Removal of Radioactive Waste Tank and Drain Lines from the Whiteshell Laboratories Research and Development Laboratory Complex - 14341

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ABSTRACT

Whiteshell Laboratories (WL) is a nuclear research establishment owned by the Canadian government and operated by Atomic Energy of Canada Limited (AECL) since the early 1960s. WL is currently under a decommissioning license and the mandate is to remediate the nuclear legacy liabilities in a safe and cost effective manner. The WL Project is the first major nuclear decommissioning project in Canada and is being decommissioned under the auspices of the Natural Resources of Canada, Nuclear Legacy Liability Program. A major initiative underway is to decommission and demolish the main R&D Laboratory complex. The Building 300 R&D complex was constructed to accommodate laboratories and offices which were mainly used for research and development associated with organic-cooled reactors, nuclear fuel waste management, reactor safety, advanced fuel cycles and other applications of nuclear energy. Building 300 is a three storey structure of approximately 17,000 m^2. In order to proceed with building demolition, the contaminated systems inside the building have to be characterized, removed, and the waste managed. The Uranium Thorium Separation (UTS) and the low level liquid waste (LLLW) drain line system were two such radiological systems contained in Building 300 that required decommissioning and removal.

The UTS tank was used to collect thorium-nitric acid solution generated in the Uranium Thorium Separation (UTS) process and was a 2300 liter vertical cylindrical tank. The tank was drained and the heel was neutralized and removed, with residual crud remaining on the tank walls. The clearances in the room containing the tank were small, and as a consequence the tank had to be sectioned in-situ. Sectioning was done by use of electric plasma cutting and chipper saw.

The LLLW system was designed to drain radioactive liquid waste from radioactive material handling fume hoods, radiological sinks and floor drains in Building 300. Building 300 contains a few laboratories that posed primarily an actinide contaminant hazard and the remaining laboratories posed mixed fission product/actinide contaminant hazards. All of these laboratories fed into the LLLW drain line system. The removal of these drain lines encompassed the disconnection of a series of 92 glass drain line branches originating from laboratories located on the highest point on the 2nd floor leading down further through laboratories and rooms on the 1st, and basement floor levels and accumulating into stainless steel lines running down into the Building 300 crawlspace leading to the main header. The (non-compacted) volume of drain lines

was estimated to be 1.63 m^3 and approximately 200 sections of line were removed, totaling 337 m in length. Various low-tech measures were used to protect the workers and environment during disconnect and removal of the drain lines while minimizing time and cost to remove the drain lines. Such measures included the use of modified glove bags, expanding foam and shaving foam, as well as in-field actinide monitoring, protective clothing and respirator protection. A combination of swipe analysis and use of an in-situ object counting system was used for final characterization of the removed drain lines.

Operating experience and lessons learned during the removal of the LLLW drain lines and UTS tank have been recorded and incorporated into future decommissioning projects.

INTRODUCTION

Building 300 (B300) was constructed in various stages from 1966 to 1985 to accommodate laboratories and offices for research and development associated with organic-cooled reactors, nuclear waste management, reactor safety, advanced fuel cycles and other applications of nuclear energy.

In preparation for eventual demolition of B300, radioactive drain lines and contaminated tanks first had to be removed. For the drain lines, this included disconnecting and removing the drain lines, associated fume hoods, sinks, drains, and obstructing cabinets and ceiling tiles. For the contaminated tanks, this includes removal of the tanks and their associated piping.

The drain lines and tank sections were handled according to job specific hazard/risk assessment and work instructions.

Most waste generated from this work were impossible/impractical or economically unreasonable to decontaminate, or could not be verified to satisfy unconditional release criteria. As such, they were placed in waste storage containers, compacted if possible and placed into waste storage on site.

SYSTEM DESCRIPTION AND SCOPE OF WORK

UTS Tank

The Uranium Thorium Separation (UTS) tank was used to collect thorium-nitric acid solutions generated in the Uranium Thorium Separation research and development process conducted in the 1980s. The UTS tank was a 2300 litre vertical cylindrical tank with flanged and dished ends, and stood 2.1 m tall. The material of construction was 316L stainless steel and was constructed of 8 mm rolled plate walls with 9 mm thick end caps.

The scope of work for the UTS tank removal included disconnecting, disassembling and removing the tank and associated piping. Drain lines connecting the Uranium Thorium Separation (UTS) process equipment to AD-TK7 tank and any remaining contents, were removed previously.

