CHARACTERIZATION OF TANK 241-Z-361

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ABSTRACT

This paper describes how engineering inputs were incorporated into detailed plans, reviewed, approved, and subsequently implemented at the DOE Richland (DOE-RL) Hanford Site, near Richland, Washington. Nuclear safety aspects are emphasized; specifically, the use of project-specific safety basis documentation (regulatory requirements are discussed in the companion papers). An out-of-service sealed underground settling tank (241-Z-361) within the security perimeter of the Plutonium Finishing Plant (PFP) was identified as a known potential hazard. Potential hazards initially identified were: degraded structural integrity, explosive concentrations of flammable gas in the vapor space, chemical instability, and poorly defined nuclear criticality characteristics. The tank contains approximately 70m^3 of plutonium bearing sludge, with a plutonium content estimated at 30 kg. The paper discusses the processes leading up to, and the safe venting and sampling in 1999, of Tank 241-Z-361.

BACKGROUND

The 241-Z-361 Tank is an underground settling tank within the security perimeter of the PFP Complex (Figure 1A). When it was in service, the tank received all low salt, liquid effluents discharged from PFP processes from 1949 to 1973. The tank was taken out of service in 1973; pipes were capped in 1975 and then sealed in 1985. The tank contains approximately 2.4 m (94 inches) of plutonium bearing sludge, with a plutonium content estimated at 30 kg.

The tank is a reinforced concrete rectangular underground structure. It is 7.93 m (26 feet) long and 3.97 m (13 feet) wide and varies between 5.28 m (17 feet) (inlet, north end) and 5.49 m (18 feet)(outlet, south end) deep as internal dimensions. The base mat is 0.23 m (9 inches) thick with grout and waterproofing added for a total thickness of 0.31 m (12 inches). All walls are 0.31 m (12 inches) thick and the roof is 0.54 m (10 inches) thick. The top of the tank was sealed with 0.64 cm (1/4”) mastic and an additional 10.1 cm (4 inches) of concrete were poured over the mastic with 5.1 cm x 5.1 cm x 36 cm (2”x 2” 14”) gauge reinforcement mesh.

The interior of the tank was lined with 0.95 cm (3/8”) carbon steel on the bottom and up the sides to within 15 cm (6”) of the roof. A protective coating was placed outside the liner as a corrosion barrier. Two 15 cm (6”) stainless steel pipes lead into the tank (from the retention basin and 241-Z) at the north end of the tank and one 20 cm (8”) stainless steel pipe forms the discharge at the south end of the tank (Figure 1B).

The tank roof has three large penetrations and eight riser penetrations. Three foot manholes exist at the north and south ends of the tank. The third large penetration is a four-foot diameter concrete plug in the geometric center of the tank roof. There are two 20 cm (8” risers), one 5.1 cm (2”) riser and one 7.6 cm (3”) riser built into the south west corner of the tank, and one 7.6

cm (3") riser built into the northeast corner of the tank. One 15 cm (6") riser penetration was installed through the center concrete plug and two 20 cm (8") riser penetrations installed north of the center plug. All eight risers are capped or flanged closed and no equipment remains installed in the tank (Figure 1C).

As a result of corrosion, the liner plate below the former liquid level appears to be absent down to the sludge.. One of the south end 20 cm (8") risers had a dry well installed, and it is also corroded away. The inlet and outlet pipes have been isolated and plugged or flanged two feet from the outer wall of the tank. The reinforced concrete poured over the top of the tank has been removed over the two manholes and the tank was opened for sampling in the mid-1970's. The manhole covers were subsequently reinstalled, covered with weather covers and buried. The tank is covered with approximately two feet of soil.

In October of 1997, the tank was declared an Unreviewed Safety Question (USQ) by DOE-RL. Specific hazards identified in the USQ are structural integrity, flammable gas, chemical stability, and criticality.

PROJECT APPROACH

This project in essence was a study in risk management. However, in this case risk management included more than the classical "frequency of occurrence vs. consequences" decision making process. This project expanded the definition of risk beyond the "cost schedule performance" aspects normally associated with project management to include the political and regulatory considerations brought into play by the declaration of the tank as an USQ. This declaration resulted in significantly enhanced levels of interest and oversight for all project decisions and risks by bringing the DOEHQ, DNFSB, EPA, WDOE, WDOH, media, public, and various Hanford oversight groups into the review process.

During the early planning for the methodology for opening the tank, the DNFSB played a significant oversight role, and continued their involvement until the tank was ventilated. Regulatory agencies (WDOE, WDOH, and EPA) involved themselves early on with all decisions concerning technical approaches and means for controlling personnel and biosphere risks. The public wanted assurances that employees and the environment were not placed at undue risk, and finally, the Hanford workers themselves had reservations about their personal safety.

The net effect of the interest in the tank was a reduced decision making authority (or autonomy) for the project team. As a result, the majority of the project decisions were based upon conservative assumptions and analyses (containing conservative assumptions) in order to reduce the perceived risk(s) by all parties involved in the project.

To ensure the risks assumed were within the "comfort zone" of all participants, the characterization of Tank 241-Z-361 was separated into two phases, with each phase further sub-divided into distinct tasks, or work scope. The phased approach to the work enabled us to obtain information, which reduced some of the unknowns, which then allowed planning and identification of the controls for the next step in the characterization process.

Phase I of the characterization project included all of the analyses, documentation, approvals, procedures, equipment, and personnel required to; Task 1 - Load test the tank, Task 2 - Open one riser, install a breather filter and passively ventilate the tank, and Task 3 - Vapor sample the headspace and videotape the interior of the tank.

Phase II of the characterization project included all analyses, documentation, approvals, procedures, equipment, and personnel required to; Task 1 - Install structural piers into the soil around the tank, Task 2 - Place the truck bridge on the structural supports and place the sample truck into sampling position, and Task 3 - Obtain core samples.

