TRITIUM SYSTEMS TEST ASSEMBLY STABILIZATION

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ABSTRACT

The Tritium Systems Test Assembly (TSTA) was a facility dedicated to tritium technology Research and Development (R&D) primarily for future fusion power reactors. The facility was conceived in mid 1970’s, operations commenced in early 1980’s, stabilization and deactivation began in 2000 and were completed in 2003. The facility will remain in a Surveillance and Maintenance (S&M) mode until the Department of Energy (DOE) funds demolition of the facility, tentatively in 2009. A safe and stable end state was achieved by the TSTA Facility Stabilization Project (TFSP) in anticipation of long term S&M.

At the start of the stabilization project, with an inventory of approximately 140 grams of tritium, the facility was designated a Hazard Category (HC) 2 Non-Reactor Nuclear facility as defined by US Department of Energy standard DOE-STD-1027- 92 (1997). The TSTA facility comprises a laboratory area, supporting rooms, offices and associated laboratory space that included more than 20 major tritium handling systems. The project’s focus was to reduce the tritium inventory by removing bulk tritium, tritiated water wastes, and tritium-contaminated high-inventory components. Any equipment that remained in the facility was stabilized in place. All of the gloveboxes and piping were rendered inoperative and vented to atmosphere. All equipment, and inventoried tritium contamination, remaining in the facility was left in a safe-and-stable state. The project used the End Points process as defined by the DOE Office of Environmental Management (web page http://www.em.doe.gov/deact/epman.html) to document and define the end state required for the stabilization of TSTA Facility. The End Points process added structure that was beneficial through virtually all phases of the project.

At completion of the facility stabilization project the residual tritium inventory was approximately 3,000 curies, considerably less than the 1.6-gram threshold for a HC 3 facility. TSTA is now designated as a Radiological Facility. Innovative approaches were employed for characterization and removal of legacy wastes and high inventory components. Major accomplishments included:

- Reduction of tritium inventory, elimination of chemical hazards, and identification and posting of remaining hazards.
- Removal of legacy wastes.
- Transferred equipment for reuse in other DOE projects, including some at other DOE facilities.
- Transferred facility in a safe and stable condition to the S&M organization.

The project successfully completed all project goals and the TSTA facility was transferred into S&M on August 1, 2003. This project demonstrates the benefit of radiological inventory reduction and the removal of legacy wastes to achieve a safe and stable end state that protects workers and the environment pending eventual demolition of the facility.

INTRODUCTION

At the start of the stabilization project, with an inventory of approximately 140 grams of tritium, the facility was designated a HC 2 Nuclear Facility. The primary objective of the TSTA Facility Stabilization Project (TFSP) was to remove the tritium inventory, including all bulk tritium, tritiated water, tritium-contaminated high-inventory components and to stabilize equipment that will remain in the facility. Most of the gloveboxes and much of the process and support piping were rendered inoperative but remained in place. All equipment, and inventoried tritium contamination, remaining in the facility was left in a safe-and-stable state. Long-term S&M is planned for the facility.

Three key aspects of the stabilization project are emphasized in this paper. These include the end point process used to define the end state for the facility, the reduction in tritium inventory essential to downgrade the facility hazard category, and the successful waste management to achieve project goals.

END POINT PROCESS

The TFSP used the End Point process to plan and document the end state required for stabilization of the TSTA Facility, and the transition of the facility from the Department of Energy Office of Science to the Office of Environmental Management (DOE-EM). An objective for the TFSP was to ensure a cost effective post-transfer S&M and eventual demolition of TSTA.

End Point Process

End points were specifications of the conditions and other requirements to be achieved at the completion of the stabilization project. They defined the requirements for the transition of TSTA from an operational facility to a surplus facility. End points for the TFSP were developed using experience and methods developed and applied by EM-20 throughout the DOE complex.

The process adapted for TFSP is documented in the project's End Point Document. The end point process ensures that the work being conducted has a basis that can be traced back to a set of objectives.

TFSP Objectives and Criteria

The end point objectives were high-level drivers for specific end points. The TFSP-specific stabilization objectives are listed in Table I TFSP stabilization objectives for end point determination along with their bases. These objectives were implemented via criteria in Table II as indicated in the last column in that table. The subjects and statements of criteria were TSTA specific, but were developed with the benefit of experience on other DOE deactivation projects.

