DECONTAMINATION AND DECOMMISSIONING OF A PLUTONIUM FABRICATION FACILITY

Robert A. Hunt
Donald Paine, PhD
Michael L. West
EcoTek, Inc.
NFS Plutonium Facilities Decommissioning Project
Erwin, Tennessee

ABSTRACT

EcoTek, Inc. was contracted in July 1987 to manage an active project involving the decontamination and decommissioning (D&D) of a plutonium fabrication facility at Nuclear Fuel Services, Inc. (NFS) in Erwin, Tennessee. Approximately 10,500 square feet of currently unused plutonium fabrication facilities are located in two separate buildings on the NFS-Erwin site. Waste processing strategy centers around decontamination and sectioning with an ultra-high pressure water jetting system incorporating a recirculated medium; volume reduction in a high capacity shear/baler; and material control accountability utilizing a five station active-passive neutron non-destructive assay (NDA) system. A stainless steel containment has been constructed to house the sectioning and decontamination station. This containment attaches directly to the shear/baler, which has been modified to encapsulate all surfaces subject to contamination. The NDA system consists of five stations: 1) pre-decontamination inventory station, 2) decontamination assay station, 3) nuclear safety and accountability monitoring system, 4) bale and drum counter, and 5) bulk mixed uranium-plutonium oxide assay system. The majority of waste consists of 136 gloveboxes containing process equipment. Additional sources are ventilation ductwork, piping, conduit, scabbled concrete and soil. This paper will present a brief synopsis of the overall decommissioning approach which received United States Nuclear Regulatory Commission (USNRC) approval on June 20, 1989.

DECOMMISSIONING OBJECTIVES

The primary objective of the D&D effort is to remove all transuranic (TRU) wasteby April 15, 1992. By contract, all TRU waste must be received by the Department of Energy - Idaho National Engineering Laboratories (DOE-INEL) no later than this date. Specific plan objectives are:

1) To restore the existing facilities and site to levels of contamination which will permit "unrestricted" use, including possible use for future NFS requirements;
2) To accomplish the work in a safe and environmentally acceptable manner in accordance with all applicable federal and state regulations;
3) To minimize the volume of waste shipments;
4) To keep the TRU waste volume below 5,500 ft^3;
5) To complete all shipments to DOE no later than April 15, 1992;
6) To meet the above objectives while performing the work in the most cost effective manner; and,
7) To maintain exposures As Low As Reasonably Achievable (ALARA).

INFORMATION

Site Description

The NFS site, approximately 58 acres, is located within the Erwin city limits. The City of Erwin has a population of approximately 5,600 people and is the seat of Unicoi County (population approximately 16,000). The area is within the mountainous region of east Tennessee. The site occupies arelatively level area 25-50 feet above the Nolichucky River. To the north, east, and south, the mountains rise to elevations of 3,500-5,000 feet within a few miles of the site.

Plutonium Facilities History

The plutonium facilities at NFS-Erwin were constructed in 1964-1965. Figure 1 shows the plutonium facilities in relation to the Erwin plant site. Between 1965 and 1972, NFS processed 812 kilograms of plutonium for four primary customers. The largest order covered the manufacture of about 2,000PuO_2-UO_2, mixed oxide (MOX) fuel rods for the Southwest Experimental Fast Oxide Reactor (SEFOR). This was a joint undertaking of General Electric, the AEC and several utility companies. The GE-SEFOR order (746 kgs Pu) and the DuPont-SROO order (16 kgs Pu) comprised 94% of the Erwin job orders which utilized plutonium.