The work involved the following specific tasks:

- Review Hazards and Risks and develop a plan.
- Set up of tools and equipment and clearly mark work areas, and contamination control boundaries.
- Prepare work area(s) and establish required ventilation controls.
- Prepare tank by removing exterior pipe, valve, ventilation and other peripheral connections.
- Mark and cut up tank and associated drain pan into suitable sizes, in-situ.
- Characterize, package and remove tank sections and other associated waste.
- Repair or fire stop any floor and wall penetrations.
- Return the room housing the tank to WL Decommissioning Operations for re-use.

LLLW Drain Lines

LLLW system was designed to drain radioactive liquid waste from radioactive material handling fume hoods, radiological sinks and floor drains in Building 300. The drain lines originated from labs spanning three floors, which connected to a main header in the building crawl space. The total length of drain lines were 337 m (~1100 feet) and consisted of 38 mm (1.5”), 50 mm (2”), 75 mm (3”) and 100 mm (4”) piping. The piping was predominately glass although some lines were stainless steel (mainly those in the building crawl space). The LLLW drain lines were configured in a series of 92 drain line branches, which linked together, originating from laboratories on 2nd, 1st and basement floors which connect to a main header in the building crawl space. The labs in B300 were used for a variety of experiments involving actinides, dissolved nuclear fuel, fission and corrosion products, irradiated pressure tubes, amongst others.

The scope of work in removing the drain lines included disconnecting and removing radioactive LLLW piping, fittings, sinks and drains from sources within the laboratories, and sealing closed the severed pipe connection. Each branch was removed starting at the highest point in the branch and working toward the main header in the crawl space, starting on the branch with the lab with the lowest hazard working up to the highest, for each floor. Severed connections to the main header were capped to allow the LLLW drain system to continue servicing other facilities.

The work involved the following specific tasks:

- Review Hazards and Risks and develop a plan.
- Creating access to the drain lines.
- Verification of in-field piping against drawings.
- In-field radiological survey and characterization of piping.
- Establishing appropriate contamination zone controls.
- Disconnecting and capping waters sources at sinks and drain pipes.
- Disconnecting and removing sinks and fittings.
- Removal of cabinets and countertops housing sinks and fittings.
- Disconnection and removal of drain pipes including any abandoned drain piping.
- Obtaining waste radiological characterization swipes and radiation measurements.

- Reassessment of the hazard.
- Cutting pipe to length suitable for placement in waste containers for storage at WL WMA.
- Segregating of workplace generated wastes into likely clean and radioactive waste based on radiological screening surveys.
- Clearance monitoring of likely clean material if feasible and processing of radioactive waste.
- Sealing of floors and ceiling passages with fire stop as required.
- Final radiological surveys of areas.

RADIOLOGICAL HAZARDS

The primary radiological hazard for both the UTS tank and LLLW drain line removal was potential dispersion of loose contamination, leading to airborne contamination, clothing and skin contamination and/or contaminated cuts. The external radiation hazards for these jobs were minimal.

UTS Tank

The UTS tank and associated drain and sampling lines, contained Uranium/Thorium Separation solution. The primary radionuclides of concern, which were found on the interior of the tank on the order of 1E4 to 1E6 Bq/L,were:

- Uranium and progeny
- Thorium and progeny

Secondary radionuclides of concern were found on the tank exterior and room surfaces, were:

- mixed beta/gamma/alpha emitting fission products: Cs-137, Sr-90 with trace amounts of Am-241 (Cs:Am = 40 to 80:1).
- The tank exterior and drip tray also had Th-232 and progeny.

Working dose rates for this job were on the order of 0.1 mSv/h. The total collective dose measured during the execution of the work was 0.182 p-mSv and the highest individual dose was 0.021 mSv as recorded by electronic personal dosimeters (EPDs). Maximum external whole body dose rate, as recorded by EPDs, encountered during the execution of the work was 0.21 mSv/h.

LLLW Drain Lines

The labs in B300 were used for a variety of experiments involving actinides, dissolved nuclear fuel, fission and corrosion products, irradiated pressure tubes, amongst others. The primary radionuclides of concern were:

- Mixed fission products from irradiated fuel (Sr-90, Cs-137, Am-241) used in some labs
- Actinides from plutonium compounds (Am-241, Pu-238, Pu-239, Pu-240, Pu-241) used in some labs

Secondary radionuclides of concern were:

- Tritium (H-3)
- Np-237 used in sorption studies

It was not believed that any significant amounts of these radionuclides were disposed through the radioactive drain lines during their operational lifetime.

