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Eliminating costly tests for PVC geomembranes by using new ASTM D 7177 air channel test for field seams.

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ABSTRACT
Air channel strength testing of dual track thermal welds of PVC geomembranes has been developed to provide quality assurance for the full length of PVC geomembrane field welds, eliminating the need for cutting holes in the liner to perform destructive peel testing. The testing method was adopted as ASTM D 7177 Standard Specification in June 2005 and has been published for use since the 2006 construction season. This paper will present a detailed case history of the installation quality control and engineering quality assurance programs implemented on the 787,800 square foot 40 mil PVC geomembrane lagoon system installed at the Village of Manton Wastewater Treatment Lagoon improvement project in Manton, MI, USA. The design engineers at Fleis & Vandenbrink Engineers worked with the Michigan Department of Environmental Quality to eliminate the outdated and highly inaccurate water balance test by requiring air channel testing for PVC geomembrane field seams. The 40 mil PVC geomembrane was installed using dual track thermal welding and all field seams were air channel tested for seam continuity and peel strength. The success of this project has provided the basis for implementing this new testing technology in lieu of the water balance test, saving the customer precious time and ultimately precious funding.

1. INTRODUCTION

In Michigan, there have been numerous projects to rehabilitate old existing waste water lagoons. Many of these lagoons were constructed over thirty years ago and simply used native soils or natural clay as a bottom liner. At the time, clay was a suitable option for a liner system to minimize infiltration into the soil and potentially the water table. With the advances in geosynthetic technology over the past few decades, there are now a plethora of better liner systems. Using Government grants and funding through the United States Department of Agriculture (USDA) Rural Development, many communities have been able to rehabilitate their waste water treatment plants to include a new geosynthetic liner system. In the spring of 2006 the Village of Manton, Michigan began this process.

2. CONTRACTORS

Fleis & Vandenbrink Engineers from Grand Rapids, Michigan were retained by the Village and given the task of designing the new system and construction oversight for the project. The project was advertised for public bid proposals. Team Elmer's was selected as the Prime Contractor to complete the project and selected Environmental Protection, Inc. (EPI) as the PVC geomembrane fabricator and installer. The project specifications also required an independent third party construction quality assurance firm specifically to inspect the geomembrane liner installation and testing. STS Consultants, Ltd. was retained for this purpose as the independent third party construction quality assurance (CQA) firm.

3. DESIGN

The existing lagoon system was made up of three large lagoons. The new design would require two of the existing lagoons be renovated to include two settling lagoons (lagoons number two and four) and one aeration basin (lagoon 1a). The third existing lagoon would be removed from service but left intact for future expansion.

The excavation phase began by draining each lagoon. Once the lagoon had drained down to a workable level, the contractor began with the sludge drying and removal. After the sludge removal was complete, the subgrade was excavated down to the existing clay liner system. Since this project was a rehabilitation of existing lagoons, the engineer also designed a gas venting system into the subgrade that would allow any gases from organic degradation to vent outside the liner and not be trapped below the liner system. A sand cushion layer was then placed over the clay subgrade in preparation for the PVC geomembrane.

The new design specified 40 mil PVC geomembrane be used as the primary liner system in the rehabilitated lagoons. For the three new lagoons, a total of 787,800 square feet of 40 mil PVC geomembrane would be required to completely line the lagoons. EPI fabricated the 40 Mil PVC geomembrane into panels as large as

15,000 square feet (75 feet wide & 200 feet long) for this project. By fabricating large custom sized panels, the amount of field seams required would be minimized.

The sequence was essentially the same for each lagoon. Once the PVC geomembrane was installed and all testing had been completed, the excavation contractor began placing the cover soil. One foot of cover soil was placed over the entire liner system using heavy equipment and GPS guided bulldozers for finish grading. The side slopes were also covered with rip rap to maintain the cover soil and minimize erosion. Once the excavation, liner placement and cover soil phase was completed, each individual lagoon was placed back into service prior to beginning work on the next lagoon. This sequence allowed the Village of Manton to continue uninterrupted service during the rehabilitation process.

