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REMOTE INSTALLATION OF RISERS ON UNDERGROUND
NUCLEAR WASTE STORAGE TANKS

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By
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March 1988

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West Valley Nuclear Services Company, Inc.
West Valley, New York

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by

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and
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Prepared for

U. S. Department of Energy
Assistant Secretary for Nuclear Energy

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ABSTRACT

The West Valley Demonstration Project was established to solidify 2120 m³ (560,000) gallons of high-level nuclear waste generated during six years of commercial nuclear fuel reprocessing. This liquid will be processed to remove radioactive elements which, with the remaining sludge, will be combined with glass formers and be converted into borosilicate glass. Risers were installed on the high-level tank for installation of pumps which will be used to remove the liquid and sludge. The extensive use of remote technology was required to install the risers and to minimize operator exposure to high levels of radiation and contamination.

The riser installation required remotely: drilling through two feet of concrete shielding; installing pump access pipes which are welded to the tank top; and cutting holes in tanks located 3658 mm (12) feet below ground. These operations were successfully completed 13 times without exposing personnel to high-level radiation or contamination. Specially designed remote equipment was developed for each step of this operation. Extensive operator training in the use of this equipment was performed on a tank with low radiation prior to work on the high-level tank.

This paper discusses the application of remote technology that assured a quality job was safely accomplished.

I. Introduction

Congress passed the West Valley Demonstration Project (WVDP) Act in October 1980 and directed the U. S. Department of Energy (DOE) to undertake a high-level radioactive waste management demonstration project at the West Valley site. Under the Act, the DOE is responsible for solidifying the high-level waste (HLW) in a form suitable for transportation to a federal repository for permanent disposal. West Valley Nuclear Services Company, Inc. (WVNS), a wholly owned subsidiary of Westinghouse Electric Corp., is the prime contractor for the DOE.

A major portion of this project is the solidification of 2120 m³ (560,000 gallons) of liquid HLW generated during six years of commercial fuel reprocessing operations in the 1960s and early 1970s. The solidification process involves vitrifying the waste to produce borosilicate glass encapsulated in stainless-steel canisters. The canisters will ultimately be sent to a federal high-level waste repository for permanent disposal.

The bulk of HLW is contained in an underground storage tank (8D-2). The alkaline solution has precipitated solids in the complex internal structure of the tank. A special array of eight liquid transfer and sludge sluicing pumps is required to transport the waste to: a) an ion exchange system for the liquid, and b) a glass melter for the sludge. This required the installation of pipes (risers) to provide penetration into the tank for the subsequent installation of pumps. Very high levels of radiation at the tank top demanded that riser installations be performed remotely. A spare tank (8D-1), available for emergency storage of the high-level waste, will be used for processing the liquids in ion exchangers. This tank, with low radiation background, was used to proof test the equipment and train personnel, while installing five risers. Figure 1 shows the location of risers on the two tanks.

TANK 8D-1

TANK 8D-2 (WVNS INSTALLED)

FIGURE 1
Riser Installation on Tanks 8D-1 and 8D-2

Riser installation consisted of the following steps:

Installing a construction caisson to establish a work area, drilling a 102-mm (4-inch diameter) pilot hole in the concrete vault roof, installing a 1016-mm (40-inch diameter) casing centered on the pilot hole, coring a 762-mm (30-inch diameter) hole in the concrete vault roof, removal of interfering steel-beam roof stabilizers (rafters) on the tank roof, grinding the tank top for welding, fitting the riser to the tank top, welding the riser to the tank top, pressure testing to verify the integrity of the weld, welding load transfer devices to the riser, flame cutting the tank roof, and installing a radiation shield plug.

This paper discusses the technology developed, and the challenges met and overcome during the Remote Riser Installation (RRI) project.

II. Description

Tanks 8D-1 and 8D-2 are each encased within a reinforced concrete vault having a minimum thickness of 610 mm (2 feet). The carbon-steel tanks are 21.3 m (70 feet) in diameter and 8230-mm (27 feet) deep. A 1219-mm (4-foot) crawl space separates the tank roof and the vault roof, and a 610-mm (2-foot) annulus space separates the tank and vault walls. The vault roof is 2438 mm (8 feet) below grade.

