LLNL and DOE Collaborate on Successful Fusion Facility Cleanup

Livermore expertise in handling tritium and low-level radioactive waste, combined with careful planning and multidisciplinary teamwork, led to success.

CAN an industrial building that has been contaminated by large amounts of radioactive and toxic materials be cleaned up well enough to be returned to general use? Thanks to Lawrence Livermore's decontamination expertise, the answer is yes.

Livermore and DOE's Oakland Operations Office teamed up to decontaminate, decommission, and close out—on time and under budget—the Ann Arbor Inertial Confinement Fusion Facility in Michigan. This abandoned facility, which KMS Fusion had used for laser fusion experiments (funded in part by the DOE) from 1978 through 1991, included 60 chemistry laboratories associated with loading tritium into millimeter-size glass laser targets. Thousands of mostly laboratory-size containers of chemicals and solvents, some containing tritium, were scattered around the 9,000-square-meter (100,000-square-foot) building. Initially, there was some question whether it could be decontaminated or would have to be razed.

At DOE–Oakland's request, the Laboratory took over technical oversight of the decontamination and decommissioning effort in April 1994 and, working side-by-side with DOE–Oakland personnel, successfully completed the work a year later—two weeks early—and within the agreed-upon $2.5-million budget. The effort was first estimated to take three years and cost $5 million.

DOE selected Livermore for this effort because of its existing expertise in handling bulk tritium and low-level radioactive waste and for its ability to quickly assemble multidisciplinary teams to meet project objectives under tight time and dollar constraints. Livermore recently demonstrated these capabilities in the decontamination and decommissioning of its own Tritium Facility (see article, *Energy & Technology Review*, March 1995).

"Cleaning up a facility contaminated with tritium involves three activities: decontamination, decommissioning, and closeout," said Mark Mintz, manager of Livermore's Tritium Facility and leader of the Laboratory's overall effort (see Figure 1). "Decontamination involves removal of radioactive or chemically hazardous substances.

