at the West Jefferson North facility is the Hot Cell Laboratory, where metallurgical operations supported nuclear research projects such as the examination of power and research reactor fuels and post-irradiation examination of fissile, control rod, source, and structural reactor materials and instrumentation. When operations officially ceased in 1987, the laboratory housed four large hot cells and ten smaller alpha-gamma cells. The BCLDP will utilize these cells to remotely process and package materials contaminated by the research activities performed in the Hot Cell Laboratory. These radioactive waste materials will include defense-related transuranic (TRU) wastes packaged for ultimate disposal at the WIPP.

In accordance with the DOE-Ohio Strategic Plan, the decontamination of the West Jefferson buildings and associated grounds is to be completed by the end of 2005. To meet the scheduled completion date, source term (i.e., containerized TRU waste) must be removed and isolated in on-site shielded storage or shipped to an off-site location by the end of 2002. This process will require the BCLDP to generate containers of RH-TRU wastes prior to the formal implementation of WIPP acceptance criteria for such waste. Therefore, the BCLDP has had to begin packaging these materials in accordance with the current disposal requirements for contact-handled (CH-) TRU waste and the draft guidelines for RH-TRU waste (1).

WIPP REQUIREMENTS FOR VISUAL EXAMINATION

The NMED requires generators of TRU waste to confirm the physical composition of every waste container in accordance with the Waste Analysis Plan (WAP) requirements of the WIPP Hazardous Waste Facility Permit (2,3). This confirmation is achieved using visual examination or radiography verified by visual examination (4). The WAP allows visual examination to be used under three different scenarios:

1. To confirm acceptable knowledge (AK) during the packaging of newly generated waste
2. To substitute for radiography to verify AK for retrievably stored waste
3. To check quality control for radiography.

Visual examination consists of a semi-quantitative and qualitative evaluation of the waste container contents. Unlike other confirmation techniques, no equivalent sampling and analysis guidance is currently available from the U.S. Environmental Protection Agency (EPA). For this reason, each site generating TRU waste is responsible for developing a methodology that addresses the requirements described in the WAP to create an auditable visual examination record.

BCLDP VISUAL EXAMINATION APPROACH

The BCLDP has chosen to visually examine every waste container as it is generated in lieu of radiography. The WAP requires generators choosing this option to document the examination on video/audio tape and waste inventory sheets. The primary objective of the BCLDP is to generate sufficient documentation to demonstrate that the characterization results would not change even if additional information was generated using radiography or additional visual inspection.

The BCLDP utilizes an innovative video/audio documentation system during waste packaging to meet the WIPP requirements for visually verifying and documenting the physical contents of each TRU waste container. The system creates a video/audio record that can be easily reviewed if any questions arise about a container or a specific waste item in a container. The videotape will allow for future visual re-inspection of packaged items and minimize personnel exposure associated with re-handling of waste materials. The BCLDP video/audio system documents the following certification activities:

- Verification that the correct Waste Matrix Code has been applied to the waste being packaged
- Verification that the proper waste stream has been applied to the container
- Verification of the EPA hazardous waste codes applied to the waste being packaged
- Verification that the container does not hold any prohibited items, such as
    - Free liquids in amounts greater than the permit allows
    - Compressed gas containers
    - Unvented containers over 4 liters in size
    - Nonradionuclide pyrophoric materials
    - Ignitable, reactive, or corrosive wastes
- Confirmation of the number of confinement layers
- Confirmation of the installation of filter vents, both on the drum and any confinement layers requiring a vent
- Demonstration that the container is empty at the beginning of the process, thereby negating aspiration requirements
- Application of a custody seal and the recording of the seal number

The video system records TRU waste packaging from the time the container is empty until the container has been loaded and sealed with a custody seal. In some instances, the container liner may be sealed with a custody seal so that it can be stored until it is placed into the drum for shipment. This sealing of the liner is required if the storage is to take place out of camera range. Once the TRU waste is in the drum and the drum is sealed, no video recording is required until the loading process when drums are put into shipping containers to be shipped off-site. The loading process will be recorded with a digital handheld recorder.