The remote equipment utilized on the RRI project was designed and built by Westinghouse and Rockwell Hanford Operations (RHO). The equipment was shop tested in Hanford, Washington, and field acceptance tested at the WVDP. Tank 8D-1, having low-level radioactivity, was used for acceptance and proof testing of equipment. The first riser installation (M-6, see Figure 1) was performed by RHO personnel. The second riser installation (M-7) was performed by the West Valley personnel with RHO supervision. Three additional risers (M-2, M-3, and M-8) were installed on 8D-1 by WVNS to provide experience for the operators and to perform equipment and

procedural modifications dictated by operating experience. This strategy also was planned to practice radiological control functions which assured personnel exposure was kept as low as reasonably achievable on the HLW Tank (Figure 2) - a West Valley and Department of Energy commitment.

III. Approach

The riser installation operation consists of eight discrete steps. Preparations such as installing the construction caisson, pouring the concrete for shielding around the caisson, 102-mm (4-inch diameter) pilot hole and casings had been completed prior to setting up for the vault and tank work.

1. Core Drilling Vault Roof

In order to gain access to the tank roof, a 762-mm (30-inch-diameter) hole must be cut through the 610-mm (2-foot-thick) concrete roof of the vault. This provides adequate clearance for the new riser.

The 762-mm (30-inch-diameter) vault penetration (Figure 3) was accomplished with concrete coring equipment expressly designed for this purpose. The coring equipment consisted of a hydraulic power pack unit, the coring machine, and an operating station. The coring machine included a core retaining device to prevent the core from falling onto the tank. The core retainer device (Figure 4) fit through the 102-mm (4-inch-diameter) pilot hole previously drilled. The coring bit was a conventional design using synthetic diamond impregnated bits.

The coring machine was lowered onto the load bearing casing prior to the drilling operation. Taper pins were driven into matching holes in the side of the casing to secure the machine in place. The power pack control station, a series of hydraulic control valves, was

REMOTE RISER INSTALLATION

Figure 2
High-Level Tank (8D-2) with a Riser in Place

Figure 3
Core Drilling Device with Suspended Vault Cutout

Figure 4
Closeup of Core Retaining Device

positioned near the casing to permit the operator to monitor the cutting operation. Coring duration for each location on both 8D-1 and 8D-2 averaged 10 hours.

2. Rafter Cutting

The tank roofs were strengthened by carbon-steel channels welded in place and spaced 475 mm (18 inches) apart. Prior to welding the riser on the tank, two interfering rafter sections had to be removed for each riser. To assure that the top of the tank was not breached, work was completed in two steps: 1) The upright sections of the rafters were cut away with an oxygen-acetylene torch, and 2) The remainder (~ 16 mm (0.625 inches)) was removed by grinding.

The rafter cutting machine was an extensively modified commercial unit made semiautomatic to cut in two planes carrying a flame torch. The sequence of cutting was effected using microprocessor controls.

The rafter cutter (Figure 5) and operating shaft was L shaped; since the rafter cutter arm is about 1016 mm (40 inches) long and the access hole is 762 mm (30 inches) in diameter, a special entry technique was required. First, the rafter cutter was rigged to hang vertically, making it possible to pass through the vault cut. Taking advantage of the 1219-mm (4-foot) crawl space between the tank and the vault, the drive head was remotely driven to the center of the rail, shifting the center of gravity and causing the cutting arm to rotate to the horizontal position. It was then remotely positioned onto a rafter for the first cutting operation. The rafter cutter was then moved to the second rafter, the sequence repeated and the entry technique was reversed to withdraw the unit to the surface. The two cut rafter sections were freed with a breakaway tool and retrieved with an electromagnet.

Figure 5
Preoperational Mock-Up of Oxyacetylene Rafter Cutter

The rafter cutting and all other subsequent steps were performed remotely from an Instrument Control Trailer (Figure 6). This trailer was set up with CCTV monitors, tape recorders, and specially designed control panels to remotely operate the grinding, welding, and torch-cutting operations (Figure 7).

3. Roof Grinding

The lower channel flanges of the rafters were removed by grinding and this operation also prepared the tank roof for riser attachment welding.

