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Evaluation of Potential Water Intrusion Sources, Tank 241-AY-101

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U.S. Department of Energy Contract DE-AC27-99RL14047

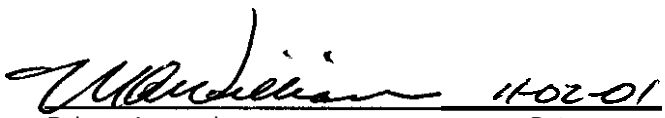
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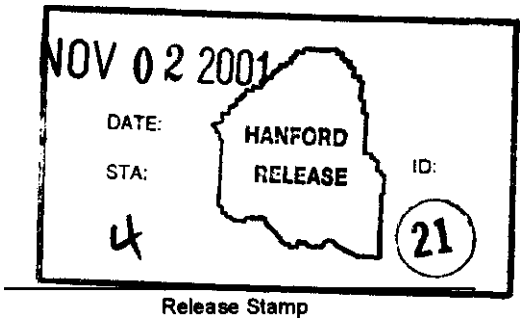
Abstract: This report documents the results of evaluation of potential sources of external water intrusion into Tank 241-AY-101. Two sources of water instrusion have been identified that have the potential to contribute to leakage into the tank annulus. These sources have include natural storm-induced run-on and run-off, and leakage from water lines located above the tank dome.

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EXECUTIVE SUMMARY

Video inspections performed within the Tank 241-AY-101 (Tank AY-101) annulus have identified widespread corrosion on the exterior of the primary tank and the interior of the secondary tank liner. The corrosion has been determined to be a result of water intrusion in the annulus coupled with the shutdown of the annulus ventilation system for an extended time period (Anantatmula 2001). Water intrusion into the annulus of Tank AY-101 is most likely from the identified leak in the raw water system piping located above the tank. The 241 AY-IOI ***Raw WaferLine** Leak Inspection **Plan,*** (Bellomy, 2001b) was prepared to provide an inspection plan to assess the integrity of the raw water lines.

No evidence of leakage was found upon initial inspection of the raw water system valves in the as-found condition. However, when the raw water system supply lines were filled, raw water leaked through both valves V-110 and V-160 with the valves in the closed position, and valve V-114 in the 01E valve pit was found to be leaking externally. The 01E valve pit is located 15 feet above and directly over the flashing that covers the gap between the primary tank and the liner. The direct leak path from valve V-114 is through 13-1/2 feet of soil overburden and 18 inches of the concrete dome before reaching the steel dome liner.

An attempt to quantify the leak rate did not produce any conclusive results, however, that is thought to have been due to the low system pressure used during the test. Raw water supply was at 55 psi during the test and the normal operating pressure is routinely over 100 psi. Although a leak was found at valve V-114, an additional leak in the supply lines above the tank is also a possibility. The tank and raw water system were installed in the early **70's** and the piping is buried directly in the soil without any cathodic protection. The supply lines directly above the dome include approximately 80 feet of 1-1/2 diameter schedule 40 carbon steel pipe and 250 feet of 2 inch schedule 40 carbon steel pipe.

The raw water system supply valves for both Tank AY-101 and AY-102 have been removed and replaced with blind flanges so that the system will be isolated and no longer a source of water intrusion.

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1.0 INTRODUCTION

Recent video inspections performed within the Tank **241-AY-101** (Tank **AY-101)** annulus have identified widespread corrosion on the exterior of the primary tank and the interior of the secondary tank liner. The corrosion has become much more prevalent than that previously observed in **1992,** and is more significant and widespread than that observed at other tanks. The corrosion has been determined to be a result of water intrusion in the annulus coupled with the shutdown of the annulus ventilation system for an extended time period (Anantatmula **2001).** Three possible sources of water intrusion were considered - **(1)** water ingress from the primary tank, **(2)** condensation of ambient air in the annulus, and (3) water intrusion from an external source. Water ingress from the primary tank was ruled out due to the absence of any radiation signal from the continuous air monitors. Condensation of ambient air near the top of the annulus walls and riser pipes would not provide the volume of water necessary to explain the extent of corrosion observed in the Tank **241-AY-101** annulus. The most likely source of water intrusion, for the degree of corrosion observed in the Tank **AY-101** annulus is from an external source.