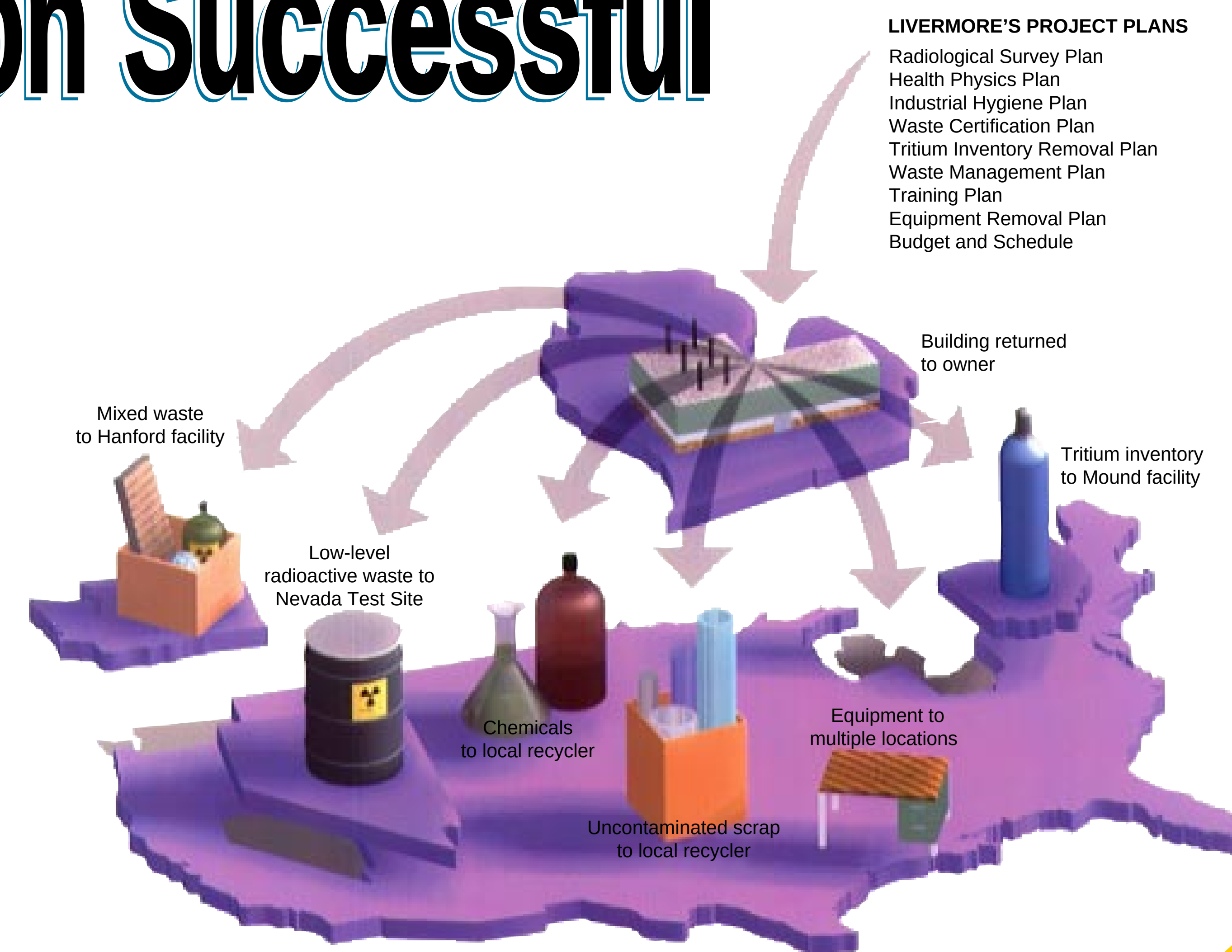

Figure 1. Plans for decontamination, decommissioning, and closeout of the Ann Arbor Inertial Confinement Fusion Facility in Michigan were key to the outcome of Livermore's effort.

Decommissioning is the shutdown, if necessary, and removal of all the experimental and laboratory equipment and office furnishings. Closeout essentially means proper disposition of the government property in the facility." And certification of the wastes had to occur before removal and disposition could take place. (See box pp. 16–17.)

A number of factors made the work challenging. The facility had been abandoned for nearly two years, during which time Michigan's cold winters, combined with deferred maintenance of the heating system, had caused some pipes to freeze and burst. Flooding in areas where chemicals were kept spread contamination and dissolved labels on containers. In addition, some tritium spread inside the building as a result of fighting a fire in a copier room. Tritium also contaminated some asbestos, itself a hazardous material.

Teams Go to Work

To execute the project, the Laboratory formed a team consisting of hazardous waste management experts,

Waste Certification

Laboratory tritium experts turned for help to another small cadre of experts from LLNL's Waste Certification program. These individuals quickly established a process at KMS to ensure that low-level radioactive and mixed (radioactive and hazardous) waste from the closed facility met the stringent acceptance criteria for disposal at both DOE's Nevada Test Site (NTS) and Hanford, Washington, complex.

Two Waste Certification program members, manager Bob Fischer and waste certification engineer John Shingleton, spent several weeks coordinating the waste certification activities in Michigan, while others supported the effort from Livermore. One of the most important tasks at Livermore was developing a waste sampling and analysis plan, which was done by waste certification engineer Blanca Haendler.

Actual sampling was conducted by a Livermore Hazardous Waste Management team. Once the sampling results were back from an outside testing laboratory, Haendler reviewed all the data, which showed that the liquids were primarily mixed waste. As a result, LLNL people arranged for storage at the Hanford site because it is the designated storage/disposal site for DOE mixed waste from non-defense-related programs such as that from KMS.

At KMS, Fischer and Shingleton conducted classroom and hands-on training to ensure that workers understood the requirements imposed by the two waste storage/disposal sites. The training was patterned after existing LLNL training courses and modified for the facility in light of State of Michigan regulations.

Figure 2. At the Ann Arbor Initial Confinement Fusion Facility, waste was packaged for transport after certification by the Livermore Waste Certification staff.

Another important task at KMS was to establish a computer database, modeled after those used at LLNL, to characterize the processes involved in the generation of KMS waste streams. To that end, three former KMS employees were retained to help LLNL specialists conduct a comprehensive room-by-room evaluation of former processes and to identify the contents of 10 stored waste drums. The object was to characterize both the legacy waste (in the drums generated by KMS during its operations) and the process waste that would be generated from the decontamination and decommissioning activities.

All 10 legacy waste drums were sorted and repackaged item by item (Figures 2 and 3), with a few materials removed for special treatment. Then Waste Certification people worked with another Hazardous Waste Management team to package the waste and transport it (with accompanying documentation) to Hanford and NTS.

Fischer notes that waste certification work at Ann Arbor required expertise in container procurement, calibration, tritium monitoring systems, document control, training, nonconformance reporting, waste tracking, surveillance, shipping, certification, radiation detectors, health physics, industrial hygiene, and transportation. Indeed, detailed knowledge in all these areas is needed for everyday tasks that the group performs.

Certifying Waste Day to Day

At Livermore, the Waste Certification program ensures that LLNL manages its radioactive waste to meet the requirements of the designated waste disposal facilities, in particular, low-level radioactive waste destined for disposal at NTS. Some of the work focuses on sampling and analysis of waste streams such as liquid decontamination wastes, gravels, contaminated soil, and high-efficiency particulate air filters.