The grinding operation was performed by a remotely operated turntable device, magnetically clamped to the tank roof. The grinder pivoted about the turntable centerline on a nominal 711-mm (28 inch) diameter (Figure 8). The operator had complete, remote control of the grinder position in the vertical and azimuthal direction. This operation was monitored by a CCTV observation camera that was mounted on the turntable. The grinding process continued until a uniform circle of bright metal on the tank top was visible on the television monitor (Figure 9). Constant attention to grinding was necessary to avoid penetrating the 10-mm (7/16-inch-thick) roof; depth of cut was usually 0.075 mm (0.003 inches) or less.

Tank 8D-1 has a slight slope to the roof. Each riser had to be ground slightly on the bottom surface to assure a sound fit up for welding. No slope existed on tank 8D-2 and risers could be located without fit up grinding.

Figure 6
Instrument Control Trailer

Figure 7
Interior View of Control Trailer

Figure 8
Remote Grinding Turntable

Figure 9
Final Condition of Tank Surface After Grinding Operation

4. Riser Installation

The grinding turntable was converted into a MIG welding turntable by changing tooling. The weld head incorporated independent cam followers to track irregularities in the tank roof, thus maintaining the proper torch-to-joint clearance. A weld wire feeder was mounted directly on the turntable to minimize the feed distance.

Immediately before each remote-riser-to-roof weld was made the welding turntable was tested on a full-scale surface mock-up of the riser base (Figure 10). The new riser was repositioned on the tank roof. The riser-to-roof joint was remotely inspected for cleanliness and joint fit-up before initiating the automatic weld sequence. The internal fillet weld was visually inspected with the turntable camera. To verify the integrity of the weld, it was pressure tested, using a shielded leak test fixture, at 138 kPa (20 psi) air for 30 minutes. Acceptance criteria were no visible pores ($>1/16$ inch) and no loss of pressure.

After the weld passed inspection, a vertical preload of 35.6 kN (8,000 lbs.) was applied to the riser through the shielded test fixture until the load transfer devices were welded in place (Figure 11). The shield concrete and steel blocked radiation beams from the HLW, allowed the upper riser welds to be safely accomplished manually. The "doughnut," the main load transfer member of the installation, was welded to the riser while maintaining the preload, thus diverting the load from the tank top to the concrete vault roof.

Figure 10
MIG Welder Being Used on Full Scale Mock-Up

Figure 11
Application of Preload and Manual Weld of Transfer Device.
Shield Plug In Place Reducing Work Area < 1.0 mrem

5. Tank Roof Cutting

The final operation in the installation was cutting through the tank top within the riser to provide direct access to the tank interior. Since radioactive contamination was now a possibility, the operation was performed within a containment tent (Figure 12). Both 8D-1 and -2 are maintained at a negative pressure of 1.25 kPa (5 inches of water). However, tank ventilation was increased to provide 0.76 m/sec (150 lfm) flow across the cut tank top to avoid contamination from entering the containment tent area.

A second turntable, equipped with an oxygen-acetylene torch, was used to cut through the tank roof. The turntable was outfitted with electromagnets to hold the turntable in place during the tank cut and retrieve the roof cutout. This turntable, generically the same as the grinding and welding turntable, was dedicated to the roof cutting operation since contamination was a possibility.

The riser shield plug was removed from the riser through the roof of the tent and tank ventilation increased (Figure 13). As in previous operations, the turntable was operationally bench tested immediately before being lowered into the riser. A lens filter (#3) was placed in front of the CCTV camera so the welder could observe the cutting process on the monitor. The 635-mm (25-inch) diameter hole was cut in approximately three minutes. The plate was cut at a 35-degree angle to prevent the cutout from falling into the tank in the event of a momentary power loss. After the cut was made, the cutout was brought to the surface using the turntable magnets. While still within the containment tent, the cutout was bagged and boxed according to nuclear waste disposal criteria. The turntable was also bagged and the shield plug reinstalled in the riser (Figure 14).