Table I TFSP stabilization objectives for end point determination

Objectives	Basis
1. Comply with DOE Life Cycle Asset Management Order, DOE O 430.1A	Objectives of the DOE G 430.1-5, *Transition Implementation Guide* as specifically defined by the MOA for Transfer (between DOE-SC and DOE-EM) and the associated Survey Report.
2. Comply with LANL Laboratory Implementation Requirements	Checklist developed by FMU-64 for transfer of surplus facilities, derived from "Laboratory Excess Space and Surplus Facility Requirements," LIR-230-01-01.0
3. Protect the Public and the Environment	Standard stabilization and deactivation end point objectives (See DOE G 430.1-5)
4. Protect the S&M Worker	Standard stabilization and deactivation end point objectives (See DOE G 430.1-5)
5. Facilitate Future D&D	Standard deactivation end point objectives applied to ensure that facility cranes and hoists are maintained and will be available for facility demolition.

TFSP Project and TSTA Facility Cases

"Cases" refers to logical grouping of end points, based on physical and functional attributes of the facility. For the TFSP project the spaces and systems were assigned to these cases based on the unique qualities of the TSTA facility:

- **Case 1: Overall Project Requirements –** This case assigned end point requirements that were not uniquely associated with a specific space or system. These were primarily administrative and included documentation requirements.
- **Case 2: Spaces –** The spaces represent physical boundaries and/or functional delineations.
- **Case 3: Operable Systems and Equipment –** The stabilized end state required some systems and equipment to remain operable for S&M and/or D&D.
- **Case 4: Abandoned Systems and Equipment –** Most systems and equipment were stabilized (abandoned) in-place, or removed (e.g. a complete experimental system, including a glovebox and controls, was shipped to Idaho).

The TFSP end points were organized into these four Cases in the TSTA End Points Document. The four cases expanded into multiple project requirements, six spaces (Case 2), eleven operable systems (Case 3) and 38 abandoned systems and equipment that comprised over 400 specific end points (Case 4). These end points were developed as checklists that were used to assess performed work and became objective evidence of project completion. During project execution metrics such as Fig. 1 were used to track project progress. Figure 1 depicts the TSTA process area and provides an easy method for project tracking, by color coding, the status of systems, equipment and components.

Table II TFSP stabilization criteria for end point determination

Criteria Subjects	Criteria Statements	Used to Fulfill Objectives
1. Structural and Boundary Integrity	Structural and boundary integrity will be such that: 1) S&M or D&D personnel are safe, 2) contamination or hazardous materials remaining in the facility are contained or have been stabilized against release, and 3) intrusion by unauthorized personnel, animals, and plants are prevented.	1, 3, 4
2. Nuclear Materials	Accountable Tritium has been removed (100 Curies of tritium is an accountable quantity). Tritium surface contamination, or permeated into materials not intended for tritium storage, should not be considered accountable.	1
3. Hazardous Materials	Hazardous materials and chemicals have been removed in compliance with environmental regulations. Any hazardous materials remaining in the facility are labeled and confined or have been stabilized to prevent release. Documentation of quantities and location of remaining hazardous materials is complete.	1,2
4. Operational Systems and Equipment	Service and utility systems and equipment required to support S&M and maintain stable conditions (such as lighting, exhaust ventilation, sump pumps, etc.) are operational. Equipment that has been judged to be essential for future S&M or D&D (such as cranes or jib hoists) remains operational.	1, 3, 4, 5
5. Abandoned or Removed Systems and Equipment	Nonessential systems and equipment have been: 1) abandoned in place and isolated, characterized, vented, and/or sealed, or 2) removed.	1, 3, 4
6. Personnel Safety	The safety of S&M and D&D personnel are safeguarded by stable conditions, postings, and written procedures that have been established in accordance with standard procedures for radiological protection and industrial safety practice. Contamination remaining in the facility is clearly identified and has been stabilized. ESA will maintain, and follow, appropriate procedures for activities in TSTA until the transfer to FWO is effected. FWO may adopt the ESA procedures, but any required modifications will be the responsibility of FWO.	1, 4
7. Waste	Removable wastes have been disposed. The only liquid wastes remaining are minimal quantities within installed equipment that cannot be readily removed.	1, 2, 3
8. Housekeeping	Classified and valuable materials are removed. Trash, furniture, and other loose equipment and materials have been removed.	2, 3
9. Administrative	Facility-specific records and documents have been transferred. This includes, for example, the Safety Basis, other regulatory requirements (such as permits), contracts, purchase orders, and other agreements. Reporting requirements are identified. Government owned capital assets are listed.	1, 2
10. Characterization	Data for as-left materials and conditions important to S&M and future D&D have been recorded and are retrievable.	1, 4, 5
11. Reduce S&M Costs	To the extent practicable, S&M requirements have been minimized.	1, 2

