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MEMORANDUM FOR: Ross A. Scarano, Chief
Uranium Recovery Licensing Branch

THRU: John J. Linehan, Section Leader
Operating Facilities Section I
Uranium Recovery Licensing Branch

FROM: Ted L. Johnson
Operating Facilities Section I
Uranium Recovery Licensing Branch

SUBJECT: SITE VISIT REPORTS ON SWEETWATER AND TETON TAILINGS POND LINER FAILURES

Enclosed is a site visit report for the subject facility. This report will be supplemented at a later date with recommendations regarding installation and inspection of liners and liner construction. In addition, we will determine if any license conditions were violated in the construction or operation of the ponds.

T. L. Johnson

Ted L. Johnson
Operating Facilities Section I
Uranium Recovery Licensing Branch
Division of Waste Management

Enclosure:
As stated

SITE VISITS TO SWEETWATER AND
UNC TETON MILLS TO INSPECT POND LINERS

A. Sweetwater

On Saturday, January 10, 1981, Mr. R. E. Williams (University of Idaho - NRC Advisor) and Mr. T. L. Johnson, NRC, visited the Minerals Exploration Co. Sweetwater site. The purpose of the visit was to inspect the reported failure of the synthetic liner of the tailing pond.

When we arrived at the site, we found that the liner had been repaired. However, the comnplete repair process to restore the liner to its original condition had not been totally finished. The pond liner was intact except at those locations where repairs were being implemented. The pond contained approximately four feet of water and sediment. The sediment consisted of approximately 3,000 tons of slurry that was present in the mill in October when the fire that forced the mill to shut down occurred. This slurry was removed from the mill and piped into the tailings pond after the fire. The liquid consisted of precipitation and water that had been added by the company for purposes of holding the liner in place and protecting the PVC bottom from ultraviolet radiation.

A bench, which exists on the embankment slope approximately 30 feet from the top of the embankment, had been covered previously with sand. However, we noted that apparent wind and water erosion had removed the sand cover from the bench.

The liner reportedly had not experienced excessive wind-airfoil problems because of the precautionary measures that had been taken during the design and installation of the liner. These measures included the installation of "sand tubes" along the liner above the bench. These sand tubes consist of approximately six-inch diameter columns of hypalon filled with sand. The length of the columns is about 100 feet and they are spaced approximately 30 to 50 feet apart. The columns are glued to the hypalon liner in a direction parallel to the slope of the embankment. The second technique for controlling airfoil effects consists of the installation of vents along the top of the liner and along the downgradient edge of the bench. The function of the vents is to create a vacuum in the vicinity of a hole in the liner so that air will be pulled out from beneath the liner. The combination of the vent system and sand columns appears to exclude wind effects as a direct explanation for the failure of the liner.

The general condition of the liner has been affected by the occurrence of small holes which need to be patched frequently. Sweetwater management personnel reported that approximately 50 such holes have been repaired since the liner was installed. Our inquiry about the cause of the holes led to the explanation that they are produced primarily by the dropping of objects by work crews. However, we observed that sharp, small pebble-like positive features occur in the subgrade under the liner. It is not possible to determine whether these pebble-like features are rocks or clods of dirt. We were informed that design specifications required only that rock particles in excess of three inches in diameter be removed from the surface prior to the installation of the liner. Therefore, at least a portion of the small positive features beneath the liner are rocks.

We noted that the subgrade beneath the liner is not smooth. It appears that small ridges and depressions are present in the subgrade beneath the liner. These may be the imprints of vehicles used to install the liner. Other non-uniform features in the subgrade consist of small linear depressions parallel to the slope. These may have been produced by runoff events prior to the installation of the liner. It does not appear that these .tures had a significant impact upon the liner failure.

We noted that the fence around the outer edge of the top of the embankment is probably not sufficient to preclude the entry of wild game into the tailings pond area. The requirement that this fence be installed was a product of a license variance that permitted Minerals Exploration Inc. to install the liner without a cover. The fence was intended to prevent sharp-hoofed animals such as antelope and mule deer from damaging the liner. Sharp-hoofed animals apparently had no impact on this liner failure.

A leak detection system was installed beneath the liner during the construction of the pond. This leak detection system consists of trenches filled with gravel connected to a sump that exits to the top of the embankment via a PVC pipe. The performance of the leak detection system during the failure is not well understood. Apparently some liquid has appeared in the leak detection system but it is not clear that it is connected with the failure.

