PRC-STP-00740 -FP
Revision 0

# Management of Hanford KW Basin Knockout Pot Sludge as Spent Nuclear Fuel

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

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**APPROVED**
*By Julia Raymer at 3:28 pm, Oct 22, 2012*

Release Approval Date

# Management of Hanford KW Basin Knockout Pot Sludge as Spent Nuclear Fuel

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## INTRODUCTION

CH2M HILL Plateau Remediation Company (CHPRC) and AREVA Federal Services, LLC (AFS) have been working collaboratively to develop and deploy technologies to remove, transport, and interim store remote-handled sludge from the 105-K West Reactor Fuel Storage Basin on the U.S. Department of Energy (DOE) Hanford Site near Richland, WA, USA. Two disposal paths exist for the different types of sludge found in the K West (KW) Basin. One path is to be managed as Spent Nuclear Fuel (SNF) with eventual disposal at an SNF at a yet to be licensed repository. The second path will be disposed as remote-handled transuranic (RH-TRU) waste at the Waste Isolation Pilot Plant (WIPP) in Carlsbad, NM.

One of the primary objectives at Hanford is cleanup of the River Corridor, which borders the Columbia River. One of the last facilities containing nuclear material is the 105-K West Reactor Fuel Storage Basin, where highly radioactive sludge remains from the long-term storage and degradation of SNF. Once these sludge materials are removed, the remaining structure will be demolished and removed.

This work falls within the responsibility of the CH2M HILL contract with the DOE that AFS supports as a preselected contractor providing design, engineering, and testing resources and expertise. An experienced, integrated CH2M HILL/AFS team was formed to design and build systems to retrieve, interim store, and treat for disposal the KW Basin sludge, namely the Sludge Treatment Project (STP). The STP is organized into two key subprojects: the Knockout Pot (KOP) Disposition Subproject and the Engineered Container Retrieval and Transfer System (ECRTS) Subproject.

This paper describes the systems developed and executed by the KOP Disposition Subproject for processing and interim storage of the sludge managed as SNF, (i.e., KOP material).


Fig.1: K East and K West Reactor Basins and the Cold Vacuum Drying Facility.

## TECHNICAL CHALLENGES

Historically, efforts to transfer and handle K Basins sludge have proven to be very difficult. The systems used for cleaning the fuel and the pumping systems used to move the sludge from K East to KW Basin had very high failure rates due to the abrasive nature of the material.

Maintenance is complicated because equipment is located beneath 17 feet (5.2 m) of water and could be obscured by suspended particles. Filtration systems are not easily back-flushed and can become blinded. The broad range in particle densities; 1 to 19 g/cm$^3$, requires retrieval and transfer systems to pump high volumes of water at high velocities to assure relatively uniform transfer. Those density differences created concerns that metallic uranium could segregate and accumulate with accompanying thermal and hydrogen gas generation issues. In addition, high dose rates associated with sludge in the range of 2 Sv/hr requires remote and automated systems for process equipment.

Consequently, the STP adopted a policy requiring a strong technical basis for the design of the processing system. This technical basis was supported by an extensive characterization program that established radio-chemical and physical properties of sludge in each canister. This data was then used to develop process parameters and requirements, develop simulants for equipment testing and verification, and establish a safety basis for the process. In addition, full-scale equipment testing including integrated tests with prototype equipment and a full range of simulants was completed. Operating procedures were developed at the full scale prototype and operator training was also conducted on the prototype.

**KNOCKOUT POT DISPOSITION SUBPROJECT**

The KOP Disposition Subproject was responsible for the disposition of KOP material within the KW Basin. The scope of the KOP Disposition Subproject included the following activities:

- Retrieved, washed, and inspected KOP material to characterize its physical properties
- Designed, fabricated, tested and installed KOP processing equipment in KW Basin
- Sorted the KOP material by density and size
- Loaded the processed KOP material into multi-canister overpacks (MCOs)
- Transported the MCOs to the Cold Vacuum Drying Facility (CVDF) and dried the contents of the loaded MCOs
- Transported the MCOs to the Canister Storage Building (CSB) for off-loading and interim storage

**Origin of KOP Material**

KOP material originated from the fuel and scrap cleaning process used in the SNF process at K Basins. Fuel was cleaned in the primary cleaning machine (PCM), which provided mechanical agitation and flushing to remove particulate from fuel by slowly tumbling the fuel canisters past high-pressure water jets. Particulate material in the canisters, small uranium metal fragments and internal fuel particulate from damaged fuel assemblies, and coatings on fuel assemblies and canisters were also removed during the cleaning process.

