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IN-TANK INSPECTIONS OF BURIED AND SUB-SURFACE HLW TANKS

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Abstract

In-tank and in-vault camera inspections are a useful method of inspecting tanks containing radioactive wastes. This paper discusses camera inspections conducted on historic radioactive waste tanks in 2003. It describes the equipment used for the inspections, how they were conducted, the observations that were made, and how the information will be used to assist in the planning of waste retrieval operations.

1. INTRODUCTION

Atomic Energy of Canada Limited (AECL) has stored radioactive waste solutions, originating from operating facilities at the Chalk River Laboratories (CRL) site, for over five decades. These wastes are commonly referred to as the Stored Liquid Wastes, and were generated from historic fuel reprocessing, isotope production, regeneration of ion exchange resins and decontamination of reactor loops. There are 21 tanks in total and all but 2 of the tanks are housed in buried or sub-surface vaults. The mandate of the Liquid Waste Transfer & Storage (LWTS) Project is to provide equipment and facilities to remove the liquids and sludges from the tanks, transport them to an interim storage facility, and store them safely for 25 years.

In-tank camera inspections of the SLWR tanks were conducted to validate sludge quantities, and predict tank integrity, presence of debris, identify difference with respect to tank drawings, determine the consistency of sludge and the presence of any build-up on the walls above the waste level. Inspections also augmented knowledge of tank internals and vault configuration to facilitate the specification of retrieval equipment and tank access interfaces. The Stored Liquid Waste Remediation (SLWR) field assessments were initiated in 2003 May and concluded by mid-November. During that period, 16 tanks and 11 vaults were inspected. The purpose of the field assessments were to inspect the vaults for debris, signs of tank corrosion and tank modifications, and inspect the tanks for debris, signs of tank corrosion, tank modifications, presence of an organic layer and sludge consistency and supernate and sludge depth.

2. EQUIPMENT

Three video camera units were purchased from IST (Imaging Sensing Technology, New York):

- **A Rees Dot Cam** – A small "fixed angle" camera with auto focus and integrated lighting. It measures just over 1 inch in diameter and less than 6 inches long.
- **A Mini-PTZ** – A pan, tilt and zoom camera with integrated light source. It measures approximately 3 inches in diameter by 12 inches in length. It has a controller that allows the

camera to be rotated, zoomed in and out, manually focussed, and also allows the light intensity to be adjusted.

- **An RC-93** – A small “fixed angle” camera similar to the Rees Dot Cam with manual focus and adjustable light intensity. It is slightly larger in length and diameter than the Rees Dot Cam.

All video images were recorded on DVD and filed as per project procedures.

Where space was available, auxiliary lighting was used to illuminate interior tank and vault surfaces. In most cases, the light used was a small 30-watt halogen unit measuring 1.6" in diameter.

This equipment allowed for the inspection of tanks with penetrations as small as 2" in diameter. Zoom and pan-tilt capabilities could only be used in tanks with a 3" or larger penetration. For all inspections, the camera was threaded onto an aluminium or stainless steel pole. The control cable was contained inside the pole for protection against contamination.

3. PREPARATIONS

Figure 1: Cold-Test Facility

Extensive preparation work was conducted prior to performing the inspections. A Work Activity Plan was prepared, as well as a separate procedure for each of the four tank buildings. Radiation fields were measured in each of the work locations, a task analysis prepared, and doses expected while performing the work were estimated. In all cases, dose incurred during the work was less than those predicted when planning the work.

To assist with the preparations, a cold-test facility was built. It included a tank (roughly the same size and dimension as the smallest tank being inspected), and a wooden platform simulating the elevation of the ground or roof surface (Figure 1). The tank was filled with sand and water and all procedures and equipment were tested using this equipment prior to being used in the field. This helped improve work procedures, and also assisted with equipment selection and modification. This cold-test facility was a useful dose reduction tool because work preliminary work could be done before contaminating the equipment and exposing workers to radiation. This facility will be used in the future to mock-up retrieval operations.