AUTHORIZATION BASIS

Since the project was essentially initiated with the declaration of an USQ, one of the early efforts was creation of an authorization basis that would allow work on the tank. We recognized that we did not have enough information about the tank to prepare a document that would be adequate for all of the tasks required to characterize the tank, nor did we have the time to use the DOE ORDER 5480.23 process for Safety Analysis Reports (SAR's). Through discussion with the DOE-RL and FDH personnel we reached agreement that the best vehicle for creation of an authorization basis was the Justification for Continued Operation (JCO) identified in DOE ORDER 5480.21. However, we would use the document as an "Activity Based Authorization Agreement", rather than the normal SAR approach to an authorization basis. The main difference between the two documents (SAR vs. JCO/Activity Based Authorization Agreement) is that an authorization agreement permits all parties to accept risk with minimal analyses, focuses *only* on the specific tasks to be performed, avoids a significant fraction of the requirements of 5480.23, and may be approved by the field office. This approach significantly shortened the time from JCO revision to DOE-RL approval. In fact, through the involvement and pro-active assistance of the FDH and DOE-RL monitors, we were able to routinely issue a revised DOE-RL approved authorization basis, including Safety Evaluation Report (SER) in one week from the time the JCO completed internal review and approval. As a result, through the life of the characterization project the authorization basis never became the schedule critical path.

As we completed tasks, we gained information about the tank and were able to revise the JCO to establish adequate controls for the next work to be performed. It should be noted here that the JCO controls, in effect, are equivalent to SAR Operational Safety Requirements (OSR's) and must be managed in the same way as OSR's. The JCO was revised three times in total. Revision 0A implemented the interim controls identified in the USQ. Revision 1 revised the load controls to permit access and work on the tank within specified load constraints, and implemented the flammable gas controls developed by Lockheed Martin Hanford corporation for work on the Hanford single and double shell tanks. This permitted the opening of the tank and initial sampling activities. Revision 2 reduced the JCO controls since the flammable gas issues had been resolved, and authorized the installation of structural members (piers and bridges), and sludge-disturbing tank sampling activities.

PERFORMING ORGANIZATION(S)

The philosophical approach to the work was to find personnel/organizations and equipment that had been used to perform similar work in the past. Since the personnel within BWHC were not familiar with tank work per se, our initial efforts were focused outside PHMC in search of an experienced vendor. A few phone calls quickly revealed that *nobody* routinely opened tanks with stoichiometric ratios of hydrogen and oxygen within the tank, with no means of venting the mixture to atmosphere prior to tank entry. Consistent with the philosophy established, LHMC was approached to provide the personnel, equipment, and planning required to ventilate the tank. Similarly, DYNCOR provided the crane and rigging expertise for setup and tear down of tents, bridges, etc.

Since LMHC sampling personnel had routinely opened tanks with suspected flammable gases, the project team elected to use the Tank Waste Remediation System (TWRS) authorization basis controls for work in and around suspected flammable gas tanks for Tank 241-Z-361. These controls had been thoroughly reviewed by DOE, DNFSB, and a multitude of contractors and provided a framework for work on this tank that had already been approved by the oversight organizations. Further, to eliminate as many possible chances for errors, we also elected to use TWRS procedures, work control processes, and work management (supervisors and Persons-In-Charge (PIC’s)). This eliminated as much as possible the use of unfamiliar work package format, procedures, and terminology. It also eliminated potential communication errors during performance of the work from different management.

Within the framework of PHMC contracts (Figure 1D), a Memorandum of Understanding was developed to define the expectations, roles and relationships between PHMC contractors, funding, work scope, reporting requirements, and so on. Key to the success of this approach was the cooperation of BWHC Management and Personnel within the PFP organization. The approach to this tank was entirely new. Prior to this time, *outside* construction contractors had been allowed to perform work inside of the protected area, but never had another *operating* contractor been authorized to do this type of work.

A specific roped off area was established around the tank, identified as the *exclusion zone*, and required specific training and other approvals to access the area. Even though BWHC could not transfer the Price-Anderson implications to the LMHC organization should anything go awry, it was recognized that it was a risk that BWHC (and Hanford) needed to take. Consequently, when LMHC was working on the tank within the exclusion zone, the area was treated as though it was a LMHC facility. BWHC/PFP provided management oversight and coordination, but did not direct the work. This permitted LMHC to use all of their internal work control processes and systems.

WORK CONTROL

The work control process followed within the PFP perimeter fence was similar to that used for construction work, with a few wrinkles. The JCO controls recognized that the controls had the value of OSR's. Since the DOE Orders required the Plant Review Committee (PRC)(or equivalent) to review and approve authorization basis documents, procedures and controls, the JCO added a control for the work process itself. The PFP PRC was required to review the work packages to ensure themselves that the JCO specified controls (e.g. authorization basis) were in fact embodied into the procedures and work planning.

The work packages were managed within PFP under a ”traveler”. The traveler is a work document that is attached to the plans, drawings, etc of others that enables the plant to control work performed by others, usually construction contractors or PHMC support contractors, within the facility. Work within the protected area of PFP is only permitted when that specific work and work scope has been released by the on-duty PFP shift manager, and then only after all required reviews and approvals had been completed. One of the signatures on the PFP Traveler was the PRC Chairman signifying that the PRC had completed review of the LMHC work package and procedures, and the document was ready to be released for work. This ensured proper internal reviews (ALARA, Safety, Engineering, etc.) by LMHC had been completed prior to the PFP PRC review, and that the PFP PRC review found all of the work planning and procedures were in compliance with the authorization basis (e.g. JCO).