The liner failure in the Sweetwater tailings pond appears to be the result of a combination of several variables. If any one of these variables had not been operative or had been changed, the failure would not have occurred. The variables related to the failure are:

1) The combination of mateials used in the liner, and the schedule of the liner installation;

2) The weather conditions that existed at the time of seaming;

3) The location of the contact between the two types of liner materials and the geometry of the area where the contract occurred;

4) The location of the water level and water conditions that existed at the time of the failure; and

5) The fact that the mill was not able to operate on schedule because of the October fire.

1. Liner Materials and Liner Installation Schedule

The company requested in its license application to construct a liner composed of PVC on the bottom of the tailings embankment and 36-mil reinforced hypalon on the 3 horizontal to 1 vertical slope of the embankment. This was requested because the cost of PVC is less than half the cost of hypalon per square foot. The PVC cannot be reinforced; consequently, it has a lower tensile strength than hypalon reinforced with polyester scrim. The tensile stresses on the slope are considerably greater than the tensile stresses on the bottom of the ponds. Therefore, the company and the NRC deemed it necessary to install hypalon on the slopes. This decision to use two types of material for the liner required that a seam be constructed at the line along which the two liner materials would be joined. It is not possible to seam PVC to hypalon with field seams; field seams betweeen these two types of materials are not reliable. However, it is possible to seam the two materials dielectrically in a factory or plant. In order to seam the hypalon liner on the slopes of the embankment to the PVC liner on the bottom of the embankment, the liner installer produced in their plant a ten-foot wide strip of hypalon seamed to PVC. This ten-foot wide strip extended along the length of each side and each end of the bottom of the tailings pond. The strip consisted of five feet of hypalon on the upgradient side and five feet of PVC on the side toward the the center of the pond. Ideally this strip would be connected to the hypalon on the up-slope side and the PVC on the down-slope side by a PVC to PVC field seam and a hypalon to hypalon field seam. Either of the two materials can be seamed together (but not to each other) in the field. Under ideal circumstances each of these seams would be buried in a ditch located below the break in slope at the junction of the bottom of the pond and the embankment. The hypalon to hypalon seam would be buried in a ditch about two to three feet away from the break in slope and the PVC to PVC seam would be buried in a ditch eight to ten feet toward the center of the pond from the break in slope. This arrangement would eliminate all horizontal seams from the sloping portion of the tailings pond and it would eliminate stress on the horizontal seams because they would be buried in ditches on the nearly horizontal portion of the pond bottom. This procedure is important because even a sound horizontal seam on the slope of an embankment is the weakest portion of the liner. Horizontal field seams ordinarily are made only on benches of sloping embankments; these can be buried in ditches. Burying field seams in ditches prevents the seams from being stressed in a direction parallel to the slope of the embankment. This procedure prevents the seams from pulling apart and makes the tensile strength of the liner dependent on the liner material itself, not on its seams. Factory seams are considered sufficiently strong that they do not significantly decrease the tensile strength of the liner when placed perpendicular to the slope of the embankment.

The above described procedure was not used at the Sweetwater project. The hypalon to hypalon ditch that should have been located on the nearly horizontal bottom of the pond was located slightly up the embankment from the break in slope along some portions of the pond. In addition, this ditch did not contain the seam between the hypalon to hypalon contact. The reason for this deviation from normal procedure was the fact that the excavation contractor was not able to grade the slope on the embankment rapidly enough to keep pace with the required installation schedule. With time running out, winter drawing nearer and the scheduled initiation of mill operation approaching rapidly, the decision was made to allow the hypalon to hypalon seam to be located above ground on the slope of the embankment. Only the lower edge of the hypalon on the slope of the embankment was placed in the ditch on or below the toe of the slope. This procedure not only caused the weak seam to be located on the slope of the embankment, it also forced the pond floor lining to lap upward onto the top side of the hypalon on the slopes of the embankment. This procedure could be considered analogous to placing a shingle roof on a building with the shingles lapped in such a way that a lower row of shingles laps on the top of an upper row of shingles.

2. <u>Weather Conditions</u>

The field seam was weak, as evidenced by the fact that it could be pulled apart by hand in some locations where it had not already failed. Our discussions with the liner installer (Mr. Paul Beck of Crestline Incorporated) revealed that the weak seam probably was a result of the fact that optimal temperature conditions did not exist at the time the seaming was done. The damaged seam was reportedly the last seam completed during the liner installation when temperature conditions were less than optimal. Hypalon field seams require a fairly narrow temperature window, which was probably missed when this seam was constructed.

3. <u>Contact Location</u>

The weak seam was located on the slope of the embankment approximately two feet above the break in slope. The weak seam should not have been located at this level. As previously stated above, the weak seam should have been located on the nearly horizontal bottom of the embankment.