SYSTEM DEVELOPMENT

During research and design of the video/audio system, several issues affecting quality were considered. The first quality issue concerned interruptions of power to the video system. Although emergency generators would start up within 8 to 10 seconds after power failure, it was determined that even this brief power interruption could adversely affect videotaping operations. This issue was addressed by including an uninterruptible power supply (UPS) in the system design. The UPS is a battery backup capable of powering the system for up to 30 minutes at full load. The UPS provides uninterrupted power from the time of power loss until the emergency generators start.

The second quality issue involved documenting that no materials are added to a package during off-hours. A container may collect waste over an extended period of time. A record must be created to document the integrity of the package until it is sealed. Any undocumented item collected in the container is adverse to quality. This issue was resolved by incorporating motion/light-sensing technology and constant time-lapse video recording into the system. Time-lapse recording at 10 frames per second allows for continuous coverage for up to 120 hours. Additionally, the camera senses light fluctuations caused by movement within the field of view. At the end of each day, each container is covered to assure that nothing inadvertently falls into a container. Manipulators used to handle the waste are shut down and padlocked, the lights are turned off in the area, and the motion/light detector alarm is set.

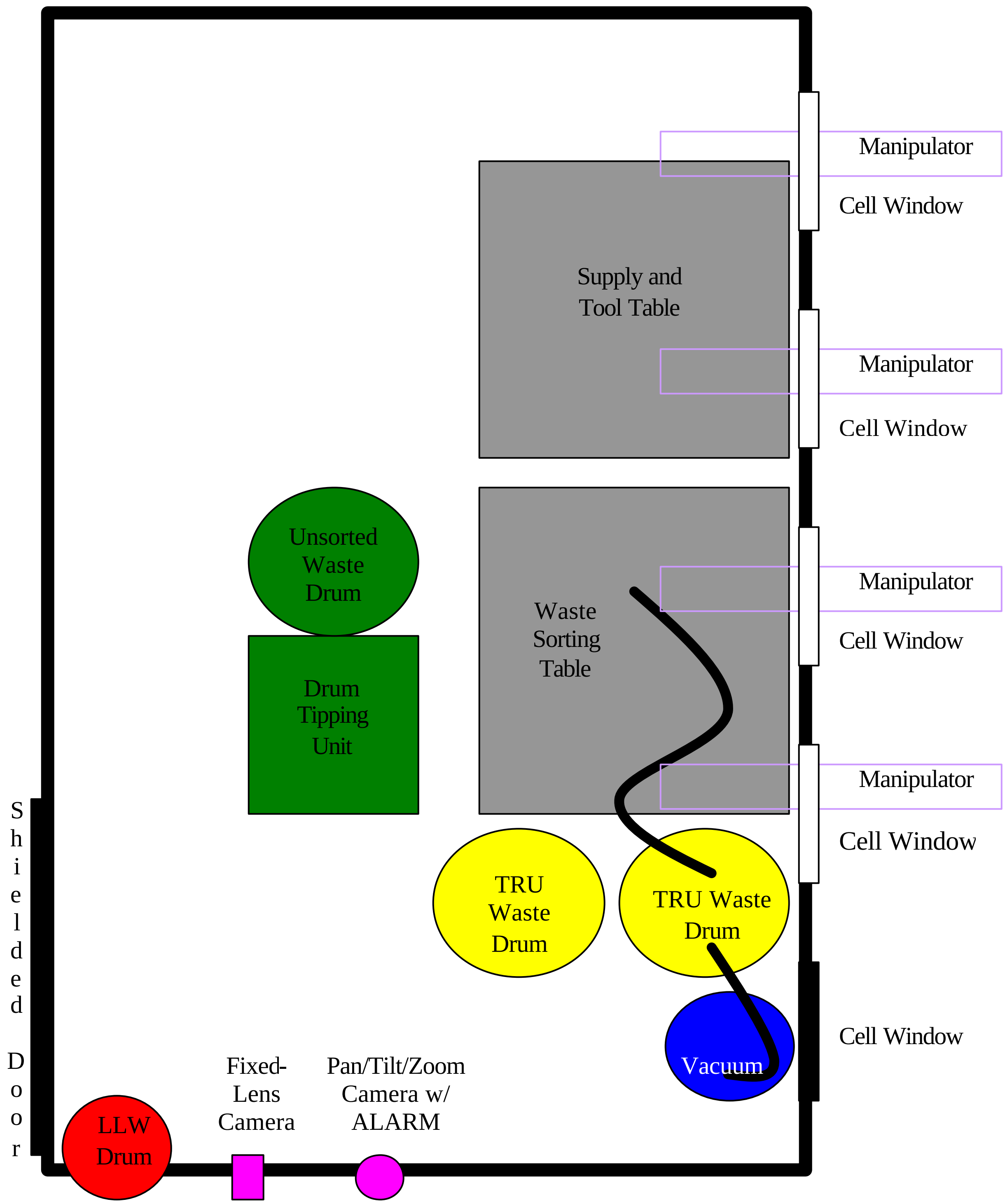
Any activity involving entry into the hot cell, movement of the manipulators, or any other motion in view of the video system will trigger the system alarm and cause the alarm light indicator to illuminate on both the camera control unit and the time-lapse recorder. During an alarm, the time-lapse recorder shifts to real-time recording (30 frames per second), and the controller superimposes the word "ALARM" onto the upper right corner of the videotape image. To review the incident, the system automatically rewinds to the precise point that the system alarmed so the event caught on tape can be scrolled through frame by frame. A nonconformance report (NCR) is written for each incident; and the Waste Certification Official, TRU Waste Site Project Manager, and TRU Waste Site Project Quality Assurance Officer review each alarm occurrence. If it is determined that its integrity may have been compromised, the container is repackaged.