The material removed from the fuel canisters during the cleaning process was collected in the PCM strainers, the Primary Processing Table (PPT), KOP vessels, IWTS strainers and settler tanks. The PCM strainers retained material greater than 0.125-inch (0.318-cm) particle size. The KOP vessels and IWTS strainers were designed to capture heavy material and material greater than 600-µm particle size that passed through the PCM strainers. The material less than 600-µm particle size was captured in the annular filters and settler tanks. The material collected in the PCM strainers, on the PPT, KOP vessels, and IWTS strainers was designated as KOP material.

**Characteristics of KOP Material**

KOP material consisted of material between 600 µm and 0.25-inch (0.64 cm) particle size. While KOP material had not been directly chemically characterized in a laboratory, the KOP material had been sampled and inspected in-basin to obtain information about characteristic of the material. Visual observations of KOP material from each of the four KOP material sources suggested the dominant presence of aluminum hydroxide, uranium oxides, uranium metal, aluminum wire and Grafoil.

The KOP material stored in the fuel canisters had significant variation in density; ranging from 1.7 to 10.4 g/cm$^3$. During in-basin inspections, direct underwater measurements of volume and mass (corrected for buoyancy) of KOP material contained in the spent fuel canisters were used to determine the bulk wet density.

Visual observations indicated that some of the KOP material particles had a dark/grey metallic appearance, indicating the presence of uranium metal (Figure 2). The dark/grey particles, when separated, had very large dose rates and densities consistent with uranium fuel fragments.

Fig.2: Presence of Uranium Metal in KOP Material.

Fine, dust–like particulate was observed in all three sources of KOP material. The dust-like material, primarily uranium oxide, was dark grey and dark brown in color. Different oxidation states of uranium oxides have different colors that vary from black to yellow and green. The colors observed during in-basin inspections were similar to the color of uranium oxides that had previously been identified in K Basins sludge samples that contain a mix of uranium oxidation states. Uranium compounds from uranium metal corrosion typically have particle sizes less than 10 µm, although larger uranium oxide agglomerates in sludge samples have been observed.

Aluminum corrosion in water at low temperature yields a series of corrosion products. Aluminum hydroxide is typically white in color, but can take on other colors depending on impurities. A considerable quantity of aluminum hydroxide was previously shown to be present on the fuel assemblies and fuel canisters. Figure 3 shows a fuel assembly and aluminum fuel canister with coating and deposits of aluminum hydroxide. Over half of the fuel canisters stored in the K Basins were made from aluminum and many had corroded. A portion of the aluminum coatings and deposits were dislodged in the PCM during fuel washing and were collected in the PCM strainers, the KOP vessels and the IWTS strainers.


Fig.3: Aluminum Hydroxide Corrosion on Fuel Canister and Fuel Assembly.

During in-basin inspections, a significant fraction of the particles in the KOP material appeared to be larger white particles, which indicated that these particles were likely aluminum hydroxide. The larger yellow particles could also have been aluminum hydroxide altered in appearance to a yellowish color due to the presence of iron. However, uranium hydrates could also appear yellow and may have contributed to the yellowish appearance. The yellow particles were significantly larger than uranium oxide particles and uranium oxide agglomerates. Observations of the PCM/IWTS strainer material indicated that aluminum hydroxide likely dominated the non-uranium fraction of this source material.

Grafoil® was also observed during in-basin inspections. The Grafoil® particles were easily distinguished by their slow fluttering motion during material handling. Grafoil® seals were used on nearly 4,000 fuel canisters in the KW Basin. Grafoil®, which is used widely in gaskets and sealing materials in many applications, is friable and is readily size reduced.