This report was prepared to document the results of evaluation of potential sources of external water intrusion into the annulus of Tank AY-101. Two sources of water have been identified that have the potential to contribute to leakage into the tank annulus. These sources include natural storm-induced run-on and run-off, and leakage from water lines located above the tank dome. Both of these sources have the potential to saturate the soil column, migrate through cracks or riser penetrations in the concrete, and flow into the tank annular space at the unsealed junction where the tank primary and secondary lines join.

2.0 BACKGROUND

In **1992,** limited inspections of the AY-101 annulus were performed as part of the Tank Farm Project Tank Integrity Assessment Program. Inspections were performed by lowering a closed-circuit television camera into the annulus at risers 17C **(79)** and **17H** (85), and viewing the visible surfaces of the primary and secondary tank liners. The presence of rust over many areas of the primary and secondary tank surfaces was observed. (Harris, **1993).** Later in **1999,** remote ultrasonic wall thickness measurements were attempted by lowering a magnetic crawler vehicle into the annular space to provide access to the primary liner. During the examination, scale and other corrosion products on the tank wall hindered the movement of the crawler on the outside surface of the primary tank. The presence of corrosion products caused a buildup of material in the magnetic wheels of the crawler, leading to a weakening of the magnetic field required for the crawler to attach itself to the liner. This resulted in the crawler becoming detached

from the tank liner such that no data could be taken and operations were halted to prevent the risk of damage to the crawler. Significant corrosion was observed by video inspections through riser 89. As a result, the *241-AY-101 Annulus Wafer Intrusion Investigation Plan,* (Bellomy, 2001a), was prepared to determine the extent of corrosion on the remainder of the tank and identify potential locations of water in-leakage into the annular space.

Eight risers were selected for video inspections of the AY-101 annulus and guidelines for performance of the inspections were provided in RPP-7540. Video inspections of the eight annulus risers were completed in January 2001. The video inspections detected the presence of unique anomalies and widespread corrosion, which led to additional inspections being performed in five other annulus risers and one primary tank riser. The additional riser inspections, which were also completed in January 2001, revealed conditions within the annulus similar to that observed in the previous eight risers.

Analysis of tank conditions concluded that the corrosion was most likely the result of water intrusion into the tank annulus together with the inoperability of the annulus ventilation system (Anantamula, 2001). Two possible sources of water intrusion into the annulus were identified. These sources include intrusion from natural storm run-on run-off and leakage from water lines located above the tank dome. Areas of excessive corrosion and potential water intrusion were mapped on tank drawings based on a review of the video data, (Aftanas, 2001). These mappings were used to evaluate potential water intrusion sources and pathways that may be contributing to the water intrusion in the annulus.

3.0 FACILITY DESCRIPTION

Tank 241-AY-101 is a 1-million-gallon double-shell tank located in the Aging Waste Facility in the 200 East Area. The AY-101 tank is made up of a carbon-steel primary tank and a carbon-steel secondary tank liner encased by a reinforced concrete shell. (Ref. Dwg. H-2-64449). The annulus region between the secondary liner and the exterior of the primary tank is 2 and a half feet wide. The secondary tank extends along the bottom, sides and upper haunch of the concrete shell. The secondary tank carbon-steel liner meets the primary tank at the haunch leaving a 0.5 to 1-inch gap between the liner and the primary tank. This gap is covered by a 14 inch wide continuous metal flashing strip that is tack welded to the primary tank and overlaps the secondary liner by about 4 inches. A 15-inch thick steel reinforced concrete dome covers the primary tank and the secondary tank liner at the upper haunch area. The entire tank is covered with soil, which ranges from close to 10 feet thick at the tank center to over 15 feet thick at the edge of the tank.

Steel riser pipes provide access to the primary tank and annulus space for waste processing and transfer operations, equipment installation, and monitoring. The risers penetrate the concrete dome and the top of the primary tank where they are welded in place to provide access to the primary tank. Similarly, risers penetrate the secondary

liner to provide access to the annulus area. Risers that are used for waste processing operations such as sluicing, and transfer are generally below grade and located in concrete reinforced pits for shielding. The pits extend down to the concrete dome where they are integrated with the concrete dome. The pits are covered with concrete cover blocks that are several feet thick in most cases. The top elevations of the pits are approximately 12 inches above grade. Smaller risers are used for monitoring instrumentation and other uses, They are also welded to the primary tank or secondary liner and extend up through the soil column to about 12 inches above grade. These risers are flanged at the top and have a bolted cover and/or concrete shield plug.

