REMOTE DISMANTLEMENT BY NOVEL ADAPTATIONS OF CONVENTIONAL EQUIPMENT

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ABSTRACT

This paper describes remote techniques used for the dismantling of an activated steel vessel, cast-in-place concrete shields and steel-plate liners, all located in a below-grade vault test reactor cell. The remote cutting of the vessel was accomplished by integrating equipment previously used for commercial light water reactor vessel inspections and an off-the-shelf plasma torch. A commercial tractor/backhoe was modified and used as stationary equipment for the remote demolition and retrieval of the concrete shield. Existing off-the-shelf hardware was integrated with specially designed mounting equipment to provide positioning and motion for the remote torch cutting of the steel liner in the test cell. The successful performance of the equipment demonstrates that adaptation and integration of proven equipment can be utilized for these varied operations which are typically a large part of any decontamination and decommissioning (D&D) project.

INTRODUCTION

"Hands-on" decontamination and decommissioning (D&D) of nuclear facilities and equipment is often constrained by high radiation fields, from preexisting as well as operations-generated radioactive contamination and dust, and by limited access that is further restricted by the physical realities of the existing structures and equipment locations. D&D tasks, such as cutting, rubblizing, and debris removal, also require dependable and rugged equipment for carrying and surviving large loads under varying and potentially unstable structural conditions. Hence, the operating environments are usually hostile to both humans and complex remote handling equipment or robotic operations. Proven equipment, if adapted to overcome these constraints, can offer cost-effective means for performing these typical tasks which are a large part of many D&D projects. This paper describes accomplishments of this nature, demonstrated in an ongoing D&D project at the Energy Technology Engineering Center (ETEC).

BACKGROUND

The ETEC facility, known both as the SNAP (Systems for Nuclear Auxiliary Power) Ground Prototype Test Facility (SGPTF) and Building 059, is located in the Santa Susana mountains of southern California. The SGPTF's test vault was constructed and operated in the 1960s to test a reactor for space applications. The reactor's core, the fuel, and the liquid metal (NaK) heat transfer loops were removed during the early 1970s following successful completion of the ground tests. The facility was then placed under maintenance and surveillance, with plans to D&D after the year 2015 when radioactivity would have substantially decayed, permitting safe, hands-on dismantlement.

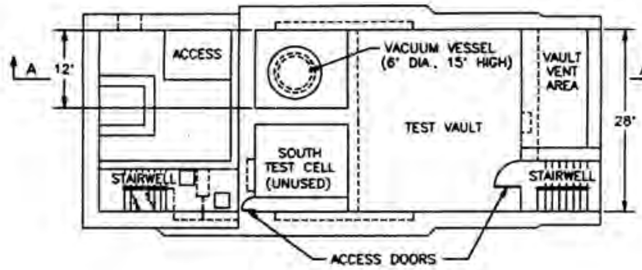
Continued surveillance and monitoring during the early 1980s revealed groundwater intrusion into the facility near the activated components and testing areas. A water management program to control this groundwater intrusion was immediately and successfully undertaken, and D&D of the entire building has since been in progress. The first phase of this D&D involved removal of activated shielding sand and buried vacuum ducts adjoining the test cell, and sealing of the water in-leakage path. This phase of work, when completed in 1989, further mitigated potential groundwater return-pathways to the environment. The second and final phase is now in progress, and includes removal of all the remaining components in the test cell, principally the stainless steel reactor test vessel, concrete shields, and steel liners. Relevant descriptions of the vault, test cell, and the components, and a discussion of the selection and implementation of remote handling techniques for removing these components are provided in the following sections.

COMPONENTS AND CONSTRAINTS

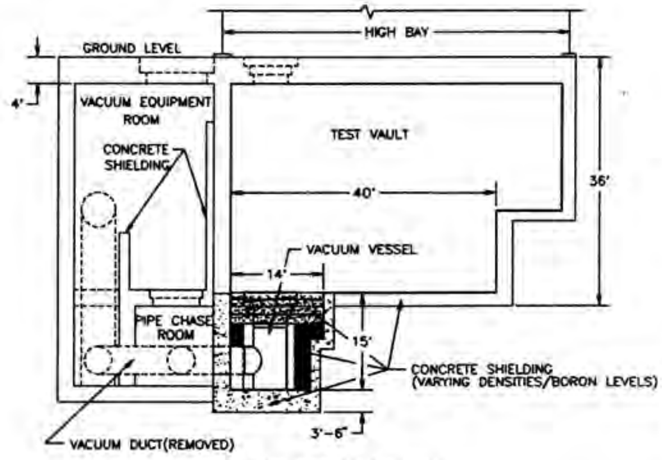
Figure 1 shows the building plan and elevation views, with locations and dimensions of the test vault. As shown, the test vault is a 40-ft-long by 28-ft-wide by 36-ft-deep underground structure with a 4-ft-thick ceiling. The 12- by 12- by 15-ft-deep test cell is below the floor in one corner of the vault. The activated components to be cut, size-reduced, and removed were all located within this test cell. They included: a cylindrical, 6-ft-diameter by 15-ft-tall, freestanding stainless steel vacuum vessel (3/8-in. wall thickness) with external coolant circulation piping and manifolds; numerous instrumentation thimbles and conduits; about 65 tons of individual concrete blocks and shield plugs; about 100 tons of poured, in-cell high-density concrete shield surrounding the vessel; and about 960 square-feet of 1/4-in. steel plate lining the cell walls and floor.