In the years following completion of the final order (1973-1985), NFS was unsuccessful in finding a disposal site for TRU wastes that would be generated from decommissioning activities. NFS was finally successful in negotiations with the DOE-INEL office in 1985. These efforts culminated on April 15, 1986, with the signing of the

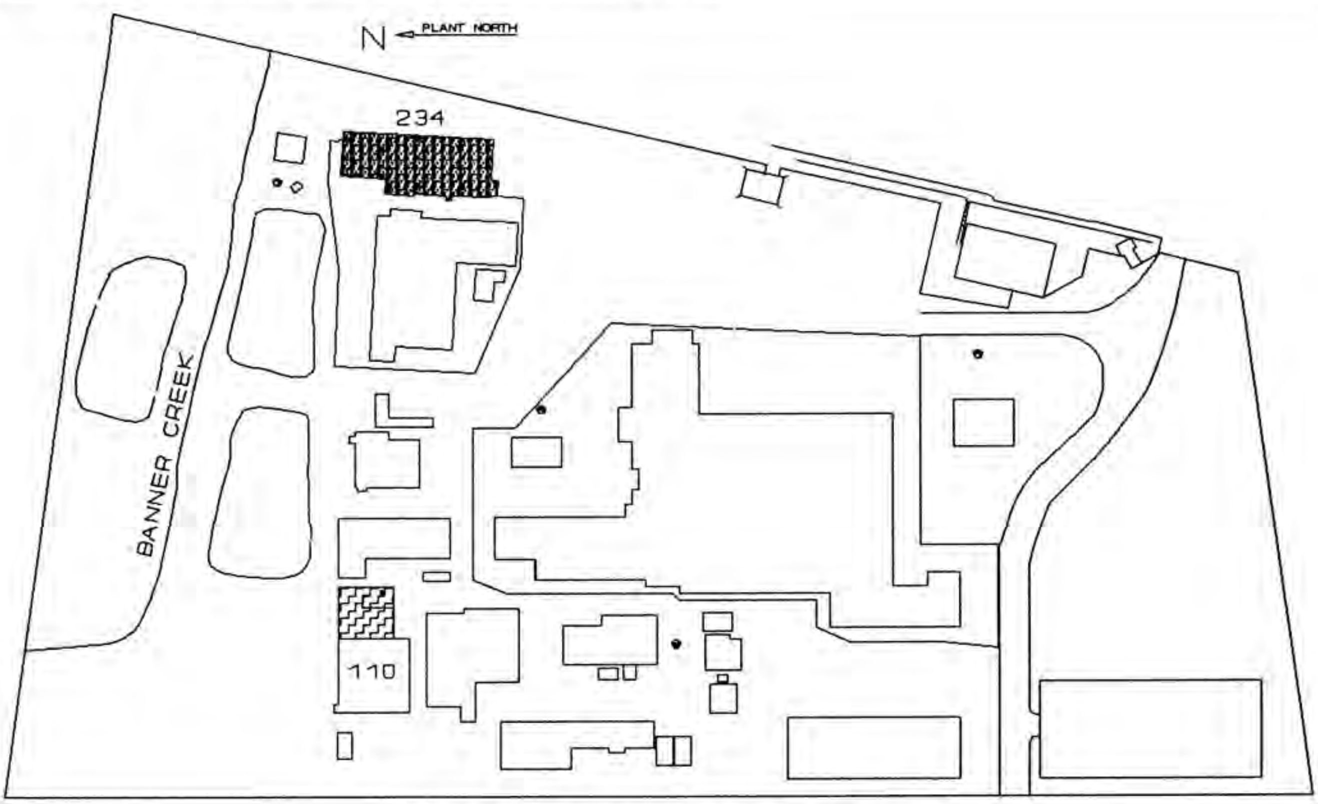

Fig. 1. Plutonium Facilities NFS-ERWIN Plant Site.

contract which allows NFS to ship its TRU wastes to DOE-INEL.

Process and Equipment Description

Capabilities of the NFS-Erwin plutonium facilities included: dissolution of plutonium metal and oxide; co-precipitation of uranium-plutonium; blending of MOX powders; pellet production and inspection; rod loading, welding and inspection; scrap dissolution; and full laboratory services.

