Turning a Liability into an Asset at Sandia California: The Tritium Research Facility Transition

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Introduction
With an investment of $20.9 million, Sandia National Laboratories/California (Sandia/CA) saved the Department of Energy (DOE) an estimated $106.3 million—a 500% return on investment. In cooperation with DOE, Sandia/CA decontaminated and transitioned (D&T) the Tritium Research Laboratory (TRL), a DOE non-reactor Category II nuclear facility. In support of the DOE’s Office of Defense Programs, Sandia/CA had conducted advanced research and development experiments at the TRL since 1977. However, in 1991, Sandia/CA scheduled the TRL for shutdown and decommissioning. By October 1996, the TRL’s D&T, rather than decontamination and demolition (D&D), resulted in the reuse of the building. Implementation of innovative D&T process techniques not only saved millions of dollars, but gained non-monetary benefits. First, the savings and benefits will be detailed, followed by descriptions of the decontamination and pollution prevention techniques.

Cost Savings
The D&T of the TRL saved DOE funds in the following five areas: process costs, equipment costs, disposal costs, building replacement costs, and administration costs. First, actual D&T process costs were less than the estimated D&D costs. D&D would have taken nine years at a cost exceeding $48 million. Taking only four years to complete, the D&T process cost approximately $21 million—only 44% of the D&D.

The second cost savings resulted from reusing Sandia/CA equipment at other DOE facilities. Savannah River, Lawrence Livermore National Laboratory, and Los Alamos National Laboratory received such items as gloveboxes, tritium monitors, safety equipment, pumps, and mass spectrometers. The replacement value of the reused equipment totaled over $43.5 million dollars. Because the
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equipment was reused and not disposed, the third savings was possible: an approximate $25 million in waste avoidance costs.

The fourth area of cost savings, building replacement, saved DOE an estimated $5.2 million. This estimated savings was based on construction costs for a new, similar building at $325 per square foot and five to ten years to design and reconstruct.

The fifth and final cost savings relates to the early completion of the project. Had the project taken the estimated nine years for D&D, the administrative costs for the additional five years would have totaled an estimated $5 million.

By conducting the D&T process, reusing equipment, avoiding disposal and building construction costs, and completing the project in four years, Sandia/CA saved DOE an estimated $106 million (see Table 1). Besides these cost savings, several non-monetary benefits were also gained from the transition of the TRL.

Table 1. Estimated and Actual Costs and Savings for D&T and D&D Processes

<table>
<thead>
<tr>
<th>D&amp;D Estimated Costs</th>
<th>D&amp;D Actual Costs</th>
<th>Early Completion Cost Savings</th>
<th>Estimated Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>D&amp; labor, decontamination, demolition, administration, etc.; 9 years to complete</td>
<td>D&amp;T labor, decontamination, demolition, administration, etc.; 4 years to complete</td>
<td>$27,670,000</td>
<td></td>
</tr>
<tr>
<td>Value of Disposed Equipment* $43,500,000</td>
<td>Value of Disposed Equipment $0</td>
<td>$43,500,000</td>
<td></td>
</tr>
<tr>
<td>Equipment Disposal Costs $24,900,000</td>
<td>Equipment Disposal Costs $0</td>
<td>$24,900,000</td>
<td></td>
</tr>
<tr>
<td>Building Replacement $5,200,000</td>
<td>Building Replacement $0</td>
<td>$5,200,000</td>
<td></td>
</tr>
<tr>
<td>Administration $5,000,000</td>
<td></td>
<td>$5,000,000</td>
<td></td>
</tr>
<tr>
<td>Total $122,150,000</td>
<td>Total $20,880,000</td>
<td>$5,000,000</td>
<td></td>
</tr>
<tr>
<td>Total $106,270,000</td>
<td>$5,000,000</td>
<td>$106,270,000</td>
<td></td>
</tr>
</tbody>
</table>

1 This amount reflects the replacement value of the equipment.

2 The equipment was prepared for reuse and shipped to LLNL, Savannah River, etc. Since shipping costs would be incurred with any equipment purchase, they were excluded from these calculations.

Non-monetary Benefits
By using innovative cleanup and pollution prevention techniques, six non-monetary benefits resulted. These include the reduction of tritium inventory to zero grams, the reduction and eventual elimination of stack releases, the reduction of personnel radiological exposures, no reportable occurrences from January 1995 through May 1996, the avoidance of generating low-level radioactive waste, and a time savings.

First, the tritium inventory reached zero grams from the operational inventory of 118.92 grams, consequently eliminating the need to track and account for the tritium on site. The accountable tritium inventory was primarily in the following forms:
- bulk tritium gas,
- tritiated waste water absorbed in clay,
- tritium stored in uranium and palladium beds,
- calibration standards of tritium gas used for the mass spectrometer,
- tritium stored in molecular sieve, and
- tritium absorbed in various metals for long term storage compatibility studies.