This seam configuration where it occurred at the water level or slightly below the water level in the pond allowed the water to move downward into the already weak seam and part it by freezing, thawing, and wave action. If the weak seam had been located on the nearly horizontal bottom portion of the lined pond it probably would not have failed. If the hypalon on the sloping embankment of the pond had been lapped over the top of instead of beneath the hypalon connected to the pond bottom liner, the weak seam probably would not have failed because the water would not have been able to enter it as readily and produce the freezing and thawing action.

4. Water Level and Wind-Wave Activity

The failure occurred at and slightly above the water line in the pond. The water line had been relatively stable because of the shut-down of the mill after the October fire. Initially, the liner was covered with sand at the location at which the water line presently is located. However, water and wind erosion had removed the sand cover from the liner prior to the failure. Consequently the liner was in direct contact with the water at the water line. The failure occurred at a field seam in the hypalon liner. The field seam extended over the entire length of the bottom of the impoundment. However, the seam did not fail along its entire length. A portion of the length of the seam was above the water level and a portion of the length of the seam was at or slightly below the water level. The actual parting of the seam occurred along its length that was at or slightly below the water level. However, a portion of the length of the seam that was above the water level was weak and reportedly could be pulled apart by hand. This condition of the seam above the water level led to the conclusion that the seam itself was weak and was prone to failure.

5. Mill Fire

If the mill had not burned in October, it would not have been necessary to cease the dicharge of tailings into the pond and the water-solids level probably would have been above the weak seam prior to the initiation of freezing and thawing conditions and the failure might never have occurred. The fire in the mill accidentally caused the static water level to be maintained at the elevation of a portion of the length of this weak seam.

The liner failure was reported by the company and repair was initiated during the week of January 5-9, 1981. The repair consisted of cutting the embankment slope hypalon liner along the edge of the ditch where its downslope edge was buried at, or slightly above, the break in slope between the embankment and the bottom of the pond. A hypalon splice was double overlapped with the hypalon splicing strip and the hypalon apron factory seamed to the bottom liner., This double overlap was glued and sandwiched between two one-inch by four-inch cedar boards. The upper edge of the hypalon splicing strip was double overlapped and glued to the hypalon cover on the embankment slope. This joint also was sandwiched between two one-inch by four-inch cedar boards. Unfortunately, sandwiching the repair seams between the cedar boards required that the seams be penetrated by nails. The potential effect of these nails on leakage is not known. In order to prevent the wind from lifting the liner and damaging the new repair seams, the company plans to install a row of sand bags along the toe of the slope on top of the hypalon splice. We suggest that if this situation is to remain stable, tailings should be introduced into the east side of the pond as soon as possible. We do believe, however, that the repaired seam will be stable, subject to protecting it by covering it with tailings.

The following people were present at the site visit and during discussions of the liner failure:

Larry Dykers - Minerals Exploration Co.
Larry Snyder - "
Jack Marshal - "
Roy E. Williams - University of Idaho (NRC Advisor)
T. L. Johnson - NRC
Paul Beck - Crestline Co. (liner installer)

There were no agreements made between NRC and Minerals Exploration Co. The purpose of the visit was only to gather facts about the liner failure.

Conclusions

We believe the major cause of the liner failure was due to the deviation from construction plans, where the field seam was placed on the slope (at the water level) rather than in the planned ditch. This caused undue stresses to be placed on the seam, for which it was not designed.

We believe the repairs made were adequate and that the seam will now be satisfactory, provided that tailings are introduced into this area to cover the seam.

B. UNC Teton Exploration

On Sunday, January 11, 1980, Dr. R. E. Williams and T. L. Johnson visited the UNC Teton Exploration Co. in-situ leach operation near Glenrock, Wyoming. The purpose of the visit was to gather information about, and to determine the cause of, a recent leak and liner failure.

Liquid wastes from the plant operation are pumped to a pair of lined evaporation ponds. Both ponds are lined with 36-mil hypalon, have 1V on 3H side slopes, and are about one acre in surface area.

Upon our arrival at the site, the repairs had been made and were being tested for leaks. The repairs had been made on two field seams that had been determined to contain void spaces between the two hypalon sheets that had been seamed. We observed that all field seams located on slopes are parallel to those slopes.

Antelope were observed to graze immediately adjacent to the site. We also observed that an antelope proof fence surrounds the ponds, such that no damage by sharp-hoofed animals should be anticipated at this site.