Equipment in the facilities is located primarily in gloveboxes or in a single limited-entry cell adjacent to the conversion area. In addition to gloveboxes, the plutonium facilities contain equipment such as: metal tanks (some containing Raschig rings); glass columns; pumps; mixing vessels; blenders; drying, conversion and sintering furnaces; pellet press; cut-off machine and centerless grinder; outgassing equipment; inspection jigs; welders; leak test equipment; liquid and high efficiency particulate air (HEPA) filters; miscellaneous laboratory equipment; ventilation fans; wet scrubbers; and piping. Figs. 2 and 3 show detailed layouts of equipment in Building 234 and Building 110, respectively.

Radiological Status

Initial radiological surveys were made in each building to provide input to planning efforts. Continuous radiological surveillance is performed at each building to maintain exposures ALARA, to prevent spread of contamination, to determine extent of decontamination required and to segregate radioactive waste. A final radiological survey will be made at each facility at the conclusion of decontamination and decommissioning (D&D) operations in compliance with the USNRC "Guidelines for Decontamination of Nuclear Facilities and Equipment Prior to Release for Unrestricted Use or Termination of License for Byproduct, Source, or Special Nuclear Material", Division of Fuel Cycle and Material Safety, July, 1982.

Facility Disposition

As previously discussed, the primary objective of the NFS D&D project is to reach an "unrestricted" use status for all remaining equipment/facilities after completion of the Final Survey. The equipment that is not contaminated or has been successfully decontaminated will either be retained for use by NFS or processed as excess equipment. There is no intent during D&D to remove the building structures since any remaining structures should meet the unrestricted release criteria.

Decommissioning Project

The purpose of the project is to decommission the NFS facilities and dispose of all contaminated waste generated at off-site burial and/or storage locations. The waste material is weighed and assayed to determine the concentration of radioactivity. The three waste classifications are Class A (< 10 nCi/gm), Class C (10-100 nCi/gm) and Greater Than Class C (< 100 nCi/gm) of TRU. Following dismantling, decontamination, shearing, baling, packaging and classifying, the waste is sent to one of the approved disposal or storage sites. INEL's facility will be used for Greater Than Class C materials. Class A and Class C material will be disposed of at an approved commercial burial facility.As decommissioning progresses, bulk quantities of MOX will be encountered. As that occurs, these materials will be collected under rigid criticality, security and material control conditions. Processing of these materials, such as screening, cleaning and drying will be required. Bulk MOX material will be packaged, stored and shipped to the Department of Energy (DOE).

Modifications to Building 234, Area D have been performed in order to construct a decontamination and volume reduction area (Fig. 2). The existing plant ventilation systems and criticality monitoring systems have been supplemented to support this area.

DECONTAMINATION AND VOLUME REDUCTION FACILITY

The Decontamination and Volume Reduction Facility (DVRF) located in Area D of Building 234, is utilized to decontaminate and volume reduce gloveboxes and other components and equipment. The major pieces of equipment associated with the DVRF are a modular enclosure (decontamination cell), an ultra-high pressure water jetting system, a high capacity shear/baler, a five station active-passive neutron NDA system, digital scales, data acquisition system (DAS) electronics, and the bale packaging and storage areas. Fig. 4 shows the layout of the DVRF.

Decontamination Cell

The decontamination cell is a modular enclosure constructed of a carbon steel frame sheathed with stainless steel. The overall dimension of the containment is 30 feet in length and 10 feet wide. It is divided equally into two 10' x 15' rooms. The first room is a material receipt airlock. The airlock is 12 feet high. The second room is the main decontamination area which is 16 feet high. Bi-fold doors lead into the airlock and provide access between the airlock and decontamination room.

Both rooms are serviced by one (1) ton capacity bridge cranes. Lighting is provided from above through polypropylene panels in the ceiling of the containment. Access ports for ventilation, supplied breathing air lines, pneumatic tool air lines, and ultra-high pressure water jetting lines are provided through the modular panels with sealable bulkhead penetrations.

The foundation of the floor is a built up concrete pad, sloped to a sump in the middle and covered with stainless steel. A fiberglass grating cover provides traction on a level surface and prevents water used in the decontamination process from pooling around the operators' feet.

