

## **Large Cask, Small Building, AREVA's Safe MLLW Disposal Solution Despite Facility Limitations – 16295**

Ronnie T. Broughton\*, PE, PMP, Adam Jones\*, PE, Paul Scott\*\*

\*AREVA Federal Services, LLC [Ronnie.Broughton@areva.com](mailto:Ronnie.Broughton@areva.com)

\*\*URS | CH2M Oak Ridge LLC

### **ABSTRACT**

In order to begin decommissioning of a 1950's research reactor, Class C Mixed Low Level Waste (MLLW) had to be removed from the facility and disposed of. The AREVA TN RAM cask, designed and licensed for shipping Type B waste packages, was chosen as the most appropriate shipping solution. Due to the building layout, crane capacity and pool size, the standard TN RAM cask loading process could not be utilized. Unique solutions and approaches had to be developed to complete the project.

AREVA designed a smaller liner insert that would house the four MLLW components in a single waste package to solve the problems related to crane capacity and physical pool dimensions. AREVA also designed and fabricated a shield bell to provide radiation shielding while moving the liner insert from the reactor pool to the cask that was staged adjacent to the reactor pool.

The AREVA team worked with the disposal facility to cover requirements for disposal of Class B MLLW. This included designing spacers filled with inert material to fulfill the requirement for maximum 10% void space in the waste package. This disposal method for Class C waste met the requirements of macro-encapsulation. Therefore, no additional treatment action was required when disposing of Class C MLLW.

AREVA's solution provides a model for disposing MLLW requiring macro-encapsulation in a single waste package. This solution also provides a model for how to adapt large shipping casks and liners to smaller aging commercial, DOE or research facilities.

### **INTRODUCTION**

In September 2014, it was discovered that the reactor pool of a 1950s era research reactor was leaking. Upon discovery, a team was formed to identify recovery options and develop plans to mitigate the hazards associated with the leaking reactor pool. The resulting solution was to remove the highly radioactive components from the pool, seal the pool with concrete plates, drain the water and then introduce a fogging agent to fix the remaining surface contamination.

A solicitation was issued in January 2015 and was subsequently awarded to AREVA Federal Services (AREVA) in May 2015.

The AREVA team was comprised of AREVA Federal Services which managed the overall contract and provided engineering design for spacers and the liner insert. The Reactors and Services division of AREVA Inc. provided tooling design and fabrication for items required to facilitate the underwater work operations. This division also provided the resources to perform the underwater operations with long-reach poles. The AREVA TN division of AREVA Inc. provided the TN RAM Cask for transport of the packaged waste. The AREVA team utilized Philotechnics Ltd. for waste profiling operations and Waste Control Specialists (WCS) for disposal operations.

The general work scope was to characterize, remove profile, package, certify and transport four irradiated components to an approved off-site facility. The packaging and removal process was to be completed in a two week window after mobilization, work planning and readiness assessments were completed. The irradiated reactor components selected for removal are listed in TABLE I. The material makeup of the three plates and the lead counterweight resulted in a MLLW classification which required special handling and disposal methods.

TABLE I. Irradiated Component Characteristics

<b>Component Name</b>	<b>Expected Weight [kg]</b>	<b>Measured Weight [kg]</b>	<b>Expected Dimensions [mm]</b>	<b>Component Rad Measurements</b>
Reactor Grid Plate	79	79	561x691x76	2173 R/hr, 2.71e+12 Bq Co-60
East Shield Plate	261	231	787x660x64	2446 R/hr, 3.85e+12 Bq Co-60
West Shield Plate	154	113	787x635x38	2158 R/hr, 1.02e+13 Bq Co-60
Lead Thermal Shield Counterweight	145	104	279 Dia. x 356 Length	239 R/hr, 1.04e+11 Bq Co-60

### **Situational Challenges**

Situational challenges started with the building itself. There were two loading bays on the east and west ends of the building for mobilizing equipment into the work area. Each set of access doors had an opening that was 3.7 m wide by 6.1 m high. The largest staging area was inside the east door which was approximately 6 m long by 3 m wide. Due to the size of the cask and transport trailer along with the

limited area available outside of the facility, a Goldhofer trailer was utilized to move the cask into the facility.