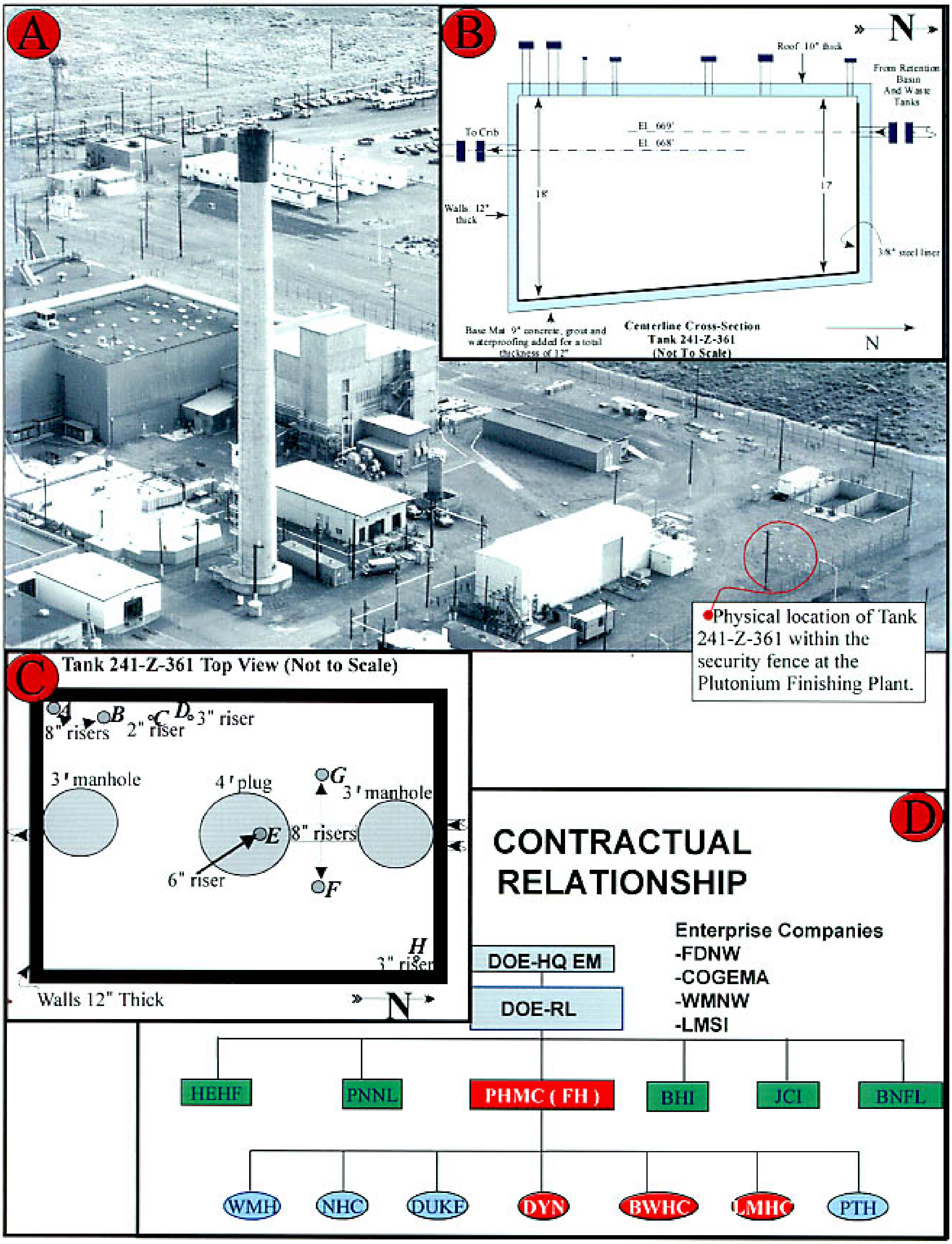


Figure 1: **A**, Physical location within PFP; **B**, Centerline cross-section of tank; **C**, Top view of tank; **D**, Contractual relationship to perform Phase I and II documentation and field activities.

One of the required "reviews and approvals" prior to release of work was completion of a Standard Startup Review (SSR).

STARTUP REVIEWS

The DOE Orders specified three levels of reviews prior to startup of facilities, new processes, and so on. These reviews (in descending order of complexity and DOE involvement) are Operational Readiness Reviews (ORR's), Readiness Assessments (RA's), and contractor reviews. With the contractual relationship between FDH and BWHC, an additional level of review was required. This review is under the umbrella of "contractor reviews" and is identified as a Standard Startup Review (SSR). The SSR consisted of a list of items, reviews, dry runs, drills, and documentation that when completed satisfactorily ensured FDH that the operator (in this case BWHC/PFP) was ready to initiate operations.

In the case of Tank 241-Z-361 five separate SSR's were performed. Each SSR building upon the previous. Within Phase I of the characterization project, the first SSR approved Task 1 - Load testing, the second approved Task 2 - Venting and Filter Installation, and the third approved the vapor sampling and video taping of the tank interior. Within Phase II of the project, the first SSR approved the installation of piers around the tank and all of the structural work, including setting the bridges. The second SSR in Phase II approved the actual core sampling operations.

PHASE I - TASK 1 LOAD TESTING

A 1975 photo of the tank interior clearly showed that a portion of the steel liner had corroded away. The absence of the liner brought into question the condition of the concrete and imbedded reinforcing steel.

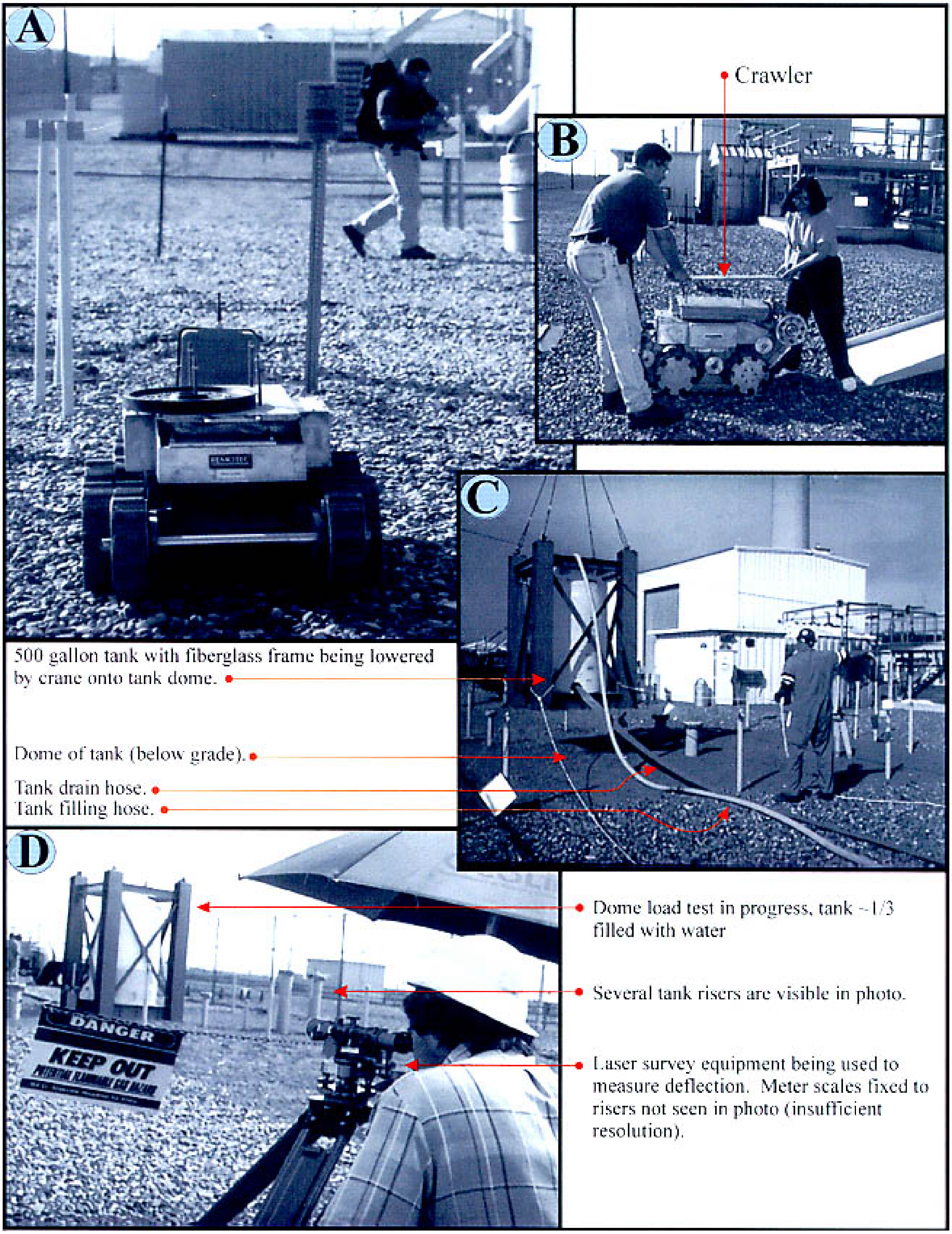
The U.S. Corp of Engineers were contacted to obtain their expertise in assessing the performance of the concrete in a hot (100 C), slightly acidic (pH 4) aqueous solution. Anecdotal data was all that was available on this subject, and that information was inconclusive. Sometimes the concrete was eaten away, and sometimes it wasn't.