Air is supplied to the containment from conditioned room air in Area D. The air is pulled in at 500 CFM with an exhaust fan. The exhaust is discharged through a HEPA filtered stack. Routine stack samples are taken to monitor airborne contaminants discharged to the atmosphere. The air intakes to the containment are also HEPA filtered to prevent spread of contamination into Area D in the event of positive pressure in the cell.

All personnel operating in the cell wear supplied air encapsulated suits. Careful personnel surveying by radiation monitors and decontamination techniques during transition out of the containment prevent the spread of contaminants outside the cell.

Ultra-High Pressure Water Jetting System

The ultra-high pressure water jetting system provides the primary means of decontamination for gloveboxes, piping and equipment. The water jet produces up to 40,000 PSI of water pressure at a 2 gallon per minute flow rate. This system has been effective in decontamination of hard surfaces at nuclear facilities across the country. Additionally, the water jet can be fitted with options that provide sectioning and concrete scaling capabilities.

During operation, the residual water from the decontamination process is picked up from the floor sump through the metal grating by a slurp pump. The water is processed through a series of filters and ion exchanges and stored for re-use by the water jet.

High Capacity Shear/Baler

A shear/baler, with modifications specified to ensure containment of contaminants, provides 377 tons of shear capacity and 180 tons of compaction force. The shear/baler can accept gloveboxes, piping, conduit and other equipment into its loading hopper, perform shearing and compacting operations with an extremely efficient hydraulics package, and deliver a 16 inch square bale of variable thickness. The