4. GEOMEMBRANE DISCUSSION

Project specification required the Minnesota Water Balance Test to be conducted if all the requirements of the air channel testing were not met to the satisfaction of the Owner. The water balance test essentially consists of filling each lagoon with clean water and measuring any change in the water level. Any water level changes are compared against a control to determine the integrity of the lagoon liner system. The control is typically a barrel placed in or near the lined area or a weather station. Measurements are taken for four weeks and compared with atmospheric gains and losses to determine the lagoon leakage rate. The downside of the water balance test is the time it takes as well as the required clean water to fill the lagoons to six feet in depth. The accuracy of the test itself makes the determination of liner integrity a real challenge. The time involved for the contractor as well as the challenge of securing the clean water to fill the lagoons is quite costly. Following are the details of how the water balance test was not required due to the high level of testing and quality control required on this project.

Prior to the lagoons being prepared, the geomembrane panels were delivered to the site and each fabricated geomembrane panel was labeled with its size and a unique serial number for quality control purposes. During installation, the panels were deployed beginning in the morning and technicians began seaming once enough panels were in place to begin. Seaming was performed using a hot air welding machine that produced a dual track thermal fusion weld with an unbonded center channel for testing. Prior to production seaming, the machines were configured and trial welds were made. These trial welds were tested with a portable tensiometer to ensure seam strengths. All field seams were dual track welded, including the “butt seams” that have the overlap from factory seams. These factory seams of each panel have the potential to leak at the intersection of field to factory seams if the welding machine is not properly configured. Special care was taken to ensure the field seams that included factory seam overlaps were sealed at each joint.

The project specifications required the 40 mil PVC geomembrane to be installed with all production field seams constructed using dual track thermal fusion welds. The dual track weld leaves an unbonded area between two parallel welds that can be air pressure tested. With this technique, the entire length of seam can be evaluated to ensure continuity as well as seam strength. Minimum required peel strength was 15 pounds per inch width and minimum required shear strength was 77.6 pounds per inch width. All of the trial welds and destruct samples were tested in peel and shear modes according to ASTM D 6392 Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams. Every destruct taken passed the requirements for peel and shear, with peel strength averaging around forty pounds per inch width.

Thermal fusion welding allows for the air channel testing to be performed once the seam is completed and the material returns to ambient temperature. This allowed the installation personnel to begin air channel testing shortly after each seam was completed. The air channel testing was typically done in the afternoon, after enough seam was completed to efficiently test. Ambient temperatures were typically between 80°F and 100°F. The geomembrane liner temperatures were normally 20°F to 40°F above the ambient temperature due to the dark coloration of the liner.

The specifications for this project required all seams be air channel tested according to GRI Test Method GM6. The project specifications did not require the test pressure in the air channel to meet the ASTM D 7177 requirements. The ASTM D7177 testing requirements specify a minimum pressure at a particular geomembrane sheet temperature. Due to the high ambient temperatures, the ASTM requirements actually correlated to the GRI GM6 test requirement which was actually slightly lower than the ASTM requirements. In accordance with the ASTM D 7177 test method which requires the seam to maintain the minimum pressure at a given sheet temperature, this test method will verify seam strength as well as continuity. EPI used the minimum requirements of the ASTM method since they were more specific to PVC geomembrane than the requirements of GM6 and provided more confidence to the CQA. GRI GM6 requires the seam of 40 mil PVC geomembrane to maintain a pressure of 20-30 psi and have no more than a five psi drop over a two minute holding period. The air channel pressures used for this project were between 20 psi and 30 psi and typically on the higher end at 25 psi to 27 psi.

Given the sheet temperatures at the time of the tests, the pressures used would ensure the seam strength of the entire length of seam according to ASTM D 7177. Any seam that did not hold the required pressure was investigated to find the leak point and then tested in each direction from the leak. The leak point was then capped with a repair patch after the air channel testing was completed. That repair patch was then tested using the air lance method according to ASTM D 4437.