The annulus is ventilated by an annulus ventilation system, however, the system had been mostly out of service for the past ten years either due to mechanical problems or a low tank liquid levels which prevent system operation. The AY-101 annulus ventilation system is presently operational.

Raw water is used at Tank AY-101 for a variety of uses including pit spray, riser spray, transfer pump wash down, transfer pump lubrication, sluicing and construction. Raw water is supplied to the AY Tank Farm from the 4-inch RW-3501-MS underground supply line which enters the farm from the east (see figure 1). Two 4-inch gate valves (V-110 and V-138) enclosed in valve pits, branch off the 4-inch supply line to supply and control raw water to Tanks 241-AY-101 and 241-AY-102, respectively. At Tank 241-AY-101, downstream of Valve V-110, the 4-inch RW-3502-M5 raw water supply line extends to the 6-foot diameter corrugated pipe AY-01A valve pit where seven raw water supply valves are located. These valves provide raw water underground to the AY-OlA pump pit and provide a source of raw water supply within the pit for construction use.

Raw water is fed from the 4 inch header pipe to each of the four sluice pits via 2-inch underground lines that run across the top of the tank on all sides except the northwest. Two 1-1/2 inch lines branch off the 2-inch line at each sluice pit to supply the riser spray ring and the pit spray nozzles. Valves for controlling each of the spray supply lines are located in 36-inch diameter cormgated steel valve boxes located outside of the sluice pits.

Recent field inspection has confirmed that the 241-AY-101 supply valve (V-110) is closed. Discussions with tank farms operations personnel indicated that the supply valve is normally maintained in the closed position and only opened when a specific need arises (water needed for construction or other tank farm activities). The pit spray and riser spray systems are non-functional and are not used; therefore, supply valves to the raw water service pits are also not used and maintained in the off position.

4.0 WATER INTRUSION INVESTIGATION

This section investigates the two sources of water intrusion that have been identified as having the potential to contribute to leakage into the tank annulus. These sources include natural rainwater and leakage from water lines located above the tank.

4.1 *Natural Storm Induced Run-on and Run-off*

A field walkdown of the area above Tank AY-101 was performed to identify any possible pathways for natural storm run-on run-off. No direct pathways to the tank dome were found. Riser penetrations and pump pits located directly above the primary tank are integral to the tank liner and any leakage would go directly into the primary tank. Riser penetrations located above the annulus, including the annulus pump pit, provide a direct path to the annulus, however any leakage would fall to the annulus floor and would not wet the wall surfaces, particularly on the roof of the dome where there is evidence of water intrusion. In addition, all penetrations and pits are covered at all times except during short operational periods. Any sustained leakage through them is therefore extremely unlikely. Valve pits outside of the sluice pits are made up of corrugated metal caissons that extend down three feet below grade, however they also covered with a metal lid.

The area above the tank is at even grade therefore there are no areas where water would collect or puddle and provide a concentrated source for water intrusion. It is not expected that there would be enough rain at any one time to penetrate the soil and concrete covers over the tank and allow leakage to the primary tank steel dome and walls.

4.2 *Pipeline Leakage*

The suspected source of water intrusion into the annulus is from leakage from direct buried pipelines located above the tank. A pipe leak could result in a localized point source, saturate the soil column above the tank and flow through fissures or cracks in the concrete dome to the steel tank dome liner. Once present at the top of the steel dome liner, water could flow down the curved surface of the primary liner, under the unsealed flashing covering the primary and secondary haunch junction, and into the annulus.

Facility drawings were reviewed to determine any water lines above the tank that if leaking, could reach the tank dome. The only lines that carry liquid on top of the tank are waste transfer lines and raw water supply lines. It is not expected that a leak in a transfer line would go undetected due to secondary containment, leak detection, and mass balance during transfers. Therefore, the most probable source of water intrusion would be from a leak in one of the raw water supply lines.