Figure 12
Tank Top Cutout Removal in Containment

Figure 13
Shield Plug Removal Through Containment Tent

Figure 14.
Completed Riser with Shield Plug In Place
Ready for Pump Installation

IV. Challenges Presented on the HLW Tank 8D-2

Some of the conditions, such as high radiation and high temperature, present on tank 8D-2 were expected; however, the effects of these conditions on the performance of the equipment was unexpected and posed many challenges. This led to additional procedural changes and equipment modifications.

To safely complete the RRI project on schedule and minimize radiation exposure, the following field solutions were performed:

Condition: High-radiation field, 350 Rem/hr at tank top, 5 to 9 Rem/hr at top of riser, which could result in unacceptable personnel exposure.

The radiation field in general work areas at ground level averaged 50 mrem/hr (see Figure 15). While DOE limits for occupational exposure are 5 Rem/yr whole body, WVNS has established a standard of holding exposure As Low As Reasonably Achievable (ALARA) with a control of less than 3 Rem/yr. In order to maintain ALARA, innovative shielding methods were designed, fabricated and installed.

- o After core drilling the 762-mm (30-inch-diameter) hole in the vault roof, temporary shielding was necessary as the permanent shield plug was designed for the installed riser. Temporary shield plugs (Figure 16) were fabricated from the original 762-mm (30-inch-diameter) core by adding bracing, lead lining, and a bail for lifting. This temporary shielding was in place whenever work was not being performed at each riser location, thereby reducing the exposure to < 1 mrem/hr; well within acceptable work area limits.

FIGURE 15
Typical Radiation Fields In General Work Areas

FIGURE 16
Vault Core Being Used as Temporary Shield Plug
Prior to Riser Installation

- o Whenever the temporary shield plug was removed for work at each riser location, above-grade shielding was necessary to provide safe working conditions. Commercially available 152-mm (6-inch-thick) concrete manhole barrels (Figure 17) were procured that reduced the general work area exposure from 50 mrem/hr to < 2.5 mrem/hr. This method was used solely on the six long (4267-mm (14-foot)) risers and in conjunction with other methods on the remaining two short (2.4-m, (8-foot)) risers.
- o Two riser locations (M-8 and M-9) were to be used for special pumps. The M-8 location houses the supernatant pump that will provide the transfer of the liquid supernatant to the ion exchange columns for removal of the radioactive cesium, and the M-9 location contains the sludge transfer pump, required to remove the sludge from 8D-2 for vitrification.

The two short riser locations required a special approach in shielding as, 1) the area between the 2438-mm (8-foot-diameter) construction caisson and the 1016-mm (40-inch-diameter) casing was not filled with grout, and 2) the riser was short and below grade. To provide the shielding necessary between the caisson and casing, water was used. With the temporary shield plug in place (exposure levels < 1 mrem/hr), the caisson and casing were made watertight and the area filled with water. The concrete manhole barrels were subsequently placed above grade around each location. Vault load analyses were performed to ensure that vault load limits were not exceeded by this method of shielding.

Condition: Combination of high radiation (350 Rem/hr), high temperature (93°C, 200°F), and high tool-holding magnetic flux resulted in severe CCTV degradation.

FIGURE 17
Concrete Barrels Reducing Work Area to <2.5 mrem/hr.

- o The grinding/welding turntable contained two cameras: one for centering the turntable onto the tank roof via a previously placed paint mark, and the second for observing the grinding operation and for weld inspection. The cameras originally mounted on the equipment were closed-circuit design (CCD) cameras.

Upon insertion in the riser, camera visibility rapidly deteriorated until, upon placement of the turntable on the tank roof, no picture was visible through the centering camera. The situation was corrected when two, high-radiation-resistant cameras were installed on the turntable with extensive equipment modifications. The centering camera gave excellent results when lowering the turntable for correct positioning in the riser.

However, when the locking magnets were activated after correct positioning was attained, the observation camera lost total image on the CCTV screen. It was determined that the strong magnetic flux from the electromagnets on the turntable disrupted the magnetic scanning coil located in the head of the observation camera. The centering camera was not affected by the magnetic flux as it was located in the shaft of the turntable, between the two magnets, thus situated in the null field of the flux and magnetically shielded. To alleviate the observation camera problem, the camera was inserted in a carbon-steel pipe which provided a magnetic shield for the camera and restored 100 percent camera visibility.