4.1 Lagoon 2 (Figure 1) was ready to be lined in June of 2006. 304,625 square feet of 40 mil PVC Geomembrane liner was supplied for this lagoon. From approximately 4,500 lineal feet of field seam in this lagoon, nine destructive samples were taken. Over 1,225 lineal feet of field seam from this lagoon were from the factory end to factory end type of field seam. This means there was a "T" from the factory seam every 6.25 feet on both panels being seamed. It was critical that these end to end seams were also dual track welded and air channel tested to ensure the integrity of the seams. Special care was taken by the seaming technicians when setting up the welder to make sure this type of seam was completely sealed. Then the air channel test also verified the strength of the seam as well as continuity.

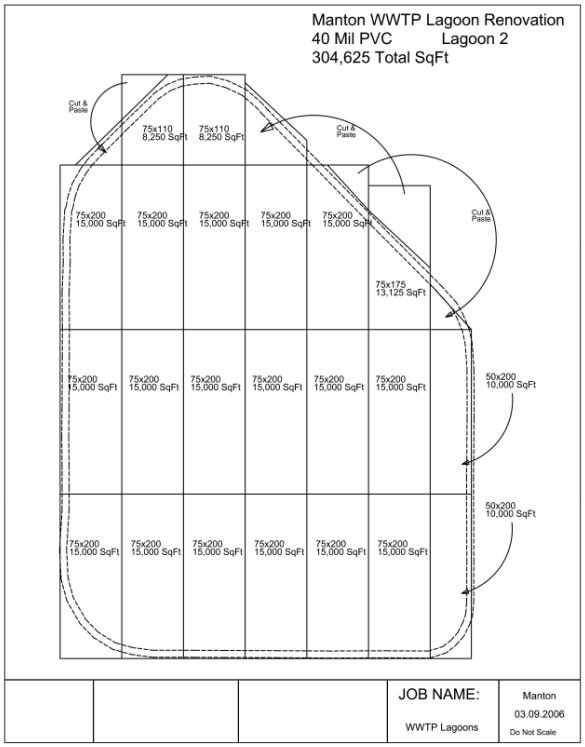

Figure 1. Lagoon 2 panel layout.

There is a potential for each of the "T" seams to have a very tiny leak at the junction of three sheets of material. This is another reason why air channel testing every seam is critical to the integrity of the liner system and not just using air channel testing for the long flat edge to flat edge seams. While destructive samples will give you a decent representative sample, they are not comprehensive. For example, if a destruct is taken in the first half of any given seam and the welding machine has a malfunction in the second half of the seam, it is possible for that section of seam to go unchecked for strength. With dual track welding and air channel testing according to ASTM D 7177, the entire length of seam will be pressurized and any section of seam that is less than the required peel strength will quite literally peel open from the inside out. This is in essence peel testing 100% of the seam from the inside out. This technological advance in non-destructive testing is also a destructive test over the entire length of seam giving all parties involved a much higher level of confidence in the final liner system.

4.2 Lagoon 1a (Figure 2) was the next lagoon to be lined in July of 2006. A little more than 76,000 square feet of PVC Geomembrane liner was required for this aeration basin. There were two destruct samples taken from nearly 880 lineal feet of field seam in this lagoon. Only about 225 lineal feet of field seam from this lagoon were from the factory end to factory end. Given the critical nature of these types of seams they were also dual track welded and air channel tested to ensure there were no leaks.