The pool footprint, of 3.4 m by 18.3 m [1], is much smaller than commercial pools. In addition, shelves were located on the pool walls which left an opening approximately 2.4 m wide through which all work had to be performed. This small pool size restricted the types of equipment and waste containers that could be used.

The overhead crane available for maneuvering equipment in the building was rated for 20 tons. This posed another challenge because the empty shipping cask with disposal liner has a combined weight of 35 tons. The normal cask loading process involves lowering both the cask and liner into the reactor pool to maintain a higher level of shielding. The crane capacity did not allow for normal lifting of the shipping cask. The hook for the overhead crane could not be lowered into the pool to retrieve components from the bottom of the pool because the distance from the fully-retracted crane hook to the top of the water surface was less than the full depth of the reactor pool. As a result, a retractable hoist had to be used under the main hook so that equipment and tools could be lowered to the bottom of the pool and fully retracted above the pool.

AREVA was required to develop alternative methodologies to manipulate the three plates based on the age and unverifiable condition of the existing wire cables.

Vertical head clearance and crane capacity with a fully loaded liner and required shielding eliminated the ability to lower the disposal liner into the pool for waste loading. There was not sufficient room or crane capacity to remove the full disposal liner with proper shielding to protect site personnel.

A requirement to have the waste disposal liner 90% full to meet disposal requirements for MLLW requiring macro-encapsulation was revealed halfway through pre-mobilization planning with the disposal facility.

### **Site Inspection**

During the planning phase, the team determined that the dimensions of the components in the pool needed to be directly measured. Component drawings provided by the site were determined to be unreliable as design basis documents. In addition, the quality of photographs provided during the proposal phase was not high resolution, reducing the level of confidence in the configuration.

A work package was developed to perform measurements of the components as soon as the team arrived on site for work preparation. The team found several aspects of the components which differed from the design drawings during this measurement work.

The reactor grid plate was much thicker than expected, was sitting on a slightly elevated component crib, and had bolts in three of the four outer corners which extended outside of the component envelope by several millimeters. The team was unable to determine if the bolts were threaded into the grid plate or were set in thru-holes. The team had to assume the bolts were threaded and develop a plan to cut the bolts once they were accessible. The east shield plate measurements were as expected. The west shield plate, as shown in Figure 1, resulted in a configuration change that created the need for size reduction prior to placing in the liner insert. The west shield plate was found to have two tabs welded to one end that were not previously documented on drawings. Each tab was approximately 12 mm thick, 50 mm wide and 50 mm long. The west shield plate was also welded or bolted to a tray which extended approximately 25 mm beyond the plate edge on two sides, making the plate 50 mm wider than previously documented. There were four tabs welded to the tray which extended another 25 mm beyond the edge of the tray. The tabs also extended between 102 mm and 152 mm upwards and had a dogleg on them extending farther out. The tabs were approximately 5 mm thick and 38 mm wide. This configuration was not reflected on any drawings or previously provided photos and was large enough that the plate would not fit into the liner insert without modification.