Other waste streams—such as contaminated laboratory trash, contaminated equipment, and empty containers—are characterized using process knowledge. In evaluating these waste streams, the program relies on detailed questionnaires. Cognizant managers must carefully scrutinize all aspects of waste generation before starting an experiment or procedure that will generate radioactive waste. Then they fill out the forms—and proceed with the task—accordingly.

For example, the process knowledge form asks about specific procedures regarding the use of materials and generation of waste containing gases, radionuclides, and hazardous, toxic, or corrosive substances. The form also specifies special treatment for safety hazards such as any free liquids, fine particles, or compressed gas that might be generated as wastes. Liquids, for example, must be solidified to a "peanut butter" type of consistency before shipment to NTS. In addition, radioactive gases and compressed gases (e.g., aerosol cans) must be depressurized or absorbed. The reasoning behind these restrictions is that NTS employees and the environment might be endangered by contaminated liquids or hazardous fine particles freed from a ruptured waste drum. Such safeguards are also important to protect public health during transport.

LLNL currently has 18 low-level radioactive waste streams certified for disposal at NTS, with an additional 5 waste streams conditionally approved. Low-level waste is the most abundant radioactive waste type generated at LLNL. Because of the multiprogram nature of the Laboratory, a wide variety of radionuclides are contained in the waste matrices. Waste certification engineer Kem Hainebach notes that although LLNL has no high-level waste (e.g., from spent nuclear fuel), there is some transuranic waste (e.g., plutonium-contaminated waste from the LLNL Plutonium Facility), defined as wastes containing long-lived radionuclides heavier than uranium, with half-lives greater than 20 years and in concentrations greater than 100 nanocuries per gram of waste. These radionuclides decay primarily by alpha-particle emission. The program is developing the necessary documents and characterization systems to allow shipment of Livermore transuranic waste to the DOE's Waste Isolation Pilot Plant in New Mexico, which is expected to open in 1998.

Figure 3. Livermore's Bob Fischer and Rod Hollister finish packaging and sealing Ann Arbor waste after it is certified for transport.

Using today's standards and procedures, LLNL ensures that there are no prohibited articles—such as batteries, free liquids, low-level mixed waste, or pressurized aerosol cans—in waste ready for disposal. For example, real-time radiography reveals the contents of drums of "legacy waste," that is, low-level, transuranic, and mixed waste that was not generated under a certification and characterization plan. Most of this legacy waste was generated during the 1980s when documentation throughout the DOE complex was inadequate compared to today's standards. The program also takes representative samples from certain waste streams and sends them to an accredited analytical laboratory. Careful review of the analytical results is required before the waste can be certified. Such efforts are very similar to that required at the former KMS facility in Ann Arbor.

Another important aspect of certification work is verifying generator-supplied waste records against the process knowledge evaluation forms. This important quality-control step provides the necessary assurances to low-level waste disposal sites that the waste meets the waste acceptance criteria. After the material is also verified, it is packaged into authorized waste containers for shipment offsite.

The Future: Ecological and Efficient

Waste Certification people are working with LLNL technical managers to plan the best ways to design experiments to reduce the hazards of waste streams—that is, to test and recycle or release noncontaminated materials and to prevent radiological contamination from spreading to noncontaminated materials. For example, program manager Fischer is helping to design waste management programs for the future National Ignition Facility. The old industry way, he notes, was to "try to figure out what to do with waste after you produce it."

Fischer says that in light of the successes at Ann Arbor, the future may also bring more off-site projects. "I think we've shown that our program can be readily deployed to other sites for substantial time and cost savings," he says.

Indeed, the program is already helping a company in Golden, Colorado, to characterize its wastes, and a much larger project has been proposed to DOE in which Livermore experts would train Bechtel employees at NTS to prepare transuranic waste drums, now in interim storage there, for disposal at the Waste Isolation Pilot Plant in New Mexico.

Figure 4. This "before" photo shows a typical lab in the Ann Arbor 9,000-m^2 facility.

a health physicist, industrial hygienists, hazards control technicians, and former KMS Fusion employees who were familiar with the building's past experimental processes. The team also set up a contract group to do many of the everyday services that are taken for granted at an operating facility—security, phone service, garbage pickup, and janitorial service.

At any one time, 15 to 25 Laboratory and DOE people worked at the facility, some of whom stayed there as long as six months. Livermore's Tom Reitz, the project leader responsible for planning and managing the Ann Arbor field operation, notes that it was not easy duty. During the winter, outside temperatures dropped below zero, and the heating system failure dropped inside temperatures to near freezing even after they purchased a large number of electric heaters to keep pipes from freezing again.