At the onset of the TRL cleanup, August 1991, 160 containers stored 118.92 grams of accountable tritium in amounts ranging from 0.01 grams to 10.78 grams. Within one year, 100 grams of bulk gas and tritiated water were shipped to the Savannah River Site and Mound Laboratories for reuse, reducing the accountable tritium inventory by 84%. The remaining inventory was eventually shipped to the Nevada Test Site for burial. By October 18, 1994—in less than three years—the accountable tritium inventory had reached zero.

The second non-monetary benefit was realized in the reduction, and eventual elimination, of stack releases. The reduction in stack releases was accomplished through careful planning and timely cleanup efforts of the major decontamination systems. In CY87, emissions totaled 1,831 curies; however, in CY96 the emissions had been reduced by 99.9% to a mere 0.078 curies. With concurrence from the Environmental Protection Agency Region 9, DOE agreed with Sandia/CA personnel that the need to monitor air emissions from the TRL stacks was unnecessary; consequently, monitoring ceased in October 1996.

Another non-monetary benefit was realized in the reduction of personnel radiological exposures. Preventing personnel exposures was a primary focus of all operations during cleanup and transition. All disassembly operations were performed under a safe work permit. All aspects of the job were reviewed by each discipline of the Environmental, Safety and Health Department. Workers were trained to operate specialized equipment and used individual operating procedures; when necessary, dry-runs were performed. These precautions and safety procedures reduced the personnel radiological
exposure from a total 0.458 person-rem in 1991 to 0.134 in 1995. (The DOE individual control limit is 2 rem.) There were no personnel exposures during 1996.

Related to this reduction was the fourth non-monetary benefit: no reportable occurrences from January 1995 through May 1996. This accomplishment resulted from the specialized training of personnel, a review of each task, and a skilled, experienced work crew.

The fifth benefit was that the low-level radioactive waste avoidance exceeded 30 million pounds, saving 9,753,600 cubic feet in landfill space. Finally, the D&T project required 56% less time to complete than the D&D process—four years rather than nine years. The result of this time savings meant a reduction in project management and administration, as well as early occupancy of the new facilities.

These cost savings and non-monetary benefits were accomplished through careful planning and innovative cleanup techniques and processes. The following details the techniques used during the D&T process.

Decontamination and Pollution Prevention Techniques
Sandia/CA designed the TRL complex to support the DOE weapons complex. It was a modern research and development facility that safely handled tritium and its associated compounds. The basic laboratory building was completed in the summer of 1975. A single-story structure, the TRL is approximately 24 meters wide and 55 meters long. The Gas Purification System (GPS), Vacuum Effluent Recovery System (VERS), and monitoring systems were completed in early 1977 and operational in late 1978. Other buildings were added to the TRL complex, but did not need to be included in the D&T. The TRL D&T encompassed the laboratory building 968 and its systems, a liquid effluent control system (LECS), and the exhaust stack.

The first and foundational process technique involved the formation of a Sandia/CA in-house reutilization project team. Members of this team included TRL, facilities engineering, maintenance, and environmental personnel. The team's interdepartmental effort and involvement assured that a planned, integrated, and efficient research environment was preserved for future occupancy, while resulting in cost savings and non-monetary benefits. Besides technical expertise, the project team also provided project management. The team carefully documented every aspect of the decontamination (or cleanup), transition, and reuse process, thereby providing a model for converting other similar facilities.

Throughout the entire cleanup process, stack releases were monitored for both species of tritium (i.e., gas and oxide) by using a bubbler system capable of distinguishing between the two species. The six-bubbler system used the first
three bubblers to remove tritium oxide from a sample stream, and the last three converted the gas to oxide through a palladium catalyst.

The initial cleanup, 1991 through 1992, evolved around the reduction of accountable tritium, resulting in a 56% effluent reduction (from 465 curies to 264). During 1993, five laboratories were emptied, which involved major cleanup of system components and initial cleanup of remaining gloveboxes. This affected the 1993 stack releases, reducing them to 188 curies. Emissions were further reduced to 95 curies in 1994 by the cleanup of all but one glovebox and the initial cleanup effort of the facility’s decontamination systems (e.g., the GPS and the VERS). During 1995, final cleanup efforts were completed by processing all remaining radioactive materials for waste disposal and emptying the building. The stack releases for 1995 were reduced to 74 curies. By the end of the entire D&T process, the stack releases had been reduced to 0.078 curies.

In the order of implementation, the following describes the processes used to disassemble, decontaminate, avoid exposures, and reduce waste of the TRL’s various systems.