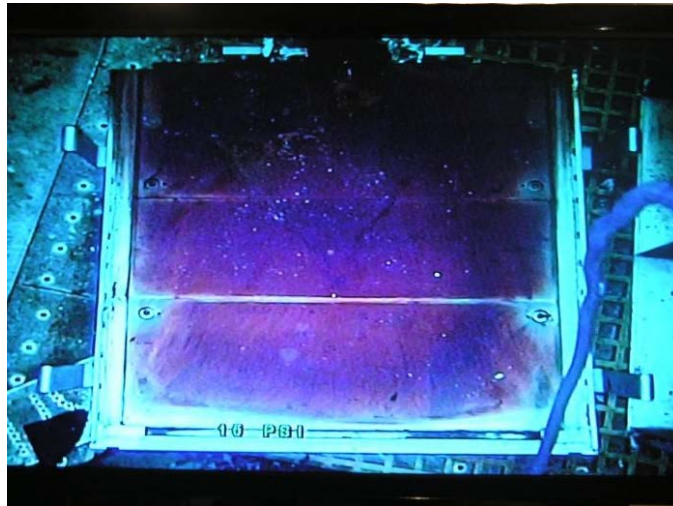


Fig. 1. West Shield Plate on the Pool Floor

The existing wire ropes and connections to the plates were inspected during the measuring operations. This inspection helped justify using the existing rigging to pick up one end of the plates instead of using the suction cup – which would introduce additional radiological and contamination concerns.

The lead counterweight was found to have a lifting lug on each end of the component with a large circular hole cut in it as shown in Figure 2. The plan to pick

up this component was changed from a clamping device to a hook that would be inserted into one of the two circular openings as a result of this finding.



Fig. 2. Lead Counterweight with Lifting Lug

### **DESCRIPTION OF METHODS AND RESULTS**

A new approach to using the cask and disposal liner was developed to overcome the physical limitations of the facility. A 1.23 m tall liner insert was designed and fabricated specifically to package the four irradiated components. This liner insert was designed such that it would fit inside the disposal liner with axial and radial spacers as shown in Figure 3. The liner insert was placed on the floor of the 9 m deep pool to facilitate component loading. The shipping cask with disposal liner was staged on a Goldhofer adjacent to the reactor pool just inside one set of loading doors. The cask and disposal liner were up-righted from the trailers outside of the building using a mobile crane and loaded onto a Goldhofer which was driven into the building through the door opening.

Based on client provided data on source terms, the liner insert was designed with a 101.6 mm thick lid and bottom surface and a 12.7 mm wall thickness. AREVA designed a shield bell to provide shielding to workers to achieve ALARA conditions. The shield bell was fabricated from spare 88.9 mm thick reactor coolant piping. Rolled steel plate 38.1 mm thick was welded to the outside of the pipe to achieve a total thickness of 127 mm. MICROShield analysis determined that this shield bell thickness combined with the liner insert thickness would result in a dose rate of 660 Micro Sieverts/hr at a distance of 6.1 m from the shield bell when the loaded liner insert was removed from the pool.