The *241 AY-101 Raw Water Line Leak Inspection Plan, RPP-7759,* (Bellomy, 2001b) was prepared to provide an inspection plan to assess the integrity of the raw water lines located above the Tank 241-AY-101 dome. The integrity of the raw water system was assessed by performing excavations, visual inspections and pressure testing. The Plan was implemented through work package number 2E-00-02160M in September of 2001. All work was performed in accordance with fieldwork procedures in HNF-IP-0842, *RPP Administration.*

The intent of the inspection plan is to provide a structured, systematic approach for assessment of the Tank AY-101 raw water system integrity while minimizing excavation and fieldwork within the tank farm. The approach outlined in the plan is as follows:

1. Expose and inspect the current condition of the Tank AY-101 raw water system valves
2. Energize the Tank AY-101 raw water system and inspect all valves for leakage.
3. Isolate the Tank AY-101 raw water system
4. Pressurize the Tank AY-101 raw water system and perform a pressure decay test to determine if there are any leaks in the system.
5. Remove and cap all Tank Farm AY-101 raw water valves and backfill.

Prior to performing the inspection procedure activities, the areas around the valve pits to be excavated were scanned for underground utilities and the valve pits were sampled for asbestos. The valves inside the valve pits included vermiculite backfill and past experience had determined that in some cases asbestos had been found mixed with the vermiculite. The asbestos sampling detected the presence of asbestos in all valve pits with the exception of the V-110 and V-138 valve boxes. Because of the prohibitive cost of removing the asbestos from the valve pits, the Inspection Plan was revised to delete the requirement to expose the valves in the valve pits. The following is a step by step account of the raw water system testing.

4.2.1 Valve inspection

Prior to performing any inspection, the valve boxes for the V-110 and V-138 supply valves were excavated and removed. The excavation was performed by hand as several underground utilities had been located in the immediate area by previously performed ground scans. The V-110 and V-138 valves were inspected after being exposed and no apparent evidence of external leakage was observed (See figure 2). Exposed piping in the excavated area was also inspected. The 4 inch raw water lines were coated with what appeared to be an asphalt type coating and showed no signs of degradation. However, a 1-1/2 inch condensate with no coating was heavily corroded. (See Figures 2a and 2b).

The remainder of the Tank AY-101 raw water system valves were then inspected for signs of leakage in the as-is condition. The valves on top of the tank are contained in valve pits and, aside from the valve stems and handles, are covered with vermiculite. There were no signs or indication of leakage observed at any of the locations.

4.2.2 Leak Testing

Testing of the raw water system involved filling the raw water system upstream of supply V-110 and then checking for leakage at the valve. ***After*** the V-110 inspection was completed, V-110 was opened and the valves downstream of V-110 on top of the tank are checked for leakage. To initially fill the system, valves V-141, V-143, V-144, V-145, V-146 and V-147 were opened at the AZ241 raw water enclosure, and V-201 was opened at the AZ-Farm Service Pit (Ref. H-14-021807, Sheet 1). Prior to opening the final upstream valve (V-160) it was observed that there was considerable moisture present in the vermiculite around the stem of valve V-114 in valve pit 01E. (See figure 3). This indicated that not only was there external leakage through valve V-114, but since both supply valves V-110 and V-160 were closed, that there was leakage through these valves as well. Valve V-160 was then opened filling the upstream side of the raw water system up to V-110. Upon inspection, there was no apparent external leakage at valves V-110, or at the AY-102 supply valve, V-138. Also, there was no apparent increase in leakage at valve V-114 in valve pit 01E

The next phase of the testing included energizing the raw water system with raw water downstream of valve V-110, and inspection for any leakage around or through the pit or riser spray control valves. Prior to performing this step a camera was inserted into the tank headspace through riser 52, and the pit leak detectors in the 01A pump pit and the 01B, 01C, 01D, and 01E sluice pits were verified as operational. The camera is required to determine if any leakage through riser spray control valves can be observed, and the pit leak detectors are required to determine if there is any water accumulation due to leakage through the pit spray control valves.

Valve V-110 was put in the open position to allow water to fill the raw water lines above the tank. Valves V-137 at valve pit 01B and V-114 at valve pit 01E were opened briefly to vent air from the system. Raw water flow was verified by observing water draining in the tank headspace out the risers of the respective pits using the CCTV. This step also verified operation of the camera. Valves V-114 and V-137 were closed as soon as flow was verified.

With the raw water lines pressurized and the raw water spay control valves closed, the CCTV was used to visually monitor risers and drains in pump pit 241-AY-01A and sluice pits 241-AY-01B, C, D and E. Water coming through the risers would indicate leakage originating from the riser spray control valves and water coming through the pit drains would indicate leakage originating from the pit spray control valves. No water was observed coming through any of the pit risers or pit drains, which indicated that none of the spray control valves were leaking through. Also, there was no activation of the pit leak detectors, which would have also indicated a leak through of the pit spray line valves.