- o During the rafter cutting sequence of the RRI, appreciable reduced camera visibility was again apparent. Due to design and operating constraints, camera replacement was not a viable alternative. Lead shielding was placed around the camera and a high-intensity light source was introduced. Visibility was improved to the extent that work could proceed safely, but not to optimum conditions.

Condition: High humidity in vault "crawl" space resulted in loss of visibility in CCTV system.

A large, dense cloud of water vapor was present after core drilling the 762-mm (30-inch-diameter) hole through the vault. This was result of the high tank temperature and in-leakage of ground water. An exhaust system was designed and installed to provide ventilation through a core-drilled penetration adjacent to that being worked, without requiring removal of the temporary shield plug. This maintained low radiation levels in the general work area while alleviating the visibility problem.

Condition: Excessive amounts of rust, scale, and concrete glaze on rafters and tank top resulted in difficulty in cutting rafters and required extensive tank top cleaning.

The large amount of sediment on the tank top and on the rafters contributed to the difficulty in cutting the channel rafters. The concrete glaze on the tank top was a result of the original construction of the reinforced concrete vault surrounding the tank. Kerf bridging, torch-tip misalignment, and blow out due to splatter were many of the problems caused by these conditions. Shims of varying thicknesses were introduced to establish the optimum distance of the rafter cutter torch tip to the rafters. This distance was unique on any riser location. Distances varied between 1.6 to 3 mm (0.06 to 0.12 inches) per rafter and were determined by performing a torch-path clearance test via CCTV on the tank top rafters prior to the above-grade bench test.

Due to the excessive sediment and scale, extensive tank top cleaning was required. The rust and scale resulted from in leakage of ground water and 93°C (200°F) temperature. As a result, the original centering paint mark was removed. This prevented accurate placement

of the grinding/welding turntable on the tank roof. A precision locating and marking tool was designed and fabricated to avoid mislocation of the grinding centerline - crucial to riser placement.

Condition: Loose surface contamination found at the 8D-2, M-7 location resulted in additional procedure, containment and schedule changes.

Each riser location was checked by qualified Radiation and Safety technicians for possible contamination after the vault core drilling operation and prior to further work. Contamination was found at M-7 (16,700 dpm smearable) but at no other locations.

This contamination required many workarounds. The entire M-7 riser installation (except core drilling) was conducted in a containment tent with the appropriate ventilation/filtration system. All other riser installations required containment only for that last step, cutting the tank top. Procedures for each step were rewritten and approved to ensure optimum safety in operating and handling of contaminated equipment. Special containment was designed and fabricated to include all phases of riser installation (rafter cutting through tank top cut). The goal was to avoid multiple operations to contain and decontaminate the equipment. Additional conditions, solutions, and cost and schedule impact are contained in Table I.

V. Radiological Exposure

Prior to initiating work on this project, a comprehensive safety analysis was prepared (reference 3). The analysis was intended to assess work associated with the riser installation and evaluate radiation exposure to personnel performing the work. The total dose estimate was 3.3 person-rem for personnel installing the risers on tank 8D-2; radiation exposure for the work on 8D-1 (in a low radiation field) was estimated to be less than 1 person-rem.

During the conduct of this work, a number of precautions were used to minimize exposure of the work force to levels As Low As Reasonably Achievable (ALARA). These included:

- o Use of radiation work permits restricting the number of personnel at the site and establishing stay times for workers.
- o Enforcement of a daily exposure limit of 100 mrem per person. There were no instances where an individual's limit was exceeded and, in general, exposures of < 25 mrem per day were experienced per operator.
- o Setting up special shielding around casings on 8D-2 once the vault roof was core drilled.
- o Daily pre-job briefings of all personnel.
- o Management walk-throughs and readiness reviews prior to major evolutions to minimize risks when high radiation or contamination could be encountered.

The work on tank 8D-1 started in April 1986 and was concluded in September 1986. Table II shows that the exposure for this portion of the work totalled 1.013 rem with the highest individual exposure being 241 mrem. The major lesson learned during this phase of the program was that additional shielding would be required when working at the opening on the High Level Waste Tank.