A considerable quantity of 0.75- to 1.25-inch (1.9-cm to 3.18-cm) long and 0.0625-inch (0.159-cm) diameter pieces of aluminum wire were observed in the KOP material during in-basin inspections (Figure 4). The source of the wire was the screens on the "open-bottomed" fuel canisters. These canisters had bottoms with multiple 1-inch (2.54-cm) holes that were covered with aluminum wire mesh. The volume of wire contained in the KOP material was estimated to be 5.5 volume percent of the total volume of KOP material.

Fig.4: Aluminum Wire Observed in KOP Material.

**Pretreatment**

The KOP material stream contained significant quantities of non-uranium-based compounds that had the potential to contribute to the bound water content of the material, and therefore affect the amount of material that could be stored in a single MCO. The KOP material was first pretreated to remove the undesirable material to the extent practicable. Optimizing the removal of non-uranium based material enabled the KOP Disposition Subproject to more cost-effectively package and manage the product stream (uranium-metal based materials) as SNF. As shown in Figure 5, the original volume of KOP material was estimated to require approximately 16 MCOs. The target with pretreatment was to only require less than 6 MCOs.

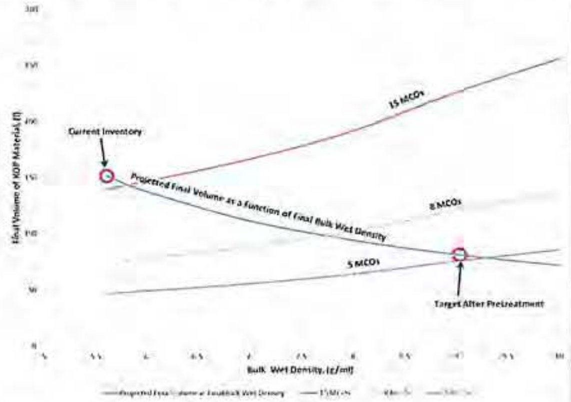


Fig.5: Number of Multi-Canister Overpacks Required.

Pretreatment activities occurred in the KW Basin between May, 2011 and July, 2011. The projects baseline design for pretreatment included:

- Removal of the less than 600-µm particles and low-density material from the KOP material stream;
- Size reduction and removal of the non-uranium, friable material from the low-density material stream in the existing KW Basin Primary Cleaning Machine (PCM); and
- Removal of aluminum wire from the low-density material stream.

A portion of the non-uranium based components, such as Grafoil and aluminum and iron compounds, could be size reduced to less than 600 µm. In order to decrease the loading of non-uranium based material into the MCOs and reduce the load on the PCM, the KOP material was first subjected to a density separation. The low-density material was removed from the KOP material stream via density separation. Density separation was based upon particle settling characteristics, which were directly related to the particle's size, shape and density. The solids removal principle was that individual solid particles whose settling rates were less than the upward flow of water through the suction wands would be removed. Conversely, solids whose settling velocities were greater than the upward velocity of the water would not be carried over and would settle into the canister.

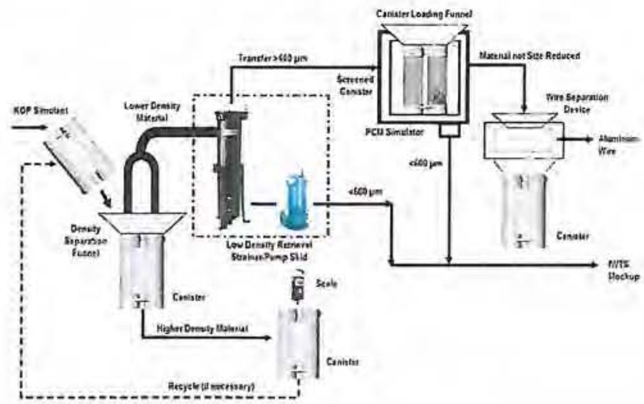


Fig.6: Pretreatment Simplified Process Flow.

Density separation equipment included a density separation funnel with dual suction wands and a low-density retrieval strainer and pump skid. The density separation funnel (Figure 7) was positioned over a standard fuel canister. Each suction wand extended into a canister barrel.