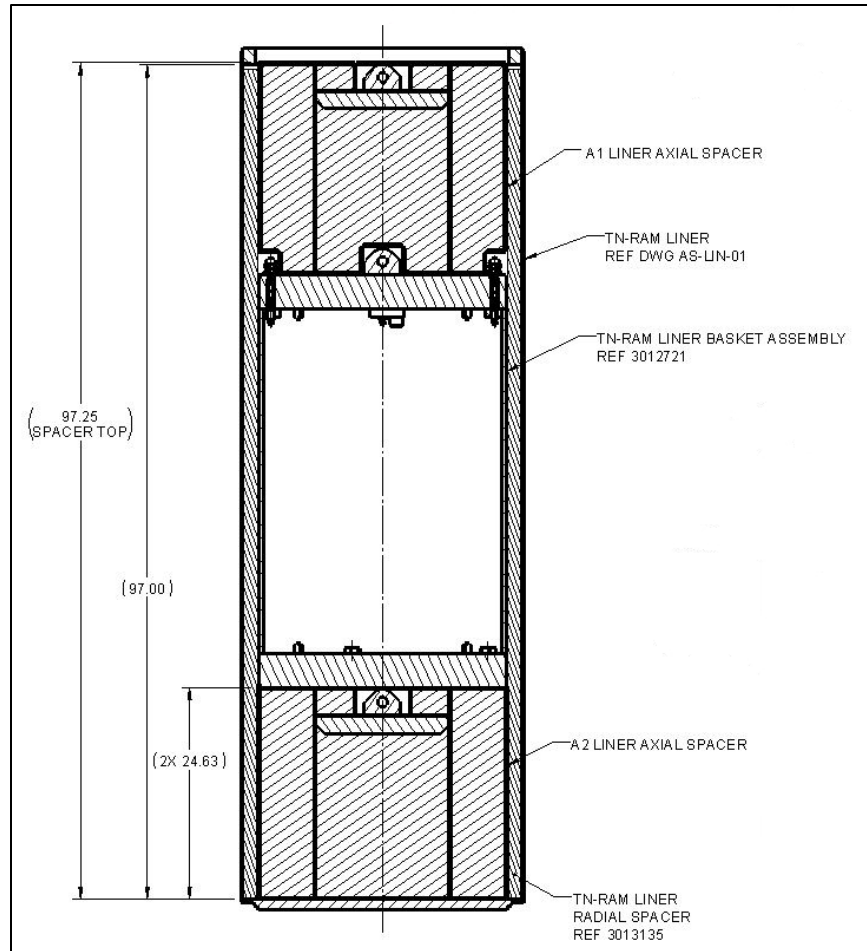


Fig. 3. Liner Assembly with Insert and Spacers

AREVA designed and fabricated tools to pick the plates up off of the pool bottom and load them into the liner insert for disposal. A pneumatic suction cup as shown in Figure 3 was chosen to lift one end of the plates 100 mm to 150 mm off the pool bottom as a contingency if the existing rigging on the shield plates could not be used. A wedge was designed to be inserted under the raised end of the plate to hold it up during a tooling change. AREVA modified a plate clamp by adding a pneumatic cylinder which pushed on the cam to ensure the cam was actuated before lifting as shown in Figure 4 to pick the plates up off the pool bottom.



Fig. 4. Plate Clamp with Pneumatic Cylinder

AREVA started with client supplied images and dimensions to design and fabricate mockup components to determine the optimum packaging arrangement and learn how to manipulate the components 9 m under water. AREVA developed a CAD model as shown in Figure 5 to determine the optimal loading of the liner insert. These mockup components were used for practice in the AREVA training facility pool to determine the best way to lift the plates from flat on the bottom of the pool.

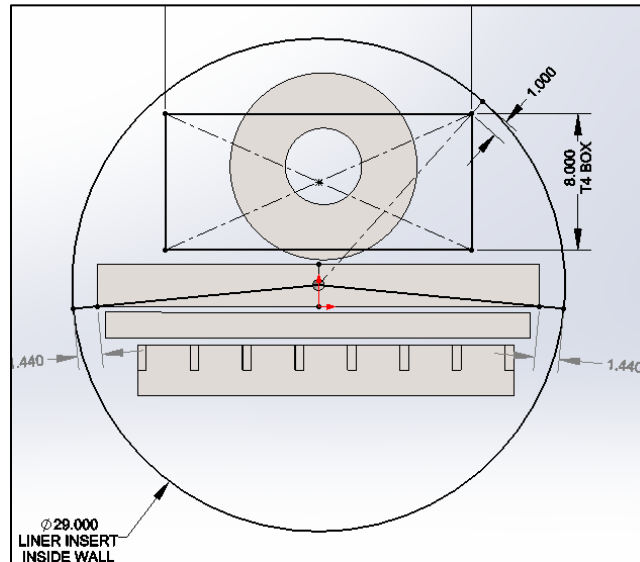


Fig. 5. CAD Loading Model

Practice loading with the mockup components and a 208 liter drum as a mock liner insert confirmed that all four components could be placed in the liner insert which was designed with an internal diameter slightly greater than that of a standard 208

liter drum. This confirmation was based on the initial data and dimensions that did not include the additional tabs.

### **Size Reduction**

The tabs on the west shield plate needed to be cut off or bent to allow the four components to fit into the liner. The material of the tabs could not be determined since they were not shown on any drawings. AREVA assumed the straps were stainless steel to be conservative. Since these were found just before implementation began, several mitigation methods were studied and pursued in parallel. Mockup tabs were also manufactured so that the various mitigation methods could be tested in the AREVA training facility before being implemented in the field.

A set of hydraulic shears was ordered which could easily cut through the tabs. These shears were identified as a contingency plan because they were difficult to maneuver underwater and had numerous crevices and inaccessible areas which would make decontaminating the tool difficult.