Access for the D&D operations was either through a 6-ft-diameter, below-grade, horizontal opening that earlier housed the vacuum duct, or by way of a 6-ft-diameter opening in the 4-ft-thick vault ceiling, 51 ft above the test cell floor. High radiation fields in the test cell ranged between 5 and 8 rad/h (contact) at the start of the project.

The limited space for ingress and egress, the high radiation levels, and the anticipated airborne release of contaminants and dust imposed serious constraints on equipment and personnel access, residence, and D&D operations in the affected areas. Exposure and ALARA (as low as reasonably achievable) considerations restricted personnel to only short-term monitored entries for essential operations such as equipment setup and retrieval. Each entry required prior approval, appropriate anti-contamination clothing, respiratory protection, and special training in confined-space entry procedures.



PLAN VIEW



SECTION A-A (ELEVATION)

Fig. 1. Building 059 -- vault plan and elevation.

TECHNICAL APPROACH

Overview

During the planning stages of the project, it was recognized that equipment to remotely cut steel and to demolish concrete from large distances would not be readily available, and that development of new equipment for one-time-only use was beyond the scope of the project. Therefore, investigations and trade studies were directed toward identifying and maximizing the use of proven equipment and adapting them to the tasks at hand. In addition to modifying the equipment designs and/or the facility features, emphasis was also placed on thoroughly pretesting the assembled equipment, as a system, in mock-up environments, and training the operators during the mock-up tests, prior to field deployment. This approach was adopted for each of the three main tasks of vacuum vessel removal, concrete demolition, and liner removal. Selection of the equipment for each task and their performance is discussed in the following paragraphs.

Vacuum Vessel Sectioning and Removal

The approach to vacuum vessel sectioning was an in-house selection derived from years of experience with systems for light water reactor in-service inspection (ISI) (1), coupled with extensive on-site use of remote plasma torch cutting for size reduction of radioactive components. A PaR (for Programmed and Remote) manipulator and experienced operators were on hand and available. Experience of particular relevance here is the reproducible and consistent performance of this system in high radiation environments and in remote locations requiring long reaches. Furthermore, choice of the plasma arc has been validated elsewhere as a primary, cost-effective means for sectioning and size reduction of steel components by studies performed at the Argonne National Laboratory (2), and most recently by the DOE Office of Technology Development for the dismantlement of the Princeton Tokomak Fusion Test Reactor (TFTR).

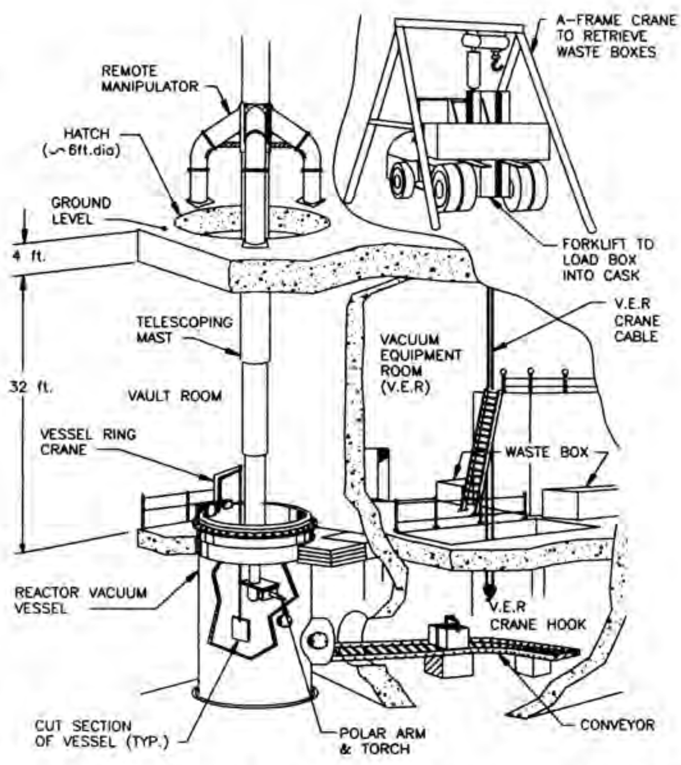


Fig. 2. Vessel remote sectioning and removal equipment installation.