The third quality issue concerned maintaining a video record of all packages in the area at all times during operation. This issue caused concern because the camera chosen to record individual waste items would require zoom capabilities to obtain a close-up video of each item as it is packaged. As the camera zooms in on individual items, the video record for peripheral activities and other containers being packaged cannot be compromised. This problem was resolved by utilizing a second area camera. The second camera has a fixed lens that maintains a wide-angle view of the entire packaging area. Therefore, when the first camera zooms in on an item to provide detail, the second camera provides security coverage to record all activities in the cell.

SYSTEM SETUP AND TESTING

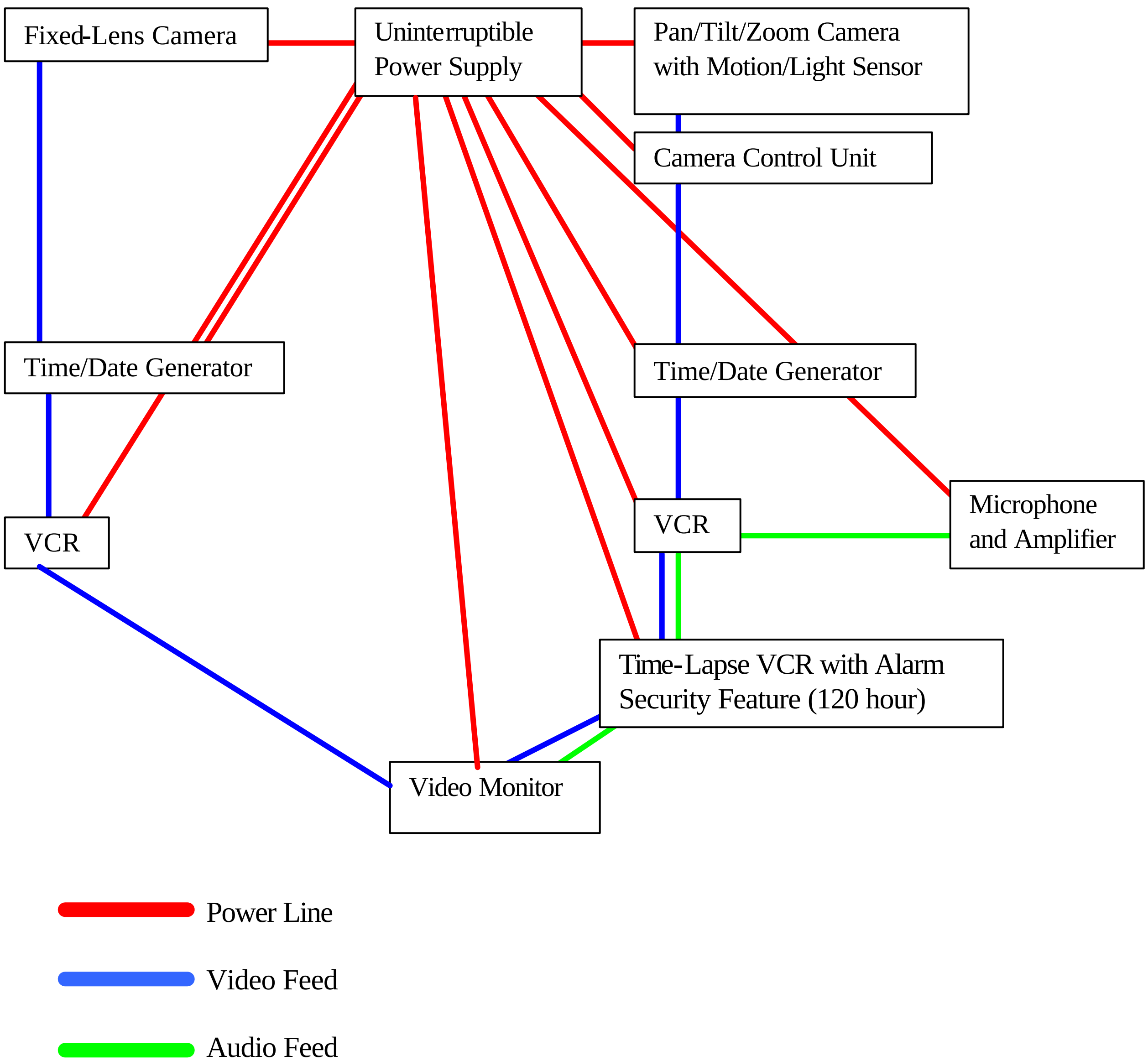
Two remotely accessed hot cells in the Hot Cell Laboratory were initially selected for waste packaging operations. The first video/audio system was installed in the Mechanical Test Cell (MTC), used originally for testing the mechanical properties of materials including spent fuel, irradiated cladding, and other structural materials. A second system was incorporated into the High Energy Cell (HEC), which was designed to accommodate the receipt, storage, transfer, and examination of entire reactor fuel assemblies. Mock-up cells were constructed to determine the best camera placement for these cells, and the system was set up in each cell accordingly.

The MTC is a small hot cell, about 18 feet long and 7.5 feet wide, with four manipulators on the front wall. Access to the cell is gained through a door on the back wall. A 1,000-pound-capacity crane runs on a rail down the middle of the length of the cell. The cell has been set up with two packaging