

Preparation of U-Plant for Final Demolition and Disposal – 12109

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## ABSTRACT

The U-Plant is one of the five major nuclear materials processing facilities at Hanford and was chosen as a pilot project to develop the modalities for closure of the other four facilities at Hanford and the rest of the Department of Energy (DOE) complex. The remedy for this facility was determined by a Record of Decision (ROD) pursuant to the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). That remedy was to "Close in Place - Partially Demolished Structure". The U-Plant facility is identified as the 221-U Building and is a large, concrete structure nominally 247 m (810 ft) long, 20 M (66 ft) wide and 24 m (77 ft) high with approximately 9 m (30 ft) being below grade level. It is a robust facility with walls ranging from 0.9 m to 2.7 m (3 ft to 9 ft) thick. One large room extends the entire length of the building that provides access to 40 sub-grade processing cells containing tanks, piping and other components. The work breakdown was divided into three major deliverables:

- 1) Tank D-10 Removal: removal of Tank D-10, which contained TRU waste.
- 2) Equipment Disposition: placement of contaminated equipment in the sub-grade cells.
- 3) Canyon Grouting: grouting canyon void spaces to the maximum extent practical.

A large number of pieces of contaminated equipment (pumps, piping, centrifuges, tanks, etc) from other facilities that had been stored on the canyon operating floor were placed inside of the sub-grade cells as final disposition, grouted and the cell shield plug reinstalled. This action precluded a large volume of waste being transported to another burial site. Finally, ~19,000 m<sup>3</sup> (~25,000 yd<sup>3</sup>) of grout was placed inside of the cells (in and around the contaminated equipment), in the major galleries, the ventilation tunnel, the external ventilation duct, and the hot pipe trench to minimize the potential for void spaces and to reduce the mobility, solubility, and/or toxicity of the grouted waste. The interim condition of the facility is "cold & dark". Upon availability of funding the structure will have contamination fixative applied to all contaminated surfaces and may be explosively demolished, with the remaining structure buried under an engineered barrier.

## INTRODUCTION

In September 2005, the U.S. Environmental Protection Agency (EPA) issued a *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) Record of Decision (ROD) for the final remediation of the Hanford site U-Plant. The Department of Energy (DOE) helped in the issuance of this ROD with Ecology's concurrence. The selected remedial action calls for consolidating and grouting equipment currently in the U-Plant into the process cells, filling the process cells, galleries, hot pipe trench, ventilation tunnel, drains and other voids below the operating deck and crane way deck levels with grout prior to demolition of the canyon roof and walls to the approximate level of the canyon deck, and burial of the remaining canyon structure beneath an engineered barrier. The remedial action calls for connected structures, namely 271-U and 276-U, to be demolished and disposed of at Hanford's Environmental Remediation Disposal Facility (ERDF). The remedy limits a large volume of waste transported to ERDF, but does not eliminate it entirely.

The CERCLA ROD describes the grouting activity as follows: Cementitious grout will be pumped into the galleries, cell drain header, process cells, and tanks to the maximum extent practical, to minimize the potential for void spaces and to reduce the mobility, solubility, and/or toxicity of the residual waste. Grout amendments, such as fly ash or zeolite clays, and the cost-benefit of using a soil-cement grout mixture will be considered during final design for grouting activities to reduce the potential for leaching

of radioactive isotopes, while maintaining desirable properties of Portland cement (e.g., a flowable, structural grout with good compressive strength).

In February 2009, the *Remedial Design/Remedial Action Work Plan for the 221-U Facility* (RD/RAWP), DOE/RL-2006-21 was approved by DOE and the two joint lead regulatory agencies (EPA and Ecology). In order to reduce redundancy, the lead regulatory agency position was changed to just be the EPA for the canyon building regulatory interface. The RD/RAWP describes the design and implementation of the remedial action process for remediation of U-Plant pursuant to the ROD. The RD/RAWP outlines and discusses grouting of U-Plant in greater detail. U-Plant is shown in an aerial photo in Figure 1.



Figure 1. Aerial Photo of U-Plant

U-Plant, located in the 200 West Area of the Hanford site, is one of three nearly identical Hanford site chemical separations plants constructed from 1943 through 1945 to support the World War II defense mission. U-Plant is also one of the five major nuclear materials processing facilities at Hanford and was chosen as a pilot project to develop the modalities for closure of the other four facilities at Hanford and the rest of the DOE complex. These massive concrete buildings were referred to as “canyons” because of the expansive main room extending the length of the buildings. The canyon building is approximately 247 m (810 ft) long, 20 M (66 ft) wide and 24 m (77 ft) high (15.5m (51ft) above grade and 7.9m (26 ft) below grade). 40 process cells, which contain deactivated process equipment, run along one side of the canyon and are shielded with interlocking concrete cover blocks. A hot-pipe trench which runs along the

other side of the canyon contains radiologically contaminated inter-cell section transfer piping and is shielded with concrete cover blocks.