Lacking any scientific/engineering method of declaring the tank "as designed/as-built", Fluor Daniel Northwest was contracted to perform a series of ACI code case analyses of the structural strength of the structure assuming the concrete had cracked and 50% of the re-bar had been corroded away. The analyses indicated that the tank walls were slightly overstressed from the soil loads alone. Clearly we could not approach the tank in this state, let alone open the risers and perform the needed tasks for characterization.

Research into the history of loads on the tank revealed that a vehicle weighing approximately 5.4 Mg (6 tons) had been driven and/or parked in the vicinity of the tank over a period of several years. In addition, a snow load of ~0.53 m (21") was put on the tank in the winter of 1989. These two loads were significantly above the existing soil loads, and indicated more conservatism in the ACI analyses than was necessary. Using the calculated loads from the vehicle and snow as the baseline acceptable loading for the tank, two load tests were planned.

The first load test used a remotely controlled "crawler" with a total footprint load of 272 kg (600 pounds) to access the area around the tank and up to the tank walls (Figure 2 [A&B]). This test provided assurances, with a safety factor of 2X, that an individual plus equipment weighing up to 136 kg (300 pounds) could safely access the tank. With this established, we were able to access the tank and examine the risers and soils for the presence of radioactive contamination and/or flammable gases. Neither was detected.

The second load test was intended to establish a safe working load over the tank dome itself for personnel to perform Phase I Tasks 2 and 3. This test involved the use of a 1,890 L (500-gallon) translucent tank, installed in a non-sparking framework of fiberglass (Figure 2 [B&C]). The fiberglass framework was selected to provide a non-sparking structural support for the tank and a means of attaching the lifting equipment to the tank. Non-sparking tools and equipment were required to avoid the risk of a deflagration until the presence or absence of flammable gases inside the tank was established. Water was slowly added to the tank in 227 kg (500 pound) increments (~60 gallons) and the load held 5 to 45 minutes while the risers were surveyed for deflection. This process was repeated until a total of 1,800 kg (4000 pounds) had been placed on the tank top with the measured deflection within previously established limits. If deflection beyond calculated maximums were observed, the load would immediately be removed and the test terminated. Deflection at the risers were measured at three points (three different risers, one each in the tank center, the SW, and NW corners of the tank) using laser survey equipment accurate to within .25 micrometers (0.001") (Figure 2D). Successful completion of this test established that personnel and equipment up to a total of 907 kg (2000) pounds, with a safety factor of 2X, could work above the tank.



Crawler

500 gallon tank with fiberglass frame being lowered by crane onto tank dome.

Dome of tank (below grade).

Tank drain hose.

Tank filling hose.

Dome load test in progress, tank ~1/3 filled with water

Several tank risers are visible in photo.

Laser survey equipment being used to measure deflection. Meter scales fixed to risers not seen in photo (insufficient resolution).

Figure 2: Tank perimeter and dome load tests: **A**, remote operation of crawler during perimeter load test, **B**, relative size of remotely controlled crawler, **C**, lowering of water tank onto the tank dome, **D**, measurement of dome deflection using a laser survey equipment.

PHASE I TASK 2 TANK VENT & BREATHER FILTER INSTALLATION

Opening the tank was a significantly greater challenge than envisioned. The calculations of hydrogen production over 15 years in a sealed tank indicated that the tank could be pressurized to ~190,000 Pa (13 psig). Although no one individual believed it could be this high given the nature of hydrogen and the tank construction, no one was able to define and defend a pressurization number different from the theoretical limit of ~190,000 Pa (13 psig). We were able to find a work plan for the 1985 sealing of the tank, but were unable to find any information on the completed work. We knew the tank originally had a sealant (not identified specifically in the construction prints, but believed to be some form of mastic) between the steel liner and the concrete. The 1975 photo showed that some of the sealant was peeling away from the concrete, but not enough information was available to predict just how much concrete surface area wasn't still sealed. It was also known that a tar like mastic had been put on the outside walls of the tank for at least the top two feet, and a 0.64 cm (¼") layer of tar was placed on top of the tank between the original tank top and a new concrete slab poured over the old one when the tank was sealed in 1985. The inlet and outlet lines had caps welded over the cut ends and then were encased in 0.61 m (2') of concrete. Similarly, we knew that each of the risers had a gasket placed between the two flange surfaces, and that each side of the gasket had been coated with a mastic. We were able to determine this information through extensive interviews with employees who were around at that time, one of which was a pipe fitter who performed some of the sealing work itself, as well as retirees that may have had information on the tank.