4. IN-TANK INSPECTION METHOD

The in-tank inspections consisted of lowering a camera and light (if space permitted) directly into the tank's air space, supernate and sludge layer. Figure 2 shows the set-up for the in-tank camera inspections. Access to tanks was obtained through existing risers or existing or new penetrations in the tanks. New penetrations were installed in 5 of the 16 tanks inspected during this campaign. In addition to the camera, a 0.25" diameter rod was also lowered into the tank (if space permitted) to allow the depth of the supernate and sludge layers to be measured. The rod was also used to stir up the sludge and observe its consistency and settling properties.

The camera assembly was mounted in a steel tripod that allowed the worker to move away from the radiation field (up to 20 mR/h) while the camera was allowed to hang in the tank. Vertical movement of the camera was completed manually by loosening lock screws on the tripod and physically lowering or raising it.

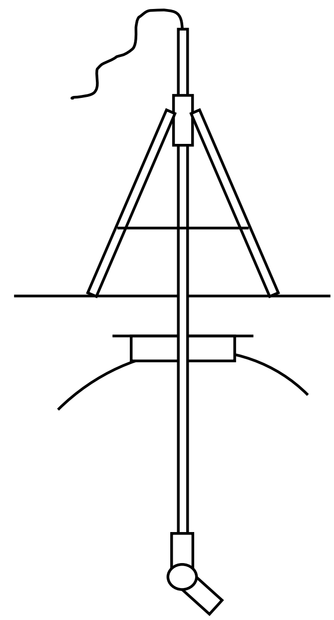

Figure 2: Camera Apparatus Lowered into Tank

5. IN-VAULT INSPECTION METHOD

The in-vault camera inspections consisted of lowering a light and camera (with pan/tilt and zoom capabilities) into the tank vaults. Access to the vaults was obtained through existing roof hatches. The camera was mounted on a pole that was held above the tank by a tripod, similar to the tank inspection method. The tripod allowed the camera operator to move away from the radiation field during the majority of the inspection, except when the camera was moved vertically within the vault to allow the full depth of the vault to be inspected.

Vault inspection of one of the four tank buildings required a slight modification to the method described above. Instead of lowering the camera vertically in the vault, the camera was fed into the vault horizontally through trench risers that extended beside the tank vault below the ground level. The trench risers measure 3 x 4 feet. Therefore, shorter poles were required and fed into the vaults horizontally with additional poles threaded on until the camera had been sufficiently inserted into the vault. Sand bags were used to hold the assembly in position (see Figure 3). Two small fluorescent lights were used to illuminate the interior of the vaults during recording.

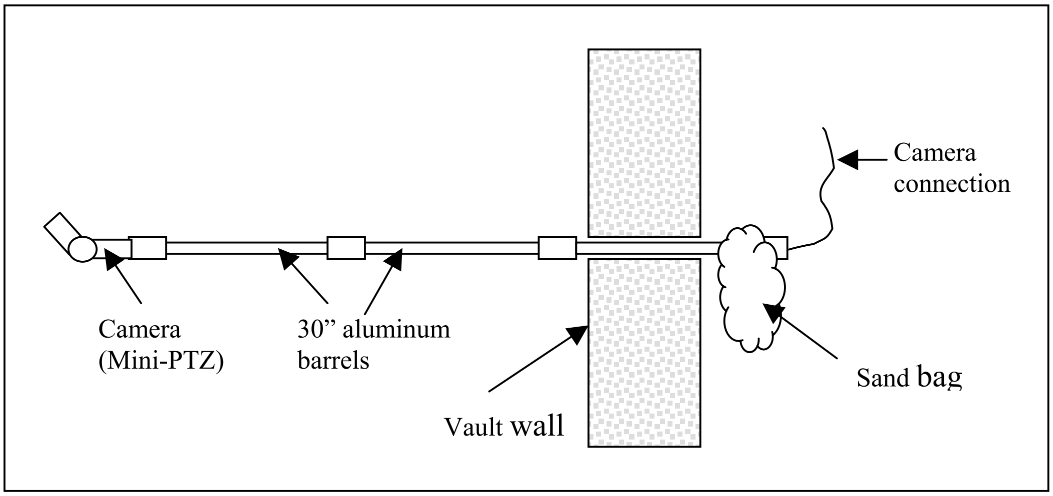

Figure 3: Camera Installed in Side of Vault

6. IN-TANK CAMERA INSPECTION RESULTS

6.1 General

The in-tank inspections allowed the inside of the tank to be inspected for the following:

- Visible corrosion, and cracking above the level of the waste;
- Debris within air gap, water layer and sludge layer;
- Piping modifications that may complicate the installation of new penetrations;
- Condition of existing lines;
- Depth of sludge and supernate;
- Consistency of sludge; and
- Any abnormalities in the tank.

6.2 Visible Corrosion and Cracking

Figure 4: Inspection of Inside Walls of Tank

The camera was used to inspect the inside walls of the tank above the level of the waste. Inspections did not reveal any visible corrosion or cracking. One of the tanks appeared to be pitted (see Figure 4) but an expert determined that this was weld splatter formed on the inside of the tank during manufacturing and not pitting.

6.3 Debris within Air Gap, Water Layer and Sludge Layer

The camera was used to detect debris floating on the surface of the waste and also debris below the supernate. This is helpful in designing retrieval equipment appropriate for the wastes. Four of the tanks were found to contain debris. Figure 5 shows a tape measure and a bolt that were found in two of the tanks. Debris that had settled below the surface of the sludge could not be detected.

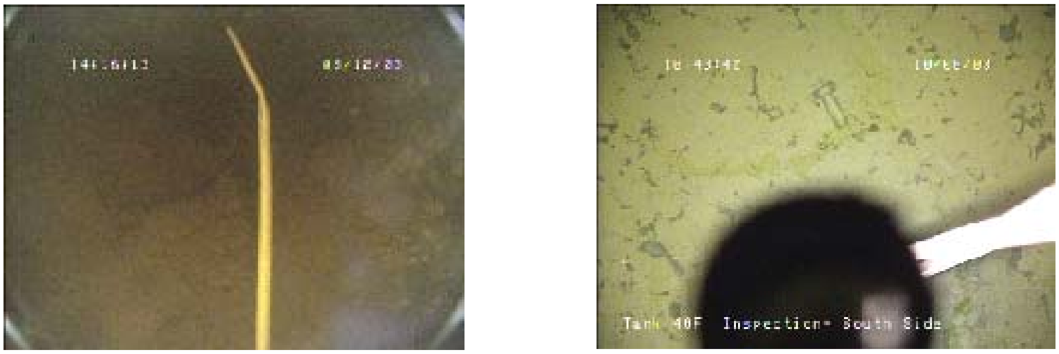

Figure 5: Debris Discovered in the Tanks

6.4 Piping Modifications

Figure 6: Piping Modifications

Camera inspection above and below the waste level was used to detect piping modifications or new penetrations in the tank. Only one of the tanks inspected revealed a discrepancy in the piping compared to the drawings. Figure 6 shows this discrepancy, a pipe situation along the centre line of the tank that was not shown on the drawing. The presence of this pipe will complicate installation and design of the retrieval nozzle. A similar pipe in another tank, based on the same drawing, could not be found. It may be present but hidden by the deep sludge in that tank.

6.5 Condition of Existing Lines

Figure 7: Precipitate on Existing Lines

The condition of existing lines was assessed visually using cameras. The inspections revealed that existing lines in the tanks are in reasonable condition considering the age of the tanks. Some of the lines were coated with precipitate that may impede use of exiting lines for retrieval operations (see Figure 7).

6.6 Condition of the tank interior above the water level

The in-tank inspections revealed that sludge and crystals have built-up on the inside walls of 13 of the 16 tanks inspected. The other three of the tanks inspected contained highly acidic wastes (pH <0) and were relatively clean (see the second photo in Figure 8). The first photo shows sludge build-up while the last photo shows crystals that have formed on the tank wall. Wall washing equipment is required to properly clean these tanks.