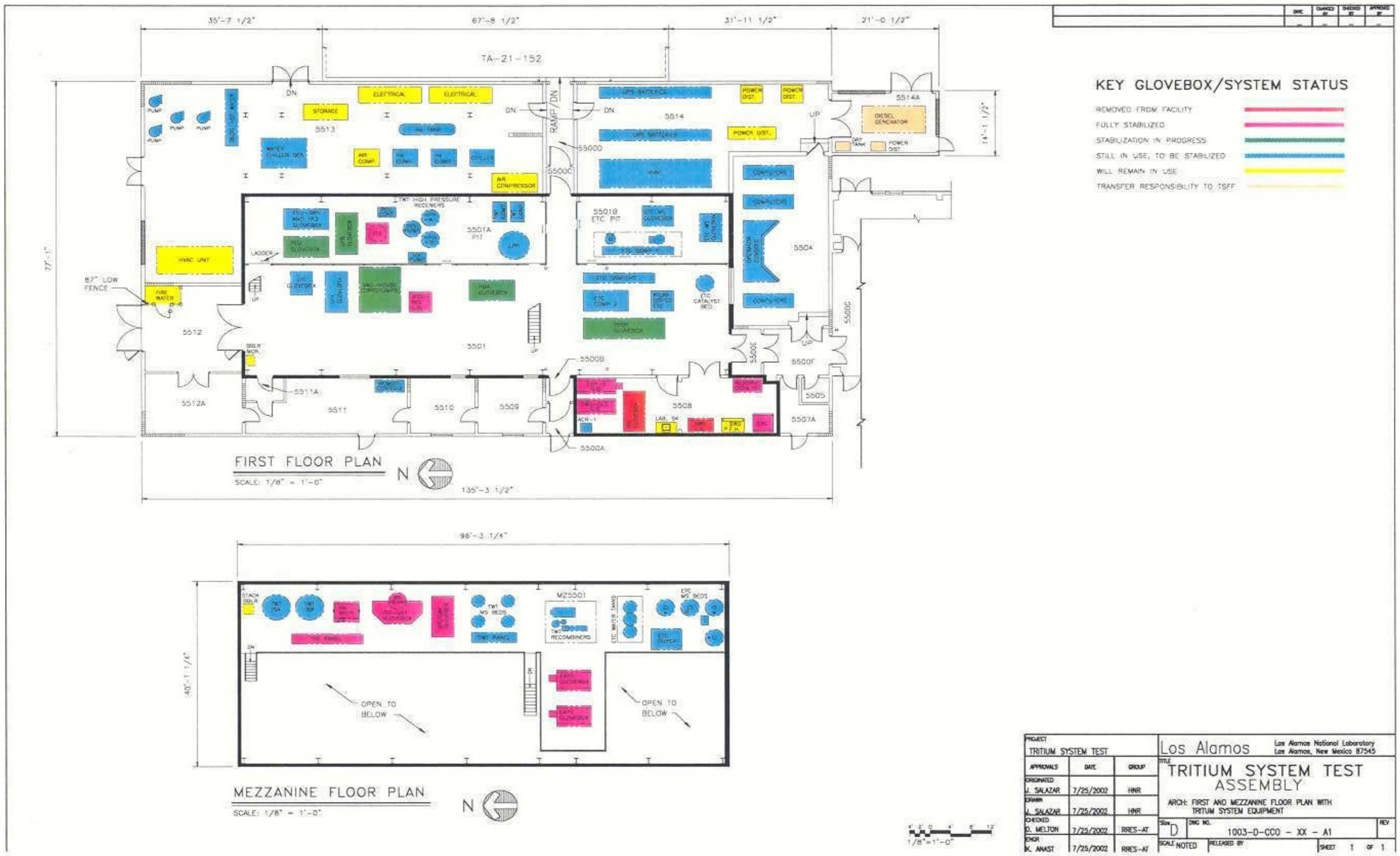

Fig. 1 Metric used to depict process area status and condition

INVENTORY REDUCTION AND FACILITY HAZARD CATEGORY DOWNGRADE

At the start of TFSP, the facility inventory included approximately 140 grams of tritium, and 44.6 kg of depleted uranium which was used to store hydrogen isotopes as metallic hydrides. The tritium inventory comprised elemental tritium, mixtures of hydrogen isotopes, tritium oxide (tritiated water), and tritium-contaminated gases. TSTA was a HC 2 Nuclear Facility. A project requirement was to reduce the tritium inventory below the 30-gram threshold for a HC 2 facility (see Fig. 2). The project also had a goal that at the time of transition the residual tritium inventory will be below the 1.6-gram threshold for a HC 3 facility, and thus qualify for designation as a Radiological Facility.

The tritium inventory in TSTA was reduced below the threshold for a HC 3 facility and all uranium was removed from the facility. During the stabilization process, tritium was transferred to the Weapons Engineering Tritium Facility (WETF) at TA-16-205, the Savannah River Site, and Area G at Los Alamos National Laboratory (LANL) area TA-54 for disposal. The remaining TSTA tritium inventory is in the form of surface contamination or residual holdup in material matrices and was reduced to less than 1/3 gram.

In TSTA, components with high surface areas were used to store and process tritium-containing gas; these were identified as high inventory components (HICs). All HICs were characterized and either removed from the facility or left open and vented. Only HICs that contain a very low residual inventory were left in the facility. Tritium-contaminated oil was drained from all pumps and compressors. Any volume that contained tritium and remained in the facility, including all process piping, was purged and vented into the facility or directly to the stack. All systems were opened and vented by April 2003 and remain open. With all components vented the TSTA stack effluent has an average release rate of less than 1 Ci/day. Figure 3 depicts the reduction in TSTA tritium inventory during the project.

Removal of bulk tritium was accomplished by collecting gas in Hydride Storage Vessels (HSVs). A total of 71 grams of good quality tritium were removed and transferred to the Savannah River Site for reuse in two HSVs.

A few items remain that are identified with a tritium inventory of 50 Ci or more that were recorded individually as accountable in the LANL Material Accountability Safeguards System (MASS). The TSTA MASS account includes eight items with a total inventory of less than 3100 Ci. These items are planned for disposal at a later date to further minimize the facility S&M requirements.