Figure 2 shows the arrangement of the PaR equipment in the facility for sectioning the steel vessel. As shown, the telescoping PaR manipulator (with remote controls) was stationed at ground level, and was capable of controlled axial and radial movement of the plasma torch mounted at the end of the telescoping mast. Additional movement was provided by a specially designed torch holder boom assembly (see Fig. 3) that included a camera, pneumatic cylinders for primary boom extension, and an automatic amperage-sensing torch positioner for fine-tuning the torch-to-cutting surface gap. All systems were cold tested extensively on a mock-up vessel (shown in Fig. 4) to obtain operating parameters prior to going "hot" in the facility.

Sectioned steel was loaded into containers placed on a powered conveyor system located in an adjacent area, as shown in Fig. 2. This conveyor was also an off-the-shelf item and was chosen for use over another one-time-use design submitted during the selection phase of the project.

Shielding Concrete Removal

The cast-in-place shielding concrete consisted of about 100 tons of concrete, steel punchings, rebar, conduit, and instrumentation piping. Tooling was required to break up the mass, cut steel where required, and load the rubble into containers. Alternative methods for accomplishing these tasks were examined in a trade study. This study concluded that the

Fig. 3. Cutting torch assembly for vacuum vessel sectioning.

best method to meet all three requirements was a manipulator arm with exchangeable end effectors to perform the necessary functions. Requirements were subsequently defined in a procurement specification to potential suppliers. Only two responses were received, each essentially proposing to connect individual components to form a system. These responses were also extremely expensive and neither showed satisfactory and proven prior performance of the proposed systems. The specification was therefore clarified to include durability and field experience requirements, and a modified tractor/backhoe configuration was the result.

As shown in Fig. 5, the existing backhoe controls were removed from the tractor and used to establish a remote system control station. Also, the backhoe arm could be removed from the tractor and mounted in a different facility location by extending the hydraulic lines. This alternative provided more freedom of access to difficult-to-reach areas. The end effectors were all off-the-shelf items (a hydraulic breaker, a shear, and a bucket that were available to fit this particular tractor) obtained for this work. Thus, the entire system was made of proven components. Although the tractor was no longer the mobile equipment it originally was, it now served as a stationary platform, with proven hydraulic and mechanical components, to perform the concrete demolition.

As in the case of the vacuum vessel sectioning, the concrete removal system was assembled and checked out on a cold mock-up (shown in Fig. 6) to verify operations and to establish set points and operating limits. Special effort was made to eliminate mixed waste generation by substituting the tractor/backhoe's normal hydraulic oil with a special nonhazardous (nonpetroleum based) oil used in food processing.