The DOE Radcon order prevented unrestricted flow of tank air into the biosphere due to potential entrainment of radioactive particles. The Clean Air Act similarly did not support unrestricted release of gases from this tank for the same reason. Thus we could not open the tank remotely. A controlled, hands-on approach was the only means available to open the tank without an uncontrolled release of trapped gas.

Starting with the presumption that the tank was at ~190,000 Pa (13 psig), a series of calculations were performed to determine flow rates vs. the size of the opening. The 7.6 cm (3") riser in the NE corner of the tank was selected for opening and breather filter installation (Figure 1C, riser H). If that riser were opened 1.6 mm (1/16") all around the flange, the flow rate would be 0.182 m^3/sec (385 cfm). Since 1.6 mm (1/16") is a very small opening and no portable glovebag could withstand this kind of pressure drop, another means of opening the tank had to be devised. The work had to be performed in a glovebag, with operators and craft on breathing air, so any method chosen had to be relatively simple to implement, and also foolproof to avoid an uncontrolled release. The method developed by LMHC involved installation of a pipe band around the flange (Figure 3A), wedges that could be screwed into the pipe flange gap, and a valved orifice sized to release gas at a controlled rate. A glovebag test was developed to determine how much flow could pass through the filtered glovebag without over pressurizing it. A flow rate of 0.0033 m^3/sec (7 scfm) caused the glovebag to "balloon" slightly, but would not cause the glovebag to fail. This flow rate was used to calculate the orifice size in the flange band (Figure 3 [B,C&D]).

Once the flow rate was established it became necessary to develop a procedure and tooling that would enable the riser flange to be breached, and yet not permit unrestricted flow through the glovebag. This was accomplished by the use of small screw driven wedges. Once the flange bolts were *slightly* loosened (1/4 turn at a time), the air space inside the glovebag was tested for flammable gases. If none were detected, the flange bolts were loosened another ¼ turn and wedges tightened into the flange gap. This process was repeated until one full turn had been completed on each of the flange bolts. If no gas was detected at the conclusion of one full turn, a non-sparking awl was used to penetrate the gasket (through the valve and orifice) to ensure the gasket was breached.

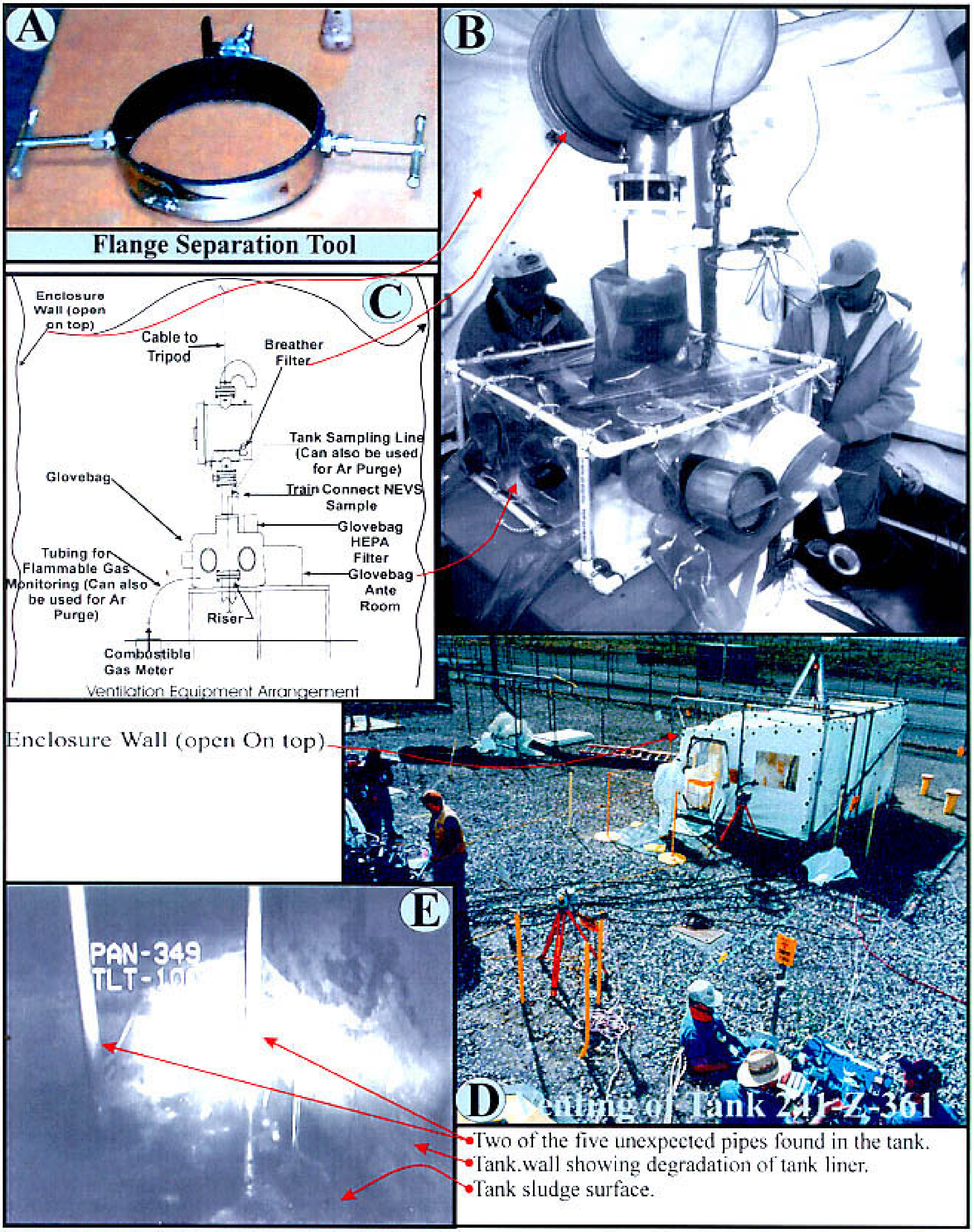
Prior to work release for this task a series of dry runs and drills were performed on a mockup of the riser, glovebag, and filter to ensure all personnel fully understood their actions in the event of an emergency. In addition, a series of larger scale drills were performed that involved the Tank 241-Z-361 team, plant operations and radcon personnel, safeguards and security personnel, and the Hanford Fire Department. These drills were performed to ensure all site personnel were able to communicate effectively and fulfill all required actions in the event of an emergency at the job site.