The valve pits were visually inspected once again for any indication of external leakage through the pit spray control valves. The leakage previously described at V-114 in valve pit 01E was the most significant leak observed, however, there was also some minor leakage around the packing of Valve V-122 in the 01A valve pit (See figure 4). In

addition to the raw water valves located on top of Tank AY-101, leakage was observed at valve V-160 located outside of the AY tank farm (See figure 5).

4.2.3 Leak Rate Test

The original intent of the Raw Water Leak Test Plan was to perform a pressure drop hydrostatic test at operating pressure to determine if there were any leaks in the system. However, since a known leak had already been observed in the 01E valve pit, this hydrostatic test was not performed and instead an alternate leak rate test was performed in an attempt to quantify the leak.

The Tank AY-101 raw water system was isolated from the rest of the system by removing and capping raw water supply valve V-110. Prior to removing the valve, system pressure was released by slowly opening valves V-114 and V-137 and the remaining raw water drained through the sluice pit 01B and 01E-pit risers, respectively. Supply valves V-106, V-146 and V-147 upstream of valve V-110 were returned to their original closed position. The Tank AY-102 raw water system was also isolated from the rest of the system by removing and capping raw water supply valve V-138.

A test manifold (See figure 6) which included a fill line port, flowmeter, and pressure gage, was installed on the down stream side of the Valve V-110 flange. The raw water system was filled with raw water through a supply line hose that originated at the AX farm. Valves V-114 and V-137 were opened briefly to vent the system, as was done previously, until the system was filled. Approximately 66 gallons were needed to vent and fill the system. The raw water supply was kept in place after the system was filled, which produced a system pressure at approximately 55 psi. Pressure and flow were monitored for 30 minutes under these conditions. The system pressure over this time period remained fairly constant at 55 psi. Minimal flow readings were observed during the first few minutes of the test and a totalized reading of 6.6 gallons was indicated. This is thought to be attributed to compressing and filling air pockets left in the system after venting. For the remainder of this time, there was no measurable flowrate or increase in totalized flow.

The inlet isolation valve was then shut so there was no additional raw water added to the system. The system was maintained at the existing pressure for an additional 30 minutes and monitored for pressure drop. During this period the pressure again remained fairly constant at 55 psi and there was no measurable decrease in pressure. Upon completion of the test, the system was depressurized by opening valves V-114 and V-137. The test manifold was removed and replaced with a blind flange. The excavation was then backfilled to grade and covered with approximately 1 to 2 inches of gravel.

The maximum pressure on the raw water system obtained during the test was 55 psi, which is less than half of the normal operating pressure. It is concluded that this lower pressure was not high enough to produce a measurable leak rate, even though a leak was previously observed at valve V-114.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Corrosion in the annulus region of Tank **AY-101** is a result of a combination of water intrusion and the inoperability of the annulus ventilation system during much of the last ten years. Water intrusion into the annulus of Tank **AY-101** has been determined to be from an external source, most likely from the identified leak in the raw water system. Raw water was found to have leaked through both supply valves **V-110** and **V-160,** while valve **V-114** in the 01E valve pit was found to be leaking externally. An attempt to quantify the leak rate did not produce any conclusive results, however, that is concluded to be due to the low system pressure used during the test. Raw water supply was at **55** psi during the test and the normal operating pressure has been as high as **140** psi.

The location of the 01E valve pit is approximately **36** feet from the tank centerline and **15** feet directly over the flashing that covers the gap between the primary tank and the liner. The direct leak path from valve **V-114** would travel through **13-1/2** feet of soil overburden and **18** inches of the concrete dome before reaching the steel dome liner.

Although a system leak was found at valve **V-114,** an additional leak in the supply lines above the tank is also a possibility. The tank and raw water system were installed in the early **70's** and the piping is buried directly in the soil without any cathodic protection. The supply lines directly above the dome include approximately **80** feet of **1-1/2** diameter schedule **40** carbon steel pipe and 250 feet of 2 inch schedule **40** carbon steel pipe.

The raw water system supply valves for both Tank **AY-101** and **AY-102** have been removed and replaced with blind flanges so that the system is isolated and no longer a source of water intrusion.