U-Plant consists mainly of a canyon, a crane way, and three galleries (i.e., operating, pipe, and electrical) running most of the length of the building. Included as part of the canyon are the process cells, hot pipe trench, ventilation tunnel and process cell drain header which also run most of the length of the building. Support systems to U-Plant are minimal and consist of electrical service for lighting and overhead cranes, and the exhaust ventilation system. An isometric perspective of U-Plant is depicted in Figure 2. A detailed cross-section of U-Plant with dimensions is shown in Figure 3. A plan view at the operating deck level of U-Plant is shown in Figure 4.

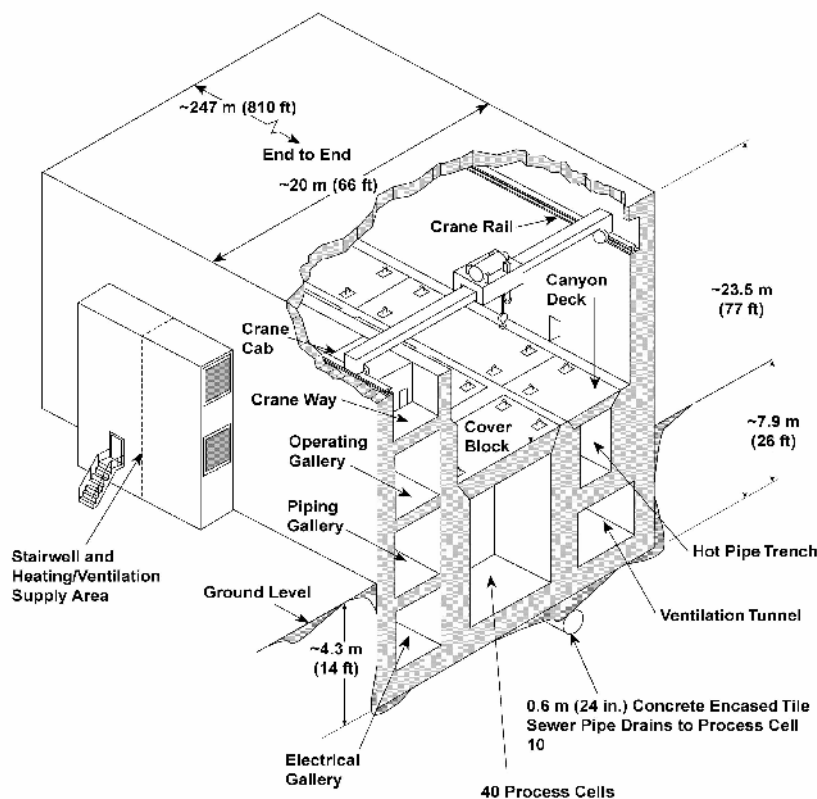


Figure 2: Isometric Perspective of U-Plant

The U-Plant facility was in Surveillance and Maintenance “S&M” condition upon the start of the project. The facility was neither cold nor dark upon project start up. The facility crane was not functioning and had to be brought online and maintained throughout the duration of the project.

The facility ventilation system has been in continuous use since installed. The system draws air from outside the facility, through the galleries, through the canyon doors and railroad tunnel, down through the cells and hot pipe trench, into the ventilation tunnel, into the external ventilation duct, through the sand filter, through fans and up the stack. The facility maintains a negative pressure that is verified daily for operational safety. Air moves from the least contaminated areas to the most contaminated areas. Negative Air Machines (NAM) and HEPA filters / vacuums are used to maintain localized negative pressures for worker protection.

- 1) Tank D-10 Removal: removal of Tank D-10, which contained TRU waste.
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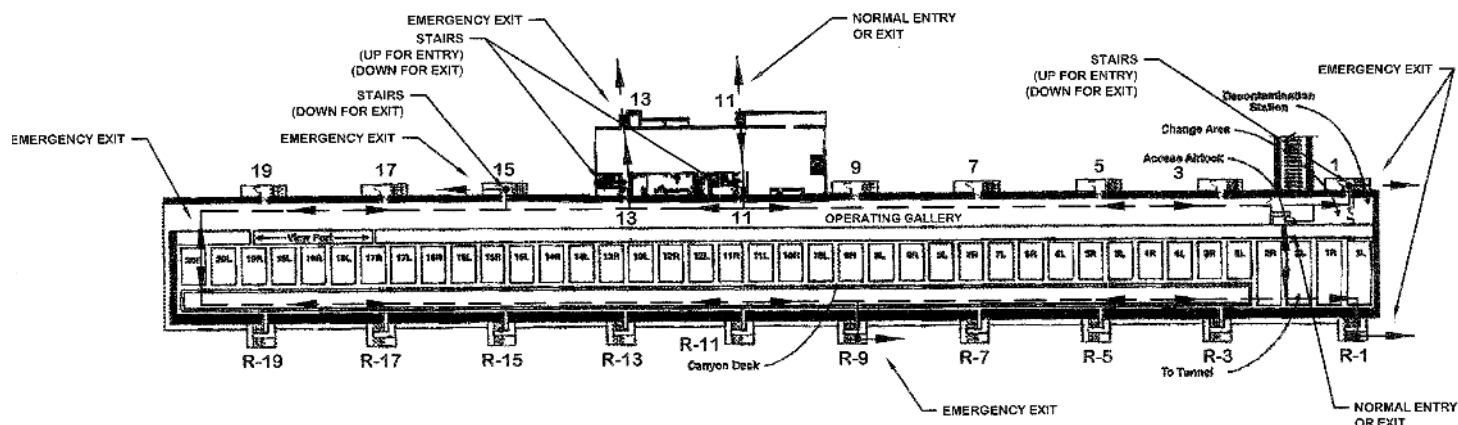