PHASE I TASK 3 - VAPOR SAMPLING & VIDEO TAPING OF TANK INTERIOR

After the tank had been successfully ventilated (Figure 3D) and the breather filter had been installed, the tank headspace was sampled for organic vapors and the interior of the tank was video taped (Figure 3E).

The headspace gas was sampled primarily to identify any volatile organic compounds that may have survived the operational envelope (e.g. steam jet transfers and storage at ~100 C) and time (26 years from the last transfer into the tank). This data was needed to validate the Data Quality Objective (DQO), and Tank Sampling and Analysis Plan (TSAP) developed to characterize the tank, and to satisfy OSHA concerns relative to occupational exposure for the workers during tank sludge sampling.

The initial sample results showed that the hydrogen level was negligible, but various volatile organics compounds (VOAs) and elevated levels of nitrous oxide were present. These three sample results were unexpected. Upon reflection, the nitrous oxide should have been expected since it was known that nitric acid was involved in the process, and certainly nitrate salts are present in the sludge.



- Two of the five unexpected pipes found in the tank.
- Tank.wall showing degradation of tank liner.
- Tank sludge surface.

Figure 3: Tank venting, breather filter installation, vapor sampling, and video taping of tank interior: **A.** pipe band, a tool to control rate of gas release, **B.** photo showing setup of glovebag with enclosure, **C.** schematic of tank venting equipment, **D.** photo of enclosure, **E.** still photo made from video tape of the tank interior.

The low levels of hydrogen are believed to be due to leakage around a tank riser. The riser upon which the breather filter was installed was found to be loose in the tank dome. Had we been able to discover this earlier in the process, the hydrogen concerns could have been alleviated. However, until the hydrogen levels were known, very little work was permitted on the tank. Given the ease with which hydrogen-oxygen mixtures may be ignited, the ability to ”shake” risers to assess their attachment to the tank was not even considered.

The amount of VOAs found was also a surprise. The characterization team felt that the elevated temperature of the tank during its 25 year operating life, and the slightly acid solution would have prevented the presence of these substances. The presence of these unexpected organics led to a ~50% expansion in the TSAP analyte list, and the requirement to vapor sample the tank on a continuous basis during sludge disturbing activities (e.g. core sampling). It is believed that the elevated levels of VOAs are, in part, degradation products from tributyl phosphate (TBP).

The video of the tank confirmed our suspicions that the tank had not appreciably degraded from the 1975 time period. However, we were shocked to discover five pipes extending from the 20 cm (8”) risers and the two 91 cm (3’) manholes down into the sludge (Figures 3E& 4A). The records indicated that everything, with the exception of the risers, had been removed from the tank in 1985. In addition, significant cracks were found in the tank dome. Some of the cracks have what appears to be ”black stuff” in them. We believe that this is some of the 0.64 cm (¼”) of tar sealer applied to the tank dome prior to the second 10 cm (4”) of concrete poured over the tar. If this assumption is valid, then several of the cracks penetrate completely through the original tank dome and support the caution applied to loads permitted on the tank. The other two items of note in the video is the presence of free liquid above the sludge, and what appears to be a remnant of the original steel liner.

During our research into the history of the tank, reference was found to drywells, but no records were ever found that supported that they had either been installed or removed. This change in tank configuration caused the team to revise our sampling plans and the TSAP. Previous planning included three full depth core samples from risers B, E, and F. However, the video also showed wires, bottles and discarded ”tubing” below riser B(Figure 3E). Because of the debris, we elected to NOT use that riser for fear the logging equipment might become entangled and compound the existing problems of core sampling this tank. Our planning was reduced to two cores (risers E and F) supplemented by down hole logging (NDA) in risers B, F, and G if the installed pipes turned out to be drywells. The down hole logging would use passive detectors and a Cf source for a neutron generator for activation analysis. Subsequent investigation (tank entries) showed the pipes to be drywells with 38 cm (15”) to 46 cm (18”) of condensation water in them. The water was removed and pipes dried in preparation for the NDA work (Figure 4A).

The free liquid found by the video was also a form of ”good news”. In 1975 the tank had been pumped of all free liquid down to a remnant heel. The heel was estimated to be about 10 cm (4”) in depth or 760 L (~200 gallons). The depth of liquid found was approximately 15 cm (6”) (actual measurement while setting up for core sampling) indicating that the sludge had apparently settled/compacted further, and it also indicated that the tank had most likely not leaked.

The remnant steel liner, if in fact that is what it is, would support an argument that the tank walls have not degraded and the tank structural strength is as designed. With the installation of the piers, any future structural loads will be applied to the piers and not the tank, so this observation basically becomes a moot point and is of no further interest.

PHASE II - TASK 1 PIER INSTALLATION

The core sample truck weighs an estimated 14,500 kg (32,000 pounds). The total weight on the truck bridges was estimated to be 16,300 kg (36,000 pounds) when personnel and ancillary equipment were included in the loads. The earlier calculations had identified that the tank walls could not withstand any significant increase in side loading above that of the soil burden. Various ways of supporting the sample truck and equipment above the tank were explored. These approaches included temporary airplane runway mats (as used by the military), bridges supported by mats, plates, or slabs to spread the load outside the tank effected zone, and structural piers that would transfer the loads to the soil column below the tank. The only methodology that would meet the structural limits imposed on the tank without requiring ridiculous bridge spans (~16.8 m or 55') was structural piers.

The problem facing the team was how to install structural piers without increasing the side loading on the tank. Use of a backhoe for excavation wasn't possible, as we couldn't get a backhoe close enough to the tank to provide the needed pier spacing without exceeding the tank load limits set by the JCO. Hand digging wasn't feasible from either a cost or personnel exposure risk. It was known that some of the subsurface soils outside of PFP were contaminated, but it was not known if the subsurface soil around the tank was contaminated. It was equally possible that the soils around the tank might be contaminated in some regions, but not others. Use of a pile driver was eliminated, as the shock of placing the piers would have exceeded the carrying capacity of the tank walls.