The preferred mitigation plan, identified after the tabs were discovered, was to use the east shield plate weighing 231 kg to bend the tabs on the west shield plate over by lowering it down on each of the four tabs. The advantage of using this plan was that it did not introduce any new equipment to the pool which could be contaminated. It was also the simpler of the two processes and it provided fewer opportunities for upset conditions and resulted in the least impact on the previously planned operations.

Testing proved that each operation was feasible and could produce the desired results. The implementation team was trained to execute both the bending and cutting operations to ensure the work could continue as planned with as little schedule impact as possible. Steps were written into the work control documents so if the bending operations were not successful, the team could immediately transition to cutting the tabs off.

### **Grid Plate Lifting Process**

A new lifting device was designed, manufactured, and load tested to move this component. A 'C-Block' was fabricated to fit into the grid openings which allowed the plate to be lifted in a level position. The tip of the lower lip has a raised portion to ensure the grid plate is held securely during movement as shown in Figure 6.





Fig. 6. C-Block Lifting Device on Mock-up Plate in Practice Pool

The grid plate was initially lying horizontally in a crib on the pool bottom. A standard plate clamp was used to lift one end of the plate enough to insert a custom-designed 'C-Block' into one of the grid openings. A wedge was inserted under the raised edge using long-reach poles once one edge was lifted high enough. The rigging was retracted and the 'C-Block' was installed while the plate was rested on the wedge. The 'C-Block' was positioned using long-reach poles and the plate was lifted. When the plate was positioned in the correct location in the liner insert, the 'C-Block' was disengaged.

### **East and West Shield Plate Lifting Process**

Based on the visual inspection performed after readiness assessment, the existing cables and connections to the plates were determined to have enough integrity to pick up one end of the plates but not enough to sustain the full weight of the plate during movement into the liner insert. The site allowed the use of the cables to pick one end of the plates up. Utilizing the existing cables to up-right the plates removed the need to utilize the suction cup therefore eliminating the potential for air born contamination generated by the air bubbles associated with the suction cup.

The two shield plates were initially lying flat on the pool bottom. Using the single available crane hook, the east shield plate was picked up slightly so a wedge could be inserted under one edge of the plate. The plate was lifted by connecting the crane to a wire rope attached to one end of the plate. Once the wedge was placed under the plate using long-reach poles, the crane was disconnected from the existing rigging and the pneumatic plate clamp was connected.

Using long-reach poles, the clamp was positioned to grip the middle of the plate. Before lifting, the pneumatic actuator was energized to engage the cam with the plate.

The east shield plate was picked up first and used to bend down the tabs on the west shield plate as shown in Figure 7. Each strap was bent individually and then the east shield plate was placed completely flat on top of the straps to flatten them as much as possible. The east shield plate was then lifted, positioned over the liner insert and lowered into the container in the prescribed location. The plate was placed into the insert and the pneumatic cylinder was disengaged which freed the plate clamp from the plate. The west shield plate was then loaded into the liner insert. The final irradiated component loaded was the lead counterweight.



Fig. 7. East Shield Plate Used to Bend Tabs (Mock-up Practice)

### **Counterweight Lifting Process**

The counterweight was picked up using one of the two lifting lugs discovered during the measurement campaign. An eye hoist hook without a safety latch was connected to the crane and lowered into the water. The hook was positioned using long-reach poles. The counterweight was moved over the liner insert and lowered into the desired location.

### **Void Fillers**

The AREVA design team worked with the disposal facility to cover all requirements associated with disposal of Class B/C MLLW, which included design of axial and radial spacers filled with inert material. Remaining voids in the liner insert were filled with recycled glass beads to fulfill the requirement for maximum 10% void

space in the waste package. The axial spacers also served to center the waste load in the shipping cask to comply with the AREVA TN RAM Cask NRC license.

### **Axial Spacers**

The axial spacers were made of steel plates and pipe structural members. Vermiculite was added to the internal cavity of the axial spacers for void filling.