The effort required a close working relationship with the DOE and many other agencies. The State of Michigan had to approve all plans. To handle and dispose of low-level radioactive waste and mixed (radioactive and chemically hazardous) waste, the Laboratory had to obtain approvals from DOE's Nevada Operations Office. To ensure compliance with all applicable requirements, DOE–Nevada and the State of Michigan frequently audited the Ann Arbor work.

The major goals of the cleanup effort were to identify and remove the tritium (present mostly as uranium hydride beds in the processing equipment), analyze and dispose of thousands of containers of chemicals (some of which were also radioactive), decontaminate and dispose of the experimental and process equipment, decontaminate the building itself, and, if necessary, remove any contamination found outside the building. See Figure 4, which shows the "before" condition of one area inside the building.

To remove the tritium-containing uranium hydride beds, the team had to restart the old process equipment—but only after assuring it could be done safely. To do that, Livermore scientists wrote operating instructions, performed dry runs, and made some minor modifications to the equipment. The retrieved uranium hydride was put in approved shipping containers and sent to Mound Laboratories for tritium recovery.

To deal with the chemicals, the team consolidated chemical containers by chemical type and identified and characterized the contents of each. They contracted out the analysis and disposition of the chemicals to a local state-licensed laboratory, which was paid for the work mostly through the value of the uncontaminated chemicals

that were recovered. The team established a waste accumulation area for handling and directing the radioactive chemicals to the proper waste receiver.

Part of the challenge of dealing with hazardous materials involved what project workers called "Easter eggs"—sealed vessels with unknown contents. In one case, the team x-rayed a welded container, which revealed that within the vessel was molecular sieve material, a special type of absorbant that had been used to trap tritium. It was disposed of as low-level waste.

The team assumed that the equipment in the building was contaminated until test results showed otherwise. They performed radiological surveys on all the facility's equipment, mostly by wiping the surface (called swiping) and reading the swipes with a scintillation counter. The team bar-coded each item with a unique identifier and set up a database to track all the samples, swipes, data, and equipment. Clean equipment and contaminated equipment that was able to be cleaned were returned to the DOE, to the General Services Administration, or was sent to government surplus. Low-level waste was sent to the Nevada Test Site for disposal.

Once the team stripped the building of all equipment, they checked the entire facility—i.e., walls, floors, ceilings, ductwork, drains—for residual contamination. Again, they did this mostly by swiping, but they also analyzed bulk building materials such as concrete and sheet rock for radioactivity. Fortunately, most contamination was limited to a surface layer; but for areas too deeply contaminated to clean, the team had to completely gut the main tritium area by removing stud walls and ducting. Here, too, Reitz recalled difficulty in removing contaminated blowers from the slippery, snow-covered roof without compromising the equipment's plastic-bag wrappings to prevent any contamination from spreading.

The exterior of the facility was surveyed in a similar way. This work was done under a separate DOE–Oakland contract by Energy Technology and Engineering Center (ETEC), which also contributed supporting staff for the facility's decontamination and decommissioning activities. ETEC tested walls, doors, and roofs and collected hundreds of samples of the 5 hectares (12 acres) of surrounding grounds. Fortunately, they found no radiological or chemical contamination above background levels.

Challenges Met

At the end of the project, the DOE returned the cleaned building to its commercial owner for unrestricted use. In a fitting conclusion to the effort, the last project people to leave the facility were two former KMS Fusion workers who had spent years working there.

Phillip E. Hill, then-leader of DOE–Oakland's Closeout, Decontamination, and Decommissioning project, summarized, "the project was accomplished efficiently and effectively as a result of DOE and LLNL working together to return the facility to the owner for unrestricted use. With an experienced team headed by Mark Mintz and Tom Reitz, LLNL successfully achieved the Department's goal of returning the facility to the owner while minimizing the cost to DOE."

Key Words: cleanup, decontamination, decommission, disposal, low-level waste, tritium, waste certification.

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About the Scientists

ROBERT P. FISCHER joined the Laboratory's Environmental Operations Group in 1988 after working in the hazardous waste industry since graduation from college. He attended San Jose State University, where he received a B.A. in chemistry and a B.S. in environmental studies in 1986. Currently manager of the Waste Certification program in the Environmental Protection Department, Fischer is also chairperson of the department's Nevada Test Site Working Group.

MARK MINTZ came to the Laboratory in 1992 and joined the Tritium Operations Group in Defense and Nuclear Technologies Directorate. Currently the Tritium Facility Manager, Mintz has written many articles on tritium handling and systems design and articles about materials science. He received a B.S. in physics from the University of North Carolina, Chapel Hill, in 1972, an M.S. in nuclear engineering from North Carolina State University, Raleigh, in 1975, and a Ph.D. in materials science from the University of California, Davis, in 1986. Prior to working at LLNL, Mintz worked for Sandia National Laboratories, Livermore, and General Atomics.