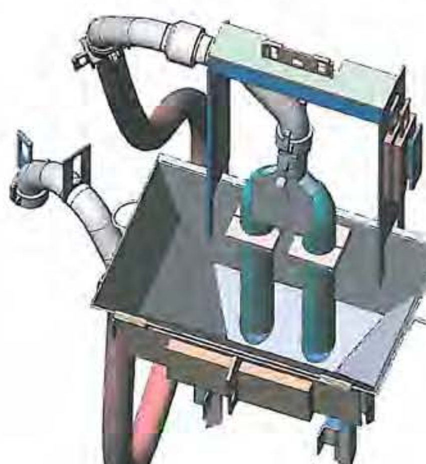

Fig.7: Density Separation Funnel.

The low-density retrieval strainer and pump skid consisted of a 600-µm strainer, a pump and flow meter transducers mounted on a common skid. The transducers provided the signal to the flow meter located on the instrument rack. From the density separation funnel, water flowed through the flow meter to the strainer and then to the low-density retrieval pump suction. The ultrasonic flow meter measured the flow rate though the suction wands and strainer.

KOP material was transferred into the density separation funnel, which directed the flow of material into the suction wands. The low-density retrieval pump, which was controlled by a variable frequency drive, provided the motive force for the upward velocity of the water in the suction wands. The nominal flow rate of the density separation operation was approximately 125 gal/min (0.47 $m^3$/min). The lower density material that was entrained in the upward velocity of the water in the suction wands was collected in the 600-µm strainer. The less-than-600 µm particles passed through the strainer and were discharged into the IWTS upstream of the pump. The higher-density material fell through the funnel and was collected in the canister that the funnel was resting on.

The size reduction equipment consisted of a screened canister, agitators, and the existing PCM, which was initially designed to clean the fuel during the SNF processing. The size reduction step physically broke-down a portion of the non-uranium based components to less than 600 µm so that it could be removed from the process and captured in the IWTS.

In order to fit within the confines of the primary clean machine, the overall dimensions of the screened canister and lids were the same as the standard K Basins double-barreled fuel canister. The difference between the screened canister and the standard canister was that rather than solid walls, the screened canister cylinder walls, bottoms, and lids were fabricated with nominal 600-µm stainless steel wedge wire screen. The lids were designed with an inside surface lining using the same 600-µm wedge wire as the screened canister (Figure 8).

The PCM consisted of a stationary outer enclosure box that housed the rotating wash basket, a wash basket drive assembly, high-pressure flush nozzles, a strainer basket located in the bottom of the PCM outer enclosure box, and associated equipment (e.g., pumps, control station). The PCM stationary outer enclosure was a steel box with hinges on one side that allowed the top of the box to be opened for access. A two-piece cylindrical wash basket designed to hold a canister was mounted inside the enclosure. The wash basket was rotated inside the enclosure by a drive mechanism. Water nozzles mounted inside the enclosure spray pressurized water through slots in the wash basket to flush out the material. A suction connection provided a continuous flow of water from the PCM enclosure to the IWTS through a strainer basket with nested 0.25-inch (0.64-cm) and 0.125-inch (0.318-cm) screens. Suction flow from the PCM was greater than pressurized water inflow to maintain basin water clarity.

The 3-inch (7.6-cm) stainless steel ball agitators used during pretreatment were placed into the barrels of the screened canister with the low-density, friable material. Physical size reduction of the material occurred when contact between the agitator and the simulant during rotation created a crushing action that in turn, size reduced the friable material. Material that was size-reduced to less than 600-µm escaped through the screen openings and flowed to the IWTS.

Fig.8: Screened Canister, Lids and Agitators.

The wire separation device (Figure 9) consisted of a loading funnel, base unit, rotating drum, perforated plate drum lid and gear drive. The bottom of the base unit, which housed the rotating drum, was configured as a funnel that rested over a canister. The rotating drum was approximately 16-inch (40.6-cm) in diameter and 24-inch (61-cm) long with a perforated plate drum lid. The loading funnel was designed to allow material to pass through into the rotating drum while retaining the size reduction agitators. The drum lid was designed such that the perforated plate was spaced slightly below the top lid plate. This precluded aluminum wire pieces from fitting through the gap between the perforated plate and the top lid plate, but allowed the smaller length particles to pass through the perforated plate. The gear drive unit, which was operated with a drum drive tool from the KW basin operating floor, rotated the drum.