tables against the middle of the front wall, accessible to the manipulators. One table is used for waste packaging; the other was set up to support packaging and manipulator repair. Two receiving drums are placed to the left of the packaging table. Behind the tables is a remote drum tipper used to raise and tip drums so that the waste inside can be pulled onto the table for sorting. A HEPA vacuum system can be used to transfer small material from the table directly into the drum. Figure 1 provides an illustration of the equipment placed in the MTC for waste packaging and video documentation.



(Fig. 1) Diagram of Mechanical Test Cell

Two video cameras are mounted on the left wall of the MTC, about 12 feet above the floor. With the exception of the wall it is mounted on, the fixed-lens camera has a view of the entire room below 12 feet. The second camera with pan/tilt/zoom capability also can view the entire room and record activities through the door into the adjoining cell. Each camera feeds its signal through a time/date generator to superimpose the time and date onto the video. Each signal is then fed into separate videocassette recorders (VCRs) for continuous recording up to 9 hours. The camera with pan/tilt/zoom capability also has motion/light-sensing technology that works in conjunction with the time-lapse recorder. During off-hour monitoring, the signal feeds out of the first VCR and into the time-lapse recorder. The camera controller is placed between the camera and time/date generator and feeds commands to the camera through the video cable. The controller also is hardwired to the time-lapse recorder so that a system alarm increases the recording rate to 30 frames per second. A diagram of the video/audio system layout is provided in Figure 2.