Working dose rates for the job were generally < 10 µSv/h. The maximum daily dose a worker received was 0.018 mSv, which was by a senior Radiation Surveyor during the characterization and source removal activities, when there were higher sources of radiation present in the labs. The collective dose received during pre-drain line removal activities was 0.029 p-mSv, which took place over a period of 5 days. The collective dose received for the removal of drain lines located in the basement, first and second floors of B300 was 0.008 p-mSv, which took place over a period of 2.5 months. The collective dose received for the removal of drain lines located in the B300 crawlspaces was 0.003 p-mSv, which took place over a period of 1 month.

WASTE MANAGEMENT

Most components, materials and equipment removed from the UTS tank and LLLW drain lines were treated and managed as radioactive waste.

UTS Tank

Removed tank piping and lines, and cut and section tank pieces were individually wrapped in plastic and sealed with tape and transferred for placement in a B-25 waste container for management as non-compactable solid low-level radioactive waste.

LLLW Drain Lines

Stainless steel drain line sections were cut into ~1.8 m sections (~5 feet) so that they could fit into a B-1000 waste storage container. The (non-compacted) volume of drain lines was estimated to be 1.63 m^3 and approximately 200 sections of line were removed, totalling 337 m in length. Glass drain line sections which were too long to fit into a B1000 were placed in a specially made waste container to fit longer items. Radioactive waste that went into a B1000 was compacted and sent to Whiteshell's Shielded Modular Above Ground Storage (SMAGS) facility.

IN-FIELD WORK , PROCEDURES, PRACTICES AND TECHNIQUES

UTS Tank

Pre-work characterization was done by cutting a section of the tank open, and obtaining samples. Most characterization was completed by doing this, and little to no characterization was required during the actual execution of the work.

The UTS tank was sectioned in-situ (See Figure 1). A number of techniques were assessed for sectioning the tank, including a plasma cutting torch, a chipper saw, and mechanical nibbler. A plasma torch was selected as the primary technique for the present job to evaluate its effectiveness for potential use in future decommissioning activities, with a chipper saw available as backup. As sections were separated from the tank, they were directed into the tank (See Figure 2), safeguarding the workers from the hot surface and jagged edges. When the bottom of the tank was too full, cutting was stopped and cut sections removed. After cutting, cutting debris was vacuumed with a HEPA vacuum. Sectioned pieces of tank were then bagged and disposed of in a B25 waste container.

An additional barrier was implemented by covering the tank surface and openings to aid more in controlling the plasma sparks and heat away from the workers directing more of it back into the tank. The use of large fire blanket was implemented to create the additional separation barrier while the workers were working above the tank.

Smoke generated by the plasma cutting equipment was a concern due to the limited space within the UTS tank room. As part of the planning and preparation, WL Engineering developed a ventilation and monitoring control plan in conjunction with HVAC, specifically outlining a procedure and conditions required during the Plasma cutting work. Implementation of a portable "High-Efficiency Particulate Air" (HEPA) air-handling unit with a flexible trunk hose and conical air inlet to capture smoke and fumes generated during the tank cutting to help reduce or eliminate smoke generated during plasma cutting.

When cutting the UTS tank using the plasma cutter, workers donned plastic suits with airline respirators.

With a third of the tank wall section remaining, the power chipper saw was tested to aid in planning similar work in the future and to provide cutting method comparison information. Use of the chipper saw required less additional support in the way of air monitoring / airflow controls / requiring only Tyvek® suits and standard full-face respirators (as opposed to plastic suits with airline respirators). With two operators, the chipper saw was able to remove more material in a single shift as operators were also able to remain working longer due to the lifted work-rest restrictions when wearing plastic suits and no longer needing to frequently change clogged-up HEPA filters as a result of plasma cutting.


Figure 1: Sectioning UTS tank in-situ **Figure 2: Sectioned pieces of the UTS tank at the bottom of the tank**

A Closed Circuit Television (CCTV) camera and monitor, including an audio surveillance system was installed to aid in monitoring of activities within the tank room. The system was identified to enhance safety and provided continuous communication and crew status information through the stages of work. A hand held marker white board was also located in the room to provided additional clarity of any audio information being provided by the workers inside, strengthening three-way communication, over potential respirator and room noise if required.

