Use of Electronic Leak Detection System in 24/7 on-line mode to control construction and operation of lined CAL lagoons

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ABSTRACT

The latest Covered Anaerobic Lagoon (CAL) equipped with Electronic Leak Detection System (ELDS), with permanently fixed position sensors (to monitor integrity of geomembrane) was built in 2011/2012 in UK. A new improved CAL design was implemented. Advancements incorporated into the new design were based on experiences from previous installations and operation of permanent ELDS, now incorporating sophisticated Continuous Monitoring Station (CMS), allowing real time monitoring of geomembrane integrity 24/7 and providing leak alarms and positioning of damage in the event of any leak. Special conductive geotextiles are used providing consistent current distribution and in the latest application a new conductive geotextile incorporating a unique signal layer was introduced. The presented article describes the use of ELDS to further perfect and continuously improve CAL construction. The 24/7 electronic monitoring and processing unit is described to help promulgate the understanding of the process of on-line geomembrane integrity testing of CAL facilities.

1. INTRODUCTION

The concept or requirement for leak detection monitoring of geomembrane lined tanks filled with liquid are as old as the use of geomembrane lining itself. The options for leak monitoring and detection of damage have historically been restricted to passive solutions. Such solutions have provided only indicative information that a tank or lagoon is 'probably' free of any damage. This unacceptable level of uncertainty is as a result of the nature of passive systems utilising drainage pipes or drainage composites. Prior to this indicative bore holes were used as integrity indicators, especially for tanks filled with toxic material or contaminants where the presence / absence of the stored material in a tank or lagoon was controlled. In both cases if the presence of the material in bore holes or the drainage system was positive, the leak was detected however it was never possible to detect the exact position of any geomembrane damage. In many cases having found that a tank was leaking, the only solution was the installation of an additional layer of the geomembrane. Unfortunately many lagoons were still found to be leaking even after a number of additional layers were installed.

The installation of five or more geomembrane layers has been seen on sites where there were still leakage problems. There have been many experiments using indication chemicals and similar tracing solutions, but none have adequately resolved the inherent problems.

2. DESCRIPTION OF APPLICATION

Resolution of the root cause of the problem (a leak through damaged geomembrane) required the use of an electronic monitoring system in order to mitigate the huge costs associated with unserviceable tanks, which could have resulted in the closure of a factory. The data from the electronic monitoring system was used to create a report of geomembrane integrity, which was issued to the inspection office at the Environmental Bureau in order to get approval to use the lagoon.

The cost of suspended production on the site was the dominant consideration and after consultations with the Client an ELDS off-line system was designed. As a result, when testing of the geomembrane was carried out with the installed system it was found that the impact of 'the electrical bridges' and ELDS electric signal formation itself, caused very complicated data analysis and their evaluation / interpretation, was practically impossible without the input of highly experienced engineers.

2.1 EUROPE

The first Covered Anaerobic Lagoon (CAL) to be equipped with permanently installed ELDS with sensors in fixed positions (to monitor integrity of geomembrane), was built in 2001 in Europe. Three different types of leak detection and location systems were applied prior to filling the lagoon with water. To enable function of the pre-filling tests a conductive geotextile was installed. The physical make up of the sealing layers (reading from bottom to top) were: HDPE geomembrane; geosynthetic drainage layer; conductive geotextile; ELDS; upper HDPE geomembrane. Both HDPE geomembranes were tested prior to filling the lagoon using an electro acoustic test method as well as wading and water lance surveys. These techniques revealed a number of leaks, which were then repaired prior to the filling process. During the filling process the permanent ELDS was used to monitor the integrity of the lagoon. Data from the ELDS was recorded and analysed in-situ requiring the permanent presence of an engineer throughout the filling process. Since then over the period of 11 years service zero leakage has been recorded. This first application was published and presented by group of authors I.D.Peggs, V.Nosko, P.Razdorov and P.Galvin at Eurogeo 2004.

2.2 NORTH AMERICA

Based on the abovementioned success, the Client wanted the system adapted in order to monitor the integrity of geomembrane layers automatically both during the construction and during the operational life of a lagoon. **The main requirement was to have information available 24/7 in the control centre for the site (via SCADA)** where all information about the function of a lagoon is coordinated (pumps, mixers, liquid levels, etc). At the time, the only system available was an off-line version, but driven by the client's desire for innovation and a culture of continuous improvements based on experiences since, a new type of system was developed. In 2008 in North America the iterative technical improvements made through continuous improvement allowed for a technological leap to a much more sophisticated electronic leak detection system which was installed complete with an on-line 24/7 testing mode. The photographs 1 and 2 below show the installation of sensors and cables to the geogrid that is to be contained along with the conductive geotextile between two layers of geomembrane.