Figure 4. Plan view of U-Plant

### Tank D-10 Removal

Tank D-10 required several work packages and many tasks to be completed. The Tank D-10 had been placed in U-Plant for storage in 1964 and had not been moved since. Several options were considered in how to remove the TRU waste. The removal of the material in Tank D-10 would have required the design and installation of a mixing system with the associated risk of fluid transfer to shipping containers and multiple container handling. Due to this complexity, a decision was made to remove the tank itself, with the TRU waste still inside.

The first major work package included the tasks of tank and material evaluation, the design, bid, build, and delivery of a customized shipping container for the transferring of Tank D-10 to the storage location, transfer vehicle selection and procurement. The container had to meet all Department of Energy (DOE) and Department of Transportation (DOT) regulations and requirements. This included completing an estimation of the quantity of the TRU waste in the Tank D-10. Once the amount of material was determined, the container's shielding requirements could be calculated and the design of the size, shape, and closure elements of the tank could begin. This work package also included the task of determining the size and weight of the filled container to properly size the transfer vehicle.

The second major work package was a series of preparations and tests on the existing condition of the Tank D-10. This work package addressed the concern that the tank's structural integrity was sufficient to safely handle the movements anticipated. Since the Tank D-10 had not been moved since 1964, the condition of the tank was of issue. A structural and corrosion review of the existing tank was performed. This review required that the tank be lifted and video be taken of the entire tank including the inside and underside of the vessel. The Tank D-10 was lifted but remained inside the sub grade cell. All video and lighting equipment had been lowered into place by using the U-Plant Bridge Crane. The video was fed outside the canyon to a remote station. All ports were plugged appropriately, a series of absorbent socks were inserted to eliminate any free liquid, and the main port had a HEPA filter installed to allow the Tank D-10 to safely "breathe". During this review a "Rad Ball" was inserted to allow testing of new equipment, and radiological measurements were taken using conventional best practices to further confirm design assumptions with empirical data.

The third major work package was the final preparation, mock ups, and removal of the Tank D-10 from Cell 30 to the transfer vehicle through the Railroad Tunnel Cell 3, and delivery to an interim storage



location at Hanford. The transfer vehicle and package went through extensive mock ups to ensure that the lid could be installed correctly, and to allow the workers opportunity to become proficient at bolting on the lid to the customized package. Time trials were held to better estimate dose time during the mock up sessions. The canyon was prepared for the movement. The transfer vehicle was prepared and moved into place in the Railroad Tunnel Cell 3. This also included the preparation of the Railroad Tunnel Cell 3 to allow such a large package to be inserted and retrieved. Piping had to be removed, and the tunnels drainage system covers had to be upgraded to handle the enormous loading. The removal of the Tank D-10 from Cell 30 and the subsequent move to Cell 3 went exceedingly well. The bridge crane operator inserted the Tank D-10 into the shipping container without event, and then installed the inner and outer lids efficiently. The proficiency gained by the craft workers during the mock up paid the dividend of lower than anticipated exposure duration. The vehicle and package were removed from the railroad tunnel, radiological surveys were taken, offsets were implemented and the package was shipped to interim storage successfully.

### **Equipment Disposition**

Equipment Disposition required several work packages to be completed. Over the decades between the 1960s until the mid 2000s, many pieces of equipment and accumulated radiological debris had been stored inside U-Plant. The remedy for this facility was determined by a Record of Decision (ROD) pursuant to the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA). That remedy was to "Close in Place - Partially Demolished Structure". This CERCLA action allowed for the disposition of the equipment in place at U-Plant.

The first work package characterized and inventoried all equipment and debris in the canyon. A master list of the equipment was created. Subset into the master list of equipment was an "equipment of concern" designation. All chemicals were identified, and then properly and temporarily stored prior to disposition. All chemicals were dispositioned in accordance with the applicable regulations and requirements for that chemical at a CERCLA site. Chemicals that were compatible with grout were solidified and incorporated with the grout.