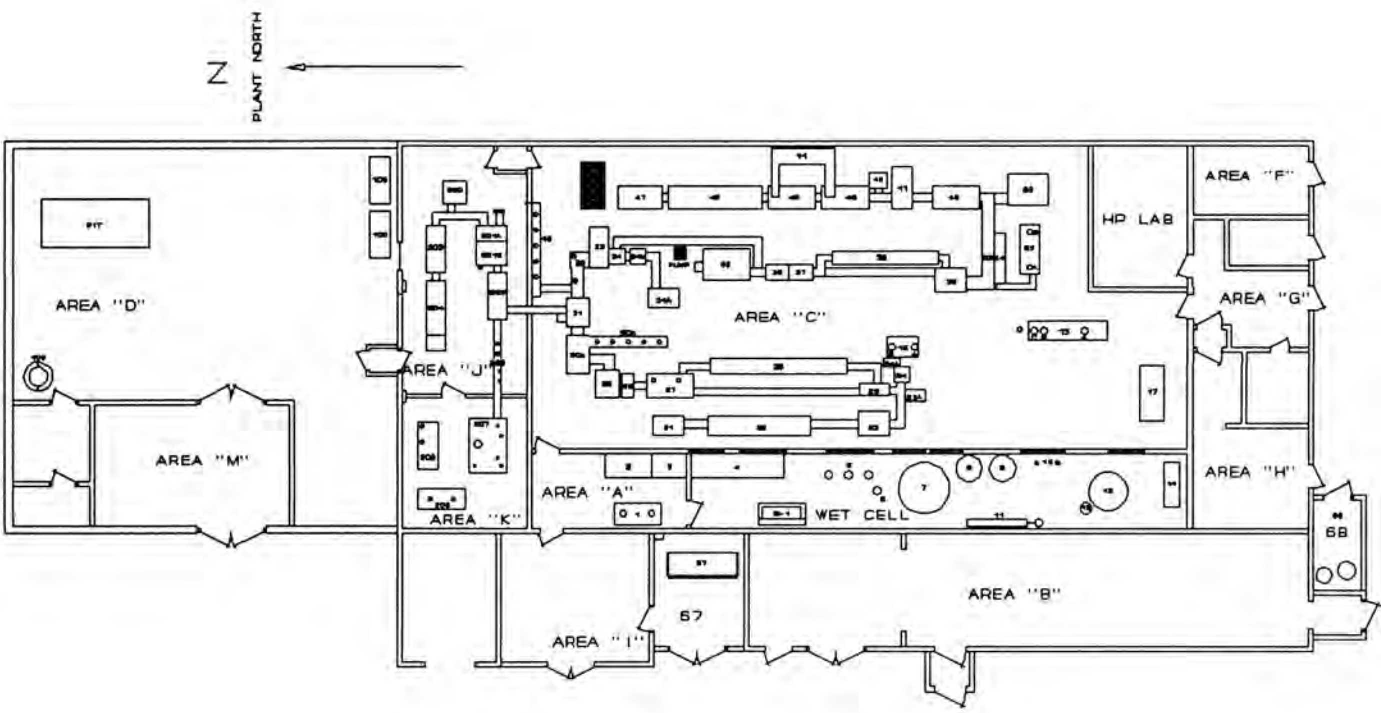

Fig. 2. Building 234 Detailed Equipment Layout.

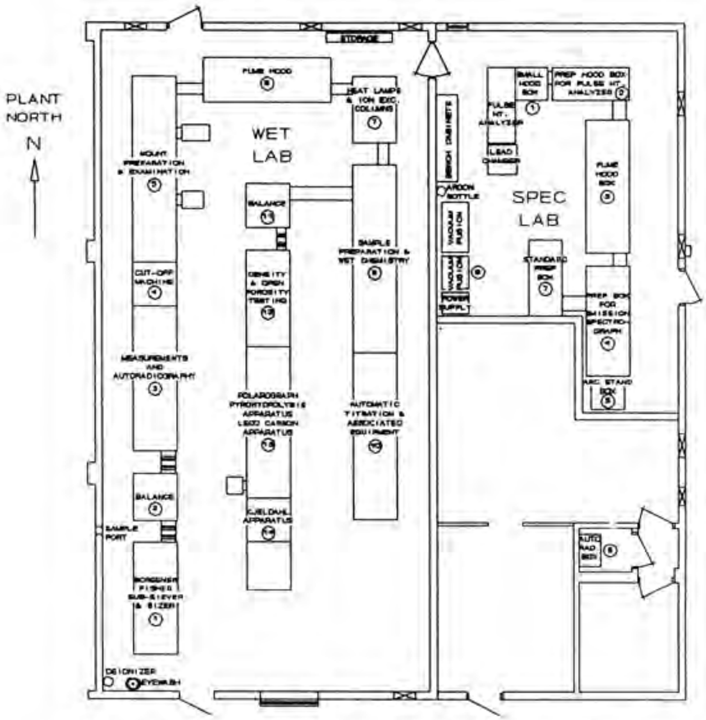

Fig. 3. Building 110 Detailed Equipment Layout.