LLLW Drain Lines

Pre-work characterization of the drain lines included walking down the accessible drain line section with 3x3 NaI detector, and taking swipes of fume hood sinks. It was not possible to do full characterization prior to start of the work, due to the vast number of branches, and the inaccessibility of the inside of the drain lines. Drain lines originating from actinide handling labs were assumed to have undetected alpha contamination from external survey. Ongoing characterization took place as each section of drain line was removed by obtaining a contamination swipe from each end of a disconnected section of drain line. Sections of drain line that could not be internally accessed by a contamination swipe, even after removal (mainly stainless steel lines), were gamma analyzed via In-Situ Object Counting System (ISOCS).

Drain lines were removed starting with the furthest up stream, moving down stream to the header. This way a slight negative pressure was maintained when working on the lines. On each floor, radioactive drain lines were removed from lowest hazard to highest hazard when feasible.

Modified glove bags were used on all actinide hazard glass drain lines, drain lines with visible presence of material/sediment inside and at the first bend in a new drain line section (i.e., the first bend coming from a drain source). A modified glove bag is a sleeve that fits over the section of drain line that is to be removed and partially over the adjacent section of drain line. It allows for de-coupling and removal of a section of drain line while containing the open ends of the drain line. After the target drain line section is decoupled from the rest of the line, the section of pipe can then be easily separated by taping it off and then cutting it off at the isolation point so that the two resulting ends are still closed off from the outside. The section of pipe to be disconnected is now completely isolated from the outside of the plastic sleeve. See Figure 3.

If no glove bag was required, the floor underneath the section of drain line was covered with plastic, the glass disconnected at their joining clamps, and the removed section bagged and disposed of appropriately. The remaining open end of drain line was then capped with plastic

Figure 3 Drain lines under fume hoods and a close-up of a modified glove bag on a glass drain line

The majority of the pipe cutting (non-glass lines) was done with a battery-powered band saw instead of a reciprocating saw to reduce the spread of debris generated from cutting. In addition, band saw blades remain cooler during operation.

Since non-glass drain lines had to be cut, it was proved too tedious and time consuming to perform a modified glove bag with a band saw inside of the bag. A solution was developed that did not require a glove bag. First, a small hole was drilled into the top of the drain line and expanding foam[1] was then injected via the drilled hole at the top of the pipe to stabilize/fix contamination in the drain lines prior to cutting. The pipes were then cut using a band saw at the location where the foam was inserted. A tray lined with wet wipes was placed under the pipe and collected the cut filings. After the line was cut, the open ends were bagged and the section removed. For reciprocating saw cuts, in addition to foaming, shaving cream was applied around the outside diameter of the pipe, and then the cut made at the location of the shaving cream. This considerably reduced the dispersion of cutting debris/contamination. Shaving cream was not required for band saw cuts because of an additional risk of the band saw blades dislodging if they got wet. Moreover, debris from band saw cuts is minimal.

Low cost, off-the-shelf items such as expanding foam and shaving foam proved effective in the safe and efficient removal of the drain lines and minimized the spread of contamination by containing it. This method was much faster than glove-bagging every 5 or 10 feet.

[1] Many expanding foams were tested on a mock-up. The expanding foam that worked under the circumstances was a two part foam that did not require external moisture to cure.

Drain line sections needed to be approximately 5 feet long in order to fit in a B1000. However, drain lines were drilled and foamed every 10 feet in-situ and then cut at these locations. Each 10 foot section was then brought out into a more ergonomic favourable location where they were drilled and foamed in the middle and then cut.

Figure 4: Inserting expanding foam, drilling a hole, and cutting a drain line with a band saw

Figure 5 Examples of cut drain lines with expanding foam inside

DOSIMETRY

Routine dosimetry common to both the UTS tank removal and the LLLW drain line removal included the following:

- Wearing of a Thermoluminicent Dosimeter (TLD) on the torso of the body (official dose),
- Whole body counts ranging from annually to every 60 days,
- Beta-in-urine analysis every 60 days.