A schematic of the radiation environment with shielding in place (to protect workers from direct exposure) is shown in Figure 18. The general work area around the precast concrete shielding was 2.5 - 20 mrem/hr. Table II shows exposure for the 8D-2 portion of the work, occurring between October 1986 and April 1987. This exposure totaled 2.428 rem which is 74 percent of the estimate for that task; maximum individual exposure was 428 mrem.

FIGURE 18
Typical Radiation Readings at Tanks.
Casing and Working Areas with Shielding in Place

This significant reduction in individual and total exposure was accomplished by the controls outlined above and constant interaction of Radiological Control technicians. The successful completion of the riser installation on Tanks 8D-1 and 2 showed that these factors indeed resulted in low radiation exposure to personnel.

VI. Conclusions

The West Valley RRI project was accomplished in approximately two years. The conceptual design was initiated in March 1985, and installation completed in April 1987.

The installation phase of this project represented many obstacles and resultant achievements in safety, cost, and schedule areas. In the safe, efficient performance of this job WVNS has demonstrated the technology, expertise, and team effort required to perform a difficult job safely.

The RRI effort is a practical demonstration of penetration to prepare for cleanup of underground storage tanks. The equipment and techniques are applicable not only to the nuclear industry, but the hazardous waste arena as well.

TABLE 1

CHALLENGES OVERCOME BY THE REMOTE RISER INSTALLATION TEAM ON HIGH LEVEL WASTE TANK 8D-2

ITEM	CONDITION	RESULT	SOLUTION	COST/SCHEDULE IMPACT	SUMMARY OF SAVINGS
1	High Radiation Field: 350 R/hr Tank Top 5 to 9 R/hr at Riser Top	Radiation field in work spaces at ground level were on the order of 50 mr/hr. Personnel could not work in that environment and maintain individual and team exposure ALARA.	Innovative shielding methods designed and implemented: o Fabricated temporary shield plugs from 30 inch diameter concrete cores cut from the vault in previous operations. o Used commercially available concrete pipe at ground level and reduced work area exposure from 50 mr/hr to < 1.0 mr/hr (used on six long risers). o Filled M-8 and M-9 pits (short risers) with water and erected concrete pipe manways. Area exposure < 1.0 mr/hr.	N/A o Cost of concrete: \$3K. o Saved design and construction of special tooling. Estimate: \$8K. o Avoided delay of two to three weeks to obtain tooling. o Allowed work to proceed in parallel with construction. Time loss of 2 weeks avoided.	Cost: \$7K Schedule: 5 Weeks
3		For short risers the concrete shield interfered with verification of riser fit up.	Designed remote level indicating device.	Avoided design and construction of special tooling. Cost savings, \$2K; schedule savings, two weeks.	
2	Combination of high radiation (350 R/hr) and high temperature (200 degrees F).	Reduced visibility to operators in Control Trailer because of CCTV deterioration.	1) Modified grinder turntable to install special high radiation camera. Design includes specially fabricated control cables with air cooling for the turntable centering camera. 2) Observation camera failed. This camera provides a top view of grinding and welding sequences. The team installed a second high radiation camera; air cooled copper coils were attached to the camera for thermal protection. 3) Replaced low intensity light source on raster cutter with high intensity source and rewired power supply.	1) Saved \$8K in replacement cameras (one per riser) by using onsite high radiation camera. o Saved one week in camera replacement effort. o Avoided work stoppage for CCTV redesign. Two weeks. 2) Saved \$12K by avoiding purchase of another special camera by using onsite equipment and adapting fixtures to take it. o Avoided work stoppage for camera redesign. One week. o Prevented excessive grinding which could have penetrated the tank causing replanning the entire job. This could result in a two month delay to SIS start up. 3) Not measurable.	Cost: \$20K Schedule: Up to 8 Weeks SIS Delay