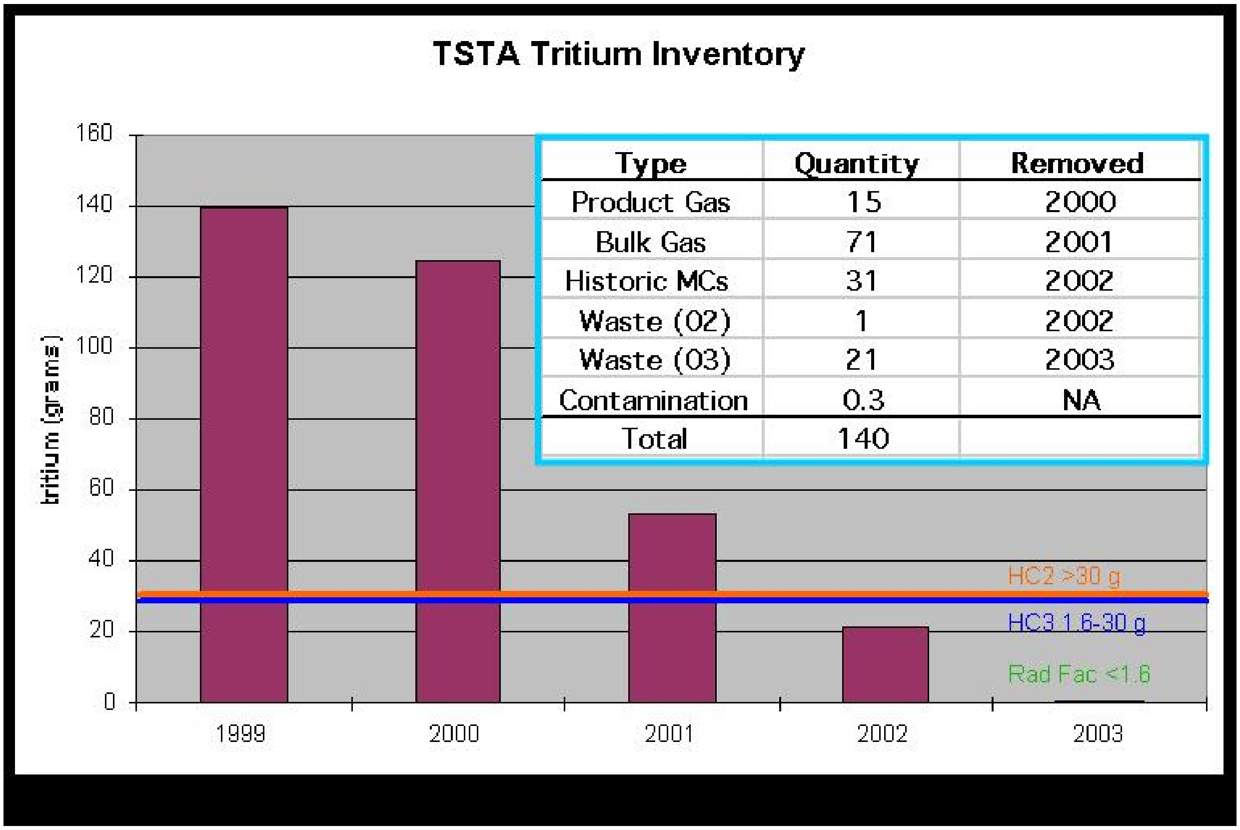

Fig. 2 TFSP tritium inventory reduction

WASTE MANAGFEMENT

Waste management activities included solid and liquid radioactive waste packaging and disposal. These activities were essential to reducing the facility tritium inventory as discussed above. Low activity solid wastes such as room trash and miscellaneous equipment from the process area were removed by conventional and routine methods including the use of standard containers such as (B-25) metal boxes. All tritium wastes from TSTA, except low activity liquid wastes, were disposed at TA-54. Radioactive liquid waste drains in the TSTA facility were used for disposal of low activity liquid wastes such as mop water used to clean the process area floors.

Disposal of some waste streams required specially designed pressure-vessel waste containers. The Waste Acceptance Criteria for the LANL disposal area, TA-54, specifies 100,000 curies/package (nominally 10 grams) as the upper limit on high activity waste. The pressure vessel design accommodated the upper limit in order to minimize waste volumes and disposal cost. The design basis was molecular sieve loaded to 25% by weight water containing a total of 10 grams of tritium per overpack. The accepted hydrogen generation rate due to radiolysis of water is 0.53 molecules-H_2/100 electron volts (eV) and the average beta energy per tritium decay is 5680 eV. Since the overpack container cannot be vented to mitigate hydrogen buildup, the containment system was designed to safely contain the pressure generated from 10 grams of tritium. The overpack containers were constructed of stainless steel to resist corrosion, embrittlement, and hydride formation on the interior of the container. Four different container designs were developed; one of these is depicted in Fig. 3.

