Decommissioning Small Research and Training Reactors; Experience on Three Recent University Projects – 12455

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ABSTRACT

Decommissioning small reactors within the confines of an active University environment presents unique challenges. These range from the radiological protection of the nearby University population and grounds, to the logistical challenges of working in limited space without benefit of the established controlled, protected, and vital areas common to commercial facilities. These challenges, and others, are discussed in brief project histories of three recent (calendar year 2011) decommissioning activities at three University training and research reactors. These facilities include three separate Universities in three states. The work at each of the facilities addresses multiple phases of the decommissioning process, from initial characterization and pre-decommissioning waste removal, to core component removal and safe storage, through to complete structural dismantlement and site release. The results of the efforts at each University are presented, along with the challenges that were either anticipated or discovered during the decommissioning efforts, and results and lessons learned from each of the projects.

UNIVERSITY OF ARIZONA REACTOR DECOMMISSIONING

The University of Arizona operated a Teaching Research Isotope General Atomic (TRIGA) pool-type reactor designed and constructed by General Atomics. The reactor itself was located in the Universities Engineering Building, in a circular pit extending approximately 4.3 m (20 feet) below ground level. Design drawings indicated the pit was constructed of a ¼ inch inner steel tank surrounded by 8 inches of poured concrete. The inside of the tank was lined with a layer of epoxy-coated gunite approximately 5 cm (2 inches) thick. The reactor was constructed in 1958, with an initial licensed power of 10 kW thermal steady state, 30 kW peak. In 1972 the original aluminum-clad fuel was replaced with stainless-steel-clad fuel, and the licensed power was increased to 110 kW thermal steady state, 650 MW peak.

A 2009 characterization survey demonstrated that there were no radiologically contaminated areas outside of the reactor pool. An activation analysis was performed on the core internals and reactor tank to determine the activated product radionuclide concentrations of the core components. The results indicated that the waste associated with the decommissioning would be Class A LLRW, with no Class B&C waste expected.

The Team of LVI Environmental Services Inc. (LVI) and Enercon Services, Inc. (ENERCON) were awarded the work to decommission the facility in February, 2011. On site work began in May 2011, and was completed in October, 2011. Site preparation activities included the installation of a temporary gantry crane, removal of interferences, installation of a portable high efficiency particulate air (HEPA) ventilation system to prevent the spread of contamination during decommissioning activities. Supplemental contamination control measures, such as surface encapsulation media and containments, were also used when appropriate.

Decommissioning activities included removal of control rod drives, the reactor bridge and under water reactor support equipment, including instrumentation, experiment components, fuel storage racks, the cooling coil, and the thermal column. Work then proceeded with the removal of reactor assembly, leaving the lazy susan, reflector, and core internals intact. Components were drained prior to removal, and were either decontaminated on site, or prepared for disposal. The reactor assembly and thermal column were packaged and shipped in a shielded IP-1 container that LVI/ENERCON designed and constructed for the project. LVI/ENERCON packaged, shipped, and disposed of all project wastes on a turnkey basis. Dose rates were lower than estimated, allowing localized handling of the reactor assembly and components.

The originally planned approach to decommissioning included the design and construction of a structural steel frame positioned directly over the reactor tank. The support structure would provide temporary structural support for shoring of the upper portions of the reactor concrete tank that would be left in place, to allow removal of all activated steel, concrete from the bottom 8 feet of the reactor pit. This support structure would also be used to lift the reactor internals from the tank, to lower tooling and personnel into the tank, and to support removal of demolished concrete, steel and soils from the tank.

However, field conditions differed significantly from those suggested by the reactor design drawings on which the decommissioning approach was based. It was determined that soils beneath the reactor room floor could not support the load of the structural steel frame and reactor concrete tank. In addition, the concrete walls outside the steel tank were up the three times thicker than depicted by the design drawings. The Team responded quickly to the change in site conditions and obtained NRC approval to revise the decommissioning approach. The presence of the thicker tank walls ultimately allowed the use of the structural steel frame to be abandoned. The thicker concrete presented some challenges to decommissioning, but it had the benefit of providing sufficient structural support to the reactor tank, during and after activated concrete removal.

Decommissioning activities were substantially complete in August, 2011. Performance of the work during the summer break minimized perturbations to university life, and student body interest in the project was limited.

LVI/ENERCON completed the final status survey in September, 2011. This included an innovative approach to allow for portions of the concrete tank to remain in place by applying the license termination criteria for soils to the residual concrete tank structure. The approach eliminated the need for design and installation of any new structure to support the unaffected upper regions of the thicker-than-expected tank, and allows for license termination to proceed. Site restoration was completed in October 2011by filling the entire reactor tank volume with concrete.