The wire separation device was designed to separate particles including uranium metal from aluminum wire. To begin the separation process, the rotating drum was partially filled with material containing small particles and aluminum wire from the size reduction process using the wire separation funnel. As the drum rotated, small particles passed through the perforated drum lid and were collected in a standard fuel canister positioned at the bottom of the base unit, while the majority of the 0.0625-inch (0.159-cm) diameter aluminum wire remained inside the drum. The small particle material collected in the fuel canister was staged for further processing during KOP Processing System activities. The wire collected in the drum was disposed of as debris.

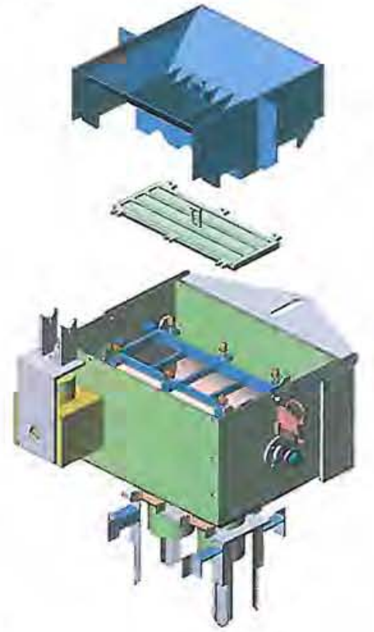

Fig.9: Wire Separation Device.

**KOP Processing System**

The KOP Processing System (KPS) was comprised of the following three main process steps: 1) size separation, 2) verification container loading, and 3) packaging.

The size separation process removed remaining particles less than 600 µm in size from the KOP material before the material was transferred to the verification container loading equipment. The size separation equipment included a size separation table, nozzle array unit, pump skid, flow meter skid and miscellaneous long pole tools.

A fuel canister loaded with pretreated KOP material was moved to the canister dump unit with existing canister handling hooks. The canister was installed into the dump fixture. A hoist operated from the monorail system and a canister hook were used to invert the canister by lifting the canister dump fixture, which rotated on a pivot to invert the canister and dump the material onto the solid surface of the canister dump unit. The dump surface area was sloped toward the gate that separated the canister dump unit and the screened separation unit. The canister dump unit, nominally 36-inch (91.4-cm) diameter, was enclosed by a vertical wall, approximately 12-inch (30.5-cm) tall.

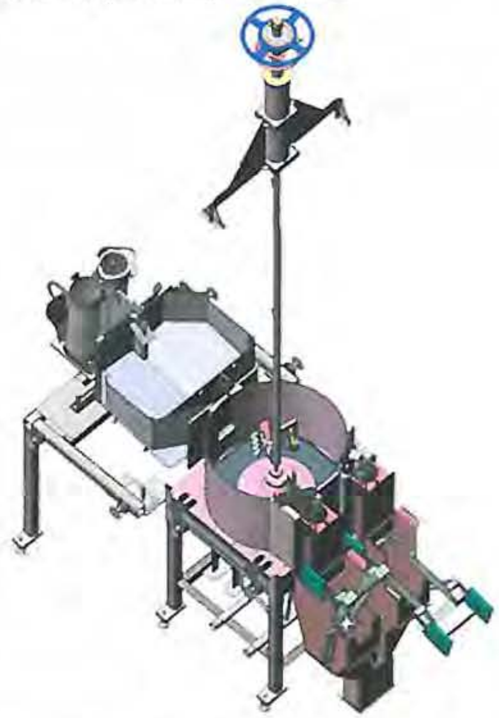

Fig.10: Size Separation Table and Nozzle Array.

A 4-liter (0.004 $m^3$) volume limiting support tool placed over the gate opening between the dump area and screen table limited the quantity of KOP material placed on the screen to less than or equal to four liters. After the tool was filled, the gate was closed and the tool was removed.

The screened separation unit consisted of a separation chamber with gates, a center cone assembly and a wedge-wire screen panel. The bottom surface of the screened separation unit was constructed with wedge-wire screen material with nominal 600-µm slot gaps. The screen, nominally 36 inches (91.4 cm) in diameter, was enclosed by a circular wall that was approximately 24 inches (61 cm) high. Three separate gates were incorporated into the circular wall. The center of the screened area was sealed off by a 20-inch (50.8-cm) diameter solid section with a 1.5-inch (3.8-cm) vertical wall that tapered to the center. This configuration created an 8-inch (20.3-cm) wide circular wedge wire screen surface for manipulation of the material with the nozzle array unit or manual long pole tools. During this manipulation, the less-than-600-µm material passed through the 600-µm screen, flowed through the size separation pump, and was directed to the IWTS.