The two ponds at the site have separate leak detection systems although there is some question as to whether they function as separate units. Data collected by the company suggests that they have functioned as separate units. The leak detection systems consist of perforated pipes in gravel trenches beneath the ponds that are connected to a sump, that in turn is connected to the surface by a vertical pipe. The water level in this pipe is monitored daily. If any water appears in the pipe, it is concluded by the company that the system is leaking and an investigation is launched. A possible flaw in the leak detection system is that a lag time could occur between the occurrence of a leak and its detection, at least at the beginning of the operation, since the collection trenches are not necessarily placed on an impervious layer. A finite amount of leakage would likely be required to build up a positive pressure sufficient to drive phreatic leachate into the leakage detection trenches. It is possible that leakage may have been occurring for some time before it was detected on November 1, 1980. However, it appears that once the leakage detection indicates the presence of contaminant in the system, it should respond rapidly to the changes in the leakage rate thereafter.

When the leak detection system indicated leakage on November 1, the company began to lower the water level in the south pond by pumping water out of it into the north pond. When the water level had been lowered approximately seven feet, a puncture in the liner was observed. This puncture was attributed to a floating device that had been placed in the pond to implement a spray system which would increase the rate of evaporation. This puncture was merely an accident of operation and had nothing to do with the failure of the liner itself.

This puncture was repaired and the use of the pond was continued. However, as the water level was raised, it was observed that the leak detection system still indicated the occurrence of leakage. Consequently the company concluded that leaks other than the one resulting from the accidental puncture must have been occurring. In order to identify the location of these leaks, the company lowered the water level in the pond by pumping water into the north pond and by trucking excess water to the Exxon Highland tailings pond. The water level was lowered in increments and the leak detection system was dewatered at the end of each increment. Utilizing this technique, the company hypothesized that it would be able to identify the elevation of the leak in the hypalon covering the slopes of the embankment. However, the leak detection system indicated that leakage was continuing even when the liquid remaining in the pond was one foot deep. At this point they concluded that the leakage was occurring through the bottom of the pond and they completely emptied the pond. They then began inspecting the liner for punctures and other types of leaks. They discovered no additional punctures similar to the one caused by the floating device. However, they did discover voids in the field seam that runs the length of the pond and the field seam that runs the width of the pond. They devised a method for detecting voids in the field seam that is somewhat unique. This method consists of utilizing an air hose with a small diameter aperture at its end to force compressed air into the seam. At points where the seam contains voids, air is allowed to penetrate the seam and it forms a bubble beneath the liner adjacent to the seam. The bubble is indicative of a leaky seam. The entire length of both field seams were examined in this manner. Several voids were detected, marked, and subsequently patched. When all voids on the field seams had been patched, the company began refilling the pond. Filling was conducted in increments and the leak detection system was monitored during the filling of each increment. As the pond level was raised, the leak detection device indicated no activity until the pond was approximately half full. At that point the leak detection device indicated that leakage was again entering the collection trenches. The water level was lowered again and the liner was inspected at this elevation. Insepction revealed that approximately fifteen pencil lead or slightly larger sized holes existed in the liner covering the slope of the pond. These were repaired and filling is now continuing. No additional leaks have been found. Two possible explanations have been proposed for the occurrence of the small punctures. These are:

1. They may have been made by a worker with a defective shoe during the repair of the seams; or

2. They may have been caused by ice falling onto the liner as the water level in the pond was lowered beneath the ice.

Probably, the explanation involving the defective shoe is most correct, although the explanation involving the ice cannot be discounted completely. In any case, neither mechanism would have produced a failure if the field seam had functioned properly in the first place and the water level in the pond not been lowered.

The liner installer was contacted and asked to participate in the repair job and to explain the failure of the seams. These discussions revealed that the field seaming was done on a cold day in the fall of 1979. Aparently the narrow temperature window necessary for the field seaming of hypalon was missed and voids in the field seam was the result. The company reported to us that the field seams were not checked either sonically or by any other method at the time of their installation.

It is noteworthy that the field seam failures did not result in parting of the seams as was the case at the Sweetwater project. We attribute this to the fact that the field seams at the Teton waste disposal facility were not installed in a direction perpendicular to the direction of the slope of the walls of the pond. Therefore, essentially no tensile stress was placed on the field seams. All stresses on the liner on the slopes were parallel to the field seams. Tensile stresses would not be expected to occur on the horizontal pond bottom.

There were no agreements or committments made between NRC and Teton Exploration Co.; the purpose of the visit was only to gather facts about the liner failures.

The following people were present at the site visit and during discussions of the liner failure:

Dick Appel - Teton
Paul Hildenbrand - Teton
R. E. Williams - NRC Advisor
T. L. Johnson - NRC

Conclusions

We believe that the repairs were performed adequately; the repairs have been checked and have been found to be acceptable. The most probable cause of the leaky seams was due to the fact that field seaming was done in less-than-optimum temperatures. We recommend that operation continue as before, with continued daily monitoring of the leak detection system.