**Decontamination of Gloveboxes Using Moist Air**
The gloveboxes were the first of the systems to be decontaminated. Since moist air exchange is a highly effective means of converting off-gassing materials to oxide, moist air humidification was used inside gloveboxes to assist with the tritium exchange process. A computer-controlled humidifier maintained an air moisture content of 70% to 80% within the gloveboxes. Using this method, the time required for decontamination of each glovebox varied among the gloveboxes, which ranged from weeks to months.

After the exchange process, the GPS was used to further clean the gloveboxes. (The GPS is described under Gas Purification System Disassembly.) The tritium collected by the GPS was converted to tritiated water, collected and solidified, and processed as low-level waste. Before any of the other systems were disassembled, their radiological conditions were analyzed.

**Pre-disassembly Decontamination Systems Analysis**
Prior to the disassembly of any component of the decontamination system, an analysis of its radiological condition was performed. A Sandia/CA-designed Portable Tritium Monitoring System (PTMS) was used for this analysis, allowing for the assessment of internal surfaces without risk to workers or the environment. Through this process, the radiological activity of the decontamination system’s components were determined, providing necessary information to set adequate safety requirements prior to disassembly. The radioactive content was determined by drawing an air sample through a series of ion chambers. After performing the analysis, the interior contents of the
decontamination systems were processed through the GPS, which was the next system to be disassembled.

**Gas Purification System Disassembly**
The GPS consisted of many components; the largest components were contained on individual fixed skids (i.e., frames onto which the equipment was bolted). Components included, but not exclusively:
- a central inlet and outlet exhaust manifold that extended down a 180 foot corridor,
- a distribution system to interconnect the sealed glovboxes to the manifold,
- a carbon trap to remove oil vapors,
- a blower section to circulate the gas,
- a catalyst section to crack hydrocarbons and oxidize the tritium,
- a dryer section to remove tritiated water from the gas stream, and
- a regeneration section to remove the tritiated water from the dryers.

The GPS had not been opened for 18 years. For safety reasons, accessing the interior was avoided by verifying that the pressure for all component piping did not exceed 1.5 atmospheres (per Nevada Test Site’s [NTS] Waste Acceptance Criteria). This approach maintained component integrity at NTS’s higher elevations and eliminated the need for disassembly of hundreds of components, resulting in reductions of stack releases and personnel exposures. To further reduce releases and exposures, the hallway manifold sections were cut into approximately 14-foot lengths, and boxed and loaded into oversized waste containers with other system components. Disassembly of the VERS followed.

**Vacuum Effluent Recovery System (VERS) Disassembly**
The VERS was a complex system of tritium-contaminated piping, which was used to collect, store, and decontaminate tritium-contaminated vacuum-pump effluent from vacuum systems. Consequently, the VERS was the most challenging of the systems to disassemble. The approximately 500-foot sections of contaminated piping had to be cut into 3-foot sections and stored in 55-gallon drums, while simultaneously preventing personnel exposure and stack releases. To prevent personnel exposure during the cutting of the pipes, the work was performed inside a portable, roll-around fume hood, using a “jaws of life.” Due to tritium off-gassing from the interior of the pipe sections, the drums (DOT 7A) were sealed with rubber gaskets and silicon sealers to prevent personnel exposure and unnecessary stack releases during storage prior to shipping. The final technique used to minimize risks and reduce waste was the use of oversized containers.

**Use of Oversized Waste Containers**
Cutting and disassembling tritium-contaminated systems increases personnel and environmental exposures. To minimize this risk, the NTS disposal facility
approved the use of oversized containers. However, NTS required that the oversized containers be made in multiples of the standard 4-foot by 4-foot by 7-foot size container. To accommodate the size restrictions, system components that posed significant safety hazards were placed in individual boxes and then placed in the oversized containers. Materials that posed less risk were cut and packaged to fit in and around the larger systems in the containers. The packaging arrangement took advantage of every inch of space. This system not only reduced personnel exposures and stack releases, it also saved disassembly time.

Conclusion
By implementing the D&T process, Sandia/CA saved DOE money, converted a building for reuse, and developed a viable D&T process that could benefit other facilities. The D&T process avoided $106 million in costs—the difference between D&D and D&T process costs, building replacement costs, equipment purchase costs, waste disposal costs, and project administration costs. Along with cost savings to DOE, the D&T process resulted in non-monetary benefits, such as a zero tritium inventory, stack emission and personnel exposure reductions, a significant reduction of reportable occurrences, and avoidance of over 30 million pounds of low-level waste. For $21 million (or 16% of the D&D process costs), Sandia/CA converted a potential liability into an asset.

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