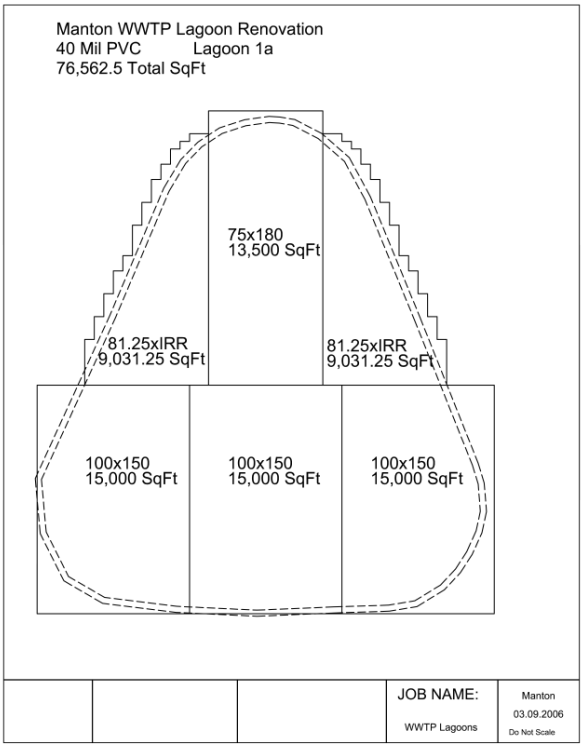

Figure 2. Lagoon 1a panel layout.

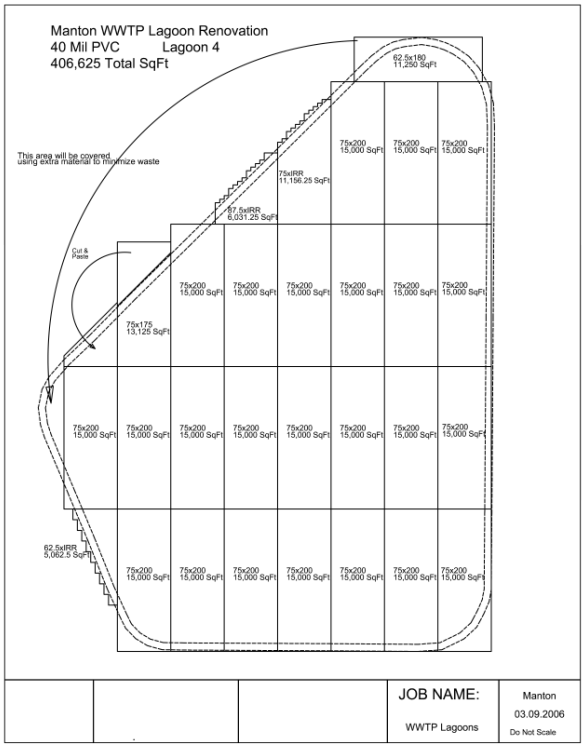

Figure 3. Lagoon 4 panel layout.

4.3 Lagoon 4 (Figure 3) was the last lagoon to be rehabilitated in August of 2006. 406,625 square feet of 40 mil PVC Geomembrane liner was provided for this lagoon. There were 16 destruct samples taken from almost 8,000 lineal feet of field seam in this lagoon. Close to 1,700 lineal feet of field seam from this lagoon were from the factory end to factory end. All seams were dual track welded and air channel tested to ensure their strength and integrity.

5. CONCLUSION

With the very short construction season in Michigan, which is typically April through October, waiting 30 days for a water balance test on each lagoon would have been a real challenge for the contractor to complete the project on schedule. Therefore, completing the air channel testing on all field seams and not being required to undertake the water balance test was a significant savings to everyone involved. In the end, this savings directly benefitted the community and the Village of Manton. This project provides a great example of how more stringent quality control procedures and requirements can actually be a cost savings in the long run.

6. REFERENCES

GRI Test Method GM6. Standard Practice for Pressurized Air Channel Test of Dual Seamed Geomembranes, *Geosynthetic Research Institute*, Folsom, Pennsylvania, USA.

ASTM D 4437, Standard Practice for Determining the Integrity of Field Seams Used in Joining Flexible Polymeric Sheet Geomembranes, *American Society for Testing and Materials*, West Conshohocken, Pennsylvania, USA.

ASTM D 6392. Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods, *American Society for Testing and Materials*, West Conshohocken, Pennsylvania, USA.

ASTM D 7177. Standard Specification for Air Channel Evaluation of Polyvinyl Chloride (PVC) Dual Track Seamed Geomembranes, *American Society for Testing and Materials*, West Conshohocken, Pennsylvania, USA.