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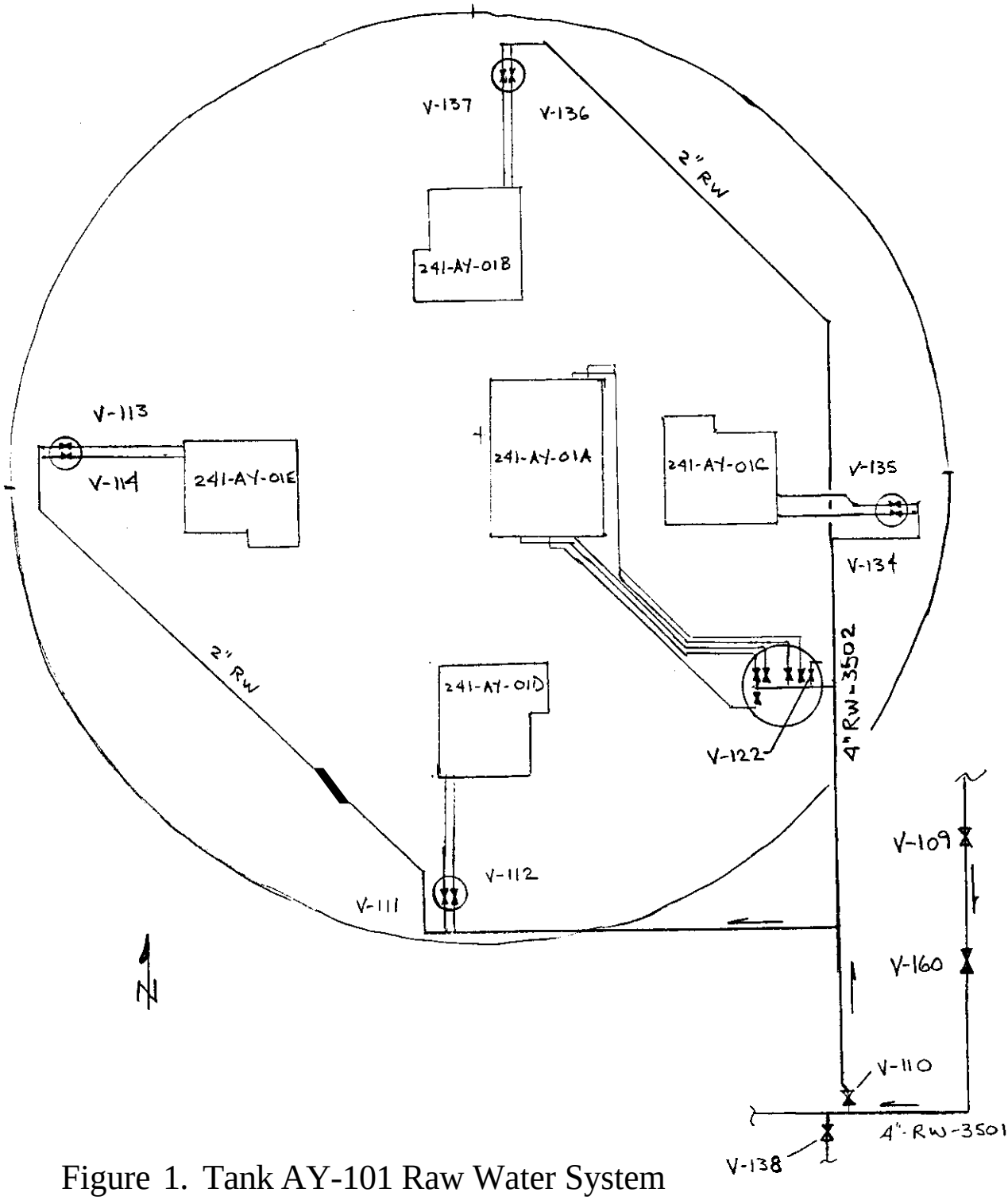