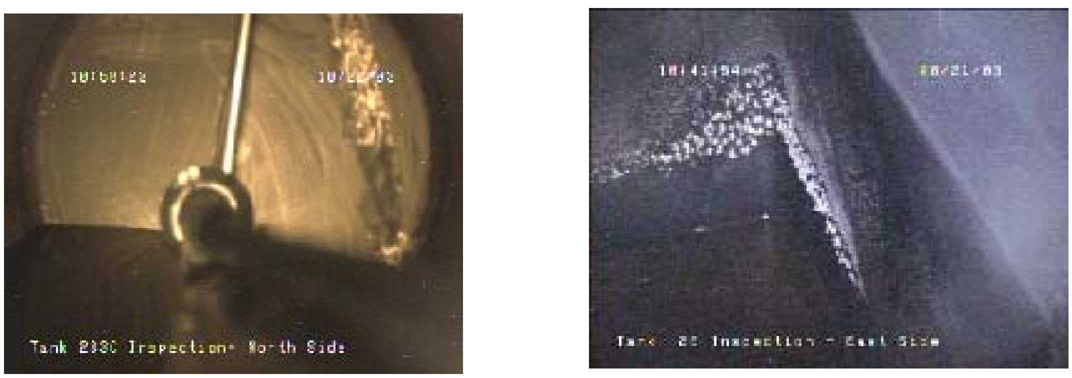

Figure 8: Sludge and Salt Build-up on Internal Tank Walls

6.7 Depth of Sludge and Supernate

Figure 9: Variation in Depth of Sludge

The in-tank inspections were used to determine the depth of sludge and supernate in the tanks by employing a rod in conjunction with the camera. The rod was lowered into the tank, marked when it came in contact with the surface of the supernate, and marked again when it came in contact with the sludge. This gave a good estimate of the depth of the supernate. The rod was then lowered further until it made contact with the bottom of the tank and marked a third time to determine the depth of the sludge and also the total depth of waste in the tank.

Sludge volumes previously estimated using freezing methods were modified as a result of the camera campaign. Figure 9 indicates that measuring sludge depth at one location in the tank may not always be accurate as sludge depth can vary throughout the tank. This “hilling” of sludge was only noticed in one of the tank.

6.8 Consistency of Sludge

By lowering the camera and rod through the supernate and into the sludge, the consistency of the sludge could be determined. (Is the sludge like baby powder or peanut butter?) This is important when designing retrieval equipment to avoid poor mixing, plugging of retrieval nozzles and settling in transfer lines. The first photo in Figure 10 reveals the surface of the sludge as seen through the supernate. Although the sludge looks hard and almost "asphalt-like" in nature, when prodded with a rod, it was discovered that the sludge was "ash-like" and could be easily mobilized. The second photo reveals the consistency of sludge, in a different tank. This zoomed-in magnification reveals the granular structure of the sludge. The third photo, taken in a different tank, reveals what might be metallic particles within the sludge.