(Fig. 2) Diagram of Video System Layout

The second video system installed in the HEC is nearly identical to the system described above. However, the camera placement was modified to compensate for the larger size of the HEC and the placement of additional equipment in the cell. The increased dimensions of the HEC will allow up to seven waste containers to be packaged at the same time. Figure 3 shows the system workstation including the monitor, UPS (next to the monitor), time/date generators (on top of the VCRs), time-lapse recorder (on the bottom shelf), camera controller (below the monitor), and the microphone and amplifier (between the controller and VCR).

(Fig. 3) HEC Video Recording Station

The BCLDP will be adding new packaging areas as other hot cells are repaired and refurbished. When new packaging areas are added, video system requirements will increase. Each packaging area will be equipped with at least two cameras per work area. However, material movement between the cells will be required so that cell-specific equipment, such as a compactor, can be used. To maintain complete video coverage, cameras will be placed at several locations to record package movements within the building. For example, compactible waste from a packaging area without a compactor will be transferred to a cell with a compactor. To record this activity, cameras in the first cell will document material being loaded into small containers. Cameras in the area adjoining the two hot cells will track the movement from one cell to another. Finally, cameras in the second cell will document the small containers being loaded and compacted into a steel liner, the liner going into a drum, and the drum being sealed.

VIDEO DOCUMENTATION

The BCLDP procedure that governs the use of the video system is written to ensure continual video coverage of packaging operations. It also provides for cross-references between the video/audio records and the paperwork records. This documentation system makes it easy to retrieve the video records for a specific item listed on the package inventory or to retrieve the package inventory for any item or package on the video. This approach results in a record that will be easily accessible by future reviewers and auditors inspecting container packaging.

The video system provides stand-alone documentation in addition to the WIPP-required supplemental information for the paperwork documentation. The system utilizes time/date generators and sound equipment to aid in documentation. The time/date generators verify the time and date for the packaging records and allow for synchronized playback from the two cameras during review. The sound equipment records information from the Waste Certification Official pertaining to the waste stream, waste matrix, and the specific items observed being packaged. The videotape number and VCR counter number are recorded onto the waste inventory sheet, providing for the timely retrieval of a specific videotape and the location on the tape to view a given waste item. To ensure videotape integrity, all videos are duplicated and stored in two separate locations, according to standard industry storage practices, in order to meet project records requirements.

VIDEO RECORD EDITING

Considerable time may pass during packaging of infrequently generated items into a waste container. The review of a complete video record for a single container could involve the inspection of numerous tapes generated over weeks of packaging; hundreds of hours of tape may have to be reviewed for a single waste container.

The BCLDP purchased editing equipment to allow digital compilation of the recorded placement of each waste item into a given waste container. This edited version of waste packaging shortens the viewing time for a given container to under an hour. Editing is done digitally on a computer hard drive so that the original recording is not compromised. During editing, the drum numbers, waste stream identification numbers, and inventory line item numbers are added to the video to aid in the review process. Due to the time it takes to prepare these video summaries, the BCLDP will not edit the tapes as standard practice, but only upon request.

The BCLDP also has the ability to capture digital still frame pictures in JPEG format from the video editing system (Fig. 4). The BCLDP will soon add equipment to transfer video into MPEG format, so that video clips can be E-mailed to anyone with questions about the packaging. The MPEG videos also can be placed on CD-ROM for viewing. All of these capabilities enhance the abilities of the BCLDP to provide visual examination documentation in part, or in its entirety, to anyone involved in packaging approval, transportation, or disposal activities.

CONCLUSION

By implementing the video/audio system described in this paper, BMI is confident the BCLDP will generate adequate documentation to support the certification of RH-TRU waste and ensure compliance with the WIPP requirements being developed. This approach will enable future review of packaging operations and inspection of packaged items without direct contact with the waste, reducing potential exposure to personnel.

(Fig. 4) Still Photos from Videotapes
(A,B,C,D, and E are in the MTC. F, G, and H are in the HEC)

REFERENCES

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