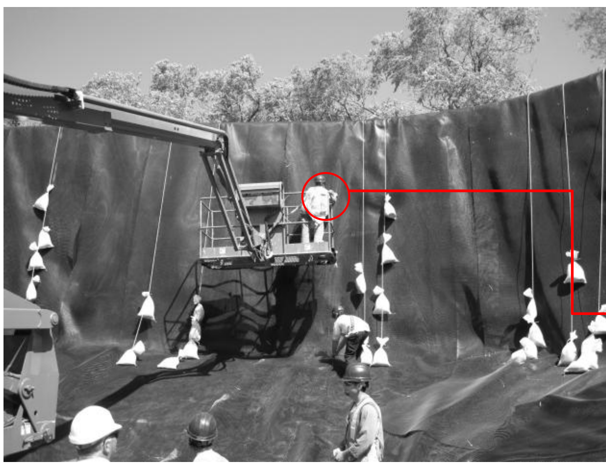

Photo 1. Installation of ELDS.

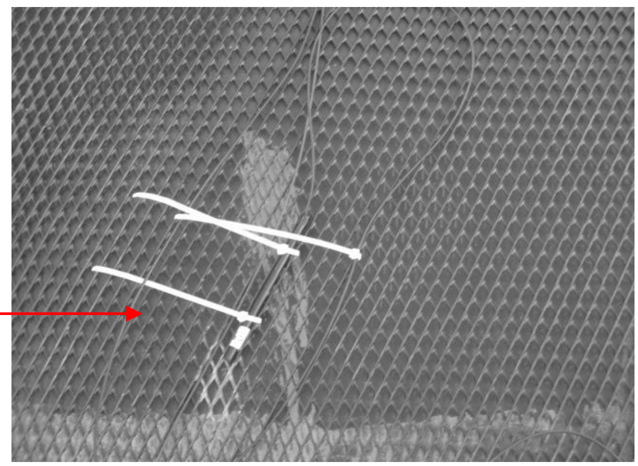

Photo 2. Detail of sensor installation.

Photo 3. General view of the tested lagoon

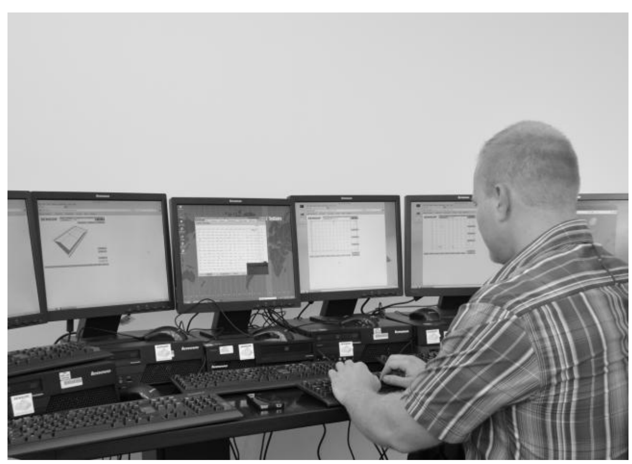

Photo 4. ELDS remote analysing centre

Unlike previous experiences, earlier involvement in the design stage made it possible to influence the process. This allowed the client eliminate the impact of 'electrical bridges' and to eliminate false signals in data scanning. In this case two geomembrane layers were installed with a conductive geotextile between in order to maintain consistent signal transfer from any damage. The sealing layers comprised (in order from bottom to top): a compacted clay base; thick protective geotextile; lower HDPE geomembrane; drainage geocomposite; conductive geotextile; ELDS; and finally the top layer of HDPE geomembrane.

2.3 EUROPE

After the successful implementation of ELDS incorporating the 24/7 monitoring concept in 2011 in Europe the same system was installed (Photo 3) but adapting the installation to work with only one geomembrane layer. 24/7 monitoring was included but **we also added a new 'Watchdog function' (a leak alarm).** The sealing layers comprised (in order from bottom to top): clay subsoil; thick protective geotextile; drainage geocomposite; **new type of conductive geotextile with integrated the signal layer (for watchdog alarm function)**; ELDS; and on the top the HDPE geomembrane. There were 400 sensors installed for monitoring the integrity of lagoon, the area monitored is 10,200m^2. The aim of the project was achieved with 100% integrity in the construction phase of the lagoon. The main aims of the project in relation to the ELDS implementation was set out as:

1. Integrity testing of a geomembrane before filling;
2. 24/7 Integrity testing during the filling lagoon with water;
3. Integrity testing during the use of the lagoon.