Prior to moving any equipment, the canyon operating floor had fixative applied to lock down contamination. All equipment also had fixative applied prior to movement. Once moved the "shadow" areas left by the moved equipment had fixative applied. Once all equipment had been dispositioned a final fixative coating was applied including the first 2.4m (8 ft) of canyon wall.

Using the master list of equipment, each piece of equipment was evaluated and if needed a size reduction task was completed to allow all of the equipment to be inserted into 35 of the 40 cells. Part of the evaluation and size reduction tasks included opening each piece of equipment for future grout operations to fill.

Using the master list of equipment, all equipment of concern was tracked and its final location was recorded. All legacy equipment was dispositioned in 35 of the 40 cells.

### **Canyon Grouting**

Canyon grouting required several work packages to be completed. It was determined to be cost effective to install a batch plant at the site. Initially a haul road and batch plant area were constructed. The Hanford Raw Water system was tapped into to provide a water supply for the batch plant. Temporary generators sized in accordance with the batch plant subcontractor's specifications were installed to power all batching operations. The batch plant was erected, commissioned, and started prior to grouting operations.

All grout materials for and products from the batch plant were managed for quality through a Quality Control / Quality Assurance (QC/QA) Program. The QA was performed by an independent subcontractor.

Beginning prior to, and continuing during erection and start up of the batch plant, core drilling was performed on the external and internal locations of the canyon. Two (2) test cores were drilled, one (1) horizontal, one (1) vertical, outside the canyon at a benign location, so that time trials could be developed. Eleven (11) horizontal cores were drilled through the external walls of the canyon to allow grout pipe access to grout delivery locations. Five (5) vertical cores were drilled in the external ventilation duct at the sand filter to allow access for grout delivery to these void spaces. Nine (9) 5.3m (17.5ft) vertical cores were drilled through the canyon operating floor into the ventilation tunnel to allow access for grout delivery. Nine (9) vertical cores were drilled through the Hot Pipe Trench cover blocks to allow for grout delivery to this void space. Vertical cores were drilled into all forty 40 cells through the cover blocks to allow for grout delivery to these void spaces. Each cell had a minimum of two openings. These openings were either created by core drilling, were from missing cover blocks, or through existing plating covering the cells. All horizontal cores were plugged using mechanical sewer plugs at both ends. All vertical cores were plugged using mechanical sewer plugs into the top of the core hole. These plugs allowed for the free removal and replacement when needed.

During the grouting process the facility was taken from an active facility to Cold & Dark status. Since operations were ongoing temporary internal power and light had to be installed. Since the crane was needed throughout the duration of the project, temporary crane power was rerouted. Likewise since the elevator was needed to move materials, temporary elevator power was rerouted as well. All temporary power was provided by generators outside the facility.

Bulkheads were required to plug all man doors, equipment doors, vent duct openings, utility sleeves, utility ducts, and various openings. All bulkhead locations were identified and conflicts with active systems traced. Lock Out / Tag Out procedures were used to remove the active utilities. Small sized bulkheads were created out of various materials. Sewer plugs both mechanical and pneumatic, plywood forms, and expanding foam are examples of materials used to block the flow of grout. 6mm (¼ in) plate steel was used for all medium sized bulkheads such as double man doors, single man doors and vent duct openings. These were then caulked and sealed to prevent leakage. A subcontract was released and completed for large bulkheads. These bulkheads were constructed with cement masonry units (CMU) block, infilled with grout, and doveled into walls and floors. These were then caulked and sealed to prevent leakage. The largest bulkhead was constructed after Tank D-10 was removed from the Railroad Tunnel Cell 3. The bulkhead was located along a projected line through the railroad tunnel down the exterior face of the canyon. This separated the railroad tunnel into two sections, internal to the canyon at 22.4m (73.5ft) and external to the canyon at 45.7m (150ft). The bulkhead was constructed using CMU block, infilled with grout, doveled into walls and floors, and reinforced with small I-beams braced and anchored to the floor and ceiling. This bulkhead was 7.5m (24.8ft) tall and 4.9m (16ft) wide.

The grout mix design was developed to meet a number of performance criteria. The first performance criterion was a compressive strength of 5.17Mpa (750psi) at 28 days. The second performance criterion was a flow distance of 24m (80ft). The third performance criterion was a maximum of 7°C (13°F) for every 45kg (100lbs) of cement. These three performance criteria guided the mix design which fulfilled the RD/RAWP requirements. This requirement was for a cementitious grout to be pumped into the galleries, pipe trench, ventilation tunnel, cell drain header, process cells, and vessels containing residual materials to the maximum extent practical, to minimize the potential for void spaces, and to reduce the mobility, solubility, and/or the toxicity of the grouted waste. The grout was also to reduce the potential for leaching of radioactive isotopes, while maintaining desirable properties of Portland cement (e.g. a flowable, structural grout with good compressive strength).