Figure 1. Tank AY-101 Raw Water System



Figure 2. Raw Water Supply Valves V-110 and V-138



Figure 2a. Raw water supply (top) and condensate pipes

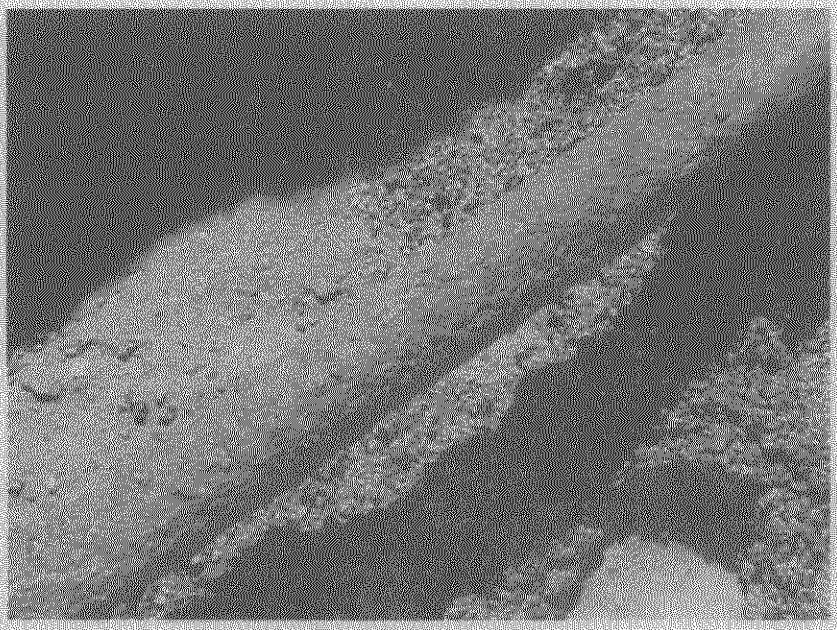


Figure 2b. Close up of condensate pipe