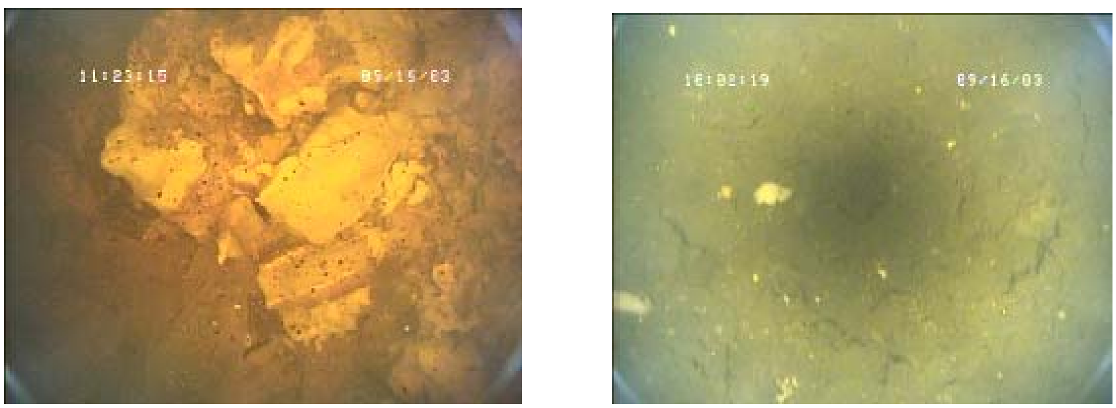

Figure 10: Close-up Photos of Sludge

6.9 Other Abnormalities

The in-tank inspections were also useful in identifying abnormalities in the current tank configurations. Figure 11 shows a tank with waste residue rings, from waste previously stored in the tank. These rings are not parallel to each other. This may indicate a shift or rotation in the tank. A thorough search of records revealed that this tank had not rotated or sunk but, rather, had been removed from service for several years and re-installed later at a slight angle. These residue rings may require aggressive cleaning methods to be completely removed.

The second photo in Figure 11 shows a cross-member support structure inside one tank. This structure was not on any of the tank drawings. Retrieval equipment design will have to avoid damaging this structure and also clean around it.

Figure 11: Tank Abnormalities

7. IN-VAULT INSPECTION RESULTS

7.1 General

The in-vault inspections were able to confirm the:

- Presence and location of any debris in the tank vaults;
- Presence and location of piping and supports within the vaults;
- Condition of the exterior of the tank;
- Condition of the secondary containment in the vaults.

7.2 Presence and Location of any Debris in Vaults

The in-vault inspections revealed some debris in the tank vaults, as can be seen in Figure 12. The photo on the left shows some plastic debris in one vault, while the photo on the right shows some mud inside the drip-tray underneath the tank. An investigation revealed that several years ago some of the vaults had been flooded for several days resulting in the muddy residue seen in this photo. No damage was caused to the tank or vault during the flood. No liquid was found in any of the vaults.

Figure 12: Debris in Vaults

7.3 Presence and Location of Piping and Supports

An important aspect of the in-vault inspections was determination of a suitable location to install new penetrations. Figure 13 reveals a maze of piping above the tanks that may impede the installation of retrieval equipment in the future.

Figure 13: Piping Above Tanks

7.4 Condition of the Exterior of the Tank

Figure 14: Rust Spots on the Outside of a Tank

Camera inspection of the vaults allowed visual inspection of the condition of the exterior of the tanks. Figure 14 shows some rust spots on the bell end of one of the tanks. Closer inspection of the video revealed that the rust was not a result of liquid rusting through from the inside of the tank but, rather, from a corroded pipe above the tank dripping on and staining the outside of the tank.

7.5 Condition of the Secondary Confinement

The in-vault inspections allowed the inside of the vaults to be visually inspected for cracks and abnormalities. The photo on the left of Figure 15 reveals that the vault is in good condition with only some paint peeling. The photo on the right confirms the T-beam roof structure, shown on the drawings, of four of the vaults. This roof structure makes access into the vaults, through the roof, extremely difficult. These inspections also allowed for drip trays to be examined to ensure their drains were visibly clear.

Figure 15: Condition of the Vault

8. CONCLUSION

Camera inspections of tanks and vaults are a valuable tool for reducing risk when designing waste retrieval equipment and planning retrieval operations.

The images recorded during the in-tank inspections will be used to:

- Design retrieval equipment and ensure that it is suitable for the configuration of the tanks and consistency of the sludge;
- Predict the extent to which each tank is expected to be cleaned using the selected retrieval technology;
- Validate volumes of supernate and sludge in the tanks;
- Characterize the sludge;
- Confirm the as-built condition of the tank and document exceptions; and
- Verify the suitability of current tank penetrations and identify locations for new penetrations.

The images recorded during the in-vault inspections will be used to:

- Verify the suitability of current vault penetrations and identify locations for new penetrations;
- Confirm the as-built condition of the vault and document exceptions; and
- Determine the condition of secondary confinement prior to disturbing the tanks.

In-tank and in-vault camera inspections are a relatively inexpensive method of assessing the condition of tanks and vaults, consistency and volume of waste and, therefore, avoiding problems that may be encountered during retrieval operations.