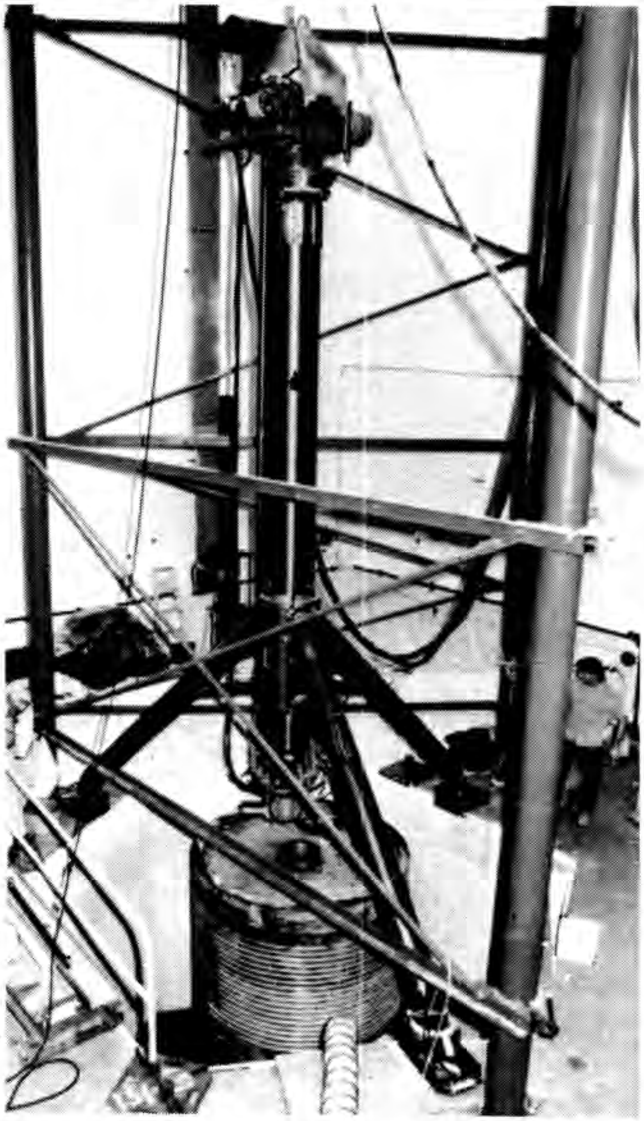


Fig. 4. Vacuum vessel sectioning equipment mock-up.

This modified system with proven components performed extremely well during the removal of the 100 tons of shielding concrete. The end effectors were changed intermittently, (by manual means) for rubblizing, shearing, and for debris removal, as necessary during the operations. Some minor modifications and repairs were required due to using the equipment beyond the original design limits. The equipment is still functional and can be reconfigured to its original (mobile) configuration for other activities.

Steel Liner Removal

As stated earlier, the entire test cell was lined with 0.25-in.-thick carbon steel plate backed by the structural concrete of the facility. Once again, the in-house ISI experience, coupled with existing plasma torch equipment, was used to fabricate systems to remotely cut sections of the plate from the wall (Figs. 7 and 8) and the floor (Figs. 9 and 10) of the test cell.

Linear, motor-driven movements along the X (width) and Y (height) axes were selected for the remote torch movements for the design of the wall cutting device, while variable polar rotation and radial arm positioning movements were chosen for the design of the floor cutting device. Considerations in

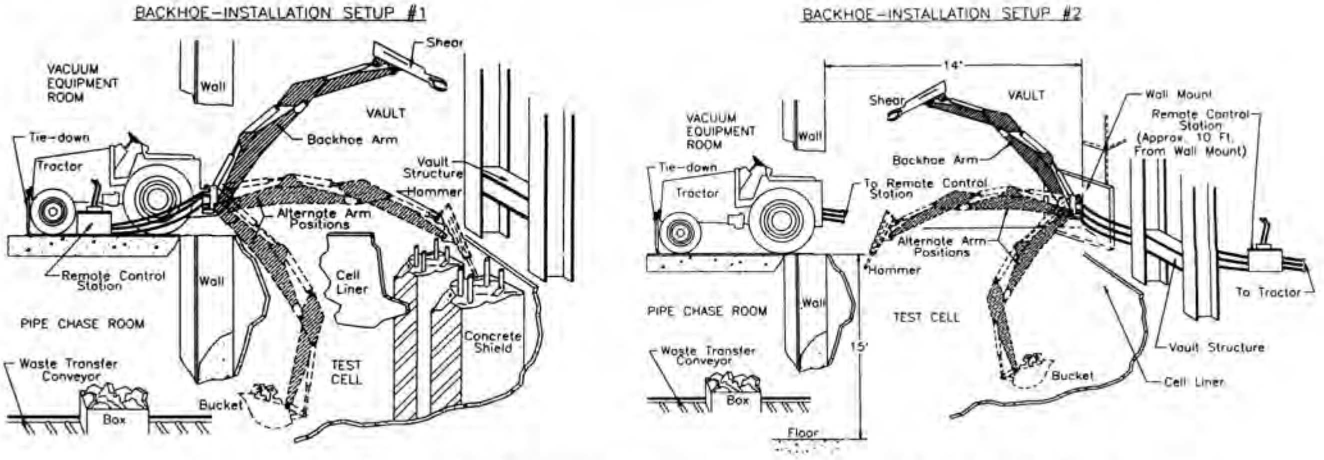


Fig. 5. Backhoe installation for concrete removal: 1) tractor mount and 2) wall mount.

arriving at these two design concepts included the test cell geometry and dimensions, construction methods previously used for the liner attachment to the walls and the floor, and options available for equipment setup and positioning. The preexisting vacuum vessel mounting ring and locator pins, for example, conveniently aided in the installation of the radial floor liner cutting device, and the same locating pins also aided in the installation and alignment of the steel frame that held the wall liner cutting device.

For the wall liner cutting device, coarse Z-axis positioning was by means of manual adjustment of slotted guide rails to set a midrange working gap. Optimum final gap setting was then achieved by tripping a pneumatic positioning cylinder to establish wall contact with a pair of fixed-diameter torch guide wheels. For the floor cutting device, only gravity, the pneumatic cylinder, and the guide wheels were required for establishing and controlling the torch-to-liner gap.