Grout was placed in U-Plant in accordance with a DOE approved sequence. The sequence was designed so as many void spaces as possible received grout from at least two directions. The sequence was also designed so that grout was placed at the lowest point first and then pushed all air up and out thereby minimizing trapped air. The quantity estimate developed was based upon typical drawings for the structure and an engineering estimate of the amount of volume that the existing equipment filled. Since the amount of existing equipment in each of the cells was documented through photographs, a team of engineers and operators reviewed each photograph and then assigned each cell a percentage of volume that the equipment filled. This generated a rough quantity parameter of +/- 25%. The sequence followed this general path:

<b>Location</b>	<b>Grout Quantity Planned</b>	<b>Unit</b>	<b>Grout Quantity Placed</b>	<b>Unit</b>
Northern Electrical Gallery	382	CY	382	CY
Northern Piping Gallery	264	CY	264	CY
Cell 10 Sump Cell	396	CY	396	CY
External Process Sewer	93	CY	106	CY
Drain Header	110	CY	110	CY
Buoyant Vessels	670	CY	124	CY
Process Cells	5,688	CY	8,768	CY
Southern Electrical Gallery	4,115	CY	5,079	CY
Southern Piping Gallery	4,050	CY	5,136	CY
Hot Pipe Trench	1,029	CY	1,455	CY
Ventilation Tunnel	2,940	CY	1,998	CY
External Ventilation Duct	581	CY	329	CY
Grout Cap	0	CY	1,572	CY
<b>Total</b>	<b>20,318</b>	<b>CY</b>	<b>25,719</b>	<b>CY</b>

Table 1. Grout Sequence and Quantities

The work was completed in accordance with approved work documents. Work was controlled through the use of work control packages augmented by Pre-Placement Readiness Checklists and Grout Insert Sheets. The work control packages contained the general activities to be performed as well as the hold points that were not to be passed. Each void space was identified and the project team signed off that the areas were ready to be void filled using the Pre-Placement Readiness Checklist. This document behaved like a Pre-Demolition Checklist ensuring that all project, environmental, radiological, health, and safety items had been completed prior to filling with grout. Each pour was controlled by a Grout Insert Sheet. This checklist was customized for each pour and informed the work crew of all necessary preparations, routing, quantities, grout types, work control steps, safety, and radiological items that had to be completed prior or during each pour. All actual pour information, temperature, times and approved changes were recorded on the Grout Insert Sheets.

The Northern Electrical Gallery was determined to be the first location to be poured for multiple reasons, it was isolated from the rest of the structure, it had good personnel access, it was a large pour, and it was a sump location. This made it ideal for use as a design verification pour. Two 55 gallon barrels were placed inside the location one had the lid removed, the other had a 75mm (3in) port drilled into the top. These 55 gallon barrels represented vessels inside the cells to be grouted. The void space was video recorded during the grout pour. Only half of the single man door bulkhead was erected so that video could be taken. Once the desired video was completed, and in between pours, the other half of the bulkhead was installed. The 55 gallon barrels were filled with grout and the results could be shown later as to the ability of the grout to flow throughout the large void space and how it filled small and medium sized orifices. Temperature readings from the void space before, during and after grout placement were recorded so that



the temperature rise would be documented. It was found that the grout flowed through cracks and crevices better than originally expected. So much so, that the grout operation was paused so that a second effort of sealing and caulking bulkheads, instrument air lines, and small electrical boxes could be completed.

The Northern Piping Gallery was the second location to be poured. It too was isolated from the rest of the structure and allowed good personnel access for post review of the pour.

Each cell from cell 2 through cell 40 had a drain. The drain header sump was located in cell 10. The drain header sump was filled to just below the invert of the drain header. The second pour in cell 10 was a self leveling grout. Measurements indicate that the grout filled the drain header in its entirety. The rest of the cell 10 was filled during the process cell grouting campaign.

A buoyant vessel was defined to be any vessel with a large internal void and small orifices for the air to escape. Three (3) cells had a total of 6 buoyant vessels. Cells with buoyant vessels had the vessels filled prior to rest of the cell. This prevented any overturning or disruption to the equipment configuration in the cell. The buoyant vessels were filled using the overhead bridge crane maneuvering a flexible grout hose, connected to a sweep elbow, connected to a series of reducers from the 125mm (5in) pipe to a 50mm (2in) outlet. This was lowered into the cell and grout flow was directed into the small orifices by the crane operator. Grout was placed into the buoyant vessel until it was determined to have flowed out of all orifices.