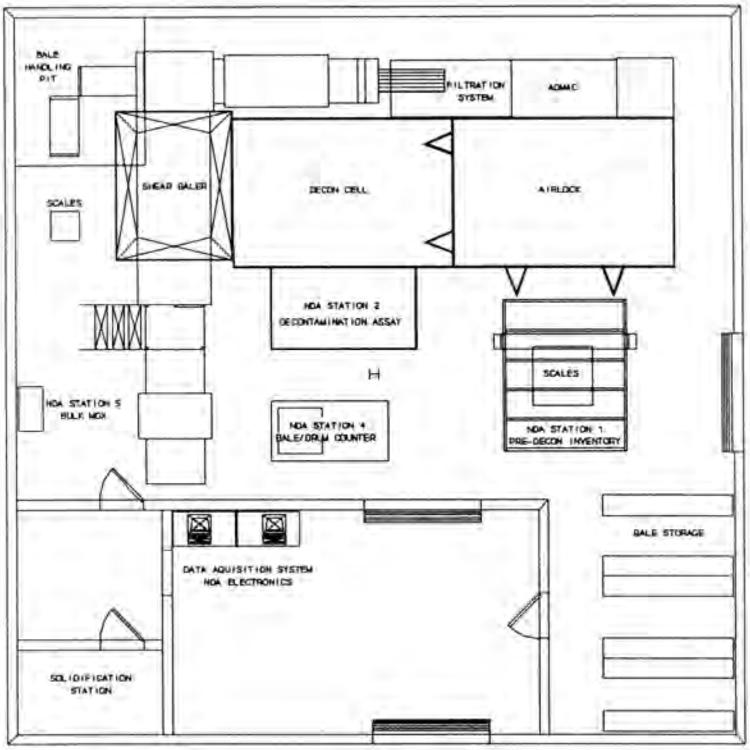

Fig. 4. Decontamination and Volume Reduction Facility.

thickness is determined by the amount of material sheared before the compaction stroke.

Major modifications have been specified to the basic shear/baler unit to ensure that contaminants are kept within the shear and compaction chambers. All internal wear plates have been seal welded to form a continuous chamber from the loading hopper to the outlet chute. A sheet metal enclosure surrounds the sliding plate and area behind the shear ram head. All hydraulic ram pistons have been fitted with bellows assemblies to prevent adhesion of airborne contaminants to the piston walls which would lead to contamination of the hydraulic system.

The top of the hopper has been fitted with a sheet metal enclosure over the top and three sides. The fourth side is flanged, fitted with a gasket and mated to the decontamination cell. The bridge crane installed in the decontamination cell extends over the top of the loading hopper to assist the operator in loading material into the shear/baler. Additionally, the side of the loading hopper adjacent to the decontamination cell has been hinged with electrically driven worm gears installed to lower the side, allowing easier access for the operator to the charging box of the shear/baler. A vertical extension, which rides in a track and folds down with this side, has been installed to provide protection to the operators in the decontamination cell from small pieces of material which might break loose and become projectiles during the shearing operation.

The controls for the shear/baler are located at a central panel outside of the containment. A Lexan^{TM} window has been installed in the containment to allow the shear/baler operator a clear view of the loading area. Emergency shutoff switches have been installed at the control panel, inside the decontamination cell and at the bale outlet chute.

A glovebox is attached to the outlet chute to provide an enclosure to seal the bales in plastic as they emerge from the shear/baler. The bale is subsequently bagged out of the glovebox to provide a double seal. Gravity roller conveyors have been installed in the glovebox to assist the operator in handling the bales.

Five Station Non-Destructive Assay System

Material control and accountability will be accomplished using a non-destructive assay (NDA) system that consists of five stations. The stations utilize combinations of passive neutron detectors, an active neutron generator and a hyper-pure germanium detector.

Station 1 is a series of passive neutron detectors used to provide an initial inventory of hold-up in equipment prior to entering the decontamination cell airlock. This inventory is used to verify hold-up measurements taken during the in-situ characterization effort and to localize hold-up to optimize decontamination efforts. The equipment is also weighed at this station with electronic scales to determine an overall concentration. This station is capable of detecting 200 milligrams of plutonium.

Station 2 is an active-passive neutron differential die-away station, utilizing a neutron generator to induce reactions in the contaminated material which can be detected by ^{3}He neutron detector tubes. Station 2 is located in a chamber immediately adjacent to and accessible from the decontamination cell. This station is utilized to determine decontamination effectiveness and is capable of detecting 10 milligrams of plutonium.

Station 3 consist of two passive neutron detector packages used for real time nuclear safety monitoring of hold-up and material accountability. These detectors are placed on the water recirculation system and the shear/baler. In addition to providing continuous monitoring, the detectors trigger an alarm at a threshold of neutron activity well below nuclear safety concern. Station 3 is capable of detecting 200 milligrams of plutonium.

Station 4 is an active-passive neutron differential die-away station used to assay bales and drums. The bales are accurately weighed, assayed, measured, and labeled with a bar code. The labeled bales are stored in identifiable locations in a shelving area. As sufficient bales are produced, packaging is accomplished in a batch mode. A computer program optimizes the packaging of the drums based on bale height and concentration, selecting bales that, when packaged together in a 55-gallon drum, minimize void space and maximize specific activity within the waste acceptance criteria of the designated burial or storage site. Station 4 is capable of detecting 2 milligrams of plutonium.