Off-the-shelf catalog items were used to provide torch movement on specially assembled structural frames suitable to the test cell configuration. The equipment performed reliably with few repairs or modifications required to complete the operations. The designs can be adapted readily to other configurations to remotely remove steel liners from walls and floors.

Fig. 6. Concrete removal equipment mock-up test

ACCOMPLISHMENTS

Using the above types of equipment for the steel vessel removal, the concrete demolition, and liner removal, all technical objectives of the present phase of the remediation project were met. Approximately 32 tons of activated steel, coolant piping and conduit, structural supports and test cell liner, and about 164 tons of ordinary, borated, and high-density reinforced concrete forms and structures were processed during these D&D activities. The operations resulted in about 7,300 cubic feet of low level radioactive waste that was packaged and shipped to an authorized disposal facility. Personnel radiation exposures were kept well below all authorized regulatory and internal limits.

Experience from planning, performing the trade studies, designing, procuring components, assembling, mock-up testing, and field operations in harsh and difficult-to-access environments with these equipment indicates that highly satisfactory performance can be obtained by integration and adaptation of proven components. Although experience-based comparisons with more sophisticated equipment (e.g., robotic systems) for performing these operations are currently unavailable, it is probable that such systems would be unable to withstand the punishing environments and loads encountered, and still operate in a reliable manner over sustained time periods, as was the case in this project.

CONCLUSIONS AND RECOMMENDATIONS

Reliable and efficient performances were achieved in: 1) remote sectioning and removal of activated steel by adapting equipment previously used for reactor vessel inspections; 2) remote demolition and removal of the concrete shield and associated pipes and rebar by modifying a tractor/backhoe to a stationary equipment configuration; and 3) sectioning and removal of vertical and horizontal steel liners using plasma torches mounted on specialized frames to enable their remote positioning and movement. All of these operations were performed in areas having difficult access problems, high radiation levels, and requiring sustained heavy-load operations and

Fig. 7. Wall liner cutting torch mock-up test.

Fig. 8. Wall liner cutting torch in test cell.

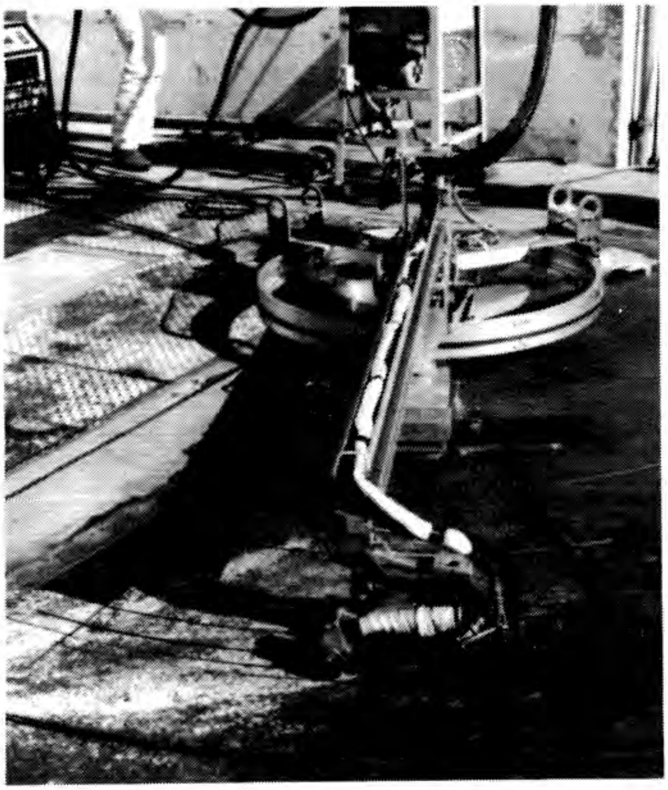


Fig. 9. Floor liner cutting torch mock-up test.

Fig. 10. Floor liner cutting torch in test cell.

long reaches (over 50 ft in the case of the vessel sectioning activity).

Remote cutting of steel and demolition of concrete are two typical activities encountered in D&D of nuclear facilities. Although varying degrees of customization might be required for a given facility, the reliable performance in this project of the equipment assembled with proven components suggests that similar equipment adaptations should be considered in the future for these typical operations.

Performance of trade studies with respect to the particular equipment needed to meet facility-specific requirements and literature and commercial vendor searches are recommended to accomplish cost-effective adaptations, and to eliminate "reinventing the wheel" or costly design and fabrication of unproven, one-time-use equipment.

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