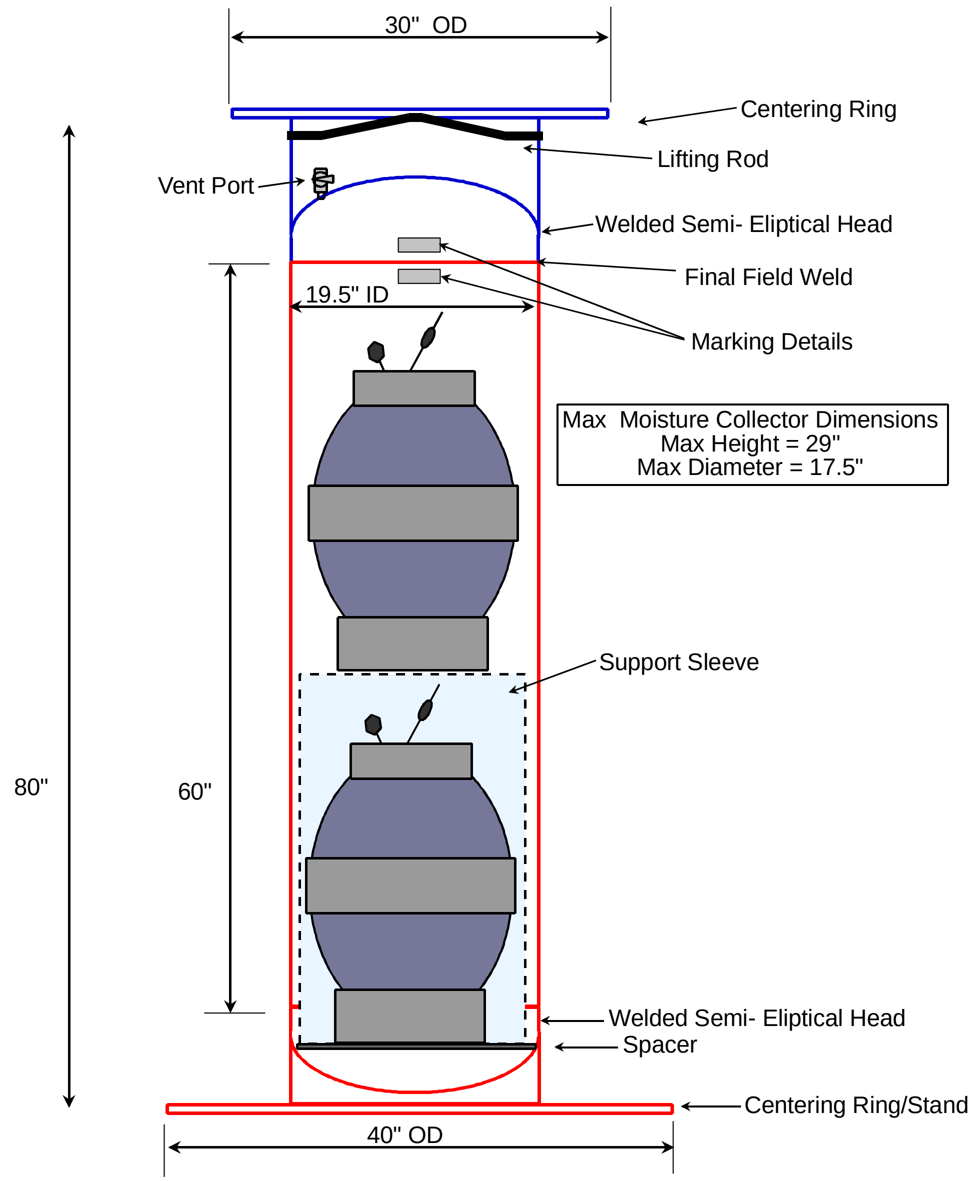

Fig. 3 Moisture Collector Overpack Design Schematic

Tritiated water containing 31 grams of tritium was disposed in thirty-six moisture collectors that were placed in eighteen pressure-vessel containers. The moisture collectors were depressurized, then loaded into overpacks in the TSTA high bay using the overhead crane. Overpacks were loaded with two moisture collectors each. After all of the overpacks were loaded, welded, and each one passed radiography examination, they were placed into transportainers. A crane lifted the transportainers onto the flat bed truck for transport to TA-54.

At TA-54 the transportainers were offloaded and the overpacks disposed in 3-foot-diameter shafts.

An additional 38 grams was removed and disposed in other specially designed high-integrity pressure-vessel waste containers. Figure 4 is two loaded overpacks ready for shipment from TSTA. Effective waste management was critical in the success of the TSTA Facility Stabilization Project.

Fig. 4 Overpack Waste Containers Containing Moisture Collectors

CONCLUSION

During the TFSP tritium was systematically removed from the facility, reducing the total residual quantity to an estimated 3100 Ci, less than 20% of the lower threshold for a HC 3 Nuclear Facility. Consequently the facility was designated a Radiological Facility. The TSTA stack effluent with all systems opened and vented is less than 1 Ci/day.

As described above the end point process was used to document completed work and provide objective evidence that the stabilization project goals were achieved. Signatures on end points checklists established verification of completed work. Both stabilization project staff and personnel from the surveillance and maintenance organization signed the checklists.

Waste management was key to the successful completion of the TSTA Facility Stabilization Project. Approximately 69 grams of tritium were successfully disposed in a safe, expedient, cost-effective manner. Another 71 grams were transferred to SRS for future reuse. The inventory was reduced and the facility was downgraded to a Radiological Facility, and transferred to DOE-EM for Surveillance and Maintenance.

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