Process Cells 1, 2, 4 through 40 were filled with grout through predetermined openings. Cells were grouted in lifts in a checkerboard type arrangement. Lifts generally did not exceed 1.8m (6ft) in height when surrounding cells did not have any grout in them. Lift thicknesses were dependent upon target heights in the cells, and administratively attempting to minimize and disperse heat accumulation in the cell, as well as minimize the risk of thermal and shrinkage cracking. No grout was permitted to be placed beyond cell 20 until a mechanical plug was inserted into the drain port of cell 20. Cells 29, 30 and 31 had a hold point in place for any grout until Tank D-10 was completely removed. No grout was permitted to be placed above the pipe jumper system in the cells until the pipe gallery was secured and backflow prevention from the cells to the pipe gallery was confirmed. In order to prevent positive air flow out of the cells, either a NAM or a passive HEPA filter was attached to the second core hole in each cell.

The southern electrical gallery pipe conveyance system started at the grout pump, through rigid pipe, through the external walls, converted to a flexible pipe and routed through existing pipe chases back down to the electrical gallery. The electrical gallery pours macroencapsulated large electrical boxes and cabinets, electrical conduits, as well as drain lines that passed through the electrical gallery. The southern electrical gallery was poured in approximately five (5) lifts. This minimized the amount of stress placed on the existing structure as well as the installed bulkheads. This also allowed for a safe and efficient daily pour routine to be developed and implemented.

The southern piping gallery pipe conveyance system started at the grout pump, through the same rigid pipe as the electrical gallery conveyance system, through the external walls, converted to a flexible pipe and routed through existing pipe chases back down to the pipe gallery. The efficiency of using the same piping system meant that fewer injection ports had to be core drilled and fewer grout lines had to be purchased. The fewer grout lines also meant for a more compact work area and less hazards to the structure and personnel. Grout was placed into the southern piping gallery in lifts that macroencapsulated equipment, piping, and pipe debris from the operating gallery. The southern piping gallery was poured in approximately five (5) lifts. This minimized the amount of stress placed on the existing structure as well as the installed bulkheads. This also allowed for a safe and efficient daily pour routine to be developed and implemented.

The Hot Pipe Trench (HPT) was the primary means for transfer piping between process cells. The system was generically referred to as the jumper system. This jumper system upon the start of this project was in the configuration that some ports were sealed and some ports were not sealed. The majority of the piping had been disconnected from the equipment inside the cells, however some of the piping was still attached. The jumper system entered and exited the cells at an elevation of -3.3m (-10.0ft) from the operating deck. Each section of the HPT had a drain system that dropped overflow from the HPT to the Drain Header underneath the process cells which lead to the cell 10 sump cell. Each section of the HPT also had ventilation ports from the cells through the HPT and then through an inverted p-trap that lead to the ventilation tunnel beneath the HPT. The inverted p-trap was designed to delay the flow of liquids from the HPT to the ventilation tunnel, but not to eliminate the potential in case of emergency. Therefore the HPT was still a means of conveyance for grout under pressure to follow the jumper system and fill in location prior to design. These locations included the 36 of the process cells, the drain header and the ventilation tunnel. The HPT was filled after the drain header, and process cells had been filled, but prior to the ventilation tunnel. This allowable the ventilation tunnel to be maintained until the very end of the pour sequence. Once the HPT grouting had begun it was seen flowing into the ventilation tunnel beneath through the p-traps. This caused the grout to be poured in lifts to seal the p-traps and allow for grout to build up to the underside of the cover blocks.

The ventilation tunnel was 3.2m (10.5ft) wide by 3.2m (10.5ft) tall and ran from cell 40 to cell 5. At cell 5 a connection from the ventilation tunnel to the external ventilation duct of 1.2m (4ft) wide by 1.8m (6ft) tall was made. This connection of the external ventilation duct ran perpendicular to the ventilation tunnel all the way to the external sand filter. The ventilation tunnel was poured through the core holes in the canyon operating floor. There were 9 core locations evenly spaced down the length of the ventilation tunnel at 5.3m (17.5ft) in depth from the operating deck. The grout lines were connected to these core locations in sequence to fill the ventilation tunnel in lifts. Sequenced grout pours were made until the each core drill location had grout flow out the top of the core.

There were two major grout quantity unknowns that had to be addressed during the grouting sequence. The first unknown was due to the nature of the building being connected by transfer piping, air duct systems, and drain systems, as well as poor As-Built information. The second unknown was the volume of the equipment that was loaded into the cells prior to the grouting phase. The estimated quantities of grout placed had to be field adjusted to allow for grout to flow into locations to fill various void spaces connecting the major elements of the structure as well as to allow for unknown voids not shown in the plans and unable to be seen due to their remote nature, and the inability to determine the actual volume that the grout would fill each individual piece of equipment that had been loaded into each cell. This is the justification of the wide volume estimate of +/- 25%. This is also recognized as a decision point for each void space to be evaluated upon reach 125% of estimated volume and the need to verify that grout was not flowing into areas of the structure that would be detrimental to work package, DSA, or future pours. Each individual void space was calculated and grout placement quantities were maintained daily to insure that the ROD was fulfilled to grout void spaces to the maximum extent practical.