In order to ensure that the ELDS was able to achieve aim 3 above it was necessary to develop a system that could filter the electrical noise generated by the production processes. The methodology adopted to test during the operational lifespan of the CAL was the use of the Watchdog system during periods of sustained production process 'noise', then to switch to scanning mode during low noise periods. This method enabled the elimination the false signals, or damaged data caused by 'noise' and was achieved by implementing a high level of data coordination through the client's SCADA system. This system and other similar systems installed around the world are monitored remotely from our monitoring (Photo 4 above). These developments took more than **10 years Research & Development** by teams of highly educated engineers.

It is very important to clearly state that the unambiguous aim was that 100% geomembrane integrity be maintained during lagoon construction process and its fluent transfer from construction to operational service. This aim was achieved by maintaining the team whose close coordination and shared experience of such installations enabled familiarity to be translated into success. Cooperation between the individual companies started on the earlier applications developing the collective intelligence as each project was completed. This intelligence is both built and capitalised by the repetitious deployment of the same installers, manufacturers and consultants on each project. The combined and thorough knowledge of all processes involved in the construction process resulted in a successfully delivered project.

The key measure of the success of the whole project was the coordination of all processes without the need to repair the geomembrane which would cause construction delay. In 2001 there were 7 anomalies; in 2007 there were only 3 anomolies; and in the year 2011 there were none (the functionality of the ELDS monitoring system was proven by successful detection of 2mm diameter test holes, shown in Photo 5 and Photo 6). This is the most important result validating the approach of learning from mistakes during the construction process and in order to achieve this the importance of maintaining the same team of companies cannot be overstated.

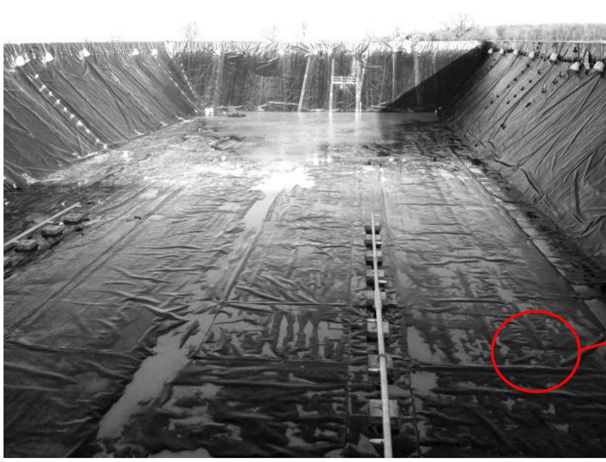

Photo 5. Position of test hole.

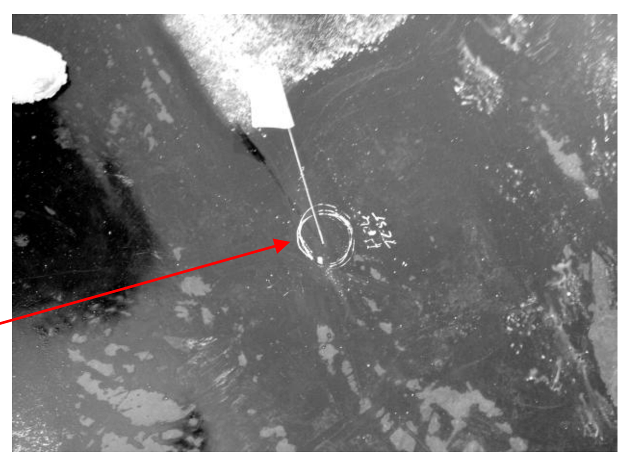

Photo 6. Detail of the test hole.

3. CONCLUSION

The latest installation was carried out during 2011/2012 where another improved CAL design was implemented to make ELDS more effective. The advancements incorporated into the design were based on the experiences from previous installations and the operation of the permanent ELDS, now incorporating the sophisticated Continuous Monitoring Station (CMS) which allows real time control of geomembrane integrity 24/7.

In each case special conductive geotextiles were used, the latest of these textiles enable CMS to provide a leak alarm in the event of a leak. The prescribed ELDS testing process has two modes:

- Watchdog monitoring mode to warn clients immediately that the integrity of the geomembrane is broken;
- Measuring mode when liner is scanned and the position of any damage / leak can be precisely located.

The abovementioned functions of the ELDS CMS system, provide 24/7 geomembrane integrity monitoring during each phase of the CAL's life, these phases are summarised as:

1. Construction Phase (pre-filling);
2. Water Filling Phase (up to maximum capacity);
3. Operational Phase.

Each of these phases present their own challenges as the dynamic forces applied to liner shift the installed system is continuously and automatically reporting to the client through their SCADA system, confirming the integrity of the protective geomembrane.

The presented article describes the use of ELDS with permanently installed sensors in fixed positions to assist in the further and continuous evolution of CAL construction perfection.

The full electronic monitoring and processing unit in 24/7 mode are described to help promulgate the understanding of the process of on-line testing of geomembrane integrity within a CAL facility.

ACKOWLEDGEMENT

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