STATE UNIVERSITY OF NEW YORK AT BUFFALO STATE UNIVERSITY REACTOR DECOMMISSIONING

State University of New York at Buffalo (SUNY Buffalo) operated a PULSTAR pool-type reactor designed and constructed by AMF Atomics. The research and test reactor facility was built between 1959 and 1961. The unit has been in Possession Only status since June 23, 1994, with all the fuel being removed from the site in 2005. The reactor was placed into operation in 1961 and operated until 1963 with materials-testing-reactor (MTR)-type fuel elements with a maximum steady-state power level of 1 MWt. In 1963 the reactor was shut down and the core and control systems were modified so that the reactor could operate with Pulse Training

Assembled Reactor (PULSTAR)-type fuel at power levels of up to 2 MWt. In 1964, the facility was re-issued an operating license for its newly modified reactor. The operating license was subsequently renewed for a period of 20 years in 1984. The reactor operated with PULSTAR-type fuel until the facility was shutdown in 1994.

ENERCON was awarded a contract in early 2009 to provide decommissioning planning services to SUNY Buffalo. Initial planning activities included the development of the Historical Site Assessment, (HSA) and the Site Characterization Plan consistent with MARSSIM guidance. Following acceptance of the Characterization Plan by the University, ENERCON's scope was expanded to include all planned decommissioning oversight activities. ENERCON will assist the university in managing all aspects of the decommissioning. ENERCON will also support the University with regulatory interaction and negotiations throughout the Decommissioning Plan approval and license termination processes. ENERCON has performed a comprehensive characterization of the site and has developed the site Decommissioning Plan and cost estimate.

A major pre-decommissioning campaign to remove legacy waste from the facility was completed during July and August of 2011. Characterization of most of the low level radioactive waste was based on the results of 10 CFR Part 61 analyses performed during the facility characterization. In addition, some activated reactor components and equipment that had been previously removed and stored at the facility were characterized based on an activation analysis separately contracted by SUNY Buffalo.

The contents of several fume hoods was carefully inspected and assessed to assure that materials met the waste acceptance criteria of the waste processing and disposal contractor. Mixed waste debris was segregated and packaged for macroencapsulation and disposal. A significant quantity of contaminated lead bricks, elemental lead shielding, and lead pigs were manually collected for recycling.

The effort also included removal of a significant quantity of concrete block that had been used as shielding during reactor operations. ENERCON designed the waste removal request for proposal so that these materials would be considered for low cost Volumetric Clearance for Alternative Disposal programs in Tennessee. Significant decommissioning savings were achieved by using this alternate disposal method for the shield blocks.

The project presented several logistical challenges, in that the facility was not designed for the movement and staging of large quantities of waste. Because of limited space and clearances within the reactor containment, all initial waste material movements were by hand. Intermodal containers could not be loaded indoors and were loaded outside in a lined and controlled waste loading and staging area. An opaque fence was erected to control work site boundaries when dose rates on intermodal containers exceeded 20 μSv/hour (2 mR/hour). Staging space around the facility was extremely limited, and waste shipments were necessarily timed to coincide with empty container deliveries. Containerized waste loading onto trucks required temporary lane closures on an active University road.

ENERCON provided turnkey waste collection, characterization, packaging, and shipping manifest preparation services for the legacy waste removal project. A total of over 121,000 kilograms of waste were shipped, as described in Table I.

TABLE I. SUNY BUFFALO LEGACY WASTE VOLUMES

Waste Description	Kilograms
Low Level Radioactive Waste (Dry Active Waste)	17,600
Depleted Uranium Shield Blocks	8,450
Contaminated Lead (Pb) for Recycling	25,900
Mixed Waste (Radioactive and Chemically Hazardous)	3,180
Activated Metals	5,500
Volumetric Clearance for Alternative Disposal	60,620

Future planned activities include efforts to remove asbestos containing material as a pre-decommissioning and interference removal activity. In 2012, a competitive bid process will be used to select a Dmolition Contractor. ENERCON will provide oversight of the decommissioning contractor and will perform the site final status survey following completion of decommissioning activities. Decommissioning is currently scheduled to be completed in 2013.

UNIVERSITY OF ILLINOIS NUCLEAR REACTOR LABORATORY DECONTAMINATION AND DECOMMISSIONING

The LVI/ENERCON Team was awarded the contract to decontaminate and decommission the University of Illinois Nuclear Reactor Laboratory (NRL) in August, 2011.The University of Illinois operated a TRIGA Mark II nuclear research reactor, manufactured by the General Atomic Division of General Dynamics Corporation in the NRL. Construction began in the summer of 1959 and the reactor first went critical on August 16, 1960. The reactor initially operated at a maximum power rating of 100 kW using fuel elements with a zirconium hydride moderator homogeneously combined with enriched uranium. By 1967, upgrades and license amendments allowed for the operating limit to be increased to 250 kW, and upgrades after 1967 boosted steady state operation to 1.5 MW and pulsing to 6000 MW. In August 1998, nearly 30 years after initial start-up and after 11,566.7 megawatt-hours (MWhrs) of operation, the TRIGA reactor was shut down permanently. In 1999, the reactor was officially placed in a SAFSTOR condition while waiting for arrangements to be made to remove and ship the reactor fuel. In August 2004, the reactor fuel was removed and shipped to the U.S. Department of Energy's (DOE) Idaho National Laboratory.