Station 5 is a passive neutron detection chamber for assaying bulk mixed plutonium-uranium oxide (MOX) retrieved from the process equipment prior to decontamination. A hyper-pure germanium detector is used for isotopic analysis of the bulk MOX which is processed and packaged for shipment to DOE.

Data Acquisition System (DAS)

In order to provide an accurate history of decommissioning activity, every opportunity has been taken to utilize electronic monitoring, recording, retrieval and reporting. Equipment is tagged and tracked by bar code from the moment it is removed from the process line to the time it is placed in a drum for burial. This audit trail provides a validation of facility characterization, real time material accountability control, and assists in management of the decommissioning effort. Records required for shipment, storage and disposal are generated by the DAS from the data base.

DECOMMISSIONING MATERIAL FLOW

Before gloveboxes and equipment are removed from the process areas, they are surveyed for contamination. All contamination is either removed or fixed in place to eliminate regeneration of airborne particulate. Gloveboxes or equipment that require dismantling or sectioning before removal are completely contained inside temporary containments (e.g., tents). All work associated with equipment removal or sectioning is conducted with respiratory protection and layered anti-contamination clothing.

All equipment removed from Building 110 is transported approximately 1/4 mile to Building 234 and the DVRF. Material transport is conducted in a sixteen foot trailer pulled by a tow motor. The trailer has been lined with formica sheathing and linoleum with all cracks and crevices sealed. The equipment is transferred into and out of the trailer through dock seals attached to the buildings. The trailer is equipped with a roll up door. The equipment removed from Building 110 enters the DVRF through the Building 234, Area M airlock.

The equipment is then moved into the DVRF to NDA Station 1. The initial assay and weight are recorded in the date acquisition system. A determination is made to ensure that safe mass limits will not be exceeded by the introduction of the material being assayed into the decontamination cell. The initial assay is also used to validate the facility characterization and to localize material hold-up for the decontamination effort.

The equipment is then introduced into the decontamination cell through an integral airlock. The material handling in the airlock and the decontamination cell is assisted by one (1) ton bridge cranes. Once the equipment is in the decontamination cell, it can be sectioned as necessary, opened and cleaned. After initial decontamination is complete, NDA Station 2 is utilized to determine if decontamination has been effective and if further cleaning is required. The goal is to decontaminate all equipment to below 10 nanocuries of TRU per gram of waste.

When the equipment is decontaminated to as low a level as achievable, it is hoisted into the loading hopper of the shear/baler. After each shearing cycle is completed, a baling cycle is performed. If additional shearing cycles are made before producing a bale, the bale becomes too thick and unmanageable. A single cycle bale is nominally 4 inches in thickness and weighs 50 pounds. The 16 inch height and width are determined by the inner dimensions of the baling chamber.

The bale exits the shear/baler into a glovebox where it is sealed in flame retardant plastic. It is then bagged out of the glovebox and heat sealed in a second layer of flame retardant plastic. The sealed bale is weighed, assayed in Station 4 and the thickness is measured. A bar code label identifying the bale is attached and the associated information is recorded in the DAS. The bale is then placed in an identified cell in a temporary storage area. When sufficient bales are produced to generate drums for shipping, the DAS is accessed and the computer selects bales for optimum packaging of 55 gallon drums.

CONCLUSIONS

During the planning phase of the NFS Plutonium facilities decommissioning project several alternative approaches to the ultra-high pressure jetting decontamination and shear/baler operation were evaluated. However, the D&D action presented in this paper provided the best means of disposing of the contaminated materials in an environmentally sound manner in association with the implementation of a program that minimized the amount of TRU and low level waste (LLW) materials requiring disposal. Costs were substantially reduced due to the decreased volume of the waste to be buried, the reduced time schedule and the fewer number of personnel required to accomplish the tasks.