The support table and funnel assembly supported the screened separation unit and the support table extension supported the canister dump unit. The funnel assembly, which was directly below the screened area, was equipped with two windows with removable light assemblies and fixed spray wands that could be operated as needed to prevent settling out of material on the funnel walls. The particles that fell through the 600-µm screen into the funnel were directed to the IWTS.

The pump skid assembly, which provided the motive force for the downward flow of water in the funnel assembly to the IWTS, consisted of two redundant pumps mounted on a common skid. The flow rate achieved by the pump was either controlled through the use of automatic flow control (in conjunction with a flow meter) or manual control using a variable frequency drive. The nominal flow rate of the size separation operation was approximately 70 gal/min (0.26 $m^3$/min). The flow meter skid assembly consisted of two individual sections of pipe each with two mounted ultrasonic flow transducers. The transducers provided the signal to the flow meter located on the instrument rack to indicate the water flow through the funnel assembly.

The primary tool for manipulation of the KOP material on the screen was the nozzle array unit. The nozzle array unit consisted of four eductor-type spray nozzles and a vertical shaft (i.e., operating column) approximately 22 feet (6.7 m) in length that housed the water supply to the nozzle array unit. The nozzle array unit was configured to rotate around the 8 inch (20.3 cm) wide circular screen surface. The operating column controls for the nozzle array, located above basin grating level, allowed the operators to raise, lower and rotate the nozzles, which provided a high degree of flexibility for manipulating and separating material.

To assist in movement of the KOP material on the size separation table, spray wands with different spray orientations (straight or angled) and eductor sizes of 0.375 inch and 0.75 inch (0.95 cm and 1.9 cm) were used. Each of the spray wands was approximately 22-feet (6.7 m) long.

The water supply manifold provided a pressure-controlled supply of water to the size separation funnel assembly fixed spray wands, the nozzle array unit and the manual spray wands. The manifold consisted of an adjustable pressure-reducing valve, manual valves, and pressure and flow instruments. The pressure control valve could be manually adjusted to reduce the water pressure and flow supplied to the nozzles based upon the nozzle height above the screen surface and/or the response of the material. The water to the water supply manifold was supplied with ion exchange module discharge water at a pressure of 100-110 psig.

After the KOP material has been screened for a selected amount of time, the remaining product stream was transferred to the verification container loading equipment. The verification container loading equipment consisted of: verification containers, verification container fill units, volume measurement tool, and a 0-100 lb (0-45.4 kg) digital load cell.

The verification containers were a 15-inch (38-cm) tall, cylindrical body that was constructed from stainless steel tubing (Figure 11). The verification container had a nominal 3 inch (7.6 cm) inside diameter. The top of the verification container consisted of a machined stainless steel flange and stainless steel brackets that enabled lifting with the bail and interfaced with the fill station unit and volume measurement tool. A 500-µm wedge wire screen was installed inside the cylindrical body. The screen allowed for drainage of water in the event of a verification container was accidently lifted out of the basin water to ensure the KOP product material remained thermally stable.

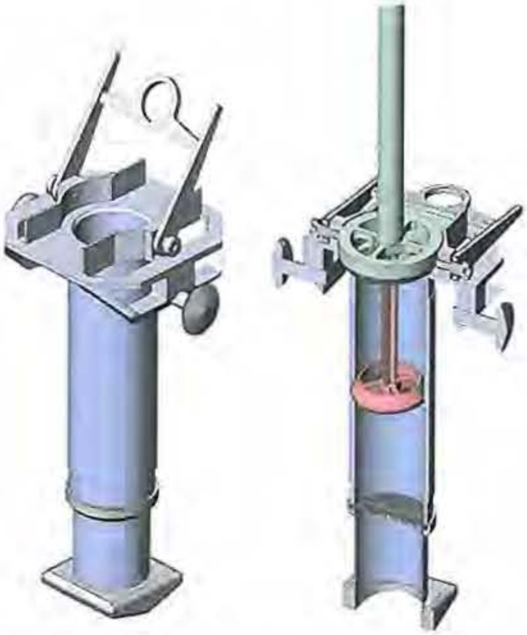

Fig.11: Verification Container and Volume Measurement Tool.