### **Inert Rubble Staging**

The RD/RAWP also required that the inert rubble from other nearby CERCLA sites be considered during remedial design for use as fill material in the future engineered barrier. Inert rubble from other nearby CERCLA sites was hauled and deposited at the U-Plant at a lay down yard. This was a great efficiency that all parties were able to recognize. This fill material was destined to be deposited at ERDF at a greater cost than the placement at U-Plant offered. This also allows for a reduction in required capacity at ERDF which is an additional efficiency as well. The engineered barrier will roughly require 325,000CM (425,000CY) of engineered fill. Approximately 206,000CM (270,000CY) of fill has been brought to U-

Plant from other nearby CERCLA sites to be used as the core material for the engineered barrier. The remaining volume will need to be specified to support vegetation at the time of the construction.

## DISCUSSION

### GROUT STUDY

An independent grout study was performed in advance of the project to provide recommendations on means and methods for project completion. The grout study recommended that 4 different types of grout could be used to fill various void spaces. A High Strength Equipment Stabilization (HSES) grout, a Flowable Non Aggregate Void Filling Slurry (FNAVFS) grout, a Low Heat Mass Void Fill (LHMVF) grout, and a Pipe Plugging Grout (PPG). At the close of the project 3 different types of grout were used. They were classified as Type A, Type B, and Type C and they corresponded to the grout study as shown. Type A was the LHMVF, Type B was the FNAVFS, and the Type C was the PPG. Since the buoyant vessels were filled prior to the remainder of the cell the HSES was not needed. The Type C (PPG) was used to fill manholes and to create stop points or walls inside of ducts limiting the flow of the other grout types from entering spaces outside of the project scope (i.e. the sand filter was not inside the ROD or project scope). The Type B (FNAVFS) was used to fill buoyant vessels and as a cap lift because it was nearly self leveling and flowed in much excess of the grout performance criteria. The Type A (LHMVF) met the grout performance criteria and also allowed the project to minimize heat gains while filling mass sections of the facility at a reduced rate as compared to the Type B. The independent grout study also recommended an onsite batch plant at a cost savings to the project as well as to improve operational flexibility.

### INTERNAL PIPING

The electrical, piping and operating galleries had thousands of meters/feet of piping throughout. Due to a lack of data the hazardous / nonhazardous piping system could not be fully classified as empty. No documentation could be found the verified that this had been completed. Some of the piping had been air gapped and physical evidence was present to allow for verification, but some systems were not air gapped. This caused the project to tap and drain systems inside of the galleries in order to verify that the systems were CERCLA compliant (i.e. free of liquids). This caused a waste of time on the project in order to perform.

### OPERATING GALLERY

A decision was made to leave the operating gallery and allow for the demolition of the above grade structure to occur at the operating gallery deck which is 600mm (2ft) above the canyon operating deck. This allows for two savings, the first is that grout will not be placed in the operating gallery, and the second is that a reduction in the overall height of the future engineered barrier by approximately 4.6m (15ft) can be recognized. The cost savings in grout combined with the cost savings of 4.6m (15ft) of placed fill in the engineered barrier, while maintaining compliance with the ROD, was what changed the plan to eliminate the operating gallery from the grouting scope of work.

### GROUT CAP

A grout cap was placed on the canyon operating deck. This was a change from the 90% design. The change occurred to protect workers. At the close of each grout pour, the grout lines must be purged (pigged out) to prevent grout from setting up inside the grout line. This pigging is performed by closing a knife valve on the grout line external to the facility, disconnecting the grout pump, attaching a pneumatic compressor with a pig launcher, opening the knife valve, and pneumatically pushing a foam ball (similar to a dense nerf ball) called a pig through the grout line and into the void space. However, once the void space is filled with grout, the high pressure pneumatic system causes grout to “explode” out of the connection hole splattering in approximately a 4.6m (15ft) diameter. In order to eliminate the uncontrolled release of energy, the void space was filled so that grout came out onto the deck, the line

was removed from the void space, and a pigging process was then controlled to eliminate the uncontrolled energy release. This provided two benefits, the safety environment inside the canyon was improved, and a grout cap was placed to positively seal all cracks / joints into each cell location.

#### TANK D-10

The shipping container for transporting the highly radioactive waste tank D-10 from U-Plant to the storage facility was designed and fabricated referencing the original as-built drawings from the 1950s for tank dimensions. Because tank D-10 was highly radioactive, it was impracticable to approach the tank to verify dimensions and configuration, causing concern with the close fit of the tank within the shipping container both in the horizontal and vertical directions. Tight clearances were necessitated to reduce the overall size and weight of the shipping container. Areas of concern were initial placement of the tank into the shipping container, placement of a restraint cone to restrain the tank from vertical movement, placement of a liner lid, and placement of the container lid.