- Work place air sampling (WPAS) performed in the vicinity of workers within the work area during cutting and disconnecting activities,
- The pipefitters wore personal air samplers (PAS) during plasma torch cutting operations,
- Personnel who may have a prior history of possible exposure to actinides had to submit Pu-in-urine sample for subsequent baseline TIMs analysis. This included any personnel who may have worked in labs or rooms with actinide radionuclides or performed work at non-WL locations with a risk of actinide exposure.
- Beta-in-urine sample and whole body count as soon as practical after completion of work package.
- Perform regular contamination swipes to confirm surfaces are remaining contamination free or below radiological control hold points.

Non-Routine dosimetry common to both the UTS tank removal and the LLLW drain line removal included:

- Nose-Smears and blows following any known or suspected inhalation intake (e.g., CAM alarm, facial contamination, high skin contamination, high clothing contamination – no respirator).
- Whole body count and/or collection and analysis of urine after any known or suspected intake as indicated by air monitoring, nose smear or blow, contaminated wound, high skin contamination or as directed by RP or Dosimetry staff.

WPAS, PAS, nose smears and contamination swipes were sent daily for total alpha and beta counting and gamma spectroscopy, to confirm no evidence of airborne contamination or the adequacy of respirator protection.

LESSONS LEARNED

UTS Tank

- Plasma cutting was found to work well, however the thickness of the tank wall was found to be underestimated for the top and bottom sections, which resulted in the purchase of a plasma cutter with insufficient output. A plasma unit with a larger cutting range may have provided additional latitude for those conditions.
- The portable HEPA filtration system used required continuous monitoring and maintenance to maintain its effectiveness. The thickness of the tank resulted in excessive smoke being generated which rapidly clogged the HEPA filter (smoked scrubber was not used) which required replacing after every 20 minutes of plasma cutting. It was felt that the filter alarm located on the HEPA, may have been set too low and that the time it took to change filters was excessive.
- Use of plasma cutting equipment within a potential contaminated environment presented safety / protection issues for the operators. Conservative planning supported the use of plastic suits on airlines in addition to the use of welding leather on top to protect the suits. The combination was found to be bulky and restrictive and created over heating of the

operator. Additional supporting personnel and training were required to effectively dress the two operators quickly and simultaneously in an effort to gain safe and optimal operator time.

- The project used an audio and video system to aid in communication and monitoring of the works inside the UTS tank room along with a hand held white marker board. The audio and video system supported communication between workers inside the room and the support team outside. Inside, the workers found it difficult to communicate between themselves due the plastic hoods and using an airline respirators. It was suggested the use of wireless communication systems could be used in similar work conditions.
- An opportunity to make brief comparison testing between plasma cutting and a hand held chipper saw was also conducted in the reduction of the UTS tank. Use of the chipper saw required less additional support in the way of air monitoring / airflow controls / requiring only Tyvek® suits and standard respirators. With two operators, the chipper saw was able to remove more material in a single shift as operators were also able to remain longer at the task. Overheating of the operators was not as critical, however there was more effort in handling and supporting the saw in situations where the saw was not supported by the surface being cut.
- In using the chipper saw it was also observed that using the saw in combination with plasma cutting, caused difficulty in crossing the saw over previous plasma cut material. The heat from the plasma system hardened the edges of the previously cut stainless steel surfaces and would damage the carbide teeth of the saw. As well, the saw was less able to negotiate tight spaces and obstructed surfaces.
- Acquisition of more specific portable equipment designed for smoke management may have been more effective.

LLLW Drain Lines

- As expected, the further downstream the drain line branch, the higher the level of contamination was found.
- The joining clamps of drain lines were the most prone to accumulating contamination (radioactive and non-radioactive)
- Foaming pipe thru a drilled hole, when both ends of the pipe are closed off, presented a potential risk of back-pressure spray and must be conducted in PPE (i.e., Respirator and Tyvek® Suit) to protect the worker from any possible contamination picked up on the foam spray. Alternatively, if possible, avoid foaming shorter, closed off sections of pipe.
- The expanding foam did a good job containing most contamination. If there were larger accumulations of contamination, then the expanding foam only contained some of it, and some of it did come out.
- A disadvantage of the foam is that it did not allow for access to make direct swipes on the line.

CONCLUSION

B300 is one of a number of nuclear facilities at the AECL Whiteshell Laboratories that require decommissioning. The decommissioning activities in B300 has enabled AECL to gain experience, lessons learned and expertise in removing contaminated drain lines, piping and tanks that will be applied to future removal on similar and higher hazard systems/equipment more safely and efficiently.