Two verification container fill station units were part of the size separation table. Each unit was designed with a separate alcove for filling the verification containers. The 12-inch high walled alcoves were separated from the screened separation area by a gate in the adjoining wall. A long pole tool was used to open the gate to the alcove such that the material from the screen could be transferred into the fill station alcove. The screened working surface extended into the alcove, which transitioned to a solid surface. A 1.625-inch (4.13 cm) diameter hole, located in the solid surface, was used for loading material into a verification container. The loading hole led to a 6.25-inch (15.9-cm) long pipe section (i.e., fill tube) that dumped into the verification container located beneath.

The nozzle array unit and manual spray wands were used to direct material into the fill station alcoves. A removable manual fill station wiper brush, centrally located within the alcove, rotated in a circle to sweep the KOP material into the loading hole. Once the fill hole was full, the wiper brush was used to level off the material. Using this process, the verification containers were filled to the desired volume of KOP material (i.e., approximately 0.95 liters or 950 $cm^3$).

After the verification container was filled with KOP material, the weight and volume measurements were taken to determine the product bulk density. The weight was measured with a hanging 0-100 lb digital load cell. The verification container volume measurement tool was used to determine the volume of KOP material in the verification container. The volume measurement tool was approximately 24 feet (7.3 m) long and consisted of two concentric tubes that slide relative to one another. The outer tube had a plate that sat on the verification container top flange to use as a reference point. The inner tube had a plate that rested on the KOP material in the verification container. The portion of the tool that extended above the basin water was calibrated such that an operator could read the volume of the KOP material from a scale and pointer. The volume measurement tool was also used to level the KOP material in the verification container prior to obtaining volume measurements.

The bulk density was used to determine if the KOP material was acceptable to be packaged or had to be further processed. If the material equaled or exceeded the bulk density target, the KOP product material was packaged into an MCO basket insert via the packaging equipment.

The packaging equipment packaged the processed KOP product into specially designed MCO basket inserts, which were then loaded into MCO scrap baskets. Once the KOP product was loaded into MCO scrap baskets, the remaining process was mechanically the same as the process previously used for the SNF project. MCOs were loaded in a specific sequence with empty scrap baskets and with the scrap baskets containing MCO basket inserts with KOP product. The MCOs were then transported to the CVDF, dried, and were then transported to the CSB for interim storage.

The MCO basket inserts (Figure 12) were designed to contain the KOP material, which when placed within existing MCO scrap baskets, permitted drying, facilitated heat transfer, and ensured adequate mass and appropriate void space in the MCO. The MCO basket inserts were copper blocks with a full-length cavity down the middle. The cavity cross section was approximately 0.75 inch by 4.5 inch (1.9 cm by 11.4 cm) with full radius corners. The size and shape of the cavity ensured thermal stability of the KOP material during drying operations. The 20.5-inch (52.1-cm) height of the block and cavity permitted the insert to hold approximately 0.95 liters (950 $cm^3$) of KOP material with some allowance for head space.

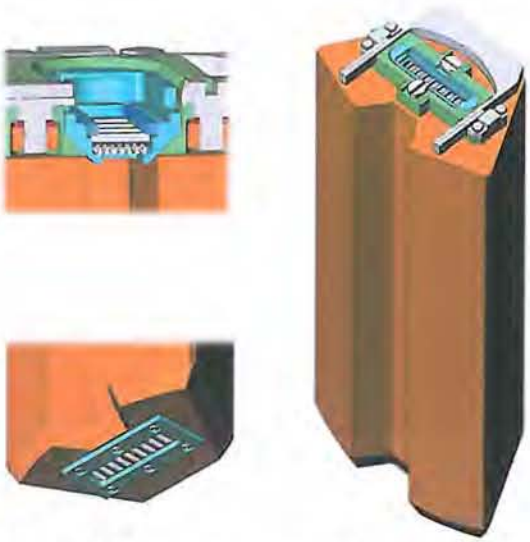

Fig.12: KOP Full-Scale Test Facility.