The first tight clearance to be encountered when placing the tank into the shipping container was aligning the tank feet with the feet guides in the shipping container. There were three tank feet that had to be aligned with the guides so that the tank could be lowered into the container and restrained from moving horizontally. The feet were circumferentially located around the tank bottom at 0°, 147.5°, and 212.5°. Shipping container as-built drawings were compared with the tank as-built drawings to ensure that the feet would engage and slide into the feet guides without bending the guides. There was a built in design clearance of 12.5mm (1/2 inch) between the feet guides and the feet to account for fabrication tolerances and misalignment of the feet on the tank circumference. As-built placement of the guides was within 2.5mm (1/10 inch) of design.

The second tight clearance was a bracket on the side of the tank that was calculated to come within 5mm (1/5 inch) from one of the liner stiffeners as the tank would be lowered into the shipping container. Review of the as-built dimensions from the tank and the shipping container did not change the clearance. The 12.5mm (1/2 inch) clearance built into the feet guides and the flexible liner side gave confidence that the tank would be completely lowered into the shipping container.

Following successful placement of the tank into the shipping container a restraint cone, designed to keep the tank from moving vertically, was placed on the tank's center flange. To ensure that the restraint cone would sit properly on the flange, it was trial fit onto the flange prior to removing the tank from the cell. The trial fit was successful, eliminating this concern.

Once the restraint cone was placed onto the tank in the shipping container, the liner lid was installed. There was concern that if the overall height of the tank with the restraint cone was too tall, that the liner lid would not seal onto the liner. Additionally, if the overall height was too tall, the container lid may not set down to seal. The shipping container was designed leaving about 25mm (1 inch) gap between the restraint screw bosses and the restraint cone. The restraint screws were designed with enough travel to make up this gap with about 25mm (1 inch) of travel available. There was adequate clearance in the design to accommodate over 25mm (1 inch) of error in the height of the tank, either too short or too tall.

#### LESSONS LEARNED

Major lessons learned from this project that are applicable at a general level are as follows.

Operations during the different phases all require power, and lights throughout the entire facility. Rather than depending on existing power and lighting, the facility should have temporary power and lights installed prior to the facility going cold and dark, but also prior to the start of main scope items. This is so that all preparations may be completed while the facility is cold and dark such as drilling into walls, and

cutting pipes. The crane and elevator should have temporary power connections external to the facility installed prior to the facility going cold and dark to eliminate conflicts internal to the structure.

Since the crane was almost 70 years old it was only marginally dependable. Due to need for a crane, an alternative method for raising and replacing cover blocks should be researched. This also generated an increase in scope to core drill at least two locations per cell so that mass grouting could be executed even if the crane was down.

The grout performance criteria for compressive strength was originally set at 10.3MPa (1,500psi) at 28 days. This was derived from two sources. The first source was a rough calculation that looked at the potential construction loading and overburden that could possibly be loaded onto the structure after demolition. This was roughly estimated, with a factor of safety, at 5.17MPa (750psi). The second source was the general classification of what “a structural grout with good compressive strength” meant. After review and discussion among the engineering group the team decided that a compressive strength of 10.3MPa (1,500psi) at 28 days could be easily asserted as a structural grout with good compressive strength. Once placement of the grout began it was quickly noted that compressive strength values ranged from 7.5MPa (1,000psi) to 17MPa (2,500psi) from the supplier. A change to the 90% design documentation was required to reflect that the performance criteria was 5.17MPa (750psi) at 28 days given that the 10.3MPa (1,500psi) requirement was twice the strength required by calculation.

The ventilation per the ROD and Documented Safety Analysis (DSA) was required to be maintained for as long as possible. The grouting sequence was, in part, developed to maximize the duration that the ventilation system ran. This allowed for a negative air pressure to be maintained on the structure for contamination control and had an added benefit of reducing worker heat stress. As the project reached the point at which the ventilation system was turned off heat conditions inside the canyon required a work regiment and personnel monitoring. If possible, it is recommended to schedule the project along with the calendar year so that grouting occurs during the winter months. This will generate cold weather concerns for the materials and personnel.

The project used three grout pumps. Two inline trailer pumps and one boom mounted pump truck. The recommendation is that the number of pumps be increased to four pumps minimum with associated crews, and that all four pumps be boom mounted pump trucks. The production rates were lower for the trailer pumps due to the additional efforts required for movement and the detailed set up required for the pump itself. These issues are lessened dramatically by the boom mounted pump truck since the unit may be set up further away, and it can demobilize/mobilize in half the time required for the trailer version.

## REFERENCES

*Remedial Design/Remedial Action Work Plan for the 221-U Facility (RD/RAWP)*, DOE/RL-2006-21

*Record of Decision for the 221-U Facility (Canyon Disposition Initiative), Hanford Site, Washington* [EPA 225]