### **Radial Spacers**

Inert insulation blankets were cut into strips and inserted around the inner wall of the disposal liner to fill the radial voids in the annulus between the inner wall of the disposal liner and the outer wall of the liner insert.

### **Waste Classification**

Concentration averaging and waste consolidation were used to reach the Class C MLLW determination for shipping and disposal. Averaging the concentration of the four waste components together in conjunction with taking credit for the full displaced volume of the disposal liner resulted in the waste shipment being 34.7% of the Class C limit.

WCS' disposal facility license [2] contains specific provisions concerning DOE waste, allowing the use of DOE Orders and its provisions for waste generation, packaging and classification. According to WCS' license (RML4100) condition 142 (c), "For the purpose of the Federal Waste Facility, the Licensee is authorized to accept for disposal waste which is handled, treated, packaged, or characterized in accordance with applicable Department of Energy orders, policies, and procedures. Waste class applies when the waste is manifested for transport, regardless if a waste class has been assigned on the manifest documents."

The chosen disposal methodology utilized MCCs. The design of the MCCs, using steel reinforced concrete that is coated to retard degradation, and the stacking arrangement provided the necessary stability required for the disposal of Class B/C waste. Containerized waste was placed within the MCCs and grout, with > 0.69 MPa compressive strength, was added to the annular space of the MCCs. This approved disposal method for Class C waste met the regulatory definition of macro-encapsulation. Therefore, no additional treatment action was required when disposing of Class B/C MLLW waste in this manner.

### **Component Movement from Pool**

The liner insert was positioned on the bottom of the pool to facilitate packaging of the irradiated components.

Recycled glass beads were added to the liner insert while still under water through a hose routed from the bridge deck above the pool as shown in Figure 8 after all components were loaded into the liner insert. The hose was attached to a pole to

provide control of the end of the hose to fill in all the voids. A large funnel was used to ensure all of the glass beads went into the hose instead of falling into the pool. Orange beads were used to allow the team to see them under the water. Once the glass beads filled the insert to the lid mating surface, the lid was placed on the liner insert for closure to ready the liner insert for removal from the pool.



Fig. 8. Glass Beads

The shield bell was lifted and lowered into the reactor pool 100 mm to 150 mm to provide personnel protection when the liner insert was lifted from the pool into the shield bell. The liner insert was lifted from the bottom of the pool into the shield bell using a 5-ton chain hoist mounted to the bridge crane hook as shown in Figure 9.