Figure 3. Moisture Present at Valve V-114 in the 01E Valve Pit

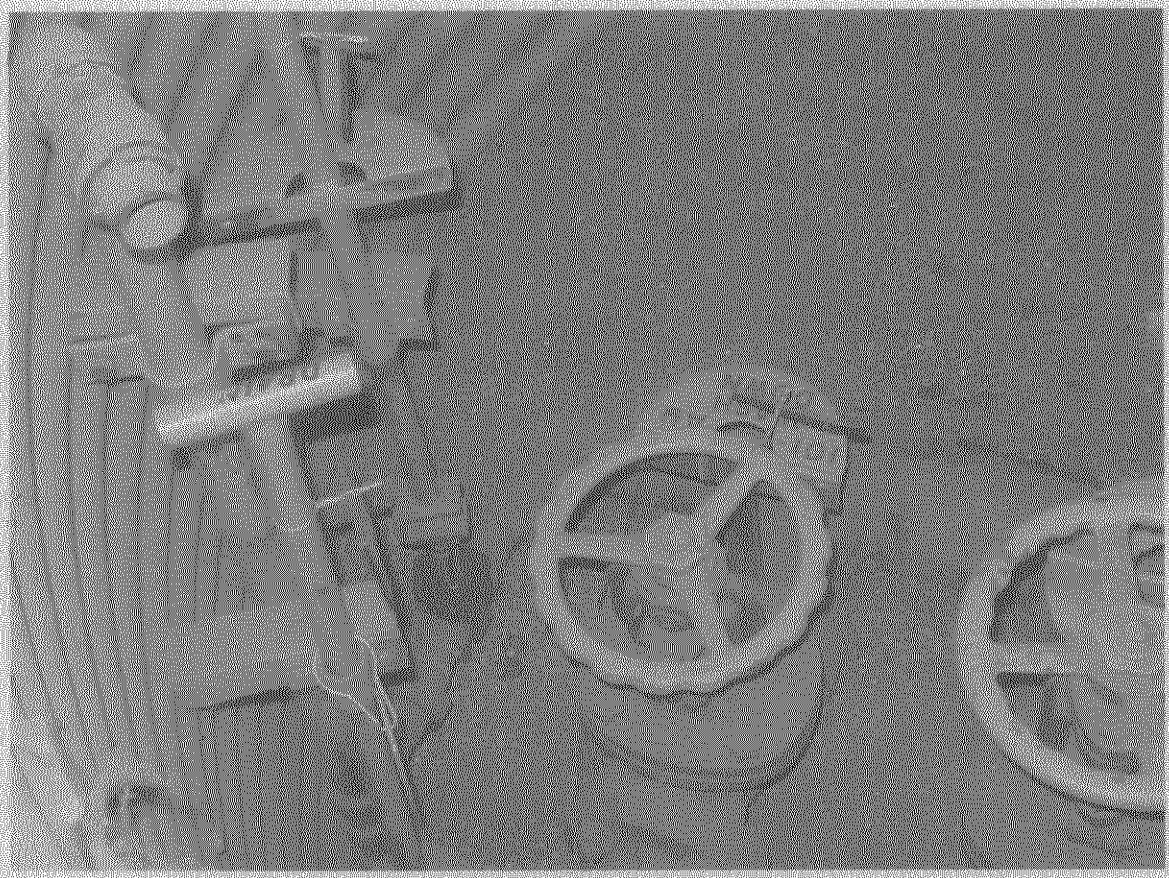


Figure 4. Leakage at Valve V-122 in the 01A Valve Pit

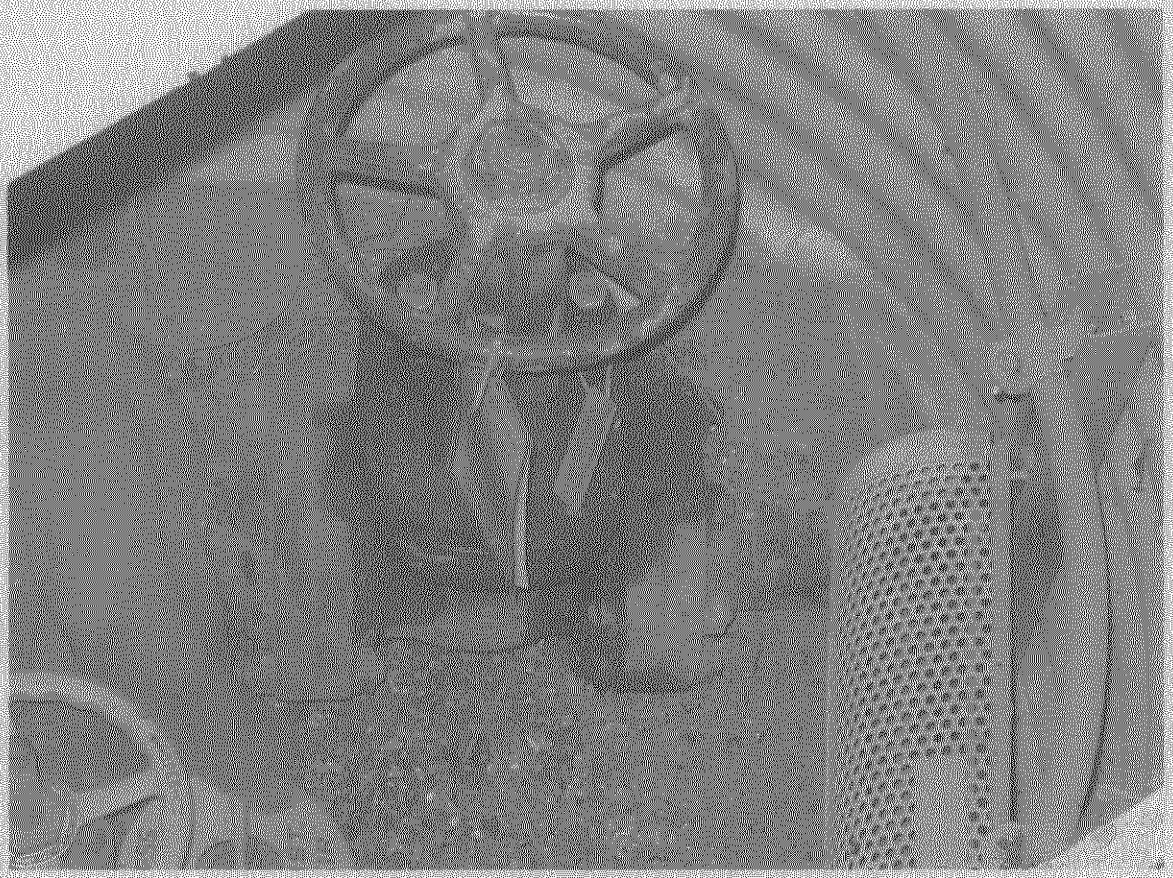


Figure 5. Leakage at Supply Valve V-160



Figure 6. Leak Rate Test manifold at Valve V-110