The bottom of the cavity was closed with a nominal 500-µm wedge wire screen and stainless steel frame bolted to the bottom of the copper block. An upper wedge wire screen assembly could be locked into place to prevent material spills in the horizontal position. The top frame also held the bail used to lift and move the insert. An existing basin canister hook interfaced with this bail with the assistance of a pole tool. The bail folded on top of the MCO basket insert, which allowed the entire assembly to fit in an MCO scrap basket compartment.

The MCO basket inserts were loaded using the insert support and fill funnel unit. During packaging of the product stream, an empty MCO basket insert was loaded into the insert support stand. The fill funnel unit was then placed on top of the insert support stand. This fixture was equipped with a lift bail that could be handled by existing basin tools. The insert support stand provided guidance so that the fill funnel sat correctly in the top opening of the insert. The fill funnel sealed along the top of the insert to prevent KOP product material from being carried out with the displaced water during dumping.

With the fill funnel in place, a filled verification container was installed into the dump fixture of the fill funnel. When the dump fixture end was lifted using a manual pole hook, the verification container automatically leaned into position to engage the pivot trunnions, the dump fixture pivoted over the funnel, the verification container was inverted, and the KOP product was funneled into the insert.

Inserts filled with KOP product material were loaded into existing unused MCO Mk1A scrap baskets, which were designed to package scrap fuel during the SNF Project. The cylindrical basket was approximately 22.6-inch (57.4-cm) diameter, 23.2-inch (58.9 -cm) high, had a center post with a 6.63-inch (16.8-cm) diameter, and was constructed of stainless steel and copper. The bottom of the basket was supported by a flat plate with holes and a screen to permit effective water flow. The center post provided handling capability.

The MCO was loaded with a maximum of 18 copper inserts in three Mk1A scrap baskets. The actual quantity of KOP product material to be loaded, and thus number of inserts allowed in an MCO was controlled to limit the uranium mass and bound water inventory per the MCO load plan. MCO basket covers were installed on the loaded Mk1A scrap baskets until the baskets were ready to be loaded into the MCO. Three empty Mk1A scrap baskets were loaded into an MCO in a specific sequence, along with the loaded Mk1A scrap baskets. The empty scrap baskets were loaded in alternating positions, beginning with the bottom basket.

**TECHNOLOGY DEVELOPMENT**

The unique nature of the KOP material resulted in the need to develop new technology and techniques to process this material in the STP full-scale testing facility (Figure 13).


Fig.13: KOP Full-Scale Test Facility.

Baseline KOP simulant recipes were derived from best estimate calculations of the nominal composition of the existing KOP material in the KW Basin and the KOP Material Process Description, Process Control Plan and Material Balance document. In-basin inspections, along with analytical models to predict the uranium metal and non-uranium metal composition of the KOP material, formed the basis for the KOP composition. Critical characteristics and process parameters were defined and evaluated to establish surrogate components for the KOP simulants.

**KPS OPERATIONS**

The conclusion of the project was the highly successful processing of all of the KOP material in the summer of 2012 (Figure 14 and Figure 15). All operations were completed on schedule, with no required modifications to the equipment. The procedures were followed without any changes. The operator training resulted in no operational upsets due to equipment design or procedural errors.

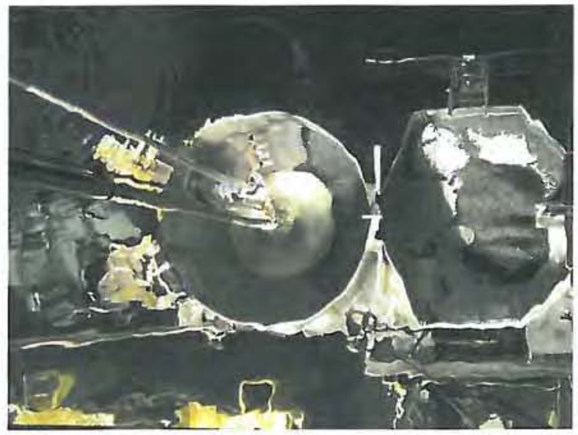

Fig.14: KPS Processing in KW Basin.

Fig.15: Final and 5th MCO on Trailer Leaving KW Basin.