The ultimate structural pier solution was the use of "screw piers". These piers have one end formed very similar to an auger, and are simply screwed into the ground. Various lengths are available, and can be joined to reach any depth required. A hydraulic driver was suspended from a tracked backhoe to give us enough reach to avoid loading the tank walls and still reach all of the needed pier locations. Steel I-beams are supported on the piers, and welded perpendicular to the short I-beams are larger I-beams for support of the truck bridges (Figure 4 [B&C]).

The actual truck bridges were 6.5 m (21' 4") in length, and had been used through the years in the tank farms to support the sample trucks. However, the bridges spanned the Z-361 tank and were thus identified as Safety Significant. The bridges did not have a "pedigree" in materials or construction, so could not be used to support the truck without modification. They were modified to provide structural support for 16,300 kg (36,000 pounds), and the shock load of the

14,500 kg (32,000-pound) truck stopping "instantly" from a speed of 0.9 m/sec (2 mph). Similarly, the structural piers were braced to provide the required anchorage for the bridges.

PHASE II - TASK 2 BRIDGE INSTALLATION AND TRUCK EMPLACEMENT

Installation of the bridges on the structural members was straightforward. They were set in place with a crane, and subsequently through bolted to the I-beams. No surprises were involved with this work.

PHASE II - TASK 3 CORE SAMPLING

The core sampling of the sludge was planned around the Tank Waste Remediation System core sample trucks. Although these trucks are large and made the use of structural members over the tank more substantial than might have been used otherwise, their use provided several significant advantages over any other method of sampling (Figure 4C).

First, the cores routinely taken from the Tank Farm single and double shell tanks are accepted by the regulators as providing representative samples adequate for characterization purposes. If any other method of sampling were selected, the issue(s) of representation and adequacy would have required resolution.

Second, the trucks and sampling equipment already existed. Use of this equipment avoided the potential R&D costs and time required developing any other sampling method. In addition, there was no guarantee that an alternate method would ultimately be successful or accepted.

Third, procedures and experienced operators trained in those procedures were available. Any new system would require the development of training and certification programs to implement the new process. In addition, any experience gained from previous sampling operations using the sampling truck may not have had any value.

For these reason, the increased cost of the heavier structural members were considered acceptable as it further reduced the operational and regulatory risks of sampling this tank.

The actual sampling of the tank was essentially uneventful and occurred as planned (Figure 3C). Cores were obtained in segments (five segments/core), and delivered to the Hanford onsite laboratory (222s) in casks. The cores were extruded in a hot cell within the 222s laboratory (Figure 4D). Analyses as defined in the sample and analyses plan (TSAP) are scheduled to be completed by May, 2000.

RESULTS

The approach implemented for this project simplified the approval process(s) and minimized the involvement of oversight organizations. The effects of each significant decision and the results of the characterization work are described below.

By verifying the conditions in the tank and surrounding area before implementing work steps that depended upon those conditions, we were able to minimize the conservatism's associated with "what if" questions. This was facilitated by avoiding the "what if" situations and accomplished by using an "Activity Based Authorization Basis" rather than the normal SAR process. This approach allowed us to define the risks of the work being planned and the mitigating factors for each identified risk. The authorization basis approval was then based upon an accepted risk. For example, the risk of a seismic event was acknowledged and accepted, but no calculations were performed to show the effects of a seismic event on the tank. Similarly, no attempt to mitigate the effects of a seismic event was considered. The tank and contents were not amenable to any form of seismic upgrade, so discussion of seismic issues was a moot point. The acceleration of the tank characterization and the ultimate remediation of the risk remained the focal point; we avoided spending time and resources on items/issues that had no impact on the project. This process was implemented using the JCO as the vehicle for the activity-based authorization. However, similar to the approval process for SAR type documents, the JCO was approved with a Safety Evaluation Report (SER). Again, the SER was short and to the point, identifying the risks and mitigating factors, and then accepting those risks. With careful planning, cooperation, and effort on the part of the Fluor Hanford Project Manager, the DOE-RL Monitor, and the performing contractor (B&W Hanford Co.) the JCO was issued, reviewed, and approved, including the SER and transmittal letters, within one week from completion of internal contractor reviews. This was accomplished on three different occasions, clearly showing the value of this authorization basis process.

Much discussion has taken place over the conservatism used during the tank opening and ventilation planning. Many have felt that less conservatism was warranted, although none of these individuals had a methodology by which we could establish an authorization basis for a less conservative approach. The 'as found' condition provides support for the conservative approach.

It was felt that if hydrogen were present it would leak through the gaskets in the tank flanges, even if the tank structure (lined and/or coated concrete) itself was impermeable to hydrogen. When the tank was initially opened, we captured some of the tank headspace gases for a "quick look" to assess the immediate risks of working around the tank. Although we found no appreciable concentrations of hydrogen, it is believed this was primarily due to the loose riser (Riser H). This riser was free to "wobble" (using the