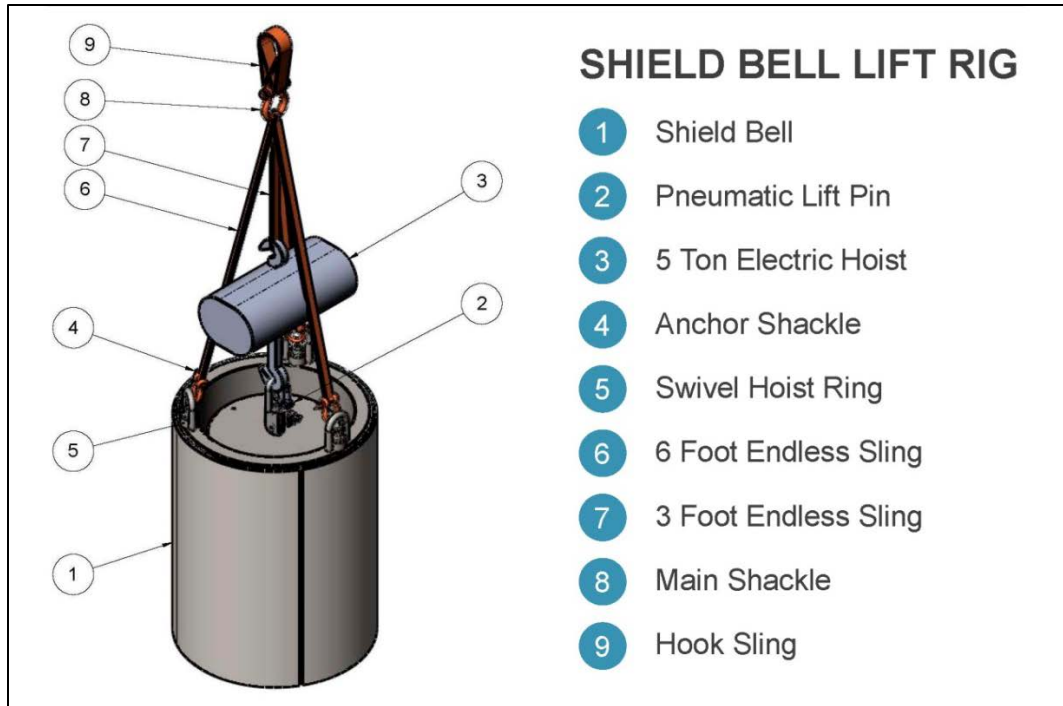


Fig. 9. Shield Bell/Liner Insert Lifting Rig

The liner insert was slowly lifted into the shield bell allowing water to drain through weep holes designed into the bottom of the liner insert. A wire screen in the weep holes prevented the glass beads from passing through the holes. The shield bell and liner insert was then maneuvered across the room to line up with the shipping cask which was staged adjacent to the reactor pool as shown in Figure 10.



Fig. 10. Liner Insert Moved to Cask



The shield bell/liner insert assembly was aligned with the shipping cask remotely with the aid of GoPro cameras mounted to the 5 ton hoist. The liner insert was lowered into the disposal liner that was previously placed in the shipping cask as shown in Figure 11. The top axial spacer, disposal liner lid and shipping cask lid were installed to complete packaging.

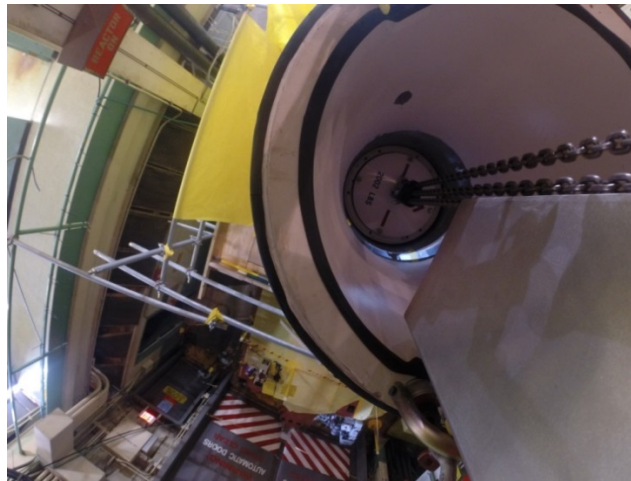


Fig. 11. Liner Insert Lowered from Shield Bell to Cask

### **Operational Performance**

Moving the liner insert from the pool to the shipping cask took approximately 3 hours. The crew of 11 workers in the building during this process received a total combined dose significantly less than the estimated dose identified in the planning stages for the project. The schedule requirement to complete packaging and removal of the irradiated components in two weeks was achieved.

### **Future Applications**

The approach developed for this unique situation can easily be applied to DOE facilities, decommissioning of research reactors or any smaller aging facility that does not have sufficient room to accommodate larger components.

### **CONCLUSIONS**

This effort was a First-of-a-Kind project for AREVA working with DOE to remove, package and transport waste from a small research reactor. The project team utilized AREVA's uniquely broad skillset to complete all phases. The project was completed ahead of schedule, under budget and significantly reduced dose for the site. To complete this project, AREVA developed and implemented a framework for dealing with unique waste types in small work areas which is flexible enough to be implemented at a variety of challenging locations in the future.

## **REFERENCES**

1. Jang, P.R. et al. "Quantitative Imaging Evaluation of Corrosion in Oak Ridge Research Reactor POOL." United States: N. p., 2006. Print.
2. Texas Commission on Environmental Quality Radioactive Material License RO4100, issued January 30, 2015.