ITEM	CONDITION	RESULT	SOLUTION	COST/SCHEDULE IMPACT	SUMMARY OF SAVINGS
3	Excessive amount of rust, scale and concrete glaze on top of 80-2 tank.	Encountered difficulty in cutting rafters.	1) Designed, tested and introduced skims to allow varying the distance of rafter cutter torch tip to rafters. 2) During cleaning of scale and concrete glaze prior to rafter cutting, a high intensity water spray was needed. The team modified tooling design to increase efficiency of the spray and vacuum removal of debris.	1) Saved redesign of cutter and tooling changes. Cost Savings: \$5K Schedule: 4 Weeks 2) Avoided need for special equipment and reduced the time required to clean tank at each location Cost Savings: \$2K Schedule: 2 Weeks	Cost: \$7K Schedule: 4 Weeks
4	High humidity. A large dense cloud of water vapor was present. This results from the high temperature and in leakage of ground water.	Unable to see components on CCTV because the vapor blocked lighting and camera vision.	Developed an exhaust system to pull vapor through riser adjacent to that being worked.	Avoided design and procurement of ventilation system. Cost Savings: \$1K Schedule: 3 Weeks	Cost: \$1K Schedule: 3 Weeks
5	Loose surface contamination found at M-7 riser location.	Tools and equipment will become contaminated when working at this location. Special controls are required to avoid spread of contamination to other locations and the environment. Condition was not expected during original planning of the job.	1) Planned work around to prevent contamination spread. This riser will be last one worked. 2) Designed special containment which will allow handling of 14 foot long riser (28 inch diameter) and all tools in containment.	Not measurable. Avoided multiple operations to contain and decon equipment. Time saved, 2-1/2 weeks. Task of decon now done in parallel rather than in series.	Schedule: 2-1/2 Weeks
6	Welding caused distortion of the 1-1/4 inch thick steel load transfer structure (doughnut).	Doughnut was designed to be welded to riser and mate with outer casing. The welded doughnut did not completely contact casing.	A pair of half rings were designed to be field fit and welded to the casing. These casing extenders afforded the necessary load transfer.	Avoided redesign and welding development. Saved \$5K. Saved three weeks engineering and purchasing of new doughnuts.	Cost: \$5K Schedule: 3 Weeks
7	Lack of fine adjustments on mobile crane controls during rafter cutter positioning.	Rafter cutter was damaged.	Installed an electric hoist in the rigging which affords precise control during installation and removal of rafter cutter.	o Prevented permanent damage to rafter cutter. Cost Savings: \$50K o Avoided downtime for minor repairs. Three days per riser = 5 weeks.	Cost: \$50K Schedule: 5 Weeks
8	Centering mark lost during tank cleanup.	Unable to accurately place grinding and welding equipment on tank top.	Designed and fabricated precision locating and marking tool.	Avoided mislocation of grinding centerline which would have resulted in rework. Savings: 3 Days per Riser = 5 Weeks	Schedule: 5 Weeks
9	High strength magnetic flux generated by turntable locking electromagnet.	High radiation camera magnetic scanning coil was affected. Loss of visibility during grinding.	Provide magnetic flux interruptor using carbon steel pipe around the camera.	o Avoided return to low radiation cameras which require two cameras per riser. Cost Savings: \$16K o Saved redesign and replacement of camera installation on turntable. Schedule Savings: 2 Weeks	Cost: \$16K Schedule: 2 Weeks

OVERALL SAVINGS

COST: \$106K
SCHEDULE: 9 MONTHS

TABLE II

PERSONNEL RADIATION EXPOSURE
DURING RISER INSTALLATION

<u>PERSONNEL</u>	8D-1 <u>6/86 - 9/86</u>	8D-2 <u>10/86 - 4/87</u>	<u>TOTAL</u>
Operator 1	0.204	0.356	0.560
Operator 2	0.241	0.376	0.617
Operator 3	0.076	0.395	0.471
Operator 4	0.189	0.428	0.617
Mechanic 1	0.049	0.158	0.207
Mechanic 2	0.066	0.136	0.202
Welder 1	—	0.162	0.162
Welder 2	—	0.162	0.162
Supervisor 1	0.065	0.049	0.114
Supervisor 2	<u>0.123</u>	<u>0.206</u>	<u>0.329</u>
	1.013 Rem	2.428 Rem	3.441 Rem
Original Estimate	≤1.0 Rem	3.3 Rem	≤4.3 Rem

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