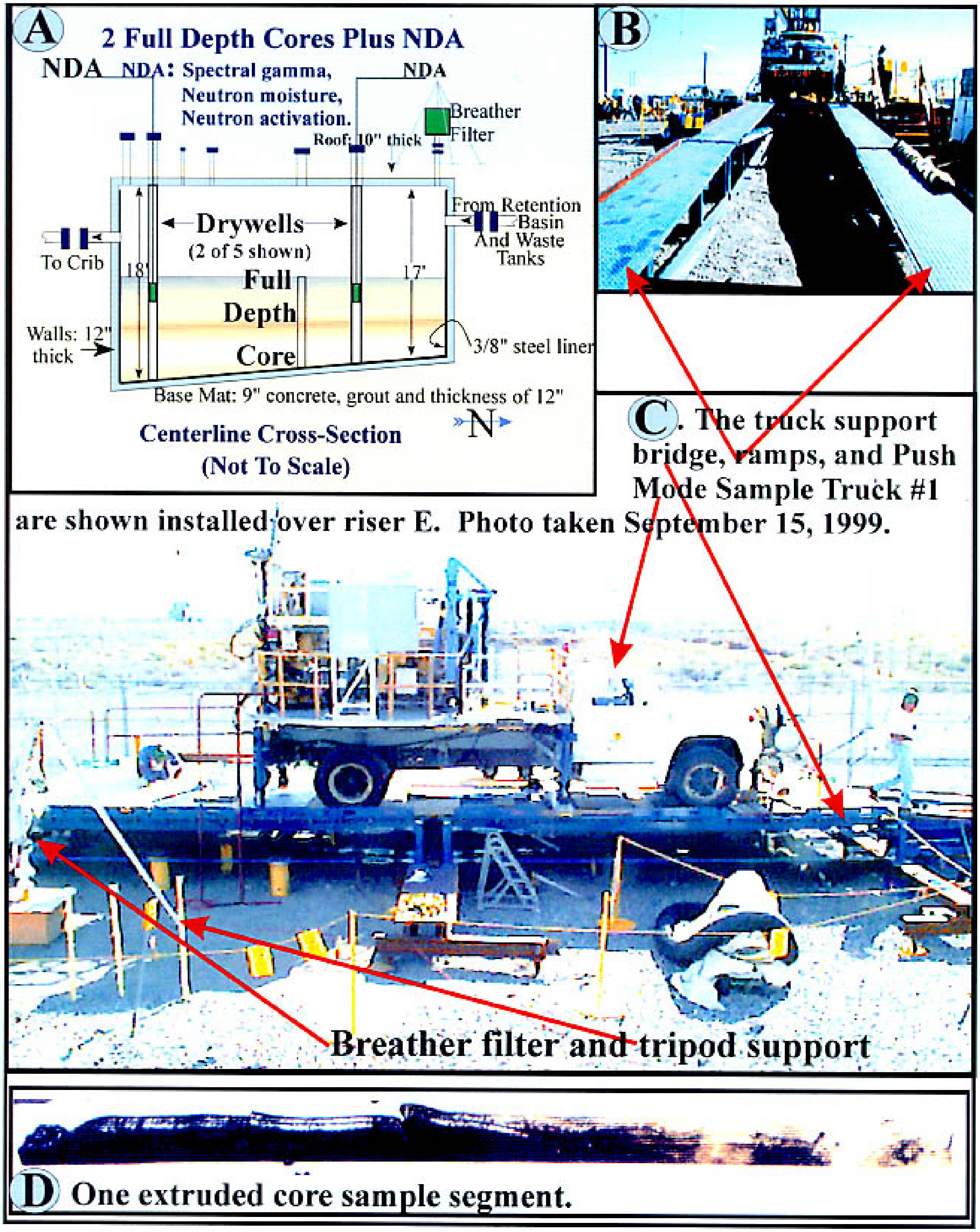


Figure 4: **A**, Schematic showing new strategy of core sampling and NDA of selected drywells. Not all core samples or NDA of drywells shown, **B**, Photograph of ramp and west end of bridge, **C**, Photograph of sampling truck positioned over riser E, **D**, Photograph of one of ten extruded core segments (five segments/core) shortly after extrusion. Strata and included salts are visible.

terminology of the craft that worked on it) and this indicates a pathway for hydrogen migration out of the tank headspace. The belief that hydrogen could migrate through the flange gaskets was put to rest in early November 1999 by LMHC. LMHC found a catch tank (used to catch spills and in-leakage from tank piping diversion boxes, and other below ground enclosures in the Tank Farm complex) that contained 16% hydrogen. This tank is a stainless steel tank with a stainless steel riser and flange. The gasket between the flange halves is a Garlock ^{TM} gasket. The presence of such a significant amount of hydrogen in this catch tank lies to rest the question of hydrogen migration through flange gaskets (at least of the Garlock^{TM} type gasket). For this tank, if the riser had not been loose, it is entirely possible that elevated levels of hydrogen (above the LFL) would have been found. Thus, conservatism for suspected hydrogen concentrations was warranted in this case.

The elevated levels of nitrous oxide also surprised us. Although the levels were not a flammable gas issue, they were high enough to require constant monitoring (OSHA limits) during the sampling operation to ensure personnel safety. For this reason also, caution in opening the tank was warranted. Personnel were in level B protection (two levels of clothing and breathing air) during the opening, but this decision was primarily based upon radiological risks. Since level B protection was planned, it was felt that the chemical/gas exposure risk was also addressed. However, lacking a radiological airborne risk, the level B protection was still warranted from a personnel safety perspective.

Examination of the tank interior supported the decision for a conservative approach to the tank structural strength. The videotapes of the tank interior show many cracks in the tank top, some of which are believed to penetrate completely through the tank dome. The tank dome was sealed in the 1985 time frame with a 0.64 cm (¼") of tar and then a second 10 cm (4") slab of concrete poured over the tar. Several of the top cracks are black and it is believed that this is some of the sealing tar that has been extruded into and through the cracks by the weight of the second concrete slab. If this interpretation of the videotapes is correct, the condition of the imbedded reinforcing steel must also be questioned. For this reason, the existing tank load limits will remain in effect for the foreseeable future.

At this time (January 2000) we do not know the concentration of Pu in the sludge as the isotopic specific analytical analyses are not complete. However, alpha analyses suggest that the Pu may be at least as high as estimated from historic data, and perhaps higher. This data should be available by the date of the WM 2000 Symposium.

The selection of performing organizations and the relationships between those organizations (management and/or control of work and personnel) were validated by the actual work.

The tank venting and sludge sampling operations were performed, for the most part, exactly as planned. There were some scheduling conflicts (expected) and some minor equipment failures (also expected) but all in all the equipment performed better than anticipated.

The performance of the LMHC personnel was exemplary. LMHC carefully selected the personnel for this tank sampling work. By prior agreement between BWHC and LMHC, the selection of the teams (opening and sampling teams) considered prior experience at or with the PFP plant, plutonium tank sampling operations, as well as extensive tank experience with the procedures and equipment planned to be used on this tank. This careful selection process proved to have been of tremendous value. The teams were comprised of management, supervisors, craft, radiation control technicians, industrial hygienists, and operators. These teams were highly motivated, completely trained, and their performance mirrored these factors. For the perceived new risks associated with this tank we performed extensive emergency drills. In addition, we prepared a mockup of the exact tank riser and performed dry runs of standard and emergency events using the planned load controls for the tank.

The personnel selection and training paid dividends. During the work there were no events, surprises, loss of contamination control, or other untoward incidents from a physical or "CONOPS" perspective.

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