LVI/ENERCON began work on the University of Illinois Nuclear Reactor Laboratory decommissioning in October, 2011. Completion of physical work and site restoration is anticipated by July, 2012. Initial efforts included upgrade and certification of the crane, and testing of temporary ventilation components to control airborne contamination generated by decommissioning activities. The reactor facility was prepared for decommissioning by removing and packaging legacy waste, including radiological debris, glove boxes, universal waste, lead, and other hazardous materials. Clean equipment and debris (furniture, electronic equipment, books, tools, etc.) was also surveyed, released, and removed from the building. Utilities were identified and isolated in preparation for reactor and systems removal activities. Final building isolation will be performed prior to demolition. The beam tubes were plugged to maintain reactor tank water levels, since they penetrate the reactor tank and reflector.

Reactor component removal began with removal of remaining control rod drives, guide tubes, reactor bridge, and underwater interferences, such as fuel racks, instrumentation, cooling lines, and irradiation components. These items were initially removed to allow removal of the top 10 feet of Bioshield. Prior to the removal of the reactor assembly, removal of clean portions of the bioshield and bulk shield tank will proceed. Bioshield demolition will consist of removing the top 10 feet of the bioshield. This portion of the work will be accomplished by wire saw cutting, which offers excellent contamination control as well as effective bulk segregation of affected and unaffected concrete regions. The clean concrete will be surveyed and released as non-radioactive material for recycle or disposal.

The lazy susan will then be removed prior to draining the tank. This sequence will reduce personnel exposure and allow a more controlled removal process by utilizing the water shielding during component dismantlement. Depending upon dose rates, the water may be drained prior to removing the reactor assembly, which will alleviate the risk of water loss upon sectioning the beam ports from the reflector, and simplify the dismantling operations.

The next task to be performed is to cut the convective cooling loop, J-Tube, and beam ports from the reactor assembly and then unbolt the core support plenum from the tank bottom. The, grid plates, , and other reactor internals will be left in place for packaging as one intact unit. The reactor assembly will be placed in an appropriate container TBD.

Activated material removal from the lower Bioshield will then be performed using a BROKK. The material will consist of concrete, rebar, tank liner, portions of the beam ports, and the shadow shields.

After the reactor assembly and activated materials have been safely removed, the LVI/ENERCON team will remove the remaining radiologically contaminated systems from the building structure, which will include:

- Primary coolant piping
- Nitrogen-16 delay tanks
- Reactor heat exchanger and pump
- Wastewater system and filters
- Retention tank, holdup tank, and filters
- Fuel storage tubes

The systems removal effort will be followed by a building surface decontamination effort. After decontamination, LVI/ENERCON will perform preliminary release surveys of the interior and exterior surfaces of the reactor facility structure to show that the license termination criteria in the approved decommissioning plan have been met.

After completion of the preliminary release surveys, the reactor facility structure, slab, pits, and foundation will be demolished using standard construction methods. The debris will be disposed at a local solid waste landfill.

The final survey will consist of a surface scan that will be performed by the health physics technicians on soil and pylon surfaces, and will include systematic soil sampling. Samples will be collected from any surface/area that exceeds the release criteria and it will be marked and set aside for decontamination/removal and resurveying. Once all required surveys are performed, the area will be considered complete and the Team will move to the next area. The completed decommissioning and survey work will be subject to independent NRC/ORISE confirmation final status surveys and sampling.

The decommissioning of the Nuclear Reactor Laboratory is occurring in the middle of a busy college campus primarily during the fall and spring semester and it is unavoidably a high-profile project. However, the balance between the University communities' right-to-know and the need-to-know aspects of site security must be handled carefully. During the initial project mobilization, the University hosted a public meeting for University personnel and community members to inform them of the pending project.

LVI/ENERCON also met separately with site security and emergency response personnel, including personnel from the local hospital emergency room. Emergency response personnel were informed of the types of radioactive materials present in the reactor facility and that would be transported in project waste shipments. Emergency response personnel were also informed of the likelihood and types of contamination events and other accidents that could result in personnel requiring on-site emergency medical attention or attention at the hospital emergency room.

Because the University has a Nuclear, Plasma, and Radiological Engineering program and a student chapter of the American Nuclear Society, LVI/ENERCON has offered routine project updates to students and staff associated with these programs. The team has also employed a University student intern to work on the project, and to support liaison with the University community. In addition to the Reactor Administrator, one of the professors from the engineering program has been an active observer of project activities, serving to keep students and other university personnel informed

Site restoration will not be started until the soil sample results and survey results for exposed soils show that the license termination levels in the decommissioning plan have been achieved. When these results have been confirmed by the LVI/ENERCON team, we will provide the information to the University. After the NRC's confirmatory inspection verifies that field work is complete and has met the decommissioning plan license termination criteria, and upon approval by the University, we will commence site restoration activities. Restoration consists primarily of restoring the site to grade, using pre-